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PERSPECTIVES on Science and Christian Faith

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Perspectives on Science and Christian Faith

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Editorial

Arie Leegwater

A Brief Excursion in Chemistry: "God-Talk" in Chemistry?

Recently, I wrote a review of two collections of philosophical essays by Eric Scerri for a British journal. The books were devoted to philosophy of chemistry and issues of chemical pedagogy. As I composed the review, I began thinking, "Would such reviews be of interest and value to readers of *PSCF?*" On the face of it, the books contained no references to God, to humans' calling in the world, or to the science/religion relationship—not a single whiff of a theology of science. So, should we simply not care and rule such reflection beyond the pale? Must, in fact, all we do be directly related to "God-talk"? A better approach to take, I would argue, is to ascertain which philosophical, metaphysical, and religious starting points radiate through a scientist's presentation and formulations. For some of us, an inviting option could be to return to an earlier time when "God-talk" was in the air, before the secularization of science took hold. But clearly, it will not do to become nostalgic about a historical "golden age" when persons such as Jan Luyken (Amsterdam, 1694) could describe chemists as "scheiders" [as practitioners of the art of separation or "*scheikunde*"], able to divide even body and soul.

Classical philosophy of science has centered on theory validation: the weighing of theories and the validity of scientific knowledge. A more recent focus has been on considering science as process and practice: "What are the historical conditions under which, and the means with which, things are made into objects of knowledge?" (Hans-Jörg Rheinberger). This contextualization of science has gone hand-in-hand with a growing awareness of the vital role that religious beliefs and commitments have played in the shaping and elaboration of scientific worldviews and pictures. These beliefs are no longer regarded as embarrassing for the reputation of a great scientist, nor are they summarily dismissed as irrelevant to scientific practice. Furthermore, they are no longer treated only as external factors that, in particular circumstances, may have retarded or advanced the internal development of valid scientific conclusions. Religious beliefs are taken seriously in the task of understanding not only the context, but also the content of scientific practice.

By careful examination, one can often find a person in his or her scientific work by noting the problems chosen, how they are formulated, the experimental evidence marshaled, and the perception of the range and scope of a theory. Take the case of Wilhelm Ostwald, a Nobel Prize winner in chemistry (1909). Ostwald wanted to develop a general chemistry (an "allgemeine Chemie") which would undergird all the subspecialties of chemistry. Ostwald's desire was to reconstruct and reformulate the principles of chemistry along more general and intuitive lines. Energy and its transformations were to be the cornerstone for Ostwald's science of energetics. He considered matter to be nothing but a complex of energy factors. Energy has a right (in addition to space and time) to be a central concept in science since "everything that happens is in the final instance nothing but a change of energy." Atomic models or atoms are nothing but "graven images" as he described them in his famous 1895 Lübeck address, "Overcoming Scientific Materialism."

The strength of Ostwald's energeticist position in chemistry is also its major weakness. He wanted to stress the fundamental importance of dynamics (reaction velocities) initially, and subsequently energy transformations at the expense of more structural questions. The relatively abstract mathematical description of energy and its exchange requires the intentional isolation, either theoretically or experimentally, of a physical system, and a conscious neglect of its typical properties and structure. This neglect—or better yet, reduction—of subsuming

typical properties as instantiations of a general law, ran counter to the major thrust of nineteenth-century chemistry. Ostwald employed a broad range of arguments: scientific, methodological, philosophical, and religious. The latter is manifest in Ostwald's commitment that the energy principle be an explanatory principle of cosmic proportions: it would be an energetics complete with a theory of happiness, an encyclopedia of the sciences, a theory of spirituality, an energetic understanding of consciousness, an argument for Esperanto, and numerous Sunday sermons (fifty-two in all), many of which exhorted his listeners to conserve energy.

Similar fine-grained considerations can be employed to examine the work of chemists such as Linus Pauling (1901–1994) and Charles A. Coulson (1910–1974). Coulson, for example, described the contributions of wave mechanics to chemistry in these words:

> You must surely have been struck by the way in which, all along, modern wave mechanics has taken up ideas of the past, and refurbished them. How astonishingly fruitful have been those semi-formulated concepts of the classical chemists: and how necessary, in a sense, it has been for wave mechanics to give flesh and blood to the spirit which it has inherited … At every turn we have seen how wave mechanics has taken their work and has added to it the quality of a deeper understanding.[1]

On the face of it, Coulson describes the development of wave mechanics in chemistry, but yet on closer examination, the statement, particularly the phrase, "give flesh and blood to the spirit which it [wave mechanics] has inherited," reveals a whole new horizon of interpretation. Is it a mere metaphorical turn, for example, as we find expressed in such titles as *Science Incarnate: Historical Embodiments of Natural Knowledge,* edited by Christopher Lawrence and Steven Shapin? Or does it rather reflect a different reading or narrative of the world? In this case, it is a Christian incarnational one: nature not read first of all as mechanism, but as God's incarnational involvement with the earth.

But back to the question at hand: Does the practice of science necessarily require "God-talk," that is, must it involve a form of theism? If we think it must, we will miss the religious dynamic operative in a scientist such as Ostwald. For Ostwald, we see a concerted effort to eradicate religion from science by a substitute religion based on energy. By contrast, in Coulson, we can admire a valiant effort to be a Christian in his scientific practice, his vocabulary and phraseology giving evidence of that effort. Clearly, to demarcate religion and science is more subtle than we often assume.

Note

[1]Charles A. Coulson, "The Contributions of Wave Mechanics to Chemistry," The 1951 Tilden Lecture, *Journal of the Chemical Society* (1955): 2084.

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In This Issue

Several of the articles in this issue reflect long-lasting and intense discussions in the Christian community. Historian Mark Noll (University of Notre Dame) leads off with an article that specifies fifteen attitudes, assumptions, and convictions that have shaped evangelical reflection on the interaction of Christianity and science. Two biologists, Harry Cook and Hank Bestman (King's University College), provide a study of the emerging discipline of biological complexity, as it teases out the nuanced interactions of a cell's cytoplasm and nucleus. This article is followed by a long-awaited author exchange between Stephen Meyer (Discovery Institute) and Dennis Venema (Trinity Western University) centered on Venema's essay book review (*PSCF* 62, no. 4 [2010]: 276–83) of Meyer's recent book, *Signature in the Cell: DNA and the Evidence for Intelligent Design*. Next is an essay book review by Daniel Brannan (Abilene Christian University) of *Reconciling the Bible and Science: A Primer on the Two Books of God,* written by two members of the Church of Christ faith community, attempting to "fully integrate evolutionary thought into theology."

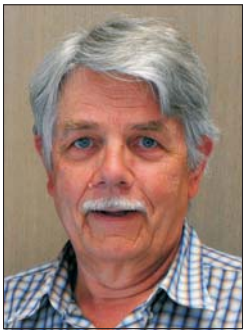
The book review section and two letters to the editor, written in response to previously published articles, complete the issue.

A last reminder: The deadline for submitting papers for the forthcoming special issue of *PSCF* on "Responsible Technology and Issues of Faith" is September 30, 2011 (see p. 182 for details).

Biological Complexity

Harry Cook and Hank D. Bestman

Harry Cook



Hank D. Bestman

Complexity is often defined in the language of mathematics, computers, or information theory. We examine biological complexity as it occurs in the cytoplasm's relation to nuclear function, and in the case of epigenetics. In the nineteenth and twentieth centuries, the pendulum swings between appreciation of biological holism and complexity, and reductionism. During the second half of the twentieth century, complexity gains a new appreciation and emerges as a field of study in its own right. We propose a description of biological complexity that includes the functional dynamics of the various structural components of biological organisms and their levels of functioning, with the higher levels imposing boundaries on the lower levels. We suggest that this complexity reveals the wisdom of the Creator.

What is complexity? That is a complex question! That is, the answers are complex, and they depend on whom you ask. In this article, we will discuss biological complexity, using the relation between nucleus and cytoplasm, and epigenetics as examples. We will provide a brief history of biological complexity and describe the difficulties in defining complexity, in general, and biological complexity, in particular. Then we will propose a characterization of what constitutes biological complexity. In keeping with common parlance, we use "complex" and "complicated" (and their accompanying nouns) more or less interchangeably. As we go along, it will become clear that "complexity" is also a topic that has given rise to distinct views about the nature of biology and the entities it studies.

Cellular Complexity: The Gene-Centered Approach

The nucleus of the cell stands out. With standard histological techniques, the nucleus is much more noticeable than the outline of the cytoplasm. The chromosomes in meiosis and mitosis present a fascinating vista of structure and function. The genetic ratios observed by Gregor Mendel are intimately related to the activities of the chromosomes in meiosis. The establishment of nucleic acid as the carrier of heredity, then the discovery of the structure of DNA, and, finally, its roles in inheritance and protein synthesis present us with a fascinating journey of discovery. With this emphasis on the nucleus and nucleic acids, the role of the cytoplasm in various functions is often underestimated, but it is gaining attention at present. In this section, we attempt to describe a holistic view of cell functions as they pertain to cellular complexity.

Harry Cook *and Hank D. Bestman met at Dordt College, in Sioux Center, Iowa, in the late nineteen seventies; Cook as faculty member, Bestman as a student. They both moved to Edmonton, Alberta, Canada, in 1979, Bestman to take up graduate studies, Cook to take a faculty position at the newly opened King's University College. Cook carried out research on fish endocrinology and followed his interests in the history and theory of biology. He is now emeritus professor of biology and is scheduled to teach his history of biology course one more time this fall.*

Hank D. Bestman *is Vice-President Academic (interim) and professor of biology and biochemistry at the King's University College in Edmonton, Alberta, Canada. He teaches courses in biochemistry and mathematical modeling in biology. After his undergraduate studies at Dordt College, where Cook was one of his mentors, he earned his MSc and PhD in plant science from the University of Alberta. In 1987 he joined Cook as a faculty member in the biology department at the King's University College. He has an active experimental research program with undergraduate students focusing on carbon metabolism in algae and computational modeling of cellular dynamic processes. Since the rise of systems biology, he has focused his theoretical reflections on the relationship between bio-complexity and emergence in the context of a systems biology approach to understanding organisms.*

Mendel and his rediscoverers worked in continental Europe; however, the new subdiscipline of genetics was especially influential and successful in the Anglo-Saxon world. The contributions of William Bateson in England, and of Thomas Hunt Morgan in the United States, are particularly significant. Bateson was an established and respected British biologist when he heard of Mendel's work, and of its rediscovery. He coined the word "genetics" and, together with Reginald Punnett, worked vigorously to establish genetics as a field of study in Britain.[1] Mendelian genetics progressed rapidly in the few years between its rediscovery and the publication of one of Bateson's major works in 1909.[2] Bateson translated Mendel's pioneering article into English, and he broadened Mendel's theory to include more organisms, including animals. Through his work, along with that of others, genetics developed into a discipline that was separate from the study of reproduction in general. Bateson also kept in mind the importance of the whole organism and the connection between genes and embryological development.[3]

Morgan, the American geneticist, continued the trend established by Bateson, and contributed much to our understanding of genetics. Switching from embryology to the new science of genetics, he adopted the fruit fly, *Drosophila melanogaster,* as his research organism. This was a brilliant choice, and a great number of key discoveries, such as mutation, linkage, sex linkage, crossing over, and the giant chromosomes, followed. This work did much to supply a biological basis for Mendel's laws. Morgan trained several graduate students who became accomplished geneticists in their own right; Alfred H. Sturtevant, Calvin Bridges, and H. J. Muller stand out.[4] Like Bateson, Morgan began his biological career as an embryologist; his impressive findings in heredity hastened the separation of genetics from other fields of study in reproduction. Throughout his life, he retained his interest in embryology, but when he was engaged in his work in genetics, he deemed the relationship between genetic factors and their effects to be of secondary importance. In 1926, he stated that "the sorting out of the characters in successive generations can be explained … without reference to the way in which the gene affects the developmental process."[5]

In a perceptive discussion, Evelyn Fox Keller discusses the "nuclear monopoly" and the disregard for developmental processes which bring about the effects of genes; she speaks of "the discourse of gene action."[6] That is, many geneticists were content to speak of gene action without knowing the mechanisms by which these actions were achieved. Keller cites Morgan's comments, relevant to the topic of this article:

> It is clear that whatever the cytoplasm contributes to development is almost entirely under the influence of the genes carried by the chromosome, and therefore may in a sense said to be indifferent.[7]

Not all cell biologists agreed with this statement by Morgan; Jan Sapp reviewed the early biological literature that stresses the role of the cytoplasm.[8] Embryologists, who continued to remind cell biologists of the importance of the cytoplasm, stressed that all cells of an early-stage embryo receive the same hereditary information, and that it is the cytoplasm that gives the impetus for the early differentiation of cells. Even Morgan reminded biologists,

> The implication in most genetic interpretation is that all the genes are acting all the time in the same way. This would leave unexplained why some cells of the embryo develop in one way, some in another, if the genes are the only agents in the results.[9]

Thus, embryologists were emphatic in pointing out the role of the zygotic cytoplasm, and the complex interaction between nucleus and cytoplasm.[10]

In continental Europe, biologists were less enamored by the Mendelian paradigm and more reticent to ignore the role of the cytoplasm and the mechanisms that linked genes and their effects. Paul Weindling describes the various ways in which German biologists of the late eighteenth and early nineteenth centuries used their excellent microscopes and cytological skills to study the roles of the cytoplasm.[11] Keller states,

> The nucleus was the domain in which American genetics staked its unique strengths, associated with American interests (and prowess), whereas the cytoplasm was associated with European, especially German, interests and prowess.[12]

In a chapter entitled "Challenging the Nuclear Monopoly of the Cell in Germany," Sapp discusses this topic, emphasizing that many German biologists saw the importance of the new genetics but, at the

same time, espoused more holistic views, and that they studied the entire cell, including the role of the cytoplasm.[13]

Because the sperm possesses little or no cytoplasm whereas the egg contributes almost all of the cytoplasm of the zygote, Keller suggests that the indifference toward the role of the cytoplasm of embryos is also due to a gender bias. The role of the cytoplasmic dowry, as it has been called, has too often been ignored. Yet, it is also remarkable that many of the embryologists, investigating the role of the cytoplasm, maternal effects, and the field of embryology generally, were women.[14]

With the discovery of the structure of DNA in 1953, the attention fell, once again, on the nucleus of the cell. James Watson and Francis Crick opened their one-page letter to *Nature* with these well-known lines, "We wish to suggest a structure for the salt of deoxyribose nucleic acid (D.N.A.). This structure has novel features which are of considerable biological interest." Near the end of the paper they add, "It has not escaped our notice that the specific pairing we have postulated immediately suggests a possible copying mechanism for the genetic material."[15] Within twenty years, the nature of the genetic code, the role of the several RNAs and the ribosomes, and the control of protein synthesis by DNA, via RNA, were elucidated.[16]

In 1958, Crick published a fascinating paper which outlined the triumphs and challenges of molecular biology at the time.[17] He recognized the sequence of nucleotides in the DNA of the nucleus to be the code for the incorporation of twenty basic amino acids into protein chains. RNA was seen to be a key in this incorporation, which occurred in the cytoplasm, and he also stated that there was more than one type of RNA. The DNA code was not yet known at this time, and Crick launched several hypotheses about the nature of the code: it would have to be a triplet code, but that still allowed for several possibilities.[18] He also formulated, in the text of the paper, but not in its present succinct form, the Central Dogma: that DNA controls the synthesis of RNA, and RNA that of proteins, and that this order cannot be reversed. He was emphatic that information could not pass from proteins to nucleic acids. Considering what was known about these matters at the time, Crick's hypothesis must be considered a stroke of genius. He professed that he was not aware of the absolutist connotations of the word "dogma," and that he used it in the sense of "grand hypothesis."[19] The nature of the genetic code and mechanisms of protein synthesis were worked out not long afterwards, in the mid-1960s.

Howard Temin's and David Baltimore's discovery of RNA retroviruses and the enzyme, reverse transcriptase, for which they received a Nobel Prize in 1975 (sharing it with Renato Dulbecco), appeared to contradict the Central Dogma, because in these viruses, the first step, in which the RNA of the virus directs the synthesis of a daughter DNA, goes against the flow of the dogma.[20] In spite of these findings, Crick, in 1970, reiterated the Central Dogma, emphasized its value and applications in molecular biology, and gave it the familiar short form that we recognize so well: DNA → RNA → Protein.[21] This formulation, while appearing to reemphasize the nuclear dogma, also hints at the importance the cytoplasm will be shown to have. Recombinant DNA technology would again emphasize the importance of DNA in bacteria,[22] and, later, of DNA in the nucleus in plants and animals. Successful application of this technology in higher organisms would, however, depend on a thorough understanding of the role of RNAs and protein synthesis in the cytoplasm, and of cell function in general.

Sequencing of DNA, although laborious at first, was aided by the development of the polymerase chain reaction[23] and improved sequencing techniques and equipment. These developments were paralleled by the identification and characterization of genes for human traits and illnesses, and optimism about the treatment of some diseases seemed, at times, little more than a ploy for increased research funding. In 1992, Richard C. Lewontin expressed his reservations:

> According to the vision, we will locate on the human chromosomes all the defective genes that plague us, and then from the sequence of the DNA we will deduce the causal story of the disease and generate a therapy. Indeed, a great many defective genes have already been roughly mapped onto chromosomes and, with the use of molecular techniques, a few have been very closely located and, for even fewer, some sequence information has been obtained. But causal stories are lacking and therapies do not yet exist; nor is it clear, when actual cases are considered, how therapies will

flow from a knowledge of DNA sequences.[24]

Some of Lewontin's critique is still relevant today.

It is clear that the next step to be taken would be the sequencing of the human genome. It was spoken of as the Holy Grail of molecular biology.[25] The project started in 1990 under the leadership of James D. Watson, and its progress gained speed as sequencing equipment improved. Craig Venter, working at a private firm, Celera Genomics, used different techniques ("the shotgun approach") to establish his version of the genome.[26]

The joint announcement of the completion of a first draft of the human genome, on Monday, June 26, 2000, was a momentous occasion. The presence of President Bill Clinton, and his role in bringing the principals of the public and private sequencing institutes together, certainly made it that. Francis Collins, who had become the head of the Human Genome Project, and Venter had agreed to bridge the differences between the public and private approaches to enable the joint announcement to be made.[27] Collins has described various aspects of his life, his work, and his views in two books.[28]

We have described the importance of the nucleus, of genes, and of DNA, and have also described the tendency in the biological establishment to isolate their role from other cell functions and to overemphasize their importance. This tendency has been strengthened by the dominance of gene-centered approaches to the study of animal and human behavior, such as sociobiology, behavioral ecology, and evolutionary psychology.[29]

Cellular Complexity: The Cytoplasm Strikes Back

The simplicity of "a gene for this and a gene for that" would soon be shaken by the sheer complexity of genetic mechanisms within the cell. "Life is Complicated" proclaims the title of a recent article by Erika Check Hayden.[30] In the article, she describes, among other things, that "web-like networks" better portray the multiple pathways between many genes and their products and effects. She illustrates this with one protein, p53, which can bind to and inhibit a DNA site, can bind to thousands of RNA sites, and, due to a process called alternate splicing, can take nine different forms. These web-like networks can be so complicated in some cases that they have been referred to as "hairballs."[31]

This complexity of gene-effect relationships is examined and highlighted by Evelyn Fox Keller in *The Century of the Gene*.[32] In her book, Keller lauds the Human Genome project because it has changed our concept of the gene and our ideas about genetics and protein synthesis. In the early days of genetics, "gene action" was assumed to take place without need of explanation; when this action was investigated in laboratories all over the world, the complexity of the processes was found to be astounding.[33] DNA was found to be of several kinds: coding, regulating, and some was labeled, perhaps prematurely, as "junk."[34] Split genes, alternative splicing, genes coding for several proteins, depending on how they were "read," and post-transcriptional modification, added to the complexity. Single proteins were found to have several functions, depending on regulatory mechanisms. When it came to hereditary illnesses, some were found to have simple genetic causes, whereas the explanation for others was said to lie in the distant future.[35] Keller states that "the function of the structural gene depends not only on its sequence but, as well, on its genetic context, on the chromosomal structure in which it is embedded …, and on its developmentally specific cytoplasmic and nuclear context."[36] She also reexamines the complexity of how a "genetic program" shapes the developing embryo. Keller concludes that the classic image of the gene will be difficult to replace, because its replacement will shatter a popular icon.[37] Furthermore, "gene talk" is an effective tool for persuasion, for funding applications, and for marketing gene-based products.[38]

A critique of Keller's views from proponents of a more traditional gene-centered view was not long in coming.[39] However, for our purposes, it is important to note that both sides of the debate would be quick to agree that the relationship between DNA and the proteins produced in the cell is an extremely complicated one; it involves many nuclear and cytoplasmic processes. Knowledge of cellular complexity is of the utmost importance in order for various biotechnologies and cell and tissue culture techniques to be successful.

The beautiful structure of membranous organelles in eukaryotic cells (cells with nuclear and other intercellular membranes) was a source of wonder

and fascination when transmission electron microscopes came into common use in the middle of the previous century. Excellent high-resolution pictures of mitochondria, chloroplasts, and Golgi bodies, published by Don W. Fawcett, heightened this sense of wonder.[40] Discovered in 1890 by Richard Altmann and named in 1898 by Karl Benda,[41] mitochondria are now known to provide energy in a form usable by the cell for all kinds of processes.

The implications of the discovery that mitochondria contain DNA are discussed in detail by Nick Lane.[42] Each of the many mitochondria in a eukaryotic cell contains several circular strands of DNA; these circular strands resemble the configuration of bacterial DNA. This mitochondrial DNA was found to code for some of the proteins that function in mitochondria. They are maternally inherited because ova, but not sperm, pass on mitochondria to the zygote.[43] In a paper and a book, Lynn Margulis suggests that mitochondria are derived from a symbiotic union of a unicellular organism and a prokaryote in a process she called endosymbiosis.[44] This would explain the similarity between bacterial and mitochondrial DNA.

In green organisms, chloroplasts, the site of photosynthesis, have also been found to contain DNA. In 1905, Konstantin Mereschkowski postulated that chloroplasts arose by cells incorporating green photosynthetic unicellular organisms.[45] Margulis included chloroplasts in her theory mentioned above. Similar to mitochondrial DNA, chloroplasmic DNA also codes for proteins that are inherent to the function of the organelle, in this case, the chloroplast.

Cytoplasmic DNA, particularly mitochondrial DNAs, have provided fascinating insights into human evolution, and into cellular function.[46] Important for the topic of this article is that it is also a crack in the wall of the "nuclear monopoly," and another demonstration of the importance of the cytoplasm in hereditary mechanisms of the cell.

The whole cell, nucleus (or the circular chromosome in prokaryotes) and cytoplasm, carries out many metabolic and reproductive tasks. DNA is of the utmost importance in these activities, but, as we hope we have demonstrated, the picture of DNA as a simple one-to-one code for protein synthesis is no longer tenable or prevalent among cell biologists. The multifarious activities of the cytoplasm are the subject of intense study.[47] This complexity is leading cell biologists to more holistic views of the cell.

Epigenetic Inheritance

Epigenetic inheritance, a topic that is receiving much attention in biological literature, is our second illustration of biological complexity. When discussing cellular differentiation in the embryo, we noted that it was caused by cytoplasmic factors, most of which were derived from the egg. When it is passed from one cell generation to another, this differentiation has been called an "epigenetic inheritance system."[48] Epigenetic changes are "heritable variants that are not due to changes in DNA sequence."[49] Eva Jablonka and Marion J. Lamb have discussed various epigenetic phenomena in a recent book.[50] These mechanisms are not dependent on the primary sequences of DNA, and they do not replace the genetic mechanisms that are commonly described in genetics textbooks.

The addition of methyl groups to specific cytosine bases in DNA prevents the production of messenger RNA ("transcription") in the nucleus. This "silencing" of genes increases when the methylation is more extensive. The methylation is heritable, i.e., it is passed on in an organism from one generation of cells to another. The types of DNA that are methylated have been identified to some extent, and the methylation process has also been linked to some kinds of cancer.[51] New sequencing methods can now detect the presence of methylation in DNA.

Modification of histones represents another epigenetic mechanism. Chromosomes are made up of DNA, and of proteins largely consisting of histones. These histones can be modified by acetylation, deacetylation, or methylation, or they can be modified in other ways.[52] These changes can increase or decrease transcription and they can be passed on from one cell generation to the next, thus creating another epigenetic mechanism.[53]

RNAs, from 21 to 24 nucleotides long, can also function in epigenetic mechanisms. Such RNAs "span all eukaryotic kingdoms in their distribution … They … serve as molecular signposts to identify targets of silencing: retroviruses, retrotransposons, aberrantly expressed genes, and normal developmental loci."[54] The source of these RNAs

has been studied, and they, too, are now considered to be part of the epigenetic machinery of the cell.

Epigenetic mechanisms are varied. The ones we have described interact with each other, and there are other mechanisms, assumed to be epigenetic, that are not included in our short survey. Because they are acquired characteristics that are passed from one cell generation to another, they are often described as Lamarckian patterns of inheritance.[55]

Other Complexities

In a discussion of the complexity of the living cell, which they term "BioComplexity," Bruggeman, Westerhoff, and Boogerd point to the usefulness of reductionistic and nonreductionistic approaches in the study of the cell.[56] They suggest that the complexity of the living cell should not be ignored, and that recognition of this complexity has brought new life to the discussion of systems biology and emergence. The complexity of biological phenomena is receiving renewed attention, and there is an increasing awareness of the incompleteness of molecular and reductionist explanations in biology, as valuable as these may be in their own right.

There are other levels of functioning within biology that manifest complexity. Biology textbooks routinely describe several levels of such functioning, such as organelles, cells, tissues, organs and organ systems, organisms, populations, communities, ecosystems, and the biosphere.[57] These levels manifest their own complexities, complexities that are biological in nature; they cannot be reduced to chemical or physical phenomena, many theoreticians of biology suggest. Such complexities as the regulation of hormone levels, the intricacies of animal behavior, and the control of population sizes all need to have their own place in biology in order to do justice to the integrity of creation and the design of the Creator.[58]

Biological Complexity and Its Theoretical Background

The topic of complexity often transcends biological discussions and touches upon other disciplines and philosophy. The huge changes which occurred in Darwin's century have to be seen in a broader context in which reductionism was present at times and holism at other times. Reaction to the reductionism of Enlightenment thinking of the previous century was thorough. While the Enlightenment emphasized scepticism and exalted reason and science, romanticism in biology (or "natural philosophy," as Erik Nordenskiöld and others call it[59]) accentuated imagination over observation, and showed a fascination with vital forces and a predilection to spin overarching speculative theories. Arthur Lovejoy states:

> The God of the seventeenth century, like its gardeners, always geometrized; the God of Romanticism was one in whose universe things grew wild and without trimming and in all the rich diversity of their natural shapes.[60]

It is safe to say that accepting complexity was not a problem for romantic biologists.

One of romanticism's most accomplished representatives, Johannes Peter Müller, had many interests. In an early paper, he speculated about numbers and identities in biology, a speculative work which he later tried to destroy. He then continued the work of Goethe and Purkinje on sensory perception; this affected his mental well-being. Later in his life, he studied nerves, muscles, and other organ systems, and carried out marine research. Müller illustrates that researchers could move from the purest speculation at the height of romanticism to biological laboratory work that we still find in our textbooks today. Nordenskiöld suggests that Müller's "mental disease involved the downfall of natural philosophy in Germany."[61]

One overarching theory that gained currency in the romantic age, idealism in biology, suggests that basic building plans, "archetypes" for some, are structural laws or types for plants or animals, or large basic groups of plants or animals.[62] This pattern of thinking also left its mark on North American biology, perhaps most markedly through the lectures and writings of J. Louis R. Agassiz. This prominent Swiss biologist accepted a position at Harvard University, where he promoted idealistic thinking in morphology and classification. For Agassiz, types or forms are created; there are timeless designs for taxa, including species. Agassiz would encounter a capable opponent in Asa Gray, eminent Christian botanist and friend of Charles Darwin. Gray suggested that God steered natural selection by providing favorable mutations to the process. He debated common descent with Louis Agassiz in writing and in public discussions.[63]

While Agassiz held on to these views until his death, it can nevertheless be said that after these debates, idealistic notions of organismal structure and design were on the wane in the mainstream of North American biology. Darwin, due to illness or personality, was wont to have other people fight his theoretical battles for him. Thomas H. Huxley and Ernst H.P.A. Haeckel, both combative persons, were only too happy to oblige;[64] they did much to spread Darwin's nonessentialist, nonidealist views.

Darwin's ideas filled the void left by the romantics, or, it could be said, they were the last nail in their coffin. As we think about holism and biological complexity, we recognize that Darwin's views in *The Origin* were not reductionist or physicalist regarding biological phenomena. In the closing paragraph of the first edition of *The Origin of Species*, Darwin seems to favor a biological origin of organisms:

> There is grandeur in this view of life, with its several powers, having been originally breathed into a few forms or into one; and that, whilst this planet has gone cycling on according to the fixed law of gravity, from so simple a beginning endless forms most beautiful and most wonderful have been, and are being, evolved.

In an 1871 letter to his friend, Joseph Hooker, Darwin states a more physicalist view:

> It is often said that all the conditions for the first production of a living organism are now present, which could ever have been present. But if (and oh what a big if) we could conceive in some warm little pond with all sorts of ammonia and phosphoric salts, - light, heat, electricity &c. present, that a protein compound was chemically formed, ready to undergo still more complex changes, at the present day such matter wd be instantly devoured, or absorbed, which would not have been the case before living creatures were formed.[65]

Thus, as is often the case with Darwin, he gives us two points of view, in this case, a nonphysicalist and a physicalist view. Wavering between two opinions is typical of Darwin's way of thinking.[66] In his extensive use of biological examples in *The Origin*, Darwin shows appreciation for biological complexity on several levels.

The pendulum between reductionist and holistic views swung again in the second half of the twentieth century. Molecular genetics and molecular approaches in such specializations as physiology, microbiology, and even classification would make many contributions, but would also lead, in some cases, to reductionism and physicalism. It is against these reductionist trends in biology that complexity thinking reacted. The great theoretician of American biology, Ernst Mayr, states,

> The claim of an autonomy of the science of living organisms … has been rather unpopular with many physical scientists and philosophers of the physical sciences. They have reacted by asserting that the seeming autonomy of the world of life does not really exist, but that all the theories of biology can, at least in principle, be reduced to theories of physics. This, they claim, restores the unity of science.[67]

Mayr then gives a helpful description of three different meanings or categories of "reductionism." He adds,

> This discussion of reductionism can be summarized by saying that the analysis of systems is a valuable method, but that attempts at a "reduction" of purely biological phenomena or concepts to laws of the physical sciences has rarely, if ever, led to any advance in our understanding. Reduction is at best a vacuous, but more often a thoroughly misleading and futile, approach. This futility is particularly well illustrated by the phenomenon of emergence.[68]

Precisely! We hope to discuss emergence, and the related topics of levels of complexity and hierarchies in a separate paper in preparation, while one of us (HB) is writing a paper on systems biology.

Complexity: An Emerging Discipline Today

As is to be expected, "complexity" is often used in its everyday meaning to describe biological phenomena, and, indeed, many complexities in biology readily come to mind. It is an interesting topic, therefore, to explore, what it is that defines complexity science. Complexity as a field of study is covered by a number of journals, and the Santa Fe Institute, in Santa Fe, New Mexico, is dedicated to the study of complexity in various guises. The institute recently sponsored a symposium on complexity and published the proceedings.[69] In an introduction to the volume, cosmologist/physicist Paul Davies states, "The study of complexity is hampered by the lack of a generally accepted definition."[70]

Peter Corning comments, "Unfortunately, the Templeton/Santa Fe symposium participants were partial to the definitions that have been developed by physicists, computer scientists, and information theorists, but this is ultimately an unsatisfactory approach to defining biological complexity." He further comments on the nature of complexity:

> What in fact does the word "complexity" connote? One of the leaders in the complexity field, Seth Lloyd of MIT, took the trouble to compile a list of some three dozen ways in which the term is used in scientific discourse. However, this exercise produced no blinding insight. When asked to define complexity, Lloyd [replied]: 'I can't define it for you, but I know it when I see it.' Rather than trying to define the properties that are commonly associated with the term, I would suggest that complexity often (not always) implies the following attributes: (1) a complex phenomenon consists of many parts (or items, or units, or individuals); (2) there are many relationships/interactions among the parts; and (3) the parts produce combined effects (synergies) that are not easily predicted and may often be novel, unexpected, even surprising.[71]

Some of the characteristics that Corning mentions will be addressed in our description of complexity.

As Corning states, some authors propose that the intricacies of complexity can be mastered with the use of computers or mathematics. For example, while Heinz R. Pagels, in an early book on complexity, recognizes a host and variety of complexities, he nevertheless suggests that the coupled capacity of computers and of human reason can help us understand the vast complexities that surround us in science and in daily life.[72] More recently, yet pursuing a similar path, Melanie Mitchell described the lack of agreement about defining complexity and its associated problems and stressed the importance of mathematics, computers, modeling, simulation, and networks in describing and studying complexity. Using computational techniques and modeling, Luis Rocha develops his theory of adaptivity and applies it to a variety of biological systems.[73] Similarly, C. S. Holling, studying diverse populations and ecosystems, uses modeling to develop his idea of resilience in ecological systems.[74] The characteristic of resilience may be applied to biological systems at other levels and to systems not discussed in this article. Without detracting from the work of these thinkers, and in agreement with Corning, we would suggest that the definition of complexity in single-celled organisms, in plants, in animals, and, indeed, in human life, requires descriptors that do justice to their separate and emergent levels of complexity.

Barbara J. Crowe, in a book that applies "complexity science" to her field of music therapy, is more definite when discussing the characteristics of complexity theory. Contrary to "empirical" (i.e., reductionist) science, as she calls it, complexity science provides helpful insights into her field, she suggests. She relates complexity to chaos theory (and the order that can emerge from chaos), unpredictability, nonlinearity, and wholeness. She concludes, "Complexity is about the real world."[75]

Although it has been difficult or impossible for thinkers to agree upon a definition of complexity in general, we will propose a description of complexity in biological structures and phenomena. This description will consist of two parts: (1) the inherent structure of living organisms, including the dynamic processes in, and related to, biological organisms, and (2) the concepts of wholeness (holism) and levels of functioning as they apply to the biological world.

The structure of cellular organelles, cells, organs, unicellular organisms, plants, and animals—the list could be made longer—is a significant part of biological complexity. We have illustrated this in the first part of our article, dealing with the relationship between nucleus and cytoplasm, and with epigenetic inheritance. In the cell, organelles, such as mitochondria, chloroplasts, and the structures involved in genetic mechanisms, are now well understood, and are known to "interact in space and time."[76] They are in a "perpetual state of transformation." Olaf Wolkenhauer and Allan Muir discuss the functional dynamics of cells—both unicellular organisms and cells that are components of organisms—mentioning the intricacies of the cell cycle, the "self-fabrication" of cells, metabolism, cell-signaling, and gene expression.[77] Thus, the structures within the cell and the dynamic processes in which they are involved are a noteworthy component of biological complexity.

When one examines multicellular organisms, plants or animals, the functions mentioned above still play a role, but we also encounter the structures and processes involved in homeostasis, sexual or asexual reproduction, and embryonic development,

growth, and differentiation (we do not distinguish between plants and animals at this time). Other complexities are notable when one examines organs, populations, and ecosystems. We conclude that at all levels of complexity studied within the discipline of biology, we find structures and processes that are an integral part of biological complexity, a part that cannot be expressed in the language of mathematics, statistics, or the computer.

A second characteristic of biotic complexity is that entities such as cells, organs, organisms, and populations, present themselves on several levels within the biological purview, as we mention above. Mayr states that in biology one deals with

> constitutive hierarchies, like the series macromolecule, cellular organelle, cell, tissue, organ, and so forth. In such a hierarchy the members of a lower level, let us say tissues, are combined into new units (organs) that have unitary functions and emergent properties. The formation of constitutive hierarchies is one of the most characteristic properties of living organisms. At each level there are different problems, different questions to be asked, and different theories to be formulated.[78]

We would add that as one moves from molecules to cells, a qualitative boundary is crossed that is different from the boundaries between the other levels of the part-whole hierarchy that Mayr mentions. We will discuss this topic more fully in a paper that we are preparing on emergence theory. Recognition of levels of functioning above the physical level is in direct opposition to the reductionism that we have mentioned above.

This "multileveledness," as it is sometimes designated,[79] has significant implications. Mayr states, "[N]ew and previously unpredictable characters emerge at higher levels of complexity in hierarchical systems."[80] For example, the behavior of stampeding bison cannot be predicted by studying their cells or organs. Studies at every level will reveal new kinds of structures, phenomena, and processes with new laws to govern them. In our paper on emergence, we will need to distinguish between various hierarchies: part-whole hierarchies, and hierarchies in levels of functioning and levels of structure.

Furthermore, the configurations and processes of a given lower level will be constrained and limited by the uses to which they are put in the level(s) above. For example, although there are many possible nucleotide sequences in a DNA molecule of a given length, only some of these sequences occur in DNA that functions in a particular living organism. Thus, Küppers states that a higher level can impose "boundary conditions" upon a lower level.[81]

Conclusions

Our discussion of the role of the cytoplasm and nucleus in the cell, and of epigenesis, illustrates the idea of complexity as it is used by scientists. These phenomena display complexity of structure and process, and they draw on functions at the physical level (e.g., DNA) and several levels of complexity within biology. The recognition of, and emphasis on, the complexities of biological phenomena and structures is a holistic response to the reductionism displayed by some molecular biologists in the second half of the twentieth century. We suggested that this kind of complexity should be defined or described in biological terms, and we gave two detailed examples.

Complexity leads into a discussion of systems biology and emergence, two topics we hope to return to later. Recognition of complexity and emergence should gain currency among Christian thinkers as they seek to do justice to created reality. The resurgence of discussions of complexity has led to an increased openness to theistic points of view.[82] A holistic view of biological processes and structures acknowledges the complexity in creation, a complexity that reveals the wisdom of the Creator.

Acknowledgments

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Evangelicals, Creation, and Scripture: Legacies from a Long History

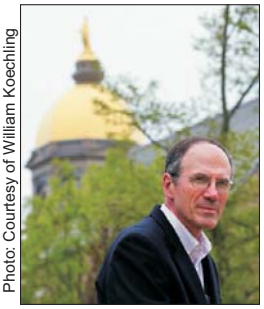

Photo: Courtesy of William Koechling

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This article specifies fifteen attitudes, assumptions, and convictions from the long history of western interaction between Christianity and science that continue to shape the perceptions of American conservative Protestants to this day. It finds three of them arising in the Middle Ages and early modern period, five from early United States history, five more from the modern university era, and two from the recent period of culture wars. The overall appeal is to realize how much pre-commitments affect contested issues of science and religion and to urge as much self-critical self-consciousness as possible when approaching such questions.

In the domain of religion and science, decisions, actions, attitudes, practices, and conflicts of the present moment require careful assessment for what they mean now and how they may affect the future. Conservative Protestants today, for example, offer many reasons for leaning against or actively combating the consensus of modern scientists concerning evolution. Some of those reasons concern narrowly defined issues of physical evidence or the interpretation of specific biblical passages, while others range to broader issues of theology, philosophy, ethnicity, family order, public education, or government. To offer historical explanations for the standoff, which this paper tries to do, is not the same as explaining the individual motives of those who engage such issues today. But it is a good way to see that modern stances represent an amalgamation of discrete attitudes, assumptions, and convictions, and that the components of this amalgamation all have a history.

The purpose of this paper is to specify fifteen of these attitudes, assumptions, and convictions, to indicate when they rose to prominence, and to suggest how they relate to contested issues of science and religion. As much as it is possible for a historian who does not believe in creation science and who looks for guidance on these issues to practicing scientists who are also orthodox Christians, this paper tries to be objective. In addition, my own judgments concerning the fifteen factors I isolate are mixed: some seem to me damagingly mistaken in their entirety, and for a combination of theological, biblical, and intellectual reasons. Most, however, seem much more difficult to evaluate, often because they once made a genuine contribution to the spiritual health of churches and the civic stability of society and may, in fact, continue to do so even when the

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circumstances in which they came into existence are no longer present. Yet taken together, the continuing functioning of these fifteen factors has created a serious problem—intellectually, biblically, theologically, apologetically, and spiritually—that damagingly constricts conservative Protestants in their engagement with contemporary science.

Deep Background

The recondite debates of thirteenth-century Catholic philosophers may seem a strange place to begin explaining the attitudes toward science of contemporary conservative Protestants, but only a little explaining will show why this is so. The particular dispute that resulted in a very important assumption in later western history concerned the relationship of God's being to all other beings. Thomas Aquinas, the Dominican friar who lived from 1225 to 1274, argued that this relationship was *analogical*, that is, while humans and the created world were certainly *like* God in many ways, the essence of God remained ultimately a mystery known only to himself. Aquinas may well have been thinking of the passage in Isa. 55:9 where the Lord tells the prophet, "As the heavens are higher than the earth, so are my ways higher than your ways and my thoughts than your thoughts."

The fact that God created the world out of nothing (*creatio ex nihilo*) was a crucial part of Aquinas' argument, because it meant that, whereas human minds could understand communication from God (i.e., revelation in nature, in Scripture, in Jesus Christ), yet human minds in principle could never grasp the essence of God. An interesting by-product of this position, which has taken on surprising relevance in contemporary debates, was Aquinas' understanding of randomness or contingency. Everything in the world, he insisted, happened because of God's direction. But some things happen contingently, or with the appearance of randomness. The logic of their contingency was perfectly clear to God, but because God in his essence is hidden to humans, humans may not be able to grasp how what they perceive as random could be part of God's direction of the universe.

The opposing view was maintained by the Franciscan priest and philosopher, Duns Scotus, who was a younger contemporary of Thomas Aquinas living from 1266 to 1308. His position argued for the *univocity* of being. The only way to know the essence of anything is through its existence. Although God is much greater and much wiser than humans, his being and the being of all other things share a common essence. God is the Creator and Redeemer of humans, but his actions toward humans can (at least potentially) be understood reasonably well, because the same laws of being apply to God as to everything else; the same way that we explain causation in every other sphere explains how God causes things to act and to be.

Scotus' approach to metaphysics (= the science of being) became, with a few exceptions, the dominant view in later western history. It is responsible for the very widely shared assumption that (1) *once something is explained clearly and completely as a natural occurrence, there is no other realm of being that can allow it to be described in any other way*.

For a very long time, this assumption was not regarded as anti-Christian, since God was considered the Creator of nature and the laws of nature as well as the active providential force that kept nature running as he had created it to run. During the Reformation era, Protestants began to place a new stress on the importance of Scripture for understanding God, themselves, the church, and everything else. That emphasis was one of the important factors accelerating the rise of modern science. In particular, as Protestants set aside symbolic interpretations of Scripture, which had been prominent in the middle ages, they stressed straightforward examination of texts in what was often called a literal approach. This approach, in turn, stimulated a similar effort at examining the natural world in such a way that the medieval idea of God communicating to humans through "two books" (nature and Scripture) took on greater force. The assumption that became very important in this process was that (2) *those who believed God created the physical world and revealed himself verbally in Scripture should* harmonize *in one complete picture what they learned about nature from studying nature and what they learned about nature from studying Scripture.* In both cases, literal knowledge was crucial, along with a belief that sources of literal knowledge could be fitted together harmoniously.

By the late seventeenth century, when science in its modern form began to expand rapidly, yet a third conviction became important, which was worked out especially in the many efforts that went into constructing *natural theology*. Natural theology was the project of explaining, often in considerable detail, what God's purposes were in creating the various parts of nature. Natural theology became a major enterprise when the earlier assumptions—metaphysical univocity and harmonization of the "two books"—encountered rapidly expanding knowledge about the physical world. Learned believers recognized the potential threat of this expanding knowledge—if scientific investigation could explain how nature worked as a system unto itself, maybe reliance on God and reference to the Scriptures were expendable. In response to this challenge, savants such as Cotton Mather in the American colonies (*The Christian Philosopher*, 1721) and William Denham in England (*Physico-Theology*, 1713) offered elaborate explanations for how the structures of the physical and animal worlds revealed God's purposes in creating things as he had made them.

The tradition of natural theology received its most famous exposition in a book by William Paley, an Anglican archdeacon, published in 1802. Its title explained what it was about: *Natural Theology: or, Evidence of the Existences and Attributes of the Deity, Collected from the Appearances of Nature*. Paley's method was to describe features of animal, human, or material reality and then to show how these features manifested God's design in and for nature. For example, the fact that animal and human bodies were symmetrical in outward appearance even as their internal organs and functions were asymmetrical provided to Paley "indubitable evidences, not only of design, but of a great deal of attention and accuracy in prosecuting the design."[1] The very important assumption behind the natural theology promoted by Paley was that (3) *not only did God create and providentially order the natural world, but humans could figure out exactly how and why God ordered creation as he did*. This assumption became critically important when later investigators of nature concluded that since no obvious intention of God explained what they discovered, belief in God was wrong-headed. Such views naturally antagonized those who continued to believe in God and therefore insisted either that new discoveries did in fact reveal a providential design or that the new discoveries had to be false.

Perhaps not many today who are engaged with contemporary debates in science and religion pause to think about historical turning points deep in the past. But the assumptions of univocal metaphysics, harmonization, and natural theology created powerful channels in which much subsequent discussion has flowed.

In American history, the attitudes, convictions, and assumptions that continue to shape contemporary disagreements arose during three distinct eras: during the years of the early republic, during the years when the modern universities came into existence, and during the recent prominence of public culture wars.

The Early Republic

The history of the United States during its first decades is important for questions of science today because of how powerful attitudes, which still influence the present, came to prominence in that period. During the late eighteenth century, the churches in the new United States existed in a state of confusing transition. They had suffered much destruction during the American Revolution, only to confront even greater challenges after the war was over. One was figuring out how to carry on religious life without the partnership of the state; another was figuring out how to bring Christianity to the vast open spaces of the new nation.[2]

From time out of mind in Christian history, churches had been supported (and regulated) by the European states; this is also how religious life had been organized in most of the American colonies. But now, with the pluralistic religious situation of colonial Pennsylvania, New Jersey, and New York as a precedent, the United States as a whole was moving rapidly toward a free market in religion. In 1791, the First Amendment to the US Constitution guaranteed the "free exercise" of religion and prohibited the creation of a national state church; soon thereafter all of the states changed their laws to meet this national standard.

A variety of powerful motives stimulated this development. One grew from the conviction that

freely chosen religion required the separation of church and state. Even more widely influential was commitment to the republican ideology that carried over from the revolt against Britain to dominate public thinking in the new nation. This republican ideology stressed the dangers of unchecked authority, the corruptibility of inherited power, and the tyrannical effect of tradition. It explained why the War for Independence had to be fought to keep colonists from being enslaved by the corrupt British Parliament and the power-obsessed British monarch.

Put positively, republican thought expressed great trust in the virtue of private persons as the best guarantee of public well-being. Because so many leading Protestants had supported the Revolution, the churches after the War embraced a kind of "Christian republicanism" in which the "virtue" required to overcome the "vice" of political corruption was depicted as flowing from the gospel.

The religion of "Christian republicanism" necessitated audacious new assumptions about authority and communication. Americans who had fought for independence to defend their "liberty," fundamentally distrusted authority handed down from on high or bestowed by virtue of inherited titles; rather, it was authority won by earning the trust of "the people" that mattered. In this republican view of social order, networks that individuals created for themselves were considered more reliable than lines of communication controlled by designated authorities.

After leaving behind religious establishments and the European reliance on tradition, and in response to the challenge of the nation's wide open spaces, American religious life underwent a great transformation. The religious practices of groups that had been marginal in the colonial period now began to set the pattern for all. Methodists under the leadership of Bishop Francis Asbury, Baptists instructed by countless local preachers, and "Disciples" and "Christians" guided by the creative leadership of Alexander Campbell and Barton Stone took the lead in preaching the salvation of souls, organizing congregations, and recruiting young men (also a few young women) to serve as itinerants. With these upstarts in the lead, the more traditional churches of the colonial era (Congregational, Episcopal, Presbyterian) also accommodated themselves to the new nation's republican and democratic values. Very soon even American representatives of the European churches with the strongest traditions of church-state cooperation (Lutherans, Catholics) adjusted to this approach.

In the effort to build churches with forms and assumptions that fit the new American nation, most of Europe's traditional authorities came under severe attack. The great exception was the Bible. Passages from Scripture had been invoked everywhere during the Revolution, though often in symbolic ways (e.g., referring to the British Parliament as "Egypt" and George Washington as "Moses") rather than in deciding whether the Revolution was a just war. In the early republic, the great engine of the revival preaching that proved so successful for Methodists, Baptists, and many others was the Bible. Scripture was preached by itinerants and by regular clergy; it was the basis for organizing churches on the frontier and maintaining stability in settled regions. In the absence of well-developed social institutions or government structures, the King James Version of the Bible was the closest thing to a universal cultural authority. And because the Bible was the people's book, which all who could read might appropriate for themselves, it almost completely escaped the suspicion that fell upon the other mainstays of historical European Christianity.

The only other authority beside Scripture to escape the attack on tradition was science, understood as an objective organization of facts not dominated by inherited authority. As with Scripture, in an intellectual environment created by republican ideology, the science that dominated early American history took a hands-on, bottoms-up, popular form. Amateurs such as Benjamin Franklin and Thomas Jefferson were lionized for their contributions, respectively, to electrical theory and natural philosophy. The same popular impulse that opened the Bible to every serious reader opened the natural world to every investigator able to communicate convincingly about the results of an experiment, whether or not the investigator had received official certification.

Popular reliance on the Bible fit perfectly with the voluntaristic organization of religion that came to replace the previous reliance on church-state establishments. Voluntarism was a mind-set keyed to innovative leadership, proactive public advocacy,

and entrepreneurial goal-setting. Voluntarism also became an extraordinarily influential practice that, beginning with church organization, soon mushroomed to inspire mobilization on behalf of myriad social and political causes. First came the extensive voluntary societies—like the American Board of Commissioners for Foreign Missions (1810), the American Bible Society (1816), or the American Education Society (1816)—that were rivaled in their religious impact on the nation's culture only by the Methodist church. But then came schools, hospitals, political parties, and even (to some degree) businesses organized often by Bible-trusting believers and even more often by an up-from-the-bottom approach.

With this new mode of organization, a period of tumultuous, energetic, and contentious innovation first reversed the downward slide of religious adherence and then began to shape all of American society. Most remarkably, voluntary evangelical religion even conquered the South, where an honor-driven culture of manly self-assertion posed a more difficult challenge to Christian faith than in Northern regions. By demonstrating how religion could thrive despite the absence of an establishment, the period's dynamic evangelicals established an enduring pattern for the future. Other religious movements that differed greatly in belief and practice from evangelicalism would flourish in the United States by adopting, to at least some degree, the free-form and populist traits that evangelical Protestants pioneered.

The results of religious transformation in the early republic were remarkable. Between 1790 and 1860, the United States population increased eight fold, but the pace of church adherence grew at double the rate of population growth. The number of Methodist churches alone multiplied by twenty-eight in this period. By 1860, although Jews and, even more, Catholics had begun to increase rapidly, the nation's formal religious life was dominated by Protestants: over 83% of the value of church property and over 95% of the churches themselves (about 50,000 of them). And the combined budgets of the churches and religious voluntary agencies—most of them evangelical Protestant—came close to matching the income of the federal government.

Alexis de Tocqueville, the period's most famous foreign observer, dwelt at length on how he thought Protestantism had shaped the entire course of the new nation. During his visit to the United States in the 1830s, Tocqueville observed what he described as a conundrum: why did religion, which because of the Constitution's separation of church and state "never mixes directly in the government of society," nonetheless exist as "the first of [the nation's] political institutions"? His explanation centered on how Protestant faith had aligned itself with republican principles of liberty: "if [religion] does not give them the taste for freedom, it singularly facilitates their use of it." In particular, Tocqueville pondered the "great political consequences" that "flowed from" the flourishing of disestablished Protestant churches. His final judgment was comparative: In Europe, "I had seen the spirit of religion and the spirit of freedom almost always move in contrary directions. Here I found them united intimately with one another: they reigned together on the same soil."[3] Tocqueville recognized that it had not been primarily government, nor an inherited religious establishment, nor Big Business that had built the American civilization he observed in the 1830s, but the enterprising activities of the churches, most of them evangelical Protestant.

The striking success of the evangelical churches in the nation's early history solidified a number of attitudes, assumptions, and convictions with broad implications for later science and religion discussions. Prominent among these was the belief that (4) *the best medium for nurturing the Christian faith in a republican and democratic society was churches organized democratically on a voluntary basis.*

Practices guided by this conviction unleashed tremendous spiritual energy with long-lasting effects. Voluntary churches, which were moving in the direction of modern parachurch organizations, combined flexible structure and creative innovation with democratic empowerment. New ideas, such as establishing missionary and social service agencies through the good will of ordinary individuals and aiming them at specific problems, flourished in this voluntaristic milieu.

For the intellectual realm, however, democratic voluntarism had its problems. Long-lasting institutions, respected landmarks, and patient cooperation have all been important—along with daring innovation—in the history of modern science. In

the American environment of the early nineteenth century that the Protestant churches did so much to build, an overabundance of innovation and a relative scarcity of other intellectual virtues prepared the way for problems later.

The early history of the United States also witnessed a number of specific developments relating to Scripture and its use. Especially important was the conviction that (5) *the Bible was a uniquely powerful agent for evangelism, training in godliness, guidance to churches, and—also—the construction of social order.* Americans had given up many of the historical props of European Christendom, including state churches, the iron fist of inherited precedent, and automatic deference to tradition. But in the Scriptures, which were increasingly accessible to all who could read, the nation's believers possessed a supreme religious authority that provided the guidance necessary for personal spiritual growth and the development of strong local churches, as well as the public norms for a republican society.

In fact, at a very early point in the nation's history, it became clear to many of the nation's intellectual leaders that (6) *the Bible, appropriated democratically, and science, also appropriated democratically, were the safest possible guardians against the corruptions of tradition and the perils of infidelity.* In these terms, the United States became a laboratory for showing how Scripture, science, and democratic common sense could overcome the corruptions of European Christendom.

Christian apologetics combining scriptural principles and empirical methods rapidly became the norm. What historian T. D. Bozeman has helpfully described as "Baconian" theology flourished; its use of a rigorous empiricism deployed on facts from human consciousness and facts from the Bible became the standard for justifying belief in God, revelation, and the Trinity.[4] At Yale, Timothy Dwight gained renown for restoring a lively Christian faith after he was named president in 1795. At least as the story came down to later generations, Dwight attacked specifically the charge made by infidel students that "Christianity was supported by authority, and not by argument." In the face of this challenge, Dwight boldly called all comers to debate the question, "Are the Scriptures of the Old and New Testament the Word of God?" After appealing for those who doubted the Scriptures to "collect and bring forward all the facts and arguments which they could produce," Dwight "triumphantly refuted their arguments[,] proved to them that their statement of facts was mistaken or irrelevant," and by "the exposure of argument" recovered the ground for full-blown Christianity.[5]

Similar empirical procedures marked out the royal road to moral certainty in ethics and also provided a key for using physical science itself as a demonstration of religious truths. In every case, as Samuel Stanhope Smith, the president of Princeton, put it in 1810, the appeal was "to the evidence of facts, and to conclusions resulting from these facts which … every genuine disciple of nature will acknowledge to be legitimately drawn from her own fountain."[6]

In the rough and tumble of the new nation, the ability to reason clearly from the Scriptures and from "the facts" of nature or consciousness—and the ability to show how Scripture aligned perfectly with these facts—was much more than a casual academic sideline. Instead, this combination offered a sturdy intellectual scaffolding that undergirded personal religion, church health, and an orderly society.

The respect for such use of the Bible in the uncertain conditions of the new republic often led to an ideology of "the Bible only." Benjamin Rush, the renowned if also controversial Philadelphia physician, revealed his trust in Scripture as the ideal guide for the new nation, when he published a grand plan for educational reform in 1791:

> We profess to be republicans, and yet we neglect the only means of establishing and perpetuating our republican form of government, that is, the universal education of our youth in the principles of Christianity, by means of the Bible: for this Divine book, above all others, favours that equality among mankind, that respect for just laws, and all those sober and frugal virtues, which constitute the soul of republicanism.[7]

Fifty years later, Robert Baird, author of the first comprehensive history of the American churches, explained to a European audience why the American churches could cooperate so well with each other on so many projects:

> They hold the supremacy of the scriptures as a rule of faith, and that whatever doctrine can be proved

> from holy scripture *without tradition* is to be received unhesitatingly, and that nothing that cannot so be proved shall be deemed an essential point of Christian belief.[8]

Rush, Baird, and many others in this period were advocating the belief that (7) *"the Bible only" provided the ideal anchor amidst the tumults of an otherwise unstable world.*

A final conviction that became well established in this early period concerned hermeneutics, the method of interpreting Scripture. The question of how best to interpret the Bible was not a major point of contention in the early national period, since the most active churches that were reviving religious life and shaping public order came from the broadly Reformed wing of British Protestantism. In contrast to Roman Catholics, Reformed believers defended *sola scriptura* against the magisterium's employment of tradition to interpret the Bible. But Reformed hermeneutics were also set apart from other Protestants who also claimed to follow *scriptura sola*. Especially those Reformed communities with strong democratic tendencies mistrusted the Lutherans, who seemed to let tradition sneak back in by the back door, and also the Anglicans, who seemed to give too much authority to reason and to the church's leaders. Instead, it was the Bible as read by ordinary believers and the Bible understood as straightforwardly as possible that allowed God's revelation to shine forth clearly and powerfully. A contributor to the *Methodist Quarterly Review* in 1843 summarized succinctly these principles of biblical interpretation as they had undergone American development in a populist and antitraditional way:

> We claim to be, not only rigid literalists, but unsparing iconoclasts—ruthless demolishers of all theories. We wish to strip the passage of all the superincumbent strata which ingenious men have deposited all round it, and come down to the plainest and most obvious literal reading of the text.[9]

In the United States, this particular hermeneutic strengthened the assumption that (8) *the best biblical interpretation was the most literal interpretation as grasped by the most democratic audience of readers*.

It is important to restate the sequence that undergirded the attitudes that took firm hold in early American history. Conventions in biblical interpretation were not worked out in academic isolation but were agents of tremendous public power forged in the crucible of practical necessity. A democratic, populist, and literal hermeneutic was the interpretive strategy that evangelical Protestants exploited to win the new republic for Christ. The social transformation that resulted seemed to validate the evangelicals' approach to Scripture. For reaching the unreached with the Christian message, for organizing congregations and building churches, for creating agencies to construct and reform society, reliance on the Bible alone, literally interpreted, worked wonders.

With such sturdy signposts marking the path that American Bible-believing evangelicals had taken, much in the later history of religion and science becomes readily understandable. Given the foundational principles put in place during this early period, only a major shift in direction could have prevented the confusion that did in fact result when the broader intellectual landscape changed. When those changes did take place in the last third of the nineteenth century, evangelicals, rather than modifying their earlier attitudes, convictions, and assumptions, expanded and strengthened them instead.

The Modern University

The intellectual and religious history of the United States entered a new era after the Civil War. The War Between the States had itself been a special trial for evangelical Bible-believers, since their principles of democratic scriptural interpretation led to confusion in the face of national crisis. Unlike the situation in earlier decades, when trust in Scripture and a common hermeneutic had fashioned spiritual and social order out of chaos, controversy over slavery paralyzed the evangelical churches. Some found it self-evident that the Bible defended slavery, some felt the Bible required abolitionism, some held that it mandated gradual improvement for the slave's lot. Evangelical voices, thus divided, were marginalized as a strong view of national union and the North's big armies took over the task of defining the national character. Shortly after the war, the social landscape also shifted dramatically because of a number of important developments. The litany is familiar from every survey textbook: immigration of non-Protestants and non-Christians challenged evangelical

hegemony over public life; the growth of great urban centers undercut the influence of rural and small town environments where evangelical Protestantism flourished; and capitalist mobilization on an unprecedented scale removed most of the nation's economic life from the influence of the churches.

Intellectually, a number of forces imported from abroad coincided with fresh efforts to ramp up American higher education in order to match the intellectual depth and sophistication of Europe's great centers of learning. A simple chronology indicates the direction of these intellectual changes. In 1859, Charles Darwin's *Origin of Species* popularized general views of natural development that had been circulating for some time, but also proposed the mechanism of natural selection as an explanation for evolutionary change over time. The former challenged literal readings of Genesis; the latter challenged the assumptions about natural theology and the harmonization of evidence from God's two books that had been popularized by William Paley. Then in 1860, seven Anglican clergymen-scholars published a book entitled *Essays and Reviews*, which for at least a decade received more attention than Darwin's *Origin*. This book was notable for advancing two ideas that offended the common assumptions of many evangelicals: first, a notion of historical understanding in which past events were interpreted according to their place in the skein of natural development rather than in relation to God; second, a notion of Scripture as needing to be interpreted like any other ancient text. The very next year, 1861, Yale University issued the first Ph.D. to be granted by an American institution of higher learning.

The drumbeat of innovation accelerated rapidly. In 1869, Charles Eliot became president of Harvard and immediately embarked on a scheme of modernizing the curriculum through the promotion of science; it was a scheme that most other American colleges and universities soon followed. That same year, Andrew Dickson White, who had become the founding president of Cornell University only three years before, gave a lecture in New York that announced a thesis he would continue to develop throughout his professional life:

> In all modern history, interference with science in the supposed interest of religion, no matter how conscientious such interference may have been, has resulted in the direst evils both to religion and to science, and invariably; and, on the other hand, all untrammeled scientific investigation, no matter how dangerous to religion some of its stages may have seemed for the time to be, has invariably resulted in the highest good both of religion and of science.[10]

Five years later a young English philosopher, F. H. Bradley, published a widely noticed essay entitled "The Presuppositions of Critical History" in which he argued that responsible historical study needed to follow the lead of science and that science was illegitimate if it referred to forces outside the natural sphere—in other words, if it referred to God. Two years later, in 1876, the Johns Hopkins University was founded with the express purpose of promoting graduate-level education in all fields, but using primarily the tools, presuppositions, and methods of the kind of critical science championed by A. D. White and F. H. Bradley.

The way that these events in the broader world of American higher education interacted with events in the world of evangelical Protestants is indicated by two other events from this same period. In 1876, the same year as the founding of Johns Hopkins University, a Presbyterian minister, James H. Brookes, convened the first of what became known as the Niagara Bible Conferences when the annual event was permanently located at Niagara-on-the-Lake in Ontario. The Niagara Conferences were notable for enlisting missionary volunteers and for increasing interdenominational fellowship. They also became a powerful venue for promoting a dispensational, premillenarian approach to Scripture that featured literal, Baconian approaches to the prophetic parts of the Bible. In addition, the Niagara Conferences also served as a spur to the formation of Bible colleges and Bible institutes that offered the broader evangelical community an alternative to the nation's new research universities.

Five years later, as part of an internal debate among American Presbyterians on the reception of advanced biblical criticism from Europe, two conservatives, Archibald Alexander Hodge and Benjamin Breckinridge Warfield, published a definitive paper entitled simply "Inspiration."[11] It offered a strenuous, painstaking defense of the belief that the Scriptures were without error in all that they revealed.

For several decades it was not apparent how developments in American higher education and developments among American evangelicals would relate to each other. Into the early twentieth century, it seemed possible that some evangelicals might combine renewed commitment to classical views of God, Scripture, and divine providence with considerable acceptance of the scientific advances and scientific methods promoted in the new universities. For example, B. B. Warfield, after defining biblical inspiration in traditional terms, devoted much effort in his later career to indicating how a conservative view of the Bible could accommodate some, or almost all, of contemporary evolutionary theory.[12] When in the 1910s the booklets entitled *The Fundamentals* were published to defend conservative Protestant doctrine, their authors included a few scholars such as James Orr of Scotland who joined Warfield in suggesting that evolution should be regarded as the divinely ordained means of organizing the natural world.

By the 1920s, however, it became clear that much of the evangelical community was alienated from the American research university and its aggressive promotion of scientific research. To many evangelicals, research universities were places that popularized ideas destructive of Christianity and where those ideas often seemed to drive out all other contenders. In this picture, denizens of the universities delighted in teaching that historical perspective meant excluding the supernatural, that scientific rigor meant denying the supernatural, and that biblical scholarship meant subordinating or greatly modifying what was meant by the supernatural. As a consequence, modern research universities might be useful places for believers to be certified for employment or for other pragmatic reasons, but it was always necessary to remember that they were institutions dominated by anti-Christian principles. For many evangelicals, therefore, the conviction spread that (9) *the modern research university defines enemy territory that can be explored only with the greatest caution and only with defenses constantly on guard for intellectual battle.*

As they saw the practical and intellectual dangers of American life in the early twentieth century, most evangelicals turned with increasing fervor to traditional Christian confidence in the Bible, but also the Bible as it had functioned so powerfully in earlier American history. Thus, they boldly proclaimed their conviction that (10) *the Scriptures—as preached to all, read by all, and applicable to all—provide the strongest support for Christian life and truth amidst the perils of the modern age.*

Despite the efforts of a few evangelicals, such as B. B. Warfield and James Orr, to work patiently through the mid-level scientific literature of the day, evangelicalism as a whole relied more on popular argumentation aimed at democratic audiences, rather than on discriminating advanced learning, to counter the anti-Christian uses of modern science. Powerful social forces fueled this populist approach. During World War I, wide swaths of the American populace, and not just evangelicals, explained what the Allies called German barbarism as an outgrowth of the godless evolutionary theories taught in the Kaiser's universities. William Jennings Bryan's famous crusade against evolution was based on a similar linkage. For Bryan, evolution may have posed some problems for biblical interpretation, but its really devastating effect was how evolution supported the Social Darwinism that trampled women, children, and the poor. Consequently, Bryan's campaign against evolution was part of his life-long effort to mobilize popular support for better treatment of society's weakest members. Given this association between evolution and the besetting sins of western civilization, it became common for evangelicals to think that (11) *popular mobilization appealing to the commonsense of ordinary Bible readers and to time-tested explanations for how God relates to nature—univocal metaphysics, harmonization, and natural theology—is the best way to enlist the Scriptures for combating infidelity and moral decline.*

In making these judgments, evangelicals by no means gave up their commitment to empirical—or what they considered properly scientific—methods, but they took these methods to be Baconian, harmonizing, and literal. They were Baconian in favoring interpretations that treated individual verses from throughout Scripture like component pieces of data to be assembled into larger themes and doctrines. They were harmonizing in wanting to keep together in one world-picture under God what the Scriptures revealed and what study of nature revealed. In this perspective, science per se was not the problem, but science distorted and misapplied for anti-Christian purposes. The conclusion followed inevitably, that (12) *when scientists or the popularizers of science make*

use of new proposals about nature to undercut traditional belief in God, the problem is almost always with those who make the proposals and almost never with assumptions about the neutral character of science or assumptions about how science and Scripture should be aligned.

Evangelical biblical interpretation also leaned strongly toward the literal. Particularly in an era when so many modernist proposals were explaining away so much of Scripture as merely metaphorical, or legendary, or spiritual but not factual, literal Bible interpretation often looked like the only way to retain any meaningful revelation from God. Many evangelicals were certain that to attempt anything but nonliteral interpretation of any part of Scripture was to slide toward the antisupernatural interpretations that from the late nineteenth century had dominated university-level higher education.

This bent toward literal interpretation also owed a great deal to the popularity of dispensational premillennialism. That interpretive scheme exerted special influence through the many prophecy gatherings run on the model of the Niagara Conference and through the notes of the widely distributed Scofield Reference Bible, which was first published in 1909. Literal interpretation of biblical prophecy about the end of the world, and especially of the book of Revelation at the end of the Bible, was easy to link with literal interpretation of biblical accounts of the origin of the world, especially as given in the early chapters of the book of Genesis. Moreover, literal interpretation of the other portions of Scripture seemed to many evangelicals only a natural extension of—and sturdy protection for—literal interpretation of the Bible's central account of the life, death, and resurrection of Christ. Thus, a complex web of assumptions and practices led to the widespread belief that (13) *the norm for interpreting all of Scripture as God's life-giving revelation is strongly supported by literal interpretations of the first and last parts of the Bible.*

Evangelical history in the early national period and in the era when research universities emerged provides the necessary background for understanding contemporary concerns of conservative Protestants about science. While important new developments have taken place since the end of the Second World War, it is no exaggeration to say that most of what creates tensions, conflicts, and uncertainties today involves the continued influence of convictions, attitudes, and assumptions that were well established before contemporary controversies arose.

Culture Wars

Since World War II, most of the uneasiness among conservative Protestants about science has resulted from carrying earlier trajectories into the present. Current uneasiness arises from the ongoing force of deeply entrenched convictions, attitudes, and assumptions. Sorting out these matters is difficult, in part because there are so many different factors feeding into the current situation, and in part because evaluating these factors requires delicately balanced judgments. As examples, the observation that nonbelievers of several types regularly use the supposedly assured result of modern science to attack traditional Christianity is hardly a baseless fantasy. In addition, Christian believers of all sorts can only applaud the devotion to Scripture that has been so prominent in evangelical history. Yet many believers today—including a growing number of evangelicals—also question some of the assumptions about how best to interpret Scripture that evangelicals often treat as interchangeable with trust in Scripture itself.

Historically considered, the modern strength of young-earth creation science is almost entirely explainable as the continuation of former predispositions. To be sure, skillful publications such as John Whitcomb and Henry Morris' *The Genesis Flood*, which appeared in 1961, have added new elements to the mix. But the impact of this and similar works depends almost entirely on a skillful evocation of assumptions about metaphysical univocity, harmonization, natural theology, and the locus of problems when science and religious seem to clash (1, 2, 3, 12) combined with forceful assertion of convictions about the truth-telling character of the Bible (5, 7, 10) along with attitudes or assumptions about the necessity of interpreting the Scriptures literally (8, 13), and the dangers of the modern research university (9)—and all promoted democratically to the public at large as the presumed best judge of such issues (4, 11).

Likewise, the intelligent design movement, with more sophistication, demonstrates an especially strong commitment to metaphysical univocity, harmonization, and natural theology (1, 2, 3), with a penchant for regarding the court of public opinion

as a capable judge of controversial issues (4, 11). Moreover, this modern situation is complicated by the fact that many of the critics of creation science and intelligent design, both believers and unbelievers, also share some of these attitudes, especially those derived from metaphysical univocity, harmonization, and natural theology.

What is new in recent decades is the broader place of modern science in American society and the multiplying engines of communication that offer much information and much opinion on issues of science and religion. From the 1950s, massive amounts of government investment in scientific research have spilled over into the provision of national science curricula for schools at all levels, including public schools. The historian Ronald Numbers has shrewdly pointed out that ideas about evolution were one thing, but teaching about evolution that was funded by the federal government and mandated for local public schools was another.[13] This combination has led many evangelicals to think that (14) *when scientific teaching that appears to undercut Christian belief is supported by both the federal government and by the scientific establishment, truth and morality are under deadly assault.*

Much recent debate over science and religion has also been caught up in the great expansion of popular communications and the even more recent democratization of mass communication through the internet. The result has been a politicization of information unlike anything seen previously in American history. Of course information has always been delivered with political, partisan, and ideological overtones. But the fervent debates that now roil the public display mistrustful extremism—and from every point on the ideological compass—reaching much farther up, out, and down than ever before. The result is that debates over science and religion are often folded into debates on many other topics. Thus, for at least some evangelicals, (15) *opposition to evolution is a useful shorthand for opposing radical feminism, the sexual revolution, the normalization of homosexuality, and alternative family definition, as well as for opposing perceived attacks on Christianity.*

* * * * *

If what I have sketched in this article portrays the past with any accuracy, it should be clear that when conservative Protestants voice objections to different aspects of modern science, they do so for a complex of well-established reasons. Progress on this front probably depends mostly on increasing the number and quality of believers who are willing to enter the world of university-level science with commitments to historical Christianity and the modern practice of science firmly in place. It may also be helped by Bible-believing evangelicals who are willing to ask how truly biblical are the convictions, assumptions, and attitudes they bring with them to the consideration of modern science.

Further Reading

The literature on subjects treated in this paper is immense beyond human comprehension. Nonetheless, a beginning can be made by attending to the discussions (and the bibliographies) found in outstanding treatments of the general subject, including John Hedley Brooke, *Science and Religion: Some Historical Perspectives* (Cambridge: Cambridge University Press, 1991); David C. Lindberg and Ronald L. Numbers, eds., *God and Nature: Historical Essays on the Encounter between Christianity and Science* (Berkeley, CA: University of California Press, 1986); and David C. Lindberg and Ronald L. Numbers, eds., *When Science and Christianity Meet* (Chicago, IL: University of Chicago Press, 2003).

Reliable orientation to the deep backgrounds of this story is found in Amos Funkenstein, *Theology and the Scientific Imagination from the Middle Ages to the Seventeenth Century* (Princeton, NJ: Princeton University Press, 1986); and Peter Harrison, *The Bible, Protestantism, and the Rise of Natural Science* (Cambridge: Cambridge University Press, 1998).

On Darwin, Darwinism, and the reception of Darwinism, outstanding accounts have been provided by Adrian Desmond and James Moore, *Darwin* (Scranton, PA: W.W. Norton and Co., 1994); James R. Moore, *The Post-Darwinian Controversies: A Study of the Protestant Struggle to Come to Terms with Darwin in Great Britain and America, 1870–1900* (Cambridge: Cambridge University Press, 1979); and Jon H. Roberts, *Darwinism and the Divine in America: Protestant Intellectuals and Organic Evolution, 1859–1900* (Madison, WI: University of Wisconsin Press, 1988).

On modern debates, see especially Ronald L. Numbers, *The Creationists*, expanded ed. (Cambridge, MA: Harvard University Press, 2006), with a good general survey also in Michael Ruse, *The Evolution-Creation Struggle* (Cambridge, MA: Harvard University Press, 2005).

An excellent account on the many surprising twists and turns in the history of issues discussed here is David N. Livingstone, *Adam's Ancestors: Race, Religion, and the Politics of Human Origins* (Baltimore, MD: Johns Hopkins University Press, 2008).

On matters more particularly related to America, see Mark A. Noll, *America's God: From Jonathan Edwards to Abraham Lincoln* (New York: Oxford University Press, 2002); and on evangelicals, David N. Livingstone, *Darwin's Forgotten Defenders: The Encounter between Evangelical Theology and Evolutionary Thought* (Grand Rapids, MI: Wm. B. Eerdmans, 1987); and David Livingstone, D. G. Hart, and Mark A. Noll, eds., *Evangelicals and Science in Historical Perspective* (New York: Oxford University Press, 1999).

An outstanding general reference is Gary B. Ferngren, ed., *The History of Science and Religion in the Western Tradition: An Encyclopedia* (New York: Garland, 2000).

Notes

[1]William Paley, *Natural Theology*, ed. Matthew D. Eddy and David Knight (1802; reprint, New York: Oxford University Press, 2006), 101.

[2]The discussion in this section is much expanded in Mark A. Noll, *America's God: From Jonathan Edwards to Abraham Lincoln* (New York: Oxford University Press, 2002).

[3]Alexis de Tocqueville, *Democracy in America*, ed. and trans. Harvey Claflin Mansfield and Debra Winthrop (1835/1840; reprint, Chicago, IL: University of Chicago Press, 2000), 281–2.

[4]Theodore Dwight Bozeman, *Protestants in an Age of Science: The Baconian Ideal and Antebellum American Religious Thought* (Chapel Hill, NC: University of North Carolina Press, 1977), 3–31.

[5]"Memoirs of the Life of President Dwight," as prefaced to Dwight, *Theology: Explained and Defended, in a Series of Sermons*, 4 vols. (New Haven, CT: 1843), 1:22–3.

[6]Stanhope Smith, *An Essay on the Causes of the Variety of Complexion and Figure in the Human Species*, 2d ed. (New Brunswick, NJ: 1810), 3.

[7]Benjamin Rush, "A Defense of the Use of the Bible as a School Book" (dated March 10, 1791), published as pp. 53–65 in John Eyten, *Our Lord Jesus Christ's Sermon on the Mount … Intended Chiefly for the Instruction of Young People*, 2nd American ed. (Baltimore, MD: 1810), 65.

[8]Robert Baird, *Religion in the United States of America* (Glasgow, 1844), 658 (emphasis added).

[9]"The Millennium of Rev. xx.," *Methodist Quarterly Review* 25 (Jan. 1843): 87, as quoted in James Moorhead, "Prophecy, Millennialism, and Biblical Interpretation in Nineteenth-Century America," in *Biblical Hermeneutics in Historical Perspective*, ed. Mark S. Burrows and Paul Rorem (Grand Rapids, MI: Eerdmans Publishing, 1991), 297.

[10]This quotation is from A. D. White's preface to his book, *A History of the Warfare of Science with Theology in Christendom*, which was published in 1896; it comes from a two-volume edition published by Peter Smith in Gloucester, MA, in 1978.

[11]A. A. Hodge and B. B. Warfield, "Inspiration," *Presbyterian Review* 2 (1881): 225-60.

[12]See David N. Livingstone and Mark A. Noll, eds., *B. B. Warfield: Evolution, Science, and Scripture: Selected Writings* (Grand Rapids, MI: Baker, 2000).

[13]Ronald L. Numbers, *The Creationists*, expanded ed. (Cambridge, MA: Harvard University Press, 2006), 264–5.

This article is edited only slightly from what first appeared on November 23, 2009, on the BioLogos website, http://biologos.org/uploads/projects/Noll_scholarly_essay.pdf. We thank BioLogos for allowing us to publish it in *PSCF*.

Stephen C. Meyer

Of Molecules and (Straw) Men: A Response to Dennis Venema's Review of *Signature in the Cell*

Stephen C. Meyer

As a longtime ASA member, I was obviously pleased to see *Perspectives on Science and Christian Faith (PSCF)* devote a review essay in its December 2010 issue to an assessment of my recent book, *Signature in the Cell: DNA and the Evidence for Intelligent Design (HarperOne 2009)*. I also welcomed the general approach of *PSCF*'s designated reviewer Dennis Venema. Unlike some critics, Venema at least attempted to assess the issues raised in *Signature in the Cell* by appealing to scientific evidence rather than merely dismissing the idea of intelligent design with pejorative labels (such as "scientific creationism") or a priori philosophical judgments (such as "intelligent design is not science").[1]

Nevertheless, Venema argued that the scientific evidence does *not* support my argument for intelligent design, and he offered several lines of evidence in an attempt to refute it. And, of course, I disagree with his arguments. In this response, I will show why. I will demonstrate that Venema did not refute the argument of *Signature in the Cell* and that he failed to do so for two main reasons:

(1) The balance of his review is spent refuting an argument that *Signature in the Cell* does not make and, thus, the evidence he cites is irrelevant to the main argument of the book; in short, Venema "refutes" a straw man;

(2) The *relevant* scientific proposals that Venema *does* cite as evidence against the thesis of the book are deeply flawed. In particular,

(a) The RNA-world hypothesis has *not* solved the problem of the origin of life or the origin of biological information.

(b) The "direct templating" model of the origin of the genetic code fails to explain both the origin of the code and the origin of sequence-specific genetic information.

Let us consider each of these problems in turn.

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Meyer's many other publications include a contribution to, and the editing of, the peer-reviewed volume Darwinism, Design and Public Education *(Michigan State University Press, 2004) and the innovative textbook* Explore Evolution *(Hill House Publishers, 2007). In the second DVD series, Meyer investigates the evidence for the historical reliability of the Bible.*

Every summer Meyer teaches at Discovery Institute's Summer Seminar on Intelligent Design in the Natural Sciences. Students accepted to the program study for a week in Seattle with a team of scientists and scholars led by Meyer. For more information on applying, visit www.discovery.org/sem.

Author Exchange

Of Molecules and (Straw) Men: A Response to Dennis Venema's Review of Signature in the Cell

Venema's Straw Man

After beginning with a reasonably accurate (though incomplete) chapter-by-chapter summary of the argument of the book, Venema makes an abrupt disconnect with his own exposition and proceeds to critique an argument wholly different from the one he has just summarized. Whereas my book attempts to establish intelligent design as the best explanation for the information necessary to produce *the first life*, Venema critiques the claim that natural selection and random mutation cannot produce the information necessary to produce new forms of life *from preexisting forms of life*. While the book presents intelligent design as an alternative to chemical evolutionary theory, Venema critiques it as if it had presented a critique of neo-Darwinism—i.e., biological evolutionary theory.

To establish that Venema failed in the main to address my argument, it might be helpful to summarize the actual argument of *Signature in the Cell* for those who have not yet read it.

From the Horse's Mouth: The Argument of *Signature in the Cell*

Signature in the Cell addresses what I call the "DNA Enigma," the mystery of the information necessary to produce the first life. The book begins by describing this enigma and how it emerged from the revolutionary developments in molecular biology during the 1950s and 1960s. When Watson and Crick discovered the structure of DNA in 1953, they also discovered that DNA stores information in the form of a four-character alphabetic code. Strings of precisely sequenced chemicals called *nucleotide bases* store and transmit the assembly instructions—the information—for building the crucial protein molecules and protein machines the cell needs to survive. Crick later developed this idea with his famous "sequence hypothesis," according to which the nucleotide bases in DNA function like letters in a written language or symbols in a computer code. Just as letters in an English sentence or digital characters in a computer program may convey information depending on their arrangement, so too do certain sequences of chemical bases along the spine of the DNA molecule convey precise instructions for building proteins.

Further, since life depends upon the presence of genetic information, any theory of the origin of the first life must provide an account of the origin of this information. As origin-of-life researcher Bernd-Olaf Küppers has explained, "The problem of the origin-of-life is clearly basically equivalent to the problem of the origin of biological information."[2]

The book then draws an important distinction between the mathematical theory of information developed by Claude Shannon at MIT during the late 1940s and what has been called "functional information,"[3] "specified information," or "specified complexity."[4] According to Shannon, the amount of information conveyed in a series of symbols or characters is inversely proportional to the probability of a particular event, symbol, or character occurring. Functional or specified information, by contrast, is present in sequences in which the *specific arrangement* of the symbols or characters is crucial to the ability of the string to perform a function or convey meaning. For example, consider two sequences of characters:

Four score and seven years ago
nenen ytawoi jll sn mekhdx nnx

Both of these sequences have an equal number of characters. Since both are composed of the same 26-letter English alphabet, the probability of producing each of those two sequences at random is identical. Therefore, both sequences have an equal amount of information as measured by Shannon's theory. Nevertheless, the first of these sequences performs a communication function, whereas the second does not.

When discussing information in a biological context, we must distinguish sequences of characters that are (a) merely improbable from (b) sequences that are improbable and also *specifically* arranged so as to perform a function. Following Francis Crick himself, I show that DNA-base sequences do not just possess "information" in the strictly mathematical sense of Shannon's theory. Instead, DNA contains information in the richer and more ordinary sense of "alternative sequences or arrangements of characters that *produce a specific effect*." DNA-base sequences convey assembly instructions. They perform functions in virtue of their specific arrangements. Thus, they do not possess mere "Shannon information," but instead "specified" or "functional information." Indeed, like the precisely arranged zeros and ones

in a computer program, the chemical bases in DNA convey instructions in virtue of their "specificity."

Having defined the kind of information that needs to be explained in any theory of the origin of the first life, the book then does two things.

First, it shows that historical scientists typically use a method of multiple competing hypotheses.[5] Contemporary philosophers of science such as Peter Lipton have called this the method of "inference to the best explanation."[6] That is, when trying to explain the origin of an event, feature, or structure in the remote past, scientists typically compare various hypotheses to see which would, if true, best explain it.[7] They then provisionally affirm the hypothesis that best explains the data as the one that is most likely to be true. Yet that raises a question: what makes an explanation best?

Historical scientists have developed criteria for deciding which cause, among a group of competing possible causes, provides the best explanation for some event in the remote past. The most important of these criteria is called "causal adequacy." This criterion requires that historical scientists identify causes that are known to have the power to produce the kind of effect, feature, or event that requires explanation. In making these determinations, historical scientists evaluate hypotheses against their present knowledge of cause and effect. Causes that are known to produce the effect in question are judged to be better candidates than those that do not. For instance, a volcanic eruption provides a better explanation for an ash layer in the earth than an earthquake because eruptions have been observed to produce ash layers, whereas earthquakes have not.

One of the first scientists to develop this principle was the geologist Charles Lyell who also influenced Charles Darwin. Darwin read Lyell's *The Principles of Geology* while onboard the *Beagle* and employed its principles of reasoning in *The Origin of Species*. The subtitle of Lyell's *Principles* summarized the geologist's central methodological principle: *Being an Attempt to Explain the Former Changes of the Earth's Surface, by Reference to* Causes Now in Operation (emphasis in title added).[8] Lyell argued that when scientists seek to explain events in the past, they should not invoke unknown or exotic causes, the effects of which we do not know. Instead, they should cite causes that are known from *our uniform experience* to have the power to produce the effect in question. Historical scientists should cite "*causes now in operation*" or presently acting causes. This was the idea behind his uniformitarian principle and the dictum, "The present is the key to the past." According to Lyell, our *present* experience of cause and effect should guide our reasoning about the causes of *past* events. Darwin himself adopted this methodological principle as he sought to demonstrate that natural selection qualified as a *vera causa*, that is, a true, known, or actual cause of significant biological change.[9] He sought to show that natural selection was "causally adequate" to produce the effects he was trying to explain.

Both philosophers of science and leading historical scientists have emphasized causal adequacy as the key criterion by which competing hypotheses are adjudicated. Philosophers of science, however, also have noted that assessments of explanatory power lead to conclusive inferences only when it can be shown that there is *only one known cause* for the effect or evidence in question.[10] When scientists can infer a *uniquely* plausible cause, they avoid the logical fallacy of affirming the consequent (or ignoring other possible causes with the power to produce the same effect).[11]

Secondly, after establishing parameters for evaluating competing explanations of the origin of the information necessary to produce the first life, I consciously employ the method of multiple competing hypotheses to make a positive case for intelligent design based upon the presence of functionally specified information in the cell. My book argues that intelligent design provides the best—"most causally adequate"—explanation of the origin of the *functional* or *specified* information necessary to produce life *in the first place*.

To do so, *Signature in the Cell* argues, first, that no purely undirected physical or chemical process—whether those based upon chance, law-like necessity, or the combination of the two—has provided an adequate causal explanation for the ultimate origin of the functionally specified biological information. In making that claim, I specifically stipulate that I am talking about undirected *physical or chemical* processes, not processes (such as random genetic mutation and natural selection) that commence only once life has begun. (Clearly, material processes that only

commence once life has begun cannot be invoked to explain the origin of the information necessary to produce life in the first place). Nevertheless, I do examine the leading naturalistic attempts to account for the *ultimate* origin of biological information, including chance-based theories, self-organizational theories, theories of prebiotic natural selection, including the RNA-world hypothesis and DNA-first, protein-first, and metabolism-first theories. As a result of this analysis, I show that attempts to account for the origin of specified biological information starting "*from purely physical or chemical antecedents*" have repeatedly failed.

On the other hand, I further argue, based upon our uniform and repeated experience, we do know of a cause—a type of cause—that has demonstrated the power to produce functionally specified information from physical or chemical constituents. That cause is *intelligence,* or *mind,* or *conscious activity*. As information theorist Henry Quastler observed, "The creation of information is habitually associated with conscious activity."[12] Indeed, whenever we find specified information—whether embedded in a radio signal, carved in a stone monument, etched on a magnetic disc, or produced by a genetic algorithm or ribozyme engineering experiment—and we trace it back to its source, invariably we come to a mind, not merely a material process. And, as origin-of-life research itself has helped to demonstrate, we know of no other cause capable of producing functional specified information starting, again, *from a purely physical or chemical state*. Thus, the discovery of functionally specified, digitally encoded information in the DNA of even the simplest living cells provides compelling positive evidence for the activity of a prior designing intelligence *at the point of the origin of the first life*.

Missing a Basic Distinction

To refute a best-explanation argument, Venema correctly understands that he must cite an alternative explanation with equal or superior explanatory power. That means he must show that some other process or cause (other than intelligence) has demonstrated the power to produce the effect in question. Unfortunately, throughout most of his review, Venema equivocates in his description of that effect (i.e., what needs to be explained). He fails to distinguish between the ultimate origin of the biological information necessary to produce *the first life* and the addition of information necessary to produce new forms of life (or new proteins) from preexisting genetic information and living organisms. Instead, he spends much of his review attempting to establish that natural selection and random genetic mutations can *add* new genetic information to preexisting organisms, apparently unaware that he is defending at length a claim that my book does not challenge. Thus, Venema incorrectly insists that "Meyer's main argument" concerns "the inability of random mutation and selection *to add* information to DNA" (p. 278, emphasis mine).

I happen to think—but do not argue in *Signature in the Cell*—that there are significant grounds for doubting that mutation and selection can add *enough* new information to account for various macroevolutionary innovations. Nevertheless, the book that Venema was reviewing, *Signature in the Cell*, does not address the issue of biological evolution, nor does it challenge whether mutation and selection can add new information to DNA. That is simply not what the book is about. Instead, it argues that no undirected *chemical* process has demonstrated the capacity to produce the information necessary to generate life *in the first place*. The book addresses the subject of chemical evolution and the origin of life, not biological evolution and its subsequent diversification. To imply otherwise, as Venema does, is simply to critique a straw man.

To those unfamiliar with the particular problems faced by origin-of-life research, the distinction between prebiotic and postbiotic information generation might seem like hairsplitting. After all, it might be argued that if natural selection can generate new information in living organisms, why can it also not do so in a prebiotic environment? Yet the distinction between a biotic and prebiotic context is crucially important. The process of natural selection classically understood presupposes the differential reproduction of living organisms and thus a preexisting mechanism of self-replication. Yet, self-replication in all extant cells depends upon functional (and therefore, sequence-specific, information-rich) proteins and nucleic acids. Yet the origin of such information-rich molecules is precisely what origin-of-life research needs to explain. For this reason, Theodosius Dobzhansky insisted, "Pre-biological natural selection is a contradiction in terms."[13] Or as

Christian de Duve has explained, theories of prebiotic natural selection fail because they "need information which implies they have to presuppose what is to be explained in the first place."[14]

Of course, some origin-of-life researchers, in particular those advocating the RNA-world hypothesis, have attempted to extend the concept of natural selection and differential reproduction to nonliving molecules. In particular, some researchers have proposed that self-replicating RNA molecules might establish something akin to natural selection in a prebiotic context. Nevertheless, I critique this proposal at length in my book (see summary below). Yet Venema neither acknowledges nor refutes that critique. Instead, he conflates the problems of generating information via biological and prebiological natural selection, and in so doing, fails to grapple with the critical difficulties in origin-of-life research that partly underscore the cogency of my argument.

In addition to "refuting" claims I do not make, Venema devotes an entire section of his review to criticizing the book for failing to discuss common ancestry.[15] Nevertheless, the theory of universal common descent is part of the theory of biological evolution—both classical Darwinism and the neo-Darwinian synthesis. Since *Signature in the Cell* does not challenge either of these two theories, there was no reason for it to address the evidence for (or against) universal common descent. Needless to say, common ancestry does not become an issue until life has arisen. And again, my book is about the origin of life, not its subsequent development.[16]

Relevant (but inadequate) Critiques: Metabolism First and the RNA World

After spending most of his critique of *Signature in the Cell* defending a mechanism of *biological evolution*, Venema does at last return to evaluating the claims of the book itself, however briefly. When he does, he grudgingly acknowledges that "Meyer is correct that no complete mechanism for abiogenesis has yet been put forward" (p. 280). Nevertheless, he then faults the book for

> focus[ing] disproportionately on outdated, discarded origin-of-life hypotheses, giv[ing] current science on the issue short shrift … for example, the major model favored by many scientists is the "RNA world" hypothesis, yet Meyer spends little time on it. Other current models, such as "metabolism first" hypotheses, receive no attention at all. This seriously compromises Meyer's argument, since his conclusion of design depends on his assertion that he has performed a "thorough search" to exclude all natural alternatives to intelligent intervention at the origin of life … Of this section [critiquing naturalistic models], the only current origin-of-life model (the RNA world) merits a slim chapter of twenty-eight pages. (p. 280)

It is important when encountering such critique to keep an eye on the ball. Discerning readers will notice that Venema did not offer what would have been necessary to refute the thesis of the book, namely, a causally adequate alternative explanation for the origin of the information necessary to produce the first life. Instead, he effectively concedes the main argument of the book by acknowledging that "no such mechanism … has been put forward" (p. 280). He does not argue, for example, that either the RNA-world hypothesis or the metabolism-first model *explains* either the origin of life or the origin of the information necessary to produce it. Instead, his critique merely distracts attention from the central issue of the ultimate origin of biological information by quibbling about the length of my chapters, my "lack of depth in modern origin-of-life research" (p. 280), and my "rookie errors" (p. 281)![17]

What of his specific criticisms? Does *Signature in the Cell* fail to make a thorough search for alternative naturalistic explanations for the origin of biological information? Does it give the RNA-world hypothesis "short shrift"?

I am sorry to say that in each case it is Venema's scholarship that is lacking. He claims that my book does not address the metabolism-first hypothesis. This is false. *Signature in the Cell* provides a detailed critique of the most extensively developed metabolism-first proposal, Stuart Kauffman's theory described in his 700-page book *The Origins of Order*.[18] Moreover, the article that Venema commends to my attention, by the late Leslie Orgel, hardly solves the problem of the origin of life or information, *as Orgel explained in the article that Venema cites*. As Orgel notes,

> The suggestion that relatively pure, complex organic molecules might be made available in large

> amounts via a self-organizing, autocatalytic cycle might, in principle, help to explain the origin of the component monomers. [Yet] I have emphasized *the implausibility* of the suggestion that complicated cycles could self-organize.[19]

In his more recent 2008 paper titled "The Implausibility of Metabolic Cycles on the Prebiotic Earth," Orgel is even more adamant:

> Almost all proposals of hypothetical metabolic cycles have recognized that each of the steps involved must occur rapidly enough for the cycle to be useful in the time available for its operation. It is always assumed that this condition is met, but in no case have persuasive supporting arguments been presented. Why should one believe that an ensemble of minerals that are capable of catalyzing each of the many steps of the reverse citric acid cycle was present anywhere on the primitive Earth or that the cycle mysteriously organized itself topographically on a metal sulfide surface? The lack of a supporting background in chemistry is even more evident in proposals that metabolic cycles can evolve to "life-like" complexity. The most serious challenge to proponents of metabolic [first] cycle theories—*the problems presented by the lack of specificity of most nonenzymatic catalysts—has, in general, not been appreciated*. If it has, it has been ignored. Theories of the origin of life based on metabolic cycles cannot be justified by the inadequacy of competing theories: they must stand on their own.[20]

Venema's citation of Orgel as a representative of the metabolism-first theory gives the misleading impression that Orgel advocated this theory and that, therefore, *Signature in the Cell* should have addressed it as a significant alternative explanation. Yet, not only does *Signature in the Cell* address, arguably, the most well-developed metabolism-first theory (i.e., Kauffman's), it also critiques the same fundamental flaw in metabolism-first theories that Orgel himself highlights, namely, that metabolism-first theories do not account for the information-rich enzymatic complexity necessary to establish autocatalytic metabolic cycles. Orgel does not just criticize these theories. His criticisms are similar to those found in *Signature in the Cell*. Why then cite Orgel against the book, as Venema does?

Venema also claims my book disproportionately focuses on outdated origin-of-life theories. Yet he fails to inform his readers that the book quite intentionally performed a chronological investigation of the major attempts that have been made to solve the problem of the origin of biological information from the 1950s until the present. Moreover, I trace the development of these ideas (a) precisely to insure that the book makes a thorough search of alternative naturalistic explanations and (b) to establish for readers the depth and severity of the problem facing naturalistic attempts to explain the origin of biological information.

Meanwhile, Venema's critique of my discussion of the RNA-world hypothesis is facile. His sole criticism of my discussion is that it encompasses "only" twenty-eight printed pages. Yet, scientific ideas are not judged by the number of words or pages required to explain (or critique) them, nor does a 10,000-word chapter including references constitute a "slim" or cursory treatment, especially since it takes far fewer words to explain the main reasons the theory fails (see below). In any case, to show that the RNA world refutes the thesis of *Signature in the Cell*, Venema needed to establish (or, at least, assert authoritatively) that the RNA world has solved the problem of the origin of life or the origin of biological information. To do that, he would need to rebut the arguments made in my chapter, and this he does not do. Nor can he do so. Instead, it is the RNA-world hypothesis that gives short shrift to the real problems facing naturalistic accounts of abiogenesis.

Problems with the RNA-World Hypothesis

As readers will recall, the RNA world was proposed as an explanation for the origin of the interdependence of nucleic acids and proteins in the cell's information-processing system. In extant cells, building proteins requires genetic information from DNA, but information in DNA cannot be processed without many specific proteins and protein complexes. This poses a chicken-or-egg problem. The discovery that RNA (a nucleic acid) possesses some limited catalytic properties similar to those of proteins suggested a potential way to solve that problem. "RNA-first" advocates proposed an early state in which RNA performed both the enzymatic functions of modern proteins and the information-storage function of modern DNA, thus allegedly making the interdependence of DNA and proteins unnecessary in the

earliest living system.[21] Yet as I show in *Signature in the Cell,* there are a number of compelling reasons to doubt this hypothesis, none of which Venema addresses or refutes.

First, synthesizing (and/or maintaining) many essential building blocks of RNA molecules under realistic conditions without unrealistic levels of intelligent manipulation from investigators has proven to be extremely difficult.[22]

Second, ribozymes acting on their own, without the help of proteins, are known to perform only a tiny set of simple reactions. They do not perform anything like the range of functions that proteins do, and there are physical reasons for this. Proteins use a combination of hydrophilic and hydrophobic building blocks to make large, well-formed molecular structures with a wide variety of stable shapes. RNAs, which are limited to four hydrophilic bases, cannot do this. Thus, for example, true protein enzymes are capable of coupling energetically favorable and energetically unfavorable reactions together. Ribozymes are not.

Third, RNA-world advocates offer no plausible explanation for how primitive RNA replicators might have evolved into modern cells that rely heavily on proteins to process and translate genetic information and regulate metabolism.[23]

Fourth, attempts to enhance the limited catalytic properties of RNA molecules in so-called ribozyme engineering experiments have inevitably required extensive investigator manipulation, thus demonstrating, if anything, the need for intelligent design, not the efficacy of an undirected chemical evolutionary process.

Most importantly for our present considerations, the RNA-world hypothesis presupposes, but does not explain, the origin of sequence specificity or information in the original (hypothetical) self-replicating RNA molecules.[24] To date, scientists have been able to design RNA catalysts that will copy only about 10% of themselves.[25] For strands of RNA to perform even this limited replicase (self-replication) function, however, they must, like proteins, have very specific arrangements of constituent building blocks (nucleotides, in the RNA case). Further, the strands must be long enough to fold into complex three-dimensional shapes (to form so-called tertiary structures). Thus, any RNA molecule capable of even limited function must have possessed considerable (specified) information content. Yet, explaining how the building blocks of RNA arranged themselves into functionally specified sequences has proven no easier than explaining how the constituent parts of DNA might have done so, especially given the high probability of destructive cross-reactions between desirable and undesirable molecules in any realistic prebiotic soup. As de Duve has noted in a critique of the RNA-world hypothesis, "Hitching the components together in the right manner raises additional problems of such magnitude that no one has yet attempted to [solve them] in a prebiotic context."[26]

Unless Venema can show that this problem has been solved in a prebiotic context, he has no grounds for dismissing my chapter as "too short." My chapter was more than long enough to expose this and several other major (and widely acknowledged) deficiencies in the RNA-world model.

Direct Template Models of the Origin of the Genetic Code

Venema offers one additional critique of *Signature in the Cell* that seems, at least, to have tangential relevance to the main argument of the book. Venema claims that *Signature in the Cell* was remiss in not discussing some recent "direct templating models" of the origin of the genetic code. He cites a paper published (as it happens, after the publication of *Signature in the Cell*)[27] by Michael Yarus and colleagues at the University of Colorado. The paper purports to show that the origin of the genetic code can be explained as the result of stereochemical affinities between RNA triplets and the corresponding (cognate) amino acids with which they are associated in the genetic code.[28]

Yarus and his co-researchers looked for RNA strands that bound certain amino acids preferentially, from a class of RNA molecules now dubbed "aptamers." Further, Yarus himself has asserted that his work undermines a key claim of the theory of intelligent design, because he thinks that it shows that specified complexity can arise by purely natural processes.[29] Moreover, Yarus et al. have assembled a significant body of novel experimental data, which they argue support their hypothesis.[30]

Yarus's work does address an important aspect of the origin-of-life problem. Nevertheless, even if its narrower empirical claims about the existence of a stereochemical basis for the genetic code are correct (and there are strong reasons to doubt this, see below), it does not follow that Yarus's work refutes the argument of *Signature in the Cell*. My book argues that organisms were intelligently designed, mainly because of the presence, in their DNA and RNA, of what might be called genetic *text* (i.e., genes)—sequences of specifically arranged nucleotide bases that provide instructions for building proteins. *Signature in the Cell* addresses what in origin-of-life research is known as *the sequencing problem*, and presents intelligent design as the solution to it.

Yarus's experimental work does not solve the sequencing problem, although he seems to think (incorrectly) that his work may solve it indirectly. Yarus et al. want to demonstrate that particular RNA triplets show chemical affinities to particular amino acids (their cognates in the present-day code). They do this by showing that in some RNA strands, individual triplets and their cognate amino acids bind preferentially to each other. Further, since they think that stereochemical affinities originally caused protein synthesis to occur by direct templating, they seem to think that solving the problem of the origin of the code would also simultaneously solve the problem of sequencing.

But this does not follow. Even if we assume that Yarus and his colleagues have succeeded in establishing a stereochemical basis for the associations between RNA triplets and amino acids in the present-day code (a dubious proposition, see below[31]), Yarus would not have solved the problem of sequencing. Why? Yarus did not find RNA strands with a properly *sequenced series* of triplets, each forming an association with a code-relevant amino acid. Instead, he and his fellow researchers analyzed RNA strands enriched in specific code-relevant triplets. They claim to have found that these strands show a chemical affinity to bind individual code-relevant cognate amino acids. But to synthesize proteins by direct templating (even assuming the existence of all necessary affinities), the RNA template must have *many properly sequenced* triplets, just as we find in actual messenger RNA transcripts.

To produce such transcripts, however, would require excising the functional (information-carrying) triplets, with code-relevant affinities, from the otherwise nonfunctional, noncode-relevant sections of RNA present in the "aptamers" in which Yarus claims to have found code-relevant affinities. Further, once excised, these functional code-relevant triplets would have to be concatenated and arranged, to construct something akin to a gene that could directly template functional proteins (see fig. 1). Yet Yarus et al. do not explain how any of this, least of all the specific arrangement of the triplets, would occur. Thus they fail to solve, or even address, the sequencing problem.

Instead, Yarus attempts to explain the origin of the genetic code—or more precisely, one aspect of the translation system, the origin of the associations between certain RNA triplets and their cognate amino acids—without explaining the origin of the sequence-specific genetic text. Thus, even if Yarus and his colleagues had succeeded in explaining the origin of these associations (which they do not, see below), and even if these associations constituted a fully *functional* code (itself a questionable proposition, see below), their work would leave unaddressed the crucial sequencing problem and the main information argument for intelligent design presented in *Signature in the Cell*.[32]

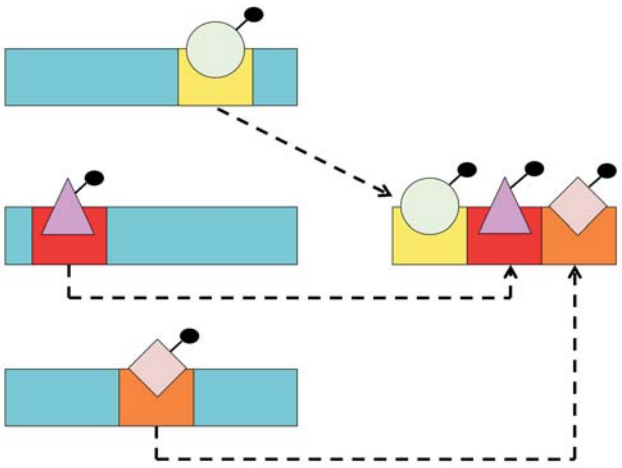

Figure 1. The sequencing problem. RNA nucleotides which bind amino acids (e.g., as represented by the green circle or purple triangle) occur in aptamers with nonbinding bases. Thus, to specify protein sequences, which require many different amino acids, code-relevant (i.e., amino acid-binding) nucleotides must be removed from their native aptamers and reassembled into new, much longer aptamers with correct orientations and molecular distances, to achieve functional sequences of binding sites.

Since Yarus's model does not solve, nor in reality address, the central information problem discussed in *Signature in the Cell*, the book did not address it. Nevertheless, I have, with Paul Nelson, performed a thorough critique of Yarus's work in a recent technical article. In addition to showing that Yarus does not (really) attempt to solve the sequencing problem, we also show that

- Yarus's methods of selecting amino-acid-binding RNA sequences ignored aptamers that did not contain the sought-after codons or anti-codons, biasing their statistical model in favor of the desired results;
- The reported results exhibited a 79% failure rate, casting doubt on the legitimacy of the "correct" results;
- Yarus et al. simply assumed a naturalistic chemical origin for various complex biochemicals, even though there is no evidence at present for such abiotic pathways;
- Recognizing the possibility that the RNA aptamers will introduce steric hindrance to peptide bond formation, Yarus et al. carefully engineer their aptamers. In short, they inadvertently and ironically simulate the need for intelligent design to make their proposal plausible.

In summary, our article shows that Yarus neither establishes a stereochemical basis for the genetic code nor explains the origin of the sequence-specific "genetic text" found in DNA and RNA.

Conclusion

I appreciate the opportunity to address the issues raised in Dennis Venema's review. Yet, clearly, Venema did not refute the argument of *Signature in the Cell*. The origin-of-life scenarios that Venema cites as alternatives to intelligent design lack biochemical plausibility and do not account for the ultimate origin of biological information. Moreover, Venema failed to recognize the importance of an elementary distinction between chemical and biological evolution in his assessment of my thesis. In this regard, his review followed a curious, but all-too-familiar pattern. Since he is unable to point to any chemical evolutionary mechanism that can account for the ultimate origin of information, Venema—like other critics of *Signature in the Cell* such as Darrel Falk and Francisco Ayala—attempts to demonstrate with various examples that the neo-Darwinian mechanism *can* generate (at least) some new information—albeit in each case *starting from a preexisting organism*. And so, he spends the balance of his review rebutting a book on biological evolution that I did not write.

Even so, readers should beware of his confident assertions about the alleged creative power of natural selection and random mutation as a mechanism of biological evolution. He claims (following Falk and various ASA bloggers), for example, that the immune system demonstrates the power of the neo-Darwinian mechanism to produce novel genetic information. Yet recently, immunologist Donald Ewert has shown that (a) the immune system produces only a limited amount of new biological information (and clearly not enough information, or the right kind of information, to accomplish major evolutionary transformations) and (b) that the immune system in no way models the *random* and *undirected* neo-Darwinian process of mutation and selection. Instead, it is *preprogrammed* to allow only certain types of mutations within certain portions of certain genes, and it uses a carefully controlled and regulated goal directed process of selection.[33] In a similar vein, protein engineer Doug Axe has decisively rebutted Arthur Hunt's critique of Axe's work,[34] which Venema recycled uncritically in his review of my book.

In any case, Venema's review of *Signature in the Cell* is compromised by his misrepresentation of the thesis of the book, by his citation of sources that do not support his critique, and by a superficial discussion of alternative theories of the origin of life. Though I appreciate his intended evidential approach, the execution of his analysis leaves much to be desired. Accordingly, I encourage *PSCF* readers to consider the merits of *Signature in the Cell* for themselves.

Notes

[1]See D. R. Venema, "Seeking a Signature," *Perspectives on Science and Christian Faith* 62, no. 4 (2010): 276–83.

[2]Bernd-Olaf Küppers, *Information and the Origin of Life* (Cambridge, MA: MIT Press, 1990), 170–2.

[3]See J. W. Szostak, "Molecular Messages," *Nature* 423 (2003): 689; R. M. Hazen, P. L. Griffin, J. M. Carothers, and J. W. Szostak, "Functional Information and the Emergence of Biocomplexity," *Proceedings of the National Academy of Sciences USA* 104 (2007): 8574–81.

[4]L. E. Orgel, *The Origins of Life: Molecules and Natural Selection* (London: Chapman and Hall, 1973): 189.

[5]T. C. Chamberlin, "The Method of Multiple Working Hypotheses," *Science* 15 (1890): 92–6; reprinted in *Science* 148 (1965): 754–9.

[6]P. Lipton, *Inference to the Best Explanation* (New York: Routledge, 1991), 1, 32–88.

[7]Ibid.

[8]C. Lyell, *Principles of Geology: Being an Attempt to Explain the Former Changes of the Earth's Surface, by Reference to Causes Now in Operation*, vol. 1 (London: John Murray, 1830–1833), 75–91.

[9]V. Kavalovski, *The Vera Causa Principle: A Historico-Philosophical Study of a Meta-Theoretical Concept from Newton through Darwin* (Ph.D. diss., University of Chicago, 1974), 78–103.

[10]M. Scriven, "Explanation and Prediction in Evolutionary Theory," *Science* 130 (1959): 477–82.

[11]S. Meyer, *Clues and Causes: A Methodological Interpretation of Origin of Life Studies* (Ph.D. diss., Cambridge University, 1990), 96–108.

[12]H. Quastler, *The Emergence of Biological Organization* (New Haven, CT: Yale University Press, 1964), 16.

[13]T. Dobzhansky, "Discussion of G. Schramm's Paper," in S. W. Fox, ed., *The Origins of Prebiological Systems and of Their Molecular Matrices* (New York: Academic Press, 1965), 310.

[14]C. de Duve, *Blueprint for a Cell: The Nature and Origin of Life* (Burlington, NC: Neil Patterson Publishers, 1991), 187.

[15]As Venema writes in part, "Meyer does not tackle this evidence or, for that matter, any evidence relevant to common ancestry" (p. 278).

[16]In fairness to Dennis, I do have an idea about how the confusion might have arisen in his mind. I do discuss *in an appendix* Doug Axe's work establishing the extreme rarity (and thus isolation, see below) of functional proteins within the vast space of possible amino acid combinations corresponding to proteins of even modest length. And it is true that Axe regards this rarity (and isolation) as a severe challenge to the efficacy of selection and mutation as a mechanism for generating new genes and proteins (and, thus, information) in a biological context. Further, Axe also favors intelligent design as an alternative to neo-Darwinian biological evolution in part for this reason.

Nevertheless, I discussed Axe's work to illustrate how various ID hypotheses can generate testable predictions in response to the objection that intelligent design does not generate testable predictions. I did not cite Axe's work as part of a critique of the neo-Darwinian mechanism (however much I may, or may not, doubt it). My argument for intelligent design as an alternative to chemical evolutionary theory conceded (at least, *ad arguendo*) the efficacy of that mechanism. I cited Axe, instead, to answer the oft-stated objection that design hypotheses are not scientific, because they make no testable predictions.

Perhaps, if Dennis reads the book more carefully, he will concede that he took my discussion of Axe's work out of context and built the balance of his critique of the book atop that misunderstanding. (By the way, in that same appendix, I also discussed various predictions that follow from front-end-loaded conceptions of intelligent design that assume the adequacy of neo-Darwinism. Obviously, if I had meant my appendix to function as a critique of neo-Darwinism, I would not have highlighted predictions that flow from ID hypotheses which assume the truth of that theory.)

[17]Venema catches a factual error in the book for which I am grateful. He notes that I should not have referred to ribosomes as "protein dominated." He is right. Ribosomes have more RNA than protein by weight (by about a 3 to 2 ratio in eukaryotes and a 2 to 1 ratio in prokaryotes). Also, RNA in the ribosome performs a necessary (though not sufficient) functional role in peptide bond formation. So the phrase "protein dominated" was ill-chosen.

Nevertheless, Venema then attempts to make a rhetorical mountain out of this factual molehill in an attempt to refute one of my critiques of the RNA-world hypothesis. He argues that "Meyer … claims that modern ribosomes are 'protein dominated' and [falsely] presents this as a hurdle for the RNA world to explain" (p. 280). According to Venema, my error undermines my critique of RNA world because it overlooks that "the modern [ribosome] system uses an RNA enzyme for protein synthesis …" (p. 280).

However, Venema misunderstands my argument and misrepresents me. First, I repeatedly note that ribosomes need *both* proteins *and* RNAs to accomplish peptide bond formation at the ribosome site (pp. 304–9). Second, I do not argue that the *absence of RNA* or the *dominance* of proteins in the ribosome represents a "hurdle for the RNA world to explain." I argue that the (mere) *presence* of proteins in the translation *system* (both in the ribosome and elsewhere) challenges the RNA-world hypothesis.

Here is why: As I explain in *Signature in the Cell,* "to evolve beyond The RNA World, an RNA-based replication system would eventually have to begin to produce proteins" (p. 305). Yet "in modern cells it takes many proteins to build proteins. So, as a first step toward building proteins, the primitive RNA replicator would need to produce *RNA molecules capable of performing the functions of the modern proteins involved in translation*" (p. 305).

Yet, as I show, RNA molecules cannot perform many of the crucial functions that proteins (and protein enzymes) can perform, including many of the functions that proteins perform in the translation process. Moreover, there are physical reasons for this. Proteins use a combination of hydrophilic and hydrophobic building blocks to make large, well-formed molecular structures with a wide variety of stable shapes, whereas RNAs, which are limited to four hydrophilic bases, cannot do this.

For example, as a result of their greater structural stability and complexity, protein enzymes can couple energetically favorable and unfavorable reactions together into a series of reactions that are energetically favorable overall. As a result, they can drive forward two reactions where ordinarily only one would occur with any appreciable frequency. RNA catalysts cannot do this. Yet such coordinated and coupled reactions are critical to many aspects of the translation process, including the reactions catalyzed by the crucial tRNA synthetases.

Because of the need for such coupled reactions and the functional limitations associated with RNA catalysts, the RNA-world hypothesis offers no credible account of the origin of a protein-based, or *even a partially protein-based*, translation system from an earlier exclusively RNA-based replication system.

Venema does not accurately represent this criticism of the RNA world, let alone answer it. Instead, he glosses over the problem of explaining the origin of proteins (or ribozymes with specific protein-like functions). As such, his review trivializes my concerns about the plausibility of the RNA-world hypothesis by obscuring its real difficulties. Once again, Venema attacks … the straw man.

[18]S. A. Kauffman, *The Origins of Order: Self-Organization and Selection in Evolution* (New York: Oxford University Press, 1993), 285–341.

[19]L. E. Orgel, "Self-Organizing Biochemical Cycles," *Proceedings of the National Academy of Sciences USA* 97 (2000): 12503–7 (emphasis added).

[20]L. E. Orgel, "The Implausibility of Metabolic Cycles on the Prebiotic Earth," *PLoS Biology* 6 (2008): 5–13 (emphasis added to highlight a critique of Kauffman's model made in *Signature in the Cell*).

[21]For example, see J. W. Szostak, D. P. Bartel, and P. L. Luisi, "Synthesizing Life," *Nature* 409 (2001): 387–90; G. F. Joyce, "The Antiquity of RNA-Based Evolution," *Nature* 418 (2002): 214–21.

[22]R. Shapiro, "Prebiotic Cytosine Synthesis: A Critical Analysis and Implications for the Origin of Life," *Proceedings of the National Academy of Sciences, USA* 96 (1999): 4396–401; M. W. Powner, B. Gerland, and J. D. Sutherland, "Synthesis of Activated Pyrimidine Ribonucleotides in Prebiotically Plausible Conditions," *Nature* 459 (2009): 239–42. For a response to Powner et al. (2009), see comments by Robert Shapiro in James Urquhart, "Insights into RNA Origins," *Chemistry World, Royal Society of Chemistry* (2009), www.rsc.org/chemistryworld/News/2009/May/13050902.asp (last accessed April 3, 2011).

Some critics of my book have attempted to dispute this claim. Darrel Falk, for example, first cites a scientific study published last spring after my book was in press. The paper authored by University of Manchester chemist John Sutherland and two colleagues, does partially address one of the many outstanding difficulties associated with the RNA world, the most popular current theory about the origin of the first life. Starting with a 3-carbon sugar (D-glyceraldehyde), and another molecule called 2-aminooxazole, Sutherland successfully synthesized a 5-carbon sugar in association with a base and a phosphate group. In other words, he produced a ribonucleotide. The scientific press justifiably heralded this as a breakthrough in prebiotic chemistry because previously chemists had thought (as I noted in my book) that the conditions under which ribose and bases could be synthesized were starkly incompatible with each other.

Even so, Sutherland's work lacks prebiotic plausibility and does so in three ways. First, Sutherland chose to begin his reaction with only the right-handed isomer of the 3-carbon sugars he needed to initiate his reaction sequence. Why? Because he knew that otherwise the likely result would have had little biological significance. Had Sutherland chosen to use a far more plausible racemic mixture of both right- and left-handed sugar isomers, his reaction would have generated undesirable mixtures of stereoisomers—mixtures that would seriously complicate any subsequent biologically relevant polymerization. Thus, he himself solved the so-called chirality problem in origin-of-life chemistry by intelligently selecting a single enantiomer, i.e., only the right-handed sugars that life itself requires. Yet there is no demonstrated source for such nonracemic mixture of sugars in any plausible prebiotic environment.

Second, the reaction that Sutherland used to produce ribonucleotides involved numerous separate chemical steps. At each intermediate stage in his multistep reaction sequence, Sutherland himself intervened to purify the chemical by-products of the previous step by removing undesirable side products. In so doing, he prevented—by his own will, intellect and experimental technique—the occurrence of interfering cross-reactions, the scourge of the prebiotic chemist.

Third, in order to produce the desired chemical product—ribonucleotides—Sutherland followed a very precise "recipe" or procedure in which he carefully selected the reagents and choreographed the order in which they were introduced into the reaction series, just as he also selected which side products to be removed and when. Such recipes, and the actions of chemists who follow them, represent what the late Hungarian physical chemist Michael Polanyi called "profoundly informative intervention[s]." Information is being added to the chemical system as the result of the deliberative actions—the intelligent design—of the chemist himself.

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

[24]Some reviewers, such as Darrel Falk and Stephen Fletcher, have also attempted to refute my critique of the RNA world by citing the recent paper by Tracey Lincoln and Gerald Joyce ostensibly establishing the capacity of RNA to self-replicate, thereby rendering plausible one of the key steps in the RNA-world hypothesis. Falk incorrectly intimates that I did not discuss this experiment in my book. In fact, I do discuss it on page 537 of *Signature in the Cell*.

In any case, Falk and Fletcher draw exactly the wrong conclusion from this paper. The central problem facing origin-of-life researchers is neither the synthesis of prebiotic building blocks or even the synthesis of a self-replicating RNA molecule (the plausibility of which Joyce and Tracey's work seeks to establish, albeit unsuccessfully, see below). Instead, the fundamental problem is getting the chemical building blocks to arrange themselves into the large information-bearing molecules (whether DNA or RNA). As I show in *Signature in the Cell*, even the extremely limited capacity for RNA self-replication that has been demonstrated depends critically on the specificity of the arrangement of nucleotide bases—that is, upon preexisting sequence-specific information.

The Lincoln and Joyce experiment does not solve this problem, at least not apart from the intelligence of Lincoln and Joyce. In the first place, the "self-replicating" RNA molecules that they construct are not capable of copying a template of genetic information from free-standing chemical subunits as the polymerase machinery does in actual cells. Instead, in Lincoln and Joyce's experiment, a pre-synthesized *specifically sequenced* RNA molecule merely catalyzes the formation of a single chemical bond, thus

fusing two other presynthesized partial RNA chains. In other words, their version of "self-replication" amounts to nothing more than joining two sequence-specific premade halves together. More significantly, Lincoln and Joyce themselves *intelligently arranged* the matching base sequences in these RNA chains. They did the work of replication. They generated the functionally specific information that made even this limited form of replication possible.

The Lincoln and Joyce experiment actually confirms three related claims that I make in *Signature in the Cell*. First, it demonstrates that even the capacity for modest partial self-replication in RNA itself depends upon sequence specific (i.e., information-rich) base sequences in these molecules.

Second, it shows that even the capacity for partial replication of genetic information in RNA molecules results from the activity of chemists, that is, from the intelligence of the "ribozyme engineers" who design and select the features of these (partial) RNA replicators.

Third, prebiotic simulation experiments themselves confirm what we know from ordinary experience, namely, that intelligent design is the only known means by which functionally specified information arises.

See S. Fletcher, TLS Letters 03/02/10, *The Sunday Times* (2010), http://entertainment.timesonline.co.uk/tol/arts_and_entertainment/the_tls/article7013742.ece (last accessed April 1, 2011); D. Falk, "Signature in the Cell" (2009), http://biologos.org/blog/signature-in-the-cell (last accessed April 1, 2011); T. A. Lincoln and G. F. Joyce, "Self-Sustained Replication of an RNA Enzyme," *Science* 323 (2009): 1229–32. See also responses to Fletcher and Falk at S. Meyer, "Stephen Meyer Responds to Stephen Fletcher's Attack Letter in the Times Literary Supplement," www.signatureinthecell.com/responses/response-to-tls.php (last accessed April 1, 2011); S. Meyer, "Response to Darrel Falk's Review of Signature in the Cell," www.signatureinthecell.com/responses/response-to-darrel-falk.php (last accessed April 1, 2011).

[25]W. K. Johnston, P. J. Unrau, M. S. Lawrence, M. E. Glasner and D. P. Bartel, "RNA-Catalyzed RNA Polymerization: Accurate and General RNA-Templated Primer Extension," *Science* 292 (2001): 1319–25.

[26]C. de Duve, *Vital Dust: Life as a Cosmic Imperative* (New York: Basic Books, 1995), 23.

[27]*Signature in the Cell* was published in June 2009, with the manuscript obviously having been completed months prior. Yarus's paper was not published until October 2009.

[28]Specifically, Venema cites M. Yarus, J. Widmann, and R. Knight, "RNA-Amino Acid Binding: A Stereochemical Era for the Genetic Code," *Journal of Molecular Evolution* 69 (2009): 406–29.

[29]M. Yarus, *Life from an RNA World: The Ancestor Within* (Cambridge, MA: Harvard University Press, 2009).

[30]See M. Yarus, "A Specific Amino Acid Binding Site Composed of RNA," *Science* 240 (1988): 1751–8; M. Yarus and E. L. Christian, "Genetic Code Origins," *Nature* 342 (1989): 349–50; I. Majerfeld and M. Yarus, "An RNA Pocket for an Aliphatic Hydrophobe," *Nature Structural Biology* 1 (1994): 287–92; I. Majerfeld and M. Yarus, "A Diminutive and Specific RNA Binding Site for L-Tryptophan," *Nucleic Acids Research* 33 (2005): 5482–93; M. Yarus, J. Widmann, and R. Knight, "RNA-Amino Acid Binding: A Stereochemical Era for the Genetic Code," *Journal of Molecular Evolution* 69 (2009): 406–29.

[31]See S. Meyer and P. Nelson, "Can the Origin of the Genetic Code Be Explained by Direct RNA Templating? A Critical Review," *BIO-Complexity* (2011).

[32]That said, *Signature in the Cell* does argue that the current genetic code (as well as the text itself) defies explanation by reference to stereochemical affinities. *Signature in the Cell* also asserts that this fact renders self-organizational explanations for the origin of the genetic code problematic. Thus, the claim by Yarus et al. to have explained the origin of the code by reference to stereochemical affinities alone, does challenge one important scientific claim of *Signature in the Cell* (although not its main argument). Nevertheless, even here, Nelson and I show in *BIO-Complexity*, "Can the Origin of the Genetic Code Be Explained by Direct RNA Templating? A Critical Review," that Yarus's direct templating model does not succeed on its own terms.

[33]See D. L. Ewert, "Adaptive Immunity: Chance or Necessity?" (2010), www.discovery.org/a/15861 (last accessed April 1, 2011).

[34]See D. Axe, "The Rarity and Isolation of Functional Proteins in Combinatorial Sequence Space: Response to Hunt," www.biologicinstitute.org/2011/05/04/correcting-four-misconceptions-about-my-2004-article-in-jmb/ (last accessed April 1, 2011).

Dennis R. Venema

Intelligent Design, Abiogenesis, and Learning from History: A Reply to Meyer

Dennis R. Venema

> *Weizsäcker's book* The World View of Physics *is still keeping me very busy. It has again brought home to me quite clearly how wrong it is to use God as a stop-gap for the incompleteness of our knowledge. If in fact the frontiers of knowledge are being pushed back (and that is bound to be the case), then God is being pushed back with them, and is therefore continually in retreat. We are to find God in what we know, not in what we don't know; God wants us to realize his presence, not in unsolved problems but in those that are solved.*
>
> Dietrich Bonhoeffer[1]

I am thankful for this opportunity to reply to Stephen Meyer's criticisms of my review[2] of his book *Signature in the Cell* (hereafter *Signature*). Meyer's critiques of my review fall into two general categories. First, he claims I mistook *Signature* for an argument against biological evolution, rendering several of my arguments superfluous. Secondly, Meyer asserts that I have failed to refute his thesis by not providing a "causally adequate alternative explanation" for the origin of life in that the few relevant critiques I do provide are "deeply flawed." I will address these issues in turn.

Straw Man or Valid Critique?

I find Meyer's claim that biological evolution is irrelevant to the argument of *Signature* curious for several reasons. The most important reason is that the basic argument of *Signature* requires that biological evolution be incapable of generating new information. A constant thread running through *Signature* is the claim that *all* information, whatever its nature, is the result of intelligence. Moreover, this assertion is proffered as the logical basis for inferring design for the origin of biological information: if information only ever arises from intelligence, then the mere presence of information demonstrates design. A few examples from *Signature* make the point easily:

> … historical scientists can show that a presently acting cause must have been present in the past because the proposed candidate is the *only known cause* of the effect in question. If there is only one possible cause of a salient piece of evidence, then clearly the presence of that evidence establishes the past existence of its cause. (*Signature*, p. 167, emphasis in original)

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> Indeed, our uniform experience affirms that specified information—whether inscribed in hieroglyphics, written in a book, encoded in a radio signal, or produced in a simulation experiment—*always* arises from an intelligent source, from a mind and not strictly a material process. So the discovery of the specified digital information in the DNA molecule provides strong grounds for inferring that intelligence played a role in the origin of DNA. Indeed, whenever we find specified information and we know the causal story of how that information arose, we always find that it arose from an intelligent source. It follows that the best, most causally adequate explanation for the origin of the specified, digitally encoded information in DNA is that it too had an intelligent source. (*Signature,* p. 347, emphasis in original)

> Moreover, because experience shows that an intelligent agent is not only a known, but the *only* known cause of specified, digitally encoded information, the theory of intelligent design developed in this book has passed two critical tests: the tests of causal adequacy and causal existence … Precisely because intelligent design uniquely passed these tests, I argued that it stands as the best explanation of the DNA enigma. (*Signature,* p. 405, emphasis in original)

The strength of this argument depends on the assertion that all information arises from intelligence. Note well: the argument requires that all information, in any form, be the result of intelligence, not just the information required for the origin of life. If any natural mechanism can be found that produces information of any sort, Meyer's argument collapses simply based on its own internal logic. This is not a peripheral argument tucked away in an appendix: it is warp and woof of the entire book, and Meyer reiterates it unchanged, even within his response.[3] It was in this context and to this end that I discussed several examples of how evolutionary mechanisms generate biological information in my original review,[4] and later in more detail as a series of blog posts for the BioLogos Foundation.[5] In those sources, readers may examine the evidence that, contra Meyer, large amounts of new information have indeed arisen through the natural mechanisms of biological evolution. If a natural mechanism can produce information, then Meyer cannot claim that only intelligence produces it. As such, he cannot reliably infer that the information we see in modern DNA was designed, since information is not uniquely associated with intelligent activity.

A second reason for puzzlement is that Meyer does indeed argue that Douglas Axe's work on *biological* evolution is evidence that information cannot arise in a *prebiotic* environment. A careful examination of how Meyer frames Axe's work is illuminating:

> Thus, as a specific test of the efficacy of the neo-Darwinian mechanism *(as well as the chance origin of information in a prebiotic setting),* Axe posed the question: How rare or common are functional protein folds within their corresponding amino acid-sequence space? … It's important to emphasize that Axe's prediction follows from the premise that intelligent design played a role in the origin of new genes and proteins during biological *(or chemical)* evolution. Since the case for intelligent design as the best explanation for the origin of biological information necessary to build novel forms of life depends, in part, upon the claim that functional (information-rich) genes and proteins cannot be explained by random mutation and selection, this design hypothesis …" (*Signature,* pp. 494–5, emphases mine)

Note several features. Clearly both biological and chemical evolution are in view here, since Meyer explicitly says so twice. He claims that Axe's work, which is about biological evolution only, is a test of the possibility that information could arise *prebiotically*. He also feels that it is "important to emphasize" that Axe's work flows from a specific premise, not a prediction. And what is that premise? That "design played a role in the origin of new genes and proteins during biological (or chemical) evolution." Meyer then goes on to cite Axe's 2004 paper as "initial confirmation" of Axe's prediction, thus providing support for his argument that information cannot arise through chemical evolution.

The important point here is simple: evidence that refutes Axe's work on biological evolution, such as I have provided, does indeed undercut Meyer's argument. Meyer cannot simultaneously claim support from Axe's work on biological evolution for his own views on chemical evolution *and* claim that I am erecting a straw man by pointing out the flaws in Axe's work. Meyer's attempt to excise it notwithstanding, this appendix is functional and relevant to the argument of *Signature*.[6] Furthermore, the point I raised in my original review still stands: the obser-

vation that biological evolution can add large amounts of information to DNA is a very good reason to investigate if similar processes were in operation at the origin of life.

Apologetics and Science: Learning from History

All apologetics arguments based on the lack of scientific knowledge, such as those Meyer employs in *Signature*, are potentially vulnerable to future advances in scientific understanding. As such, it is wise to carefully evaluate such arguments in an attempt to estimate their long-term stability. While there is no standard metric for such evaluations, I commonly keep the following questions in mind.

1. *Is scientific research in this area no longer productive?*

The most obvious question to ask when faced with such an argument is whether the relevant area of science is advancing in knowledge. In the biological sciences, a quick scan of the PubMed index is usually sufficient to answer this question.[7] Even if the specific point of knowledge claimed as unsolvable by science is not directly addressed in the current literature, it is premature to claim that it never will be solved if the field is advancing.

2. *Is the area of science used for the argument a "frontier" area of science or a well-established area in which core ideas have not changed significantly for some time?*

Frontier science differs greatly from areas in which science is more settled (so-called "consensus" or "textbook" science).[8] In the absence of a well-tested theory to inform research, investigators in the field explore numerous competing hypotheses. These hypotheses, should they find experimental support, may, in the future, become part of a more theory-like framework, though they will likely be modified in the process. Additionally, many hypotheses will be discarded along the way. In this "wild west" environment, researchers critique competing hypotheses vigorously, pointing out what they perceive as flaws and shortcomings. This is all well and good, for any explanatory framework worthy of the term "theory," in the scientific sense, must survive this trial by experimental and peer-reviewed fire.[9] Frontier science, by its very nature, is not stable for the purposes of developing apologetics arguments. It is simply not possible to argue from a position of scientific strength when the science itself is in flux. Frontier science remains a tempting source for apologists, however, in that it is a natural place to look for unanswered questions and genuine scientific controversy.

3. *Has scientific progress strengthened or weakened the argument since its publication?*

This question becomes progressively easier to answer as time goes on, and may be difficult to discern in the short term. Still, in a rapidly advancing field of science, even a few years may suffice to demonstrate a trend supporting or undermining a specific argument.

Christian apologetics has a long history of argument based on unsolved scientific questions. While *Signature in the Cell* is the current argument of choice for the intelligent design (ID) movement, other arguments at other times have played a similar role for Christian apologists. Accordingly, applying the above questions to a sampling of other works is instructive before we consider how *Signature* itself fares under the same scrutiny.

Edwards on Astronomy, 1696

John Edwards' book *A Demonstration of the Existence and Providence of God from the Contemplation of the Visible Structure of the Greater and Lesser World* was published in England in 1696, and in many ways is the "*Signature*" of its day. The main scientific controversies of the time perceived to threaten Christian faith were centered on astronomy, Copernican heliocentrism in particular. While Edwards argues against heliocentrism using both Scriptural[10] and scientific arguments, we will focus only on the latter. Key to his argument for a stationary earth in a geocentric universe is the scientific fact that the movement of the earth can be felt:

> Again, I argue thus, the Motion of the Earth can be felt, or it cannot: If they hold it cannot, they are confuted by *Earth-quakes* … I mean the gentler Tremblings of the Earth, of which there are abundant Instances in History, and we our selves have had one not long since; so that by too true an experiment we are taught that the Earth's Motion may be felt. If this were not a thing that had been frequently experienc'd, I confess they might have something to say, they put us off with this, that it is not possible to perceive the moving of the Earth: But now they cannot evade it thus; they must be

> forc'd to ackowlegd the motion of it is sensible. If then they hold this, I ask why *this Motion* also which they speak of is not perceived by us? Can a Man perswade himself that the light Trepidation of this Element can be felt, and yet the rapid Circumvolution of it cannot? Are we presently apprehensive of the Earth's shaking never so little under us? And yet have no apprehension at all of our continual capering about the Sun?[11]

Edwards draws additional scientific support for a stationary earth from other observations of physics:

> Nay, truly, if the earth were hurl'd about in a Circle (as these Persons assert) we should feel it to our sorrow, for we should not be able to keep our ground, but must necessarily be thrown off, and all Houses and other Buildings would be thrown down, being forcibly shaked off from the Circumference of the Earth, as things that are laid on a Wheel are flung off by it when it turns round. This you will find demonstrated by Dr. *More*.[12]

Note several features. Edwards is arguing from science, and doing so appropriately for his time. Earthquakes can indeed be felt, and objects placed on a spinning wheel do indeed fly off. He also discusses a failed attempt to observe the effect of stellar parallax, a key prediction of the heliocentric model. As he sees it, the science of his time is conclusive and agrees with the longstanding geocentric view of the church. As such, he sees only folly in "*Copernicus's* Gigantick Attempt to raise up the *Earth* into the place of the *Heavens*."[13] Edwards' premature conclusions are easy to see in retrospect (question #3) because we have the benefit of over three hundred years of scientific progress since the 1600s. Still, he failed to take a cautionary stance, even though the science under consideration was both progressing rapidly for its time (question #1) and very much a frontier area (question #2). Indeed, even at the time of its publication, Edwards should have been aware that Newton's work lent heliocentrism considerable theoretical support.[14]

Critics may cry foul at this point: surely there are no parallels between the geocentrism debacle and the ID movement and their argument from information. After all, this argument, Meyer assures us, is based only on cutting-edge science and an argument from *knowledge of absence* gained through a comprehensive historical survey of abiogenesis research.[15] Whereas evaluating the total failure of seventeenth-century geocentrist apologetics is easy from a modern vantage point, similar trends are present within the ID argument from information. A historical survey of this line of argumentation in ID circles will bring those trends to light. Ironically, this survey will also further make the case that the supposed failure of biological evolution to generate new information is much more a part of Meyer's argument than his response to my review would suggest, and, indeed, has been so since its inception.

Lester and Bohlin on Information Theory and Created Kinds, 1984

In 1984, a substantial work on genetics and creationism appeared: Lane Lester and Raymond Bohlin's book *The Natural Limits to Biological Change*.[16] Though written some twenty-five years before *Signature*, many arguments are familiar. For example, while discussing the possibility that mutations in regulatory regions of DNA might lead to changes outside of a "created kind,"[17] Lester and Bohlin argue that the possibility is as unlikely as the natural origin of the universal genetic code. Moreover, a natural origin for the code is absurd, since codes are uniquely the product of intelligence:

> … couldn't mutation and natural selection change the rules of regulatory mechanisms to produce biological novelty? The answer lies in the origin-of-life question. Informational codes are constructed of vocabulary and grammar. Both, of necessity, are produced only by intelligence. To argue that the genetic information in DNA originated originally as random nucleotide interactions seems analogous to claiming that the word processor, rather than the person operating it, actually authored a given book. Random changes in letter and word sequences ultimately can produce only gibberish. The same will result if one attempts to change the rules.[18]

Notice how, in this argument, developmental programs for the various created kinds are a series of informational codes. As such, like the genetic code itself, they are clearly the result of a designing intelligence.

A later section makes the point a second time. After a discussion of similarities and differences between human and chimpanzee chromosomes (in a manner that emphasizes their differences as a problem for evolution), Lester and Bohlin look to the application of information theory to genetics as the

next step for the creationist movement. Specifically, they state that this application will demonstrate two things: that intelligent design is needed for the origin of the genetic code, as well as for the origin of information for each created kind:

> However, in terms of the mechanism of limited variation, the application of information theory to the genetic machinery should prove the most promising. The crucial factor will be delineation of the necessity of *intelligent* design in the structuring of the informational content of each prototype. This will indicate the necessity of not only intelligence in originating the genetic code in the broad universal sense but also, in the specific sense, of the unique adaptive programs of each prototype. (emphasis in the original)[19]

Meyer on Biological Evolution and Information, 1999

The argument from information thus has a long history within the ID movement, tracing back to its earliest roots. More importantly for our purposes, Lester and Bohlin's line of argument is also present within Meyer's works. As Meyer notes, he wrote several articles on the origin of biological information while *Signature* was in preparation.[20] One of the earliest is in an edited volume detailing the exchange between Denis Lamoureux and Phillip Johnson in the late 1990s.[21] In this essay, we find that Meyer's defense of Johnson includes the claim that the origin of all forms of biological information is equally mysterious:

> If for example, the teleological evolutionist seeks to avoid the information-theoretic difficulties discussed above by invoking *undirected* chance to explain the origin of genetic information, his position becomes indistinguishable from standard materialistic versions of evolutionary theory (either biological or chemical) that Johnson and many others have criticized on empirical, methodological, and theological grounds. (In any case, it should be noted that neo-Darwinism has failed every bit as much as chemical evolutionary theory to provide a mechanism that can explain the origin of specified genetic information—whether the information required to build novel genes, cell types, organs, molecular machines, developmental programs, or body plans that have arisen during the history of life on earth.)[22]

It is clear that, at this time, Meyer's argument from information viewed specified genetic information in very broad terms, in keeping with Lester and Bohlin's earlier thinking. Moreover, Meyer's argument that only intelligence creates information is predicated on his assertion that "standard materialistic versions of evolutionary theory (either biological or chemical)" have failed to deliver the goods. Note well: the alleged failures of both biological and chemical evolution are presented as *equally important* for supporting Meyer's familiar argument that

> … the specified complexity or information content of DNA and proteins implies a prior intelligent cause, again because "specified complexity" and "high information content" constitute a distinctive hallmark (or signature) of intelligence. Indeed, in all cases where we know the causal origin of high information content or specified complexity, experience has shown that intelligent design played a causal role.[23]

As we have seen above, this argument is central to *Signature*. Given his position in 1999, it is surprising that Meyer claims that evidence for new information arising through biological evolution is of no import to his argument.

Meyer on Biological Evolution and Information, 2004

The use of this argument is not an isolated case for Meyer, but also forms a substantial portion of his 2004 paper published in, and subsequently withdrawn from, the *Proceedings of the Biological Society of Washington*.[24] In a discussion of the evidence for random mutation and natural selection acting over time to generate novelty, Meyer makes the following claims:

> Yet the extreme specificity and complexity of proteins presents a difficultly, not only for the chance origin of specified biological information (i.e., for random mutations acting alone), but also for selection and mutation acting in concert. Indeed, mutagenesis experiments cast doubt on each of the two scenarios by which neo-Darwinists envisioned new information arising from the mutation/selection mechanism … For neo-Darwinism, new functional genes either arise from non-coding sections in the genome or from preexisting genes. Both scenarios are problematic …

> Evolving genes and proteins will range through a series of nonfunctional intermediate sequences that natural selection will not favor or preserve but will, in all probability, eliminate … When this happens, selection-driven evolution will cease. At this point, neutral evolution of the genome (unhinged from selective pressure) may ensue, but, as we have seen, such a process must overcome immense probabilistic hurdles, even granting cosmic time.
>
> Thus, whether one envisions the evolutionary process beginning with a noncoding region of the genome or a preexisting functional gene, the functional specificity and complexity of proteins impose very stringent limitations on the efficacy of mutation and selection. In the first case, function must arise first, before natural selection can act to favor a model variation. In the second case, function must be continuously maintained in order to prevent deleterious (or lethal) consequences to the organism and to allow further evolution. Yet the complexity and specificity of proteins implies that both these conditions will be extremely difficult to meet. Therefore, the neo-Darwinian mechanism appears to be inadequate to generate the new information present in the novel genes and proteins that arise within the Cambrian animals.[25]

Here Meyer again argues against an evolutionary origin of information, and once again *biological* evolution is in view (in this instance, exclusively so). Specifically, Meyer argues (relying heavily on the works of Axe) that functional protein sequences are separated by nonfunctional intermediates, and that neutral evolution cannot be evoked to transition between functional forms.

One might wonder: if biological evolution was viewed as a potential threat to Meyer's argument in 1999 or 2004, why does Meyer not address any evidence for the ability of biological evolution to generate information in *Signature*? Applying the above diagnostic questions to this argument may be informative.

Evaluating the ID Argument from Information, 1984–2004

Having surveyed the historical importance of biological evolution to the ID argument from evolution, we are now able to apply our test questions to this apologetic as it was argued during this time.[26]

1. *Is scientific research in this area no longer productive?*

At all time points examined, and, indeed, over the entire twenty-year period, biological evolution was a productive area of scientific inquiry. As such, arguments based on perceived failings of evolution were likely to be challenged as new evidence arose. As we shall see, this was very much the case.

2. *Is the area of science used for the argument a "frontier" area of science or a well-established area in which core ideas have not changed significantly for some time?*

While biological evolution as a whole was not a frontier area during this time, several lines of inquiry within it were new or rapidly expanding. In 1984, the field of evolutionary developmental biology, or "evo-devo" was comparatively nonexistent. In 1999, comparative genomics was in its infancy, and some areas of experimental evolution such as ancestral protein reconstruction were just getting off the ground. In 2004, the chimpanzee genome project remained incomplete. As such, the ID argument from information would need to weather the storm of new evidence from these advances in order to remain viable.

3. *Has scientific progress strengthened or weakened the argument since its publication?*

This question is, of course, the crucial one. An argument is only as good as its ability to withstand new data. Unfortunately for the ID argument from information, the robust ability of biological evolution to generate new information has been increasingly documented in recent years. Let me cite a few examples.

Novel biological information does not need to arise all at once, but can arise piecemeal through independent mutation events. For example, separate mutations that do not confer a selectable advantage on their own have been shown to combine later to form new information. In other words, mutations that are neutral with respect to the survival of the organism can later be co-opted into biological information that does have a distinct survival advantage.[27]

Contrary to Meyer's assertion in his 2004 essay that proteins cannot transition to new information states via neutral intermediates, laboratory "resurrection" of ancient protein sequences has shown good evidence that such neutral intermediate states do play a key role in protein evolution.[28] New com-

parative genomics approaches indicate that such changes in protein structure and function through evolutionary mechanisms are widespread.[29] Indeed, there is strong evidence that large regions of modern vertebrate genomes, including the human genome, are the product of whole-genome duplication events hundreds of millions of years in our evolutionary past. This further adds to the list of proteins that have acquired new functions, and thus represent new biological information.[30]

Contrary to Lester and Bohlin, and Meyer's 1999 essay, evolutionary developmental biology has accumulated strong evidence that novel body plans and developmental programs are accessible to evolutionary mechanisms, specifically, through small mutations that alter the expression patterns of key regulatory genes.[31] The large biological differences between humans and chimpanzees, despite our close genetic relationship,[32] is entirely consistent with this conclusion.[33]

Taken together, these advances render the biological evolution component of the ID argument from information null and void. What seemed a strong argument in 1984, 1999, and 2004 has been weighed and found wanting.

Meyer on Chemical Evolution and Information, 2009

Why is it that Meyer chose to avoid the topic of biological evolution in *Signature*, when hitherto it was a consistent part of the argument from information, even within his own works? Certainly, the sheer size of *Signature* raises the possibility that Meyer needed to trim the argument to what he felt made the strongest case. Even so, this may be informative: it suggests that Meyer himself realizes that arguments against biological evolution as a generator of biological information are seriously compromised compared to arguments based on chemical evolution. Accordingly, Meyer focuses on abiogenesis in *Signature*, though, as we have seen, vestiges of the full argument that includes biological evolution persist within it. What is absent from *Signature*, however, is the admission that the logic that only intelligence produces information has failed. In 1999 and 2004, Meyer states that this logic covers both biological and chemical evolution. His protests notwithstanding, it continues to do so for *Signature*. Neither does Meyer provide a rationale why it should not, nor why his previous argument, recycled from these earlier essays and woven throughout *Signature*, remains valid.

Whether in 1984 or 2004, the ID movement would have done well to consider questions such as I have presented here before building an apologetic on the presumed failure of evolutionary biology. Perhaps a greater concern for the ID argument from information, beyond the failure of its inherent logic that information arises only through intelligence, is that the balance of its arguments rest on a similarly precarious foundation. As we shall see, *Signature* itself does not fare well under the same questions.

1. *Is scientific research in this area no longer productive?*

Contrary to Meyer's claim, abiogenesis research is not at an impasse. Knowledge in this area is advancing, and has done so even since the publication of *Signature*. Some of this work even threatens Meyer's remaining arguments (see below).

2. *Is the area of science used for the argument a "frontier" area of science or a well-established area in which core ideas have not changed significantly for some time?*

One of Meyer's significant criticisms of my review is that

> Discerning readers will notice that Venema did not offer what would have been necessary to refute the thesis of the book, namely, a causally adequate alternative explanation for the origin of the information necessary to produce the first life. Instead, he effectively concedes the main argument of the book by acknowledging that "no such mechanism … has been put forward."[34]

As I noted in my review, Meyer here is correct (except for his claim, that I only admit so "grudgingly," which is not the case).[35] The origin of life is an unsolved area of chemistry/biology and as such is a frontier area of science in which many competing hypotheses are under investigation. There is no consensus in the field about how life arose, though some models (such as the RNA world hypothesis) currently have more experimental support than others. As such, no one has a "causally adequate alternative explanation" to offer. Where I differ from Meyer is that I do not see this state of affairs as reason to assert that the science has conclusively failed and divine intervention is necessary.

3. *Has scientific progress strengthened or weakened the argument since its publication?*

The answer to this question is one that even the most stalwart supporter of ID should find troubling. Not two years from the publication of *Signature*, evidence from origin-of-life research has already been put forward that, by Meyer's own admission, threatens the argument of the book. As I stated in my original review,

> A rhetorical thread that Meyer weaves throughout the book is that the genetic code is arbitrary: that, in principle, any codon could have been assigned to any amino acid since there is no physical connection between them. Meyer claims that this feature of the translation apparatus is a "mystery" for origin-of-life research …
>
> However, Meyer either avoids, or is simply unaware of, a significant amount of research in this area that *has* demonstrated chemical interactions between amino acids and their cognate anticodons or codons. This productive area of research was recently reviewed in extensive detail. In brief, several amino acids directly bind RNA sequences corresponding to their anticodon or codon. This finding is strong evidence that the genetic code was established, at least in part, by the exact sort of chemical interactions that Meyer explicitly denies have ever been found. If, indeed, the genetic code was arbitrary, there would be no reason to expect these correspondences; conversely, their presence is good evidence that the modern genetic code passed through a "stereochemical era" where proteins were synthesized by direct organization on an RNA template, consonant with the hypothesis that RNA was the original genetic material.[36]

In reply, Meyer states that

> *Signature* does argue that the current genetic code (as well as the text itself) defies explanation by reference to stereochemical affinities. *Signature* also asserts that this fact renders self-organizational explanations for the origin of the genetic code problematic. Thus, the claim by Yarus et al. to have explained the origin of the code by reference to stereochemical affinities alone, does challenge one important scientific claim of *Signature* (although not its main argument).[37]

Confronted with this evidence, Meyer is, not surprisingly, concerned with rebutting it to the best of his abilities.[38] The accuracy and strength of that rebuttal is not my main concern here,[39] though I note that Meyer provides no convincing reason why these affinities are present in what he views as a chemically arbitrary code. If the code truly is arbitrary and has no stereochemical basis, then there is no reason to find the sorts of affinities that have been documented. Meyer is at pains to demonstrate that unsolved questions remain and that the work of Yarus does not explain the complete origin of the code, and rightly so: this is work in a frontier area. Unsolved issues are to be expected. It is highly unlikely that any one paper could put forward a complete explanation at this time. Science seldom overthrows apologetics arguments in one fell swoop: experience indicates that a gradual erosion is more likely. Meyer is already defending his argument against new evidence. I suspect that trend will continue in the coming years.[40]

Conclusion

In summary, what we see in *Signature* is the pared-down remnant of what was once a larger argument within the ID movement, and indeed within Meyer's own works. The reason for the paring down is obvious: comparative genomics, experimental evolution, and developmental biology have shed too much light on the ability of biological evolution to generate information. As such, only the frontier science of abiogenesis remains apologetically useful. Meyer expects it will continue to be useful for some time yet, and it likely will be for the foreseeable future. Indeed, it may endure beyond his or my lifetime. After all, John Edwards did not live to see the vindication of heliocentrism, and his argument for God supernaturally sustaining the fires of the sun and stars[41] remained a puzzle until the discovery of solar fusion in the twentieth century, over 200 years later. It may well be that the ID movement has at last reduced their argument from information to its enduring essence, but I have my doubts: abiogenesis as a field remains productive, and recent developments have already begun to erode Meyer's claims. Only time will tell. Until then, I recommend Bonhoeffer's wise counsel.

Notes

[1]Dietrich Bonhoeffer, *Letters and Papers from Prison*, enlarged ed. (New York: Macmillan, 1972), 311.

[2]Dennis R. Venema, "Seeking a Signature: Essay Book Review of *Signature in the Cell: DNA and the Evidence for Intelligent Design* by Stephen C. Meyer," *Perspectives on Science and Christian Faith* 62, no. 4 (2010): 276–83.

[3]See Stephen C. Meyer, "Of Molecules and (Straw) Men: A Response to Dennis Venema's Review of *Signature in the Cell*," *Perspectives on Science and Christian Faith* 63, no. 3 (2011): 171–82. As Meyer repeats in his reply,

> Indeed, whenever we find specified information—whether embedded in a radio signal, carved in a stone monument, etched on a magnetic disc, or produced by a genetic algorithm or ribozyme engineering experiment—and we trace it back to its source, invariably we come to a mind, not merely a material process. (p. 174)

Note how the assertion continues to claim that *all* information, whatever its nature, is derived only from intelligent sources.

[4]Venema, "Seeking a Signature."

[5]This series of posts appeared on the BioLogos blog *Science and the Sacred* (www.biologos.org/blog) and had six parts:

Dennis Venema, "Evolution and the Origin of Biological Information, Part 1: Intelligent Design," March 20, 2011, http://biologos.org/blog/evolution-and-origin-of-biological-information-part-1-intelligent-design

____, "Evolution and the Origin of Biological Information, Part 2: *E. coli* vs. ID," March 24, 2011, http:// biologos.org/blog/evolution-and-the-origin-of-biological-information-part-2-e-coli-vs-id

____, "Evolution and the Origin of Biological Information, Part 3: CSI on Steroids," April 7, 2011, http://biologos.org/blog/evolution-and-the-origin-of-biological-information-part-3-csi-on-steroids

____, "Evolution and the Origin of Biological Information, Part 4: Lost in (Sequence) Space," April 25, 2011, http://biologos.org/blog/evolution-and-the-origin-of-biological-information-part-4

____, "Evolution and the Origin of Biological Information, Part 5: Paralogs, Synteny and WGD," May 19, 2011, http://biologos.org/blog/evolution-and-the-origin-of-biological-information-part-5

____, "Evolution and the Origin of Biological Information, Part 6: A Long Look in the Mirror," July 7, 2011, http://biologos.org/blog/evolution-and-the-origin-of-biological-information-part-6

[6]In his reply, Meyer bases his complaint on the assertion that I have not read him carefully enough. I submit, based on the foregoing analysis (as well as my survey of the history of the argument from information within the ID movement and Meyer's own works, see below), that a second possibility is that I am reading him too closely for his taste.

[7]US National Library of Medicine, National Institutes of Health, www.ncbi.nlm.nih.gov/pubmed/

[8]Henry Bauer, "Frontier Science and Textbook Science," *Science & Technology Studies* 4, no. 3 (1986): 33–4.

[9]Indeed, the absence of such internal criticism and sharpening of ideas is a notable difference between science and the ID movement. Despite the range of mutually incompatible views held within the ID "big tent," members of the movement appear unwilling to critique each other academically.

[10]His scriptural arguments are also a fascinating study, however. For example, he specifically rules out that God used what we would call "accommodated language" to describe the miracle of the long day in Joshua 10.

[11]John Edwards, *A Demonstration of the Existence and Providence of God from the Contemplation of the Visible Structure of the Greater and Lesser World* (London: 1696), 45–6.

[12]Ibid., 46.

[13]Ibid., 49.

[14]Indeed, a fourth question to keep in mind is whether an apologetics argument misrepresents the state of scientific knowledge current to its time. For example, in my original review, I contend that *Signature* does so in several places, especially with regard to the RNA world hypothesis. I will not, however, point out such flaws in the following historical survey of apologetics arguments but rather grant, *in arguendo*, that they were correct representations of the science of their day, despite this being manifestly not the case.

[15]See Stephen C. Meyer, *Signature in the Cell: DNA and the Evidence for Intelligent Design* (New York: Harper Collins Publishers, 2009), 376.

[16]Lane Lester and Raymond Bohlin, *The Natural Limits to Biological Change* (Grand Rapids, MI: Zondervan, 1984).

[17]Lester and Bohlin use the terms "kind," "created kind," and "prototype" interchangeably. The sense is exactly what is called a "baramin" by other creationists.

[18]Lester and Bohlin, *The Natural Limits to Biological Change*, 159.

[19]Ibid., 167.

[20]See Meyer, *Signature*, 347.

[21]See pages 101–2 of Stephen Meyer, "Teleological Evolution: The Difference It Doesn't Make" in *Darwinism Defeated? The Johnson-Lamoureux Debate over Biological Origins*, Phillip Johnson and Denis Lamoureux (Vancouver: Regent College Publishing, 1999), 91–102.

[22]Ibid., 102–3.

[23]Ibid., 92–3.

[24]Stephen Meyer, "The Origin of Biological Information and the Higher Taxonomic Categories," originally published in *Proceedings of the Biological Society of Washington* 117, no. 2 (2004): 213–39, but subsequently withdrawn. Text available online at www.discovery.org/a/2177

[25]Ibid.

[26]As mentioned before, the fourth question (that of scientific accuracy of the apologetic at the time it was made; see footnote 14) will not be addressed, though significant flaws of this nature are present for each time point sampled.

[27]Venema, "Evolution and the Origin of Biological Information, Part 2: *E. coli* vs. ID."

[28]Venema, "Evolution and the Origin of Biological Information, Part 3: CSI on Steroids."

[29]Venema, "Evolution and the Origin of Biological Information, Part 4: Lost in (Sequence) Space." Note that this evidence is also relevant to Meyer's continued use of Axe in *Signature*.

[30]Venema, "Evolution and the Origin of Biological Information, Part 5: Paralogs, Synteny and WGD."

[31]Sean B. Carroll, "Evo-Devo and an Expanding Evolutionary Synthesis: A Genetic Theory of Morphological Evolution," *Cell* 134 (2008): 25–36.

[32]Dennis R. Venema, "Genesis and the Genome: Genomics Evidence for Human-Ape Common Ancestry and Ancestral Hominid Population Sizes," *Perspectives on Science and Christian Faith* 62, no. 3 (2010): 166–78.

[33]Venema, "Evolution and the Origin of Biological Information, Part 6: A Long Look in the Mirror."
[34]Meyer, "Of Molecules and (Straw) Men," 189.
[35]Contrary to Meyer's assumption, scientists *enjoy* areas of science in which there are challenges yet to be solved.
[36]Venema, "Seeking a Signature," 280–1.
[37]See footnote #32 in Meyer's reply. The main argument, presumably, is that the origin of life itself remains unsolved (what Meyer elsewhere calls the "thesis" of *Signature*).
[38]My critique seems to have been the impetus for Meyer to write an entire paper in reply. See Stephen C. Meyer and Paul A. Nelson, "Can the Origin of the Genetic Code Be Explained by Direct RNA Templating?" *BIO-Complexity* 2 (2011).
[39]Though it should come as no surprise that I have my reservations about it as well.
[40]A scan of recent literature supports this prediction. One example is a study that has engineered a short RNA that can act as a general RNA polyermase: A. Wochner, J. Attwater, A. Coulson, and P. Holliger, "Ribozyme-Catalyzed Transcription of an Active Ribozyme," *Science* 322 (2011): 209–12. The point is not that this (or any) paper at present solves the origin-of-life question, but rather that the field as a whole continues to advance.
[41]As Edwards writes in "A Demonstration," speaking of the stars and sun:

> This stupendous Magnitude argues the Greatness, yea the Immensity and Incomphrensiblenes of their Maker. And if it be ask'd, Whence is that Fewel for those vast Fires, which continually burn? Whence is it that they are not spent and exhausted? How are those flames fed? None can resolve these Questions but the Almighty Creator, who bestowed upon them their Being; who made them thus Great and Wonderful, that in them we might read his Existence, his Power, his Providence … (p. 61)

67th Annual Meeting of the American Scientific Affiliation

Science, Faith, and the Media: Communicating Beyond Books

Point Loma Nazarene University
San Diego, CA
July 20–23, 2012

"Therefore each of you must put off falsehood and speak truthfully to his neighbor, for we are all members of one body." –Ephesians 4:25, NIV

Some of the ways of communicating (beyond books) include film, TV, radio, Internet, and social networking. The 2012 Conference will bring ASA members together with leaders in various communication industries. These leaders will share their thoughts and ideas about ways of using modern media to communicate with the general public regarding issues of science, faith, and the interaction between the two.

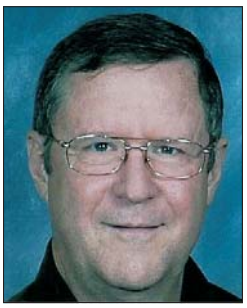
Another major meeting theme will address how the media, in general, currently portray Christians, scientists, and scientists who are Christians, and, to the extent that misconceptions exist, how they can be changed.

Plenary and parallel sessions and activities currently being planned include the following:

- Plenary and seminar presentations by science, philosophy, communication, journalism, and film studies professors and industry professionals
- Plenary interviews and round table discussions involving film, radio, and TV studio executives, actors, directors, and producers
- Seminar presentations by members from The Science and Entertainment Exchange of the National Academy of Sciences, www.scienceandentertainmentexchange.org
- Tracks on use of social networking, Internet, alternative media, and marketing
- Movie Night in "The Greek," America's oldest outdoor amphitheater

The Two Books Metaphor and Churches of Christ

Daniel K. Brannan



Daniel K. Brannan

RECONCILING THE BIBLE AND SCIENCE: A Primer on the Two Books of God *by Lynn Mitchell and Kirk Blackard. Lexington, KY: BookSurge Publishing, 2009. 266 pages. Paperback; $18.99. ISBN: 9781439240090.*

This is the first book written by members of the Church of Christ (a fellowship within the Stone-Campbell Restoration tradition) attempting to fully integrate evolutionary thought into theology.[1] In the past, members of the fellowship preferred natural theology or concordist approaches.[2] These positions were often coupled with a commitment to biblical literalism.[3] It is difficult to judge the impact of this work, or any work, on the fellowship, given our congregational polity. However, the book was the subject of a major review at the Christian Scholars' Conference at Pepperdine University in June 2011, where it was unanimously welcomed as a step forward in science/religion interactions within the Restoration tradition.[4] Mitchell is the director of the Religious Studies Program at the University of Houston and a minister of the Heights Church of Christ in Houston.[5] Blackard is a lawyer and conflict management practitioner.[6] Rather than critique evolution's validity, they accept it as the best explanation from those with expertise in the field and seek to reconcile the biblical stories with science.

Their key theme is the realization "that the Bible is not a book of science, and that to discover its fundamental truths, we need to read it as a book of theology."[7] What a refreshing statement to hear from members of a fellowship that has historically focused on "plain sense" literalism when doing its worst exegesis, and on concordism when doing its best. The authors reject both literalism and concordism in favor of higher criticism to move the fellowship into mainstream Christianity.[8] In the first three chapters, they show how the Genesis creation stories have their origins in ancient Middle Eastern stories. These epics were adapted so that monotheism could capture the imagination and teach deep theological or spiritual insights regarding age-old human questions of ontology, teleology, and the ultimate meaning of life. The authors' primary claim is that Genesis 1–11 is a polemic against polytheism and idolatry; it is not a science or history text in the sense of "showing how it essentially was."[9]

Many of our problems in perceiving God today are rooted in Greek philosophy when it was assimilated into Christian belief by the Scholastics.[10] As an example, the authors focus on Thomistic thought in integrating Greek philosophy in the first few chapters.[11] The authors also cover how medieval natural philosophy through Bacon focused on phenomenal causation but developed natural theology. Later in the eighteenth century, intellectuals reacted against

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various forms of natural theology to see nature as a self-sufficient deterministic mechanism. The scientists who promoted such mechanisms were predominately Christian—but they saw the purpose of Scripture as theology, not science. In fact, *theologically*, Christianity allowed modern science to flourish: nature is not to be worshiped but studied; it is not inherently evil, illusory, or chaotic; nature can make sense through basic laws that can be rationally and naturalistically described; the human mind can comprehend the natural world. Just as Laplace saw the cosmos as determined by natural laws, Darwin developed an explanation of the biological world as a result of natural processes without divine intervention. The fundamental thesis of *how* evolution occurred (natural selection) did not obviate the claim of God as the giver of natural law. But it did extract God from needing to directly intervene in each and every species' appearance. It was comparable to no longer needing Newton's angels to "nudge the planets" into their orbits.

The authors chronicle Darwin's thinking but ignore the severe impact that the death of his daughter, Annie, had on him. The point of chapter four is that even if Darwin had never published *The Origin*, the idea of natural selection would still have developed; Darwin's contribution was to develop a unified theory to explain speciation and provide evidence to support it. It was not until his publication of *The Descent of Man* in 1871 that the theory of evolution by natural selection seemed to attack the core of our being. Some saw it as claiming that we have no grand purpose; we are merely another animal and on Earth merely as a result of randomness, chance, and blind indifference. But is this view *necessary*? With laws of nature, one still has to metaphysically ask if there is directionality and purpose.

In chapter 5, the authors cover how Darwinian thought was received in the United States. At the close of the nineteenth century, evolution by natural selection was being assimilated into theological reflection.[12] But in the early twentieth century, reactions arose against modernism and German higher literary criticism. Coupled with this was a revival of flood geology by Seventh-Day Adventist George McCready Price. The atmosphere was saturated with biblical fundamentalism and "plain sense" exegesis. In 1909, a twelve-volume series of booklets called *The Fundamentals* began to be published by a committee of men from several Protestant denominations. The goal was to oppose modernist views and to establish what they felt to be fundamental doctrines of the Christian faith, including biblical inerrancy. At least three contributors, George Frederick Wright, B. B. Warfield, and James Orr, believed in some form of the theory of evolution. Nevertheless, the pamphlets spurred antievolution sentiment.

By the 1920s, the stage was set for entrenchment, with a variety of Christian groups committed to "plain sense" readings. These elements allowed for the perfect storm: the Scopes "monkey trial" in Dayton, TN. The arguments against Darwin had emotional intensity. Retreat into infallibility seemed the only option. Data just *had* to be explained away: fossils were planted by Satan to trick us or by God to test our faith or there was a conspiracy of science against Christianity. On the other side were those who saw Scripture to be consistent with evolution; the creation accounts were symbolic affirmations of the world's dependence on God. The authors address these concerns but fail to address the "fundamentalist anxiety" of how evolution affects the Fall doctrine.[13] A quick discussion of how John Henry Newman[14] and Frederick Tennant[15] addressed these issues in the nineteenth century would have helped. The authors conclude that

> while science did present some issues for [Christianity], the larger problems were presented by the philosophical implications … however, the philosophical implications of Darwinism have no bearing whatsoever on whether biological evolution [by natural selection] is in fact a correct understanding of man's origin and development.[16]

The authors discuss epistemology in chapters six and seven, pointing out that the "debates" between science and Scripture are due to a misunderstanding of what questions science can, and cannot, answer, and how it differs from those which theology asks. Even if one agrees that our universe seems planned, it is a metaphysical position to claim it. In contrast, the intelligent design (ID) movement sees design as provable by scientific methodology. The theological concept that God is Creator is vastly different from the weakest of the Thomistic arguments … the teleological argument from design. Christian belief flows from faith, not from a neo-Paleyan approach to natural theology such as ID. The authors conclude that theology does not design tests for the existence of God

nor does it use God to fill in gaps of knowledge. Instead, we start with the metaphysical assumption that God exists. As a person of faith, I cannot see God's existence as a hypothesis to be tested.

So what are the criteria for belief in God? Even Richard Dawkins, the vocal atheist, has realized, "the absolute impossibility of proving or disproving God …"[17] Whether one agrees with your argument depends on what counts as evidence for that individual. In epistemology, one has to first address several questions: Can logic prove existence? Does subjective experience provide for objective reality? Can physical evidence ever be offered when talking about supernatural things? Are the things internally experienced as mental events real? None of these considerations were included in the authors' attempts to address epistemological arguments. Their discussion of Hume was similarly poorly nuanced.[18] Hume's fight was mainly against the physico-theologians of the time and the teleological argument; it was not necessarily an argument against God's existence.[19] I would modify the authors' claim that Hume discredited orthodox religious belief and say instead that he discredited natural theology.

Moving on to atheism, the authors ask, "If one cannot prove the existence or non-existence of God, how does one become an atheist?"[20] The answer given, they claim, depends on how one defines atheism: simple absence of belief in deities, or positive denial or rejection of their existence. In the latter definition, what might be called "strong atheism," the secular philosophy of "scientific naturalism" is often invoked: the only things knowable are those things that are natural, physical, or material. They distinguish this from "metaphysical naturalism" which holds that the supernatural does not exist at all. From such a position, Dawkins claims that positing God is superfluous.[21] This argument aims to discredit belief but offers no proof; one *could* postulate a deity who used evolutionary processes.[22] Ultimately, atheism offers no solution to basic metaphysical questions regarding the existence of the universe or its actualization.[23]

Next, the authors turn the tables and search out the origins of modern forms of creationism. Probably the greatest influence on the rise of creationism was the reaction to modernism and the teaching of evolution in the public schools during the 1920s. Over the next 30–40 years, creationism would likely have dissolved had it not been for the emphasis on science education in the early 1960s in our race to the moon. Along with this emphasis came many science textbooks with major sections on evolution. The fundamentalist reaction was to decry the decline of traditional values and growing secularism in society, blaming it all on evolution taught in these textbooks. A variety of creationist organizations were formed in the late 1960s and early 1970s, and "creation science" or "scientific creationism" was born. Court cases decided the outcome during the 1980s.[24] Later attempts to force the teaching of ID were also rejected in 2005 as unconstitutional.[25]

The authors critique ID concepts in chapter nine. Going back to Plato and Aristotle, the claim was that there must be a "prime mover" of the universe. Aquinas revived this concept and argued that design in nature pointed toward God. The key figure was William Paley in the early nineteenth century, who taught that the natural world was so complex it must be designed. The ID movement makes the fundamental claim that "intelligent causes are necessary to explain the complex, information-rich structures of biology and that these causes are empirically detectable."[26] By making this move, they hoped to distinguish ID from a biblically based religion; the court cases exposed this deception. The authors conclude that ID is a repackaging of scientific creationism in response to negative court opinion.

The ID movement should have left the empirical detectability claim alone and embraced natural theology. Perhaps they could have gotten it into a humanities class that way. In fact, the Dover case claimed as much. Critics of the court claimed that (1) the court assumed the actions of the Dover School Board were the actions of the ID movement when ID leaders claimed otherwise; (2) the court inappropriately equated ID with creationism; and (3) the court ignored or distorted scientific testimony by inappropriately ruling that ID was not science. Reading the case and transcripts provides an entirely different perspective to these claims. The court did not decide whether ID was metaphysically right or wrong. In fact, it recognized that "reasonable people can continue to believe, on the basis of revelation and faith, that there is a Designer who designed our universe."[27]

As a theological concept, design may be seen as one way to seek coherence in theism. But it is simply not science. One cannot test or put God on trial, and indeed, thinking one can is a violation of Jesus' words (Matt. 4:7; Luke 4:12). ID is poor science, and it is horrible theology.[28] Concordism is *also* bad theology. The authors point this out by noting that

> many theologians conclude that while the Bible certainly does not argue against the big bang theory, it doesn't contain any element that is parallel to the theory … Genesis doesn't begin with a bang. It begins with a watery chaos, just like the pre-biblical Babylonian story does, and it is out of the watery chaos that the universe is built.[29]

The reference is to the earth *being* the watery chaos, with little reference to the rest of the cosmos except as heavens which were thought of as a firmament (dome-like structure) above the earth. Modern cosmology is not to be found in Genesis; consequently, concordism fails at the outset.

At best, ID is a counter-balance to the metaphysical assertions of naturalists such as Dawkins and Dennett—even if a potentially questionable one. Both camps overstep their bounds: ID claims to be science when it is really metaphysics (and a political movement), and the new atheists make metaphysical claims under the guise of science. The problem with inferring design is that humans are particularly bad at it. We can be told a design exists in a noise pattern, and we will search it out until, lo and behold, we actually see one! Not only are we pattern-seeking primates, our decisions regarding design "are largely a result of our personal experiences and the culture in which we have learned."[30] Instead, we should exhaustively search out an explanation based in natural regularity and stochasticity, without assuming design. *This* is the process of science.

We reach the crucial point in chapter ten in which proper exegesis is defined, first, by *not* using the biblical witness for history or science lessons; the focus should be on the theological message. With this perspective, a conflict position between science and theology evaporates. The only conflict is for those who are still focused on natural theology, pro or con. On the one hand, Dawkins' brand of atheism uses metaphysical naturalism (or scientism) to bolster a metaphysical position that nature is all there is and only science provides truth (a self-defeating statement). On the other hand, creationism says that only the plain sense understanding of Scripture (literalism) provides truth about origins of the cosmos and human beings; what can be discovered using our five senses and explainable by natural law is rejected in the light of a miraculous literalistic understanding. Each position is absolutist.

Unfortunately, the authors still favor some form of theistic evolution with all of creation moving toward a predetermined goal. Despite being more teleological than science allows, at least the authors admit that detecting purposefulness is through revelation, not science. Three theistic evolution positions are detailed: the origin of life itself and the spiritual nature of humans needing supernatural intervention (Francis Collins); evolution being guided by God via quantum chaos (Robert Russell); and God setting forth the laws of the universe so that it has the potential to evolve on its own and without supernatural intervention (Howard Van Till).

Van Till sees theology and the natural sciences as studying two different aspects of reality in which "we must carefully distinguish two categories of questions about the natural world."[31] These two categories are what Van Till calls "internal affairs" and "external relationships." The first is the view of natural science which empirically reveals information about the world's properties, behavior, and history; he describes these in purely natural terms. The second is metaphysical, as it concerns how the cosmos and God can be related as revealed via Scripture. Van Till sees God as endowing creation with its ability to self-organize.[32] Biological evolution is consistent with the doctrine of creation in this view. The "formational economy" of creation allows it to organize and transform itself from elementary matter to complex life forms.

In Collins's view, while there is no proof of God, the best evidence is moral law (as per C. S. Lewis and Kant before him). Collins also places weight on the scientific support for the cosmos having a beginning and obeying orderly laws. His position takes seriously that (1) the universe had a beginning about 14 billion years ago; (2) the anthropic argument is weak; (3) evolution and natural selection allow for descent with modification from a common ancestor; (4) no supernatural interference occurred once life began, including the development of humans from a common ancestor with apes; and (5) humans are

unique in their spiritual nature which cannot be fully explained by evolutionary processes (e.g., the moral law and the desire to know God).[33] Unfortunately, the last position has not been adjudicated by science so far; as such it is, potentially, a God-of-the-gaps argument.

Russell claims a "noninterventionist understanding of special providence." It is actually quite *interventionist* since God still takes action but within the laws of nature: these actions are not violations of natural law. Quantum fluctuations cause genetic variation (via mutation) which indirectly affects the course of evolution.[34] Russell interprets quantum indeterminacy "philosophically to imply that there are some events in nature for which there is no sufficient efficient natural cause."[35] This lack of a causal nexus at the quantum level allows for divine action by nudging quantum states rather than entire planets. Thus, Russell sees general divine action that creates and sustains the world *plus* special divine action that *indirectly* causes special events in the world. So, while the process of evolution may *appear* to be random chance, God knows how to play with quantum indeterminacy so that it chaotically magnifies to create the mutations needed for evolution to be guided. This places God as acting within time, knowing the outcome, and completely responsible for it, without violating a law of nature. The advantage, as Russell sees it, is that it does away with the "blind chance" claim of the metaphysical naturalists in which "blind chance" is the hidden action of the God who creates life.[36] Spooky action at a distance is deified by Russell. For me, this view provides for too much culpability when it comes to theodicy issues.

The authors fail to point out that none of the three theistic evolution positions are *scientific* explanations. They are theological constructs consistent with science in the sense that violation of natural law is not needed. However, out of the three, the only one that does not require an interventionist strategy is Van Till's. All three positions are different from ID in that they are theological concepts attempting to reconcile evolution with belief in God, rather than trying to masquerade as an alternative "science." Perhaps the major flaw in the book was this failure to critique theistic evolution. God's involvement in evolution should be left a mystery—perceived in the mind of the believer without trying to find some physicalist explanation for divine action.

The last five chapters focus on how to read the Bible as theological literature, how to make judgments about science, and how these move the authors to belief. They make the case that conflict does not exist between science and the Bible when the Bible is properly interpreted. One can assimilate evolutionary thought into a Christian concept of creation without taking Genesis 1–11 either as science or as history but, instead, as symbolic revelation for the purpose of theological insight. Many mainline Protestant churches, Roman Catholicism, and theologians agree.[37] Although not explicitly stated in chapter eleven, the authors rely on modern higher literary criticism to understand and interpret Scripture—something which Churches of Christ rejected in the early twentieth century with the rise of fundamentalism but slowly came to accept in the latter half of the past century.[38] Understanding the beliefs of the writers and their audience, including the cultural landscape when the text was written, and considering the linguistic/literary relationships in the text, help us to better see the applicability of these ancient texts to our own times.

Consequently, we should not see the Genesis stories as attempts to describe in scientific detail how the stars work, or whether the universe is geocentric or heliocentric, or how or in what time frame God went about creating the universe or humans. Without this perspective, we are bound to a "plain sense/vulgar/literal" view of Scripture and, in so doing, fulfill Augustine's prophecy of being laughed to scorn. We need to recover our sense of symbolism, metaphor, and mythic imagination when reading Scripture rather than forcing it to be "true" history or science. The authors maintain that the biblical writers never intended Scripture "to contain any science at all, whether viewed scientifically, historically, psychologically, theologically, or exegetically."[39] Scripture is meant to tell us that there is only one God through whom we may receive salvation. *That* is the sole purpose of the biblical message.

By chapter twelve, the authors have thoroughly rejected "plain sense" eisegetic approaches. They point out that even when common language is used in Scripture, it is an "accommodation principle" in order to reveal God, such that anyone may understand the basics for salvation. The *details* of Scripture, especially doctrinal matters, are best left to the magisterium of the church.[40] Personal interpretation

of Scripture without solid theological insight—so-called plain sense readings—must be rejected, even as the Ethiopian eunuch admitted to Philip in the chariot (Acts 8:30–31).

To illustrate this rejection of plain sense exegesis, the authors consider that the Genesis 1–11 stories constitute a mimetic narrative; this narrative is "a form of history and refers to historical times, event, and people, but it does not contain stories that meet the scrutiny of modern historical narrative."[41] Mimetic narrative actually *transcends* ordinary history. It is "a redescription of reality, the creation of a literary world or a textual world that reaches beyond itself and beyond its historical milieu … into the discovery of some universal truth."[42] A greater truth than mere "data and facts" would provide is generated; merely focusing on details would "obscure the truth of the broader story, so one needs to read the narrative from beginning to end to understand its meaning as a single, coherent story."[43] The focus of the Bible is to reveal the spiritual truth of the incarnation and the hope of eternal life.[44]

Using the word "myth" or "fable" in reference to a story in the Bible often gets one in trouble with fundamentalists and some evangelicals.[45] However, it is this uneducated understanding of what "myth" means that leads to confusion. Myth is not a fictional tale when used in the literary sense. Rather, it is "a legendary narrative that presents part of the beliefs of a people or that explains a particular phenomenon … [it] does not imply any judgment as to validity …"[46] The mythical origin of these accounts does not denigrate their status as God-inspired or detract from their truth and value to serve a greater purpose.

How one avoids inappropriate interpretations is also covered in chapter 12. Being aware of the flaws in our own worldviews is a first step. Closely related, the authors say,

> is the tendency to understand scripture according to the traditions to which we are accustomed, without giving any thought to those traditions and where they came from … [traditions such as] sex is the original sin, or that work is punishment for sins … or that Satan had a war with God in heaven … none of these traditions is based on scripture or biblical stories.[47]

Also inappropriate is reading Genesis in a concordist fashion: day-age theories, gap theories, placing Adam and Eve in a neolithic culture or in an oasis in the desert close to present-day Baghdad. Finally, we must not look for easy answers. Instead, we must

> deal thoroughly and honestly with the text and follow accepted principles of interpretation in an attempt to understand the meaning of the passage in its original setting … [and] to think deeply about the theological and personal implications of the deeper message.[48]

This is a much more difficult and challenging task than a simple "plain sense" reading will allow—a task best left up to the magisterium of the church.

As an example of proper exegesis, the authors detail the theologically sound interpretations of the first eleven chapters of Genesis in chapter 13. The consensus of Bible scholars today is that the first eleven chapters are a composite of writings put together by an editor or editors from a variety of sources.[49] The authors draw three conclusions about the Genesis stories: (1) they are written before modern scientific understandings of the cosmos and so use a unique prescientific language for describing the physical world; (2) they are concerned with the nature of God, not mechanisms of biological development; (3) they are a consciously symbolic work, using poetic language and similar to parables rather than factual history. The focus of the stories is symbolic in order to reveal "deep, fundamental truths about the nature of humanity and our place in the universe."[50] The point of the narrative was also to dismantle the polytheism of the time.[51] Furthermore, the stories are a part of a whole that ultimately reflects why the incarnation of Christ had to be.

Probably the toughest issue to deal with is Christian anthropology. The authors point out that to "image God" does not require us to be made fully developed or without a history of common ancestry:

> there is no difference between an existing human person whose ancestor was created instantaneously without progenitors just a few thousand years ago and an existing human person whose ancestors go back much further in time and whose lineage is much more deeply rooted in complex animal biology.[52]

To illustrate this claim, the authors use an "ontology recapitulates phylogeny" argument: each of us

develops from a zygote which shows little resemblance to a human and yet still has the potential for relationship with God once fully developed.[53] The biblical doctrine of creation simply affirms that all humans are specially created by God regardless of ontology. The critical theological point is to know that God is involved, mysteriously, in each and every human's formation and yearns for a relationship with each person. Because each of us rejects this relationship to pursue selfish interests and desires, we *each* eat of the fruit to know evil and good in a quest to be our own god. Literalism or concordism does not help us here. Symbolism does. Whether humans have their origins in two miraculously fully formed humans or whether they were a result of a long evolutionary development, the Christian doctrine of creation is that each of us is created by God in some way. If such an "origin from a single cell is okay for one individual, it should work for our whole species."[54]

The point is not to understand the two creation stories in Genesis as naturalistic, or historical, tales of how we came to be; they are theological explanations of our absolute dependence on God's providence.[55] Each story should depend on its own merits, and its individual purpose and literary style should be considered. Mitchell and Blackard prefer this approach since it argues

> for a symbolic, theological, non-scientific meaning … to convey universal truth … Genesis is literature of the symbolic imagination … the two [accounts] are different ways of telling the story for the purpose of communicating different ideas to different readers.[56]

Consequently, they consider the *theological* interpretation of Scripture as critical, as opposed to a need to be literal, which leads to the claim that evolution is a threat to the Christian faith. They also explain how Aristotelian thought on fixity of species has been assimilated into modern creationism ever since medieval theology rediscovered Greek thought. Galileo's rejection of Aristotelian astronomy and Darwin's rejection of Aristotelian biology are both arguments against these ancient Greek ideas, not against the Bible. The problem is the acceptance of Aristotelian thought upon which is layered a "biblical" interpretation. Fixity of species is *not* a biblical concept but an Aristotelian concept of forms.[57]

In chapter 14, the authors detail the symbolism of the Genesis 1–11 stories. What matters is that humans rebel against God at all stages of development, from the dawning of consciousness (an image of God) until today. In contrast with the pagan myths of the time in which the gods purposively keep humans from immortality, the Adam and Eve story places our downfall into our own hands, but we still retain the privilege of caretakers of the earth. The imagery is there to show that each of us has lost that original innocence to pursue our own self-serving nature rooted in human pride and disobedience. The authors conclude,

> Creation was good, and sin came after creation in the form of voluntary acts … We have the same freedom and responsibility, commit the same acts, and behave the same way regardless of whether we were created six thousand years ago or have been around for millions of years.[58]

The authors also reject the literalism of flood geology and the concordist approach of regional catastrophes in the Noachian deluge story. The story is not there "as a form of science that would describe how the earth's geologic features were formed … and it was not intended as a history of events."[59] Its intent is to combat depraved pagan gods and provide a "beautiful picture of salvation by grace through faith. There was no other way to be saved from destruction … except by coming to God's ark of refuge."[60] The Tower of Babel story is also explained from a theological perspective rather than as a literal reading, supporting a single origin for all languages.[61] The story covers the recurring theme of condemning the overwhelming pride of people who defy God. It also tells us today that just because we have the technology to do something, we should ask ourselves if it contributes to the kind of justice we might expect of God. Can our "progress" really be to the glory of God if it harms the poor and oppressed?

A final chapter on epistemology rounds out the book; the authors focus on the importance of trusting expertise, not authority, in providing access to truth about the way the world works and the way theological reflection works. Despite not being scientists themselves, they have the good sense to trust those who are, when discovering validity in the physical world. Consequently, they accept scientific explanations from evolution, astronomy, geology, molecular genetics, and paleontology.

They also respect theological expertise. The mysteries of the cosmos are sufficient to cause many to

insert "deity" whenever a naturalistic explanation is lacking. This is an impoverishing approach as it keeps relegating God to explain the gaps and then embarrassing the rest of us when the gaps are filled. The real mystery is, why is there a cosmos at all? What *is* its source? What is human destiny/purpose? These are the questions which theology attempts to explain. Science, by its very nature, cannot.[62] It would be better to rely on the magisterium of the church rather than on personal interpretation to help interpret Scripture. Just as we do not read a textbook of surgery and try to perform an operation on ourselves, we would do better to rely on trained experts in the field (theologians) rather than on eisegesis from the laity when we read Scripture. In the end, the best approach is to

> read Scripture in the historical and linguistic context in which it was written, to accept its mysteries, and to appreciate its fundamental truths about the relationship between God and man … this is the approach that does not conflict with all that we observe and learn about science …[63]

A literal/historical/scientific reading of the creation accounts of Genesis negates their fundamental truth and power. As Langdon Gilkey puts it, "The claim to be able literally to describe God's creative act does not so much reflect piety as it reveals the loss of the religious sense of the transcendent holiness and mystery of God."[64] It creates God in our image: as scientist, engineer, designer, artificer, cobbler, construction worker, draftsman, and watchmaker.

Unfortunately, the authors do not clarify matters by their position on theistic evolution to illustrate God's designing intelligence.[65] At least they do not defend it as scientific "proof" but as a theological concept. The problem with this approach is that they do not address all the examples of poor design—the "junk-yard wars" impression of things being hodge-podged together—that evolution often presents. There is far too much teleology in their version of theistic evolution for it to take science seriously. If the authors would consider process theology, they might improve their position of consilience between evolution and Christianity.[66] Effectively, process thought emphasizes the relational aspects of God's character: God creates *with* the world in such a way to persuade or to "lure" cooperative action from creation, not to *force* it to do as one chooses. As a result, God draws all things unto himself, offering all things in every moment the opportunity for achieving the good while " … the whole creation groaneth and travaileth in pain together … waiting for the adoption, *to wit*, the redemption of our body" (Rom. 8:22, 23; KJV). We are engaged in this process as well, since the creation waits in "earnest expectation … for the manifestation of the sons of God … [when it] shall be delivered from the bondage of corruption into the glorious liberty of the children of God" (Rom. 8:19, 21; KJV) in an eschatological future.[67] Nevertheless, Mitchell and Blackard have made a significant step forward from the fundamentalisms of plain sense readings and concordism that once characterized fellowships in the Restoration heritage.

Acknowledgment

I thank Dr. Brent Isbell, minister at University Church of Christ and adjunct instructor at Abilene Christian University, for his insightful comments on this manuscript.

Notes

[1]See Douglas A. Foster, Paul M. Blowers, Anthony L. Dunnavant, and D. Newell Williams, *The Encyclopedia of the Stone-Campbell Movement* (Grand Rapids, MI: W. B. Eerdmans Publishing, 2004). Also see Leroy Garrett, *The Stone-Campbell Movement: The Story of the American Restoration Movement* (Joplin, MO: College Press Publishing, 1987); C. Leonard Allen and Richard T. Hughes, *Discovering Our Roots: The Ancestry of Churches of Christ* (Abilene, TX: ACU Press, 1988).

[2]Ashby L. Camp, *The Myth of Natural Origins: How Science Points to Divine Creation* (Tempe, AZ: Ktisis Publishing, 1994); Robert S. Camp, ed., *A Critical Look at Evolution* (Atlanta, GA: Religion, Science, and Communication Research and Development Corporation, 1972); Donald England, *A Christian View of Origins* (Grand Rapids, MI: Baker Book House, 1972); Calvin Fields, *Things You Never Heard: Strong and Compelling Evidence Concerning the Bible, Creation, Christ, Evolution* (Phoenix, AZ: ACW Press, 2001); Jack Wood Sears, *Conflict and Harmony in Science and the Bible* (Grand Rapids, MI: Baker Book House, 1969); Elton Stubblefield, *Creation, Evolution and the Great Flood* (Ft. Worth, TX: Star Bible Publications, 1995); J. D. Thomas, ed., *Evolution and Faith* (Abilene, TX: ACU Press, 1988); Bert Thompson, *Theistic Evolution* (Shreveport, LA: Lambert Book House, 1977). These books are authored by Church of Christ members; many of them are committed to biblical literalism and young-earth creationism.

[3]In *A Critical Look at Evolution*, Camp states, "Every writer holds the conviction that the biblical account of creation is a true and factual account of the origin of life on earth, in particular human life" (p. 33). The contributors were professors of Bible, physics, and biology at Harding College, Pepperdine University, and David Lipscomb College (schools affiliated with Churches of Christ).

In Thomas' *Evolution and Faith*, a move was made toward a more modern exegesis that allowed Scripture "to stand in its own literary, historical, and religious context" and without "a 'scientific' concern or presupposition" (p. 147). However, the move is shortly reigned in: "The Genesis account of creation, therefore, should be read [as] … a straightforward, sober statement of what actually happened … its opening chapters on creation are an integral part of Genesis' uncompromising historical character" (p. 177). The contributors were professors of Bible and various science departments at Abilene Christian University, affiliated with Churches of Christ.

[4]In a session organized by Chris Doran of Pepperdine, the book was reviewed by Donna Plank from Pepperdine, David Mahfood, a divinity student from Abilene Christian University, and James Foster of Princeton. The overwhelming positive perception was the book's commitment to respecting both science and theology as separate fields that could engage in fruitful dialogue. The reviewers appreciated the fact that this book showed that being called an "accommodationist" is not a pejorative epithet but a badge of honor. The reviewers found much to be praised in the detailed exegesis of Scripture but felt that the book was light on systematic and philosophical theology. Even though the hermeneutic was never spelled out entirely, restricting the Genesis texts to *merely* an excoriation of polytheism as the authors seem to do, did not engage as robust a theology as is needed to allow a true reconciliation of science and theology. However, it did succeed in exegetically reconciling the biblical narrative with the evolutionary one. The consensus hope was that the book's audience (the educated laity in Restorationist fellowships) would finally be freed from the plain sense biblical literalism that plagues some remnants within the tradition.

[5]Mitchell is an alumnus of Abilene Christian University (BA, 1961; MA, 1969 in doctrine with minor in Hebrew) and Rice University (PhD, 1979 in religious studies—theology and theological ethics).

[6]Blackard developed Shell Oil's internal conflict management system and has authored several books on conflict management. His role with the book was to provide a layperson's perspective.

[7]Mitchell and Blackard, *Reconciling the Bible and Science*, 14.

[8]The historical-critical method is preferred by the authors; they rely on source and redaction criticism in the spirit of the Tübingen School.

[9]Richard J. Evans, *In Defense of History* (New York: W.W. Norton & Co., 2000), 14, in reference to Ranke's principle of *wie es eigentlich gewesen*.

[10]Many of the "proofs" of God using Platonic and Aristotelian ideas create more conflict with modern science than scriptural literalism.

[11]Thomistic thought became a major theological underpinning for the Catholic struggle against Protestant theology. Aspects of it are used in fundamentalist circles today (ironically assimilated by fundamentalist Protestants) when rejecting the discoveries of modern science and accepting the fixity of species and an original type species.

[12]John Henry Newman and Frederick T. Tennant are classic examples (see notes 14 and 15 below).

[13]Tatha Wiley, *Creationism and the Conflict over Evolution* (Eugene, OR: Cascade Books, 2009); Tatha Wiley, *Original Sin: Origins, Developments, Contemporary Meanings* (New York: Paulist Press, 2002); Daryl P. Domning and Monika K. Hellwig, *Original Selfishness: Original Sin and Evil in the Light of Evolution* (Burlington, VT: Ashgate Publishing, 2006); Richard Mortimer, "Blocher, Original Sin and Evolution," in *Darwin, Creation and the Fall*, ed. R. J. Berry and T. A. Noble (Nottingham, UK: Apollos, 2009), 173–96; Jerry D. Korsmeyer, *Evolution and Eden: Balancing Original Sin and Contemporary Science* (New York: Paulist Press, 1998); Patricia A. Williams, *Doing without Adam and Eve: Sociobiology and Original Sin* (Minneapolis, MN: Fortress Press, 2001).

[14]John Henry Newman, *Apologia Pro Vita Sua*, ed. Martin J. Svaglic (Oxford: The Clarendon Press, 1967), 217–8. It can also be found at the Newman reader website: www.newmanreader.org/works/apologia/part7.html (last accessed June 22, 2011).

[15]D. K. Brannan, "Darwinism and Original Sin: Frederick R. Tennant's Integration of Darwinian Worldviews into Christian Thought in the Nineteenth Century," *Journal for Interdisciplinary Research on Religion and Science* 1 (2007): 187–217. Accessible on the web at www.jirrs.org/jirrs_nr_1/08-brannan.pdf (last accessed June 22, 2011); D. K. Brannan, "Darwinism and Original Sin: Frederick R. Tennant's Analysis of the Church Fathers' Understanding of Original Sin and an Exegesis of St. Paul," *Journal for Interdisciplinary Research on Religion and Science* 8 (2011): 139–71. Accessible on the web at www.jirrs.org/jirrs_nr_8/07-06-jirrs8-brannan.pdf (last accessed June 22, 2011).

[16]Mitchell and Blackard, *Reconciling the Bible and Science*, 82.

[17]Richard Dawkins, *The God Delusion* (New York: Houghton Mifflin Co., 2006), 49.

[18]Mitchell and Blackard, *Reconciling the Bible and Science*, 104.

[19]Hume's agnosticism was more focused against philosophies that mistakenly made assumptions to come up with metaphysical claims when the facts were not properly associated in the first place. We believe in certain ways, based more on habit, social convention, and even our natural instinct, than based on data and rationality. With this view, Hume questions not only natural theology but metaphysical naturalism disguised as science.

[20]Mitchell and Blackard, *Reconciling the Bible and Science*, 106.

[21]Richard Dawkins, *The God Delusion* (New York: Houghton Mifflin Co., 2006), chap. 4.

[22]Examples of poor design are used to question a deity as a designer or at least frame the deity as capricious or inept. This argument assumes omnipotence, omniscience and omnibenevolence for God and that he exercises, in particular, the first at all times without regard for allowing freedom of all things to "become" on their own. Open and process theology see this differently.

[23]Norman L. Geisler, *Christian Apologetics* (Grand Rapids, MI: Baker Book House, 1976), 234. See the following webpage for a list of contrary arguments: www.freeinquiry.com/skeptic/theism/ (last accessed June 22, 2011).

[24]Court challenges to the constitutionality of antievolution laws occurred in 1968 when the US Supreme Court overturned an Arkansas law that had been on its books since 1928 shortly after the Scopes trial (*Epperson v. Arkansas*).

The legal strategies have been evolving ever since. One approach is the "equal time laws," a repackaging of creationism without reference to biblical themes. The equal time laws passed by Arkansas and Louisiana in the early 1980s were also struck down as unconstitutional in 1982 (*McLean v. Arkansas*) and 1987 (*Edwards v. Aguillard*). After these defeats, several new phrases were used in hopes of inserting "creation science" into the curriculum: "alternatives to evolution," "evidence against evolution," "initial complexity theory," and "intelligent design theory." See the NCSE website for details: http://ncse.com/creationism/general/antievolutionism-creationism-united-states (last accessed June 22, 2011).

[25]*Kitzmiller v. Dover*, 2005. For an analysis, see http://ncse.com/creationism/legal/intelligent-design-trial-kitzmiller-v-dover (last accessed June 22, 2011). For full text of the case, see http://ncse.com/webfm_send/73 (last accessed June 22, 2011).

[26]Mitchell and Blackard, *Reconciling the Bible and Science*, 126–7.

[27]Ibid., 133.

[28]Theologians such as John Haught testified in the *Kitzmiller v. Dover* trial that ID is "appalling theology" in that it

> is the attempt to bring the ultimate and the infinite down in a belittling way into the continuum of natural causes as one finite cause among others. And any time, from a theological point of view, you try to have the infinite become squeezed into the category of the finite, that's known as idolatry. So it's religiously, as well as theologically, offensive to what I consider the best [theology] … (p. 27 of the court transcript)

See http://ncse.com/files/pub/legal/kitzmiller/trial_transcripts/ 2005_0930_ day5_ pm.pdf (last accessed June 22, 2011).

[29]Mitchell and Blackard, *Reconciling the Bible and Science*, 135.

[30]Ibid., 139.

[31]Ibid., 150.

[32]This view is reminiscent of Augustine's seed principles; it obviates the need for a God of the gaps so characteristic of creationism and ID. God does not have to intervene over and over again to get things right.

[33]Francis S. Collins, *The Language of God: A Scientist Presents Evidence for Belief* (New York: Free Press, 2006), 200.

[34]Robert John Russell, "Special Providence and Genetic Mutation: A New Defense of Theistic Evolution," in *Perspectives on an Evolving Creation*, ed. Keith Miller (Grand Rapids, MI: Eerdmans Publishing Co., 2003), 335–69. Also cited, R. J. Russell, *Cosmology from Alpha to Omega: Towards the Creative Mutual Interaction between Theology and Science* (Minneapolis, MN: Fortress Press, 2008).

[35]Mitchell and Blackard, *Reconciling the Bible and Science*, 153.

[36]Russell, "Special Providence and Genetic Mutation," 368.

[37]The authors cite Paul Tillich as seeing no conflict between faith and reason, Karl Barth as seeing the intention of the creation accounts to emphasize the distance between cosmos and creator, and Dietrich Bonhoeffer and C. S. Lewis as denying that the creation accounts have any conflict with Darwinism and in fact emphasize our connection with the rest of creation (p. 156).

[38]Michael Wilson Casey, "The Interpretation of Genesis One in the Churches of Christ: The Origins of Fundamentalist Reactions to Evolution and Biblical Criticism in the 1920s," (master's thesis, Abilene Christian University, 1989), 261.09C338i ACU Library.

[39]Mitchell and Blackard, *Reconciling the Bible and Science*, 172.

[40]For fellowships within the Restoration movement, the magisterium is essentially the colleges and universities supported by our fellowship. Due to our congregational polity, however, this "magisterium" has no ability to enforce doctrine or dictate hermeneutic approaches.

[41]Mitchell and Blackard, *Reconciling the Bible and Science*, 177.

[42]Ibid., 179.

[43]Ibid.

[44]Even the creation of a historical biography was not the reason for recording the life and teachings of Jesus. The point of the Gospels is to convey the message of God incarnate who loves all things (the world) so much that Jesus experiences it completely as a sentient human, the very same things we do including death. Since Jesus is also divine, the Gospels tell us that he interacts with the natural world in such a way that even death is not truly the end as he ascends in the form of a glorified body to whence he came. The character of religious language is filled with symbolism; we need to avoid taking the symbolism literally.

[45]Bert Thompson, *Is Genesis Myth? The Shocking Story of the Teaching of Evolution at Abilene Christian University* (Montgomery, AL: Apologetics Press, 1986). For an analysis, see Ronald L. Numbers, *The Creationists: The Evolution of Scientific Creationism* (New York: Alfred A. Knopf, 1992), 315.

[46]Mitchell and Blackard, *Reconciling the Bible and Science*, 183.

[47]Ibid., 191.

[48]Ibid., 192.

[49]Ibid., 196. There are at least two sources: a document derived from the oral traditions of ancient Hebrew stories from the Southern Kingdom of Judah after the time of Solomon, and a similar collection of the traditions of Israel from the Northern Kingdom of Ephraim shortly after (during the exilic or late Old Testament period).

[50]Ibid., 197.

[51]Conrad Hyers, *The Meaning of Creation: Genesis and Modern Science* (Atlanta, GA: John Knox Press, 1984), 44. Overthrown are ideas of the creation (light, darkness, sky, sea, sun, moon, stars) being gods. They are merely physical created entities. Procreation is a blessing rather than something to be worshiped. All humans have God's image, not just the kings who represent the gods. The stories reveal who God is through events and actions that show he is the Creator of all things, even those things once thought to be gods themselves.

[52]Mitchell and Blackard, *Reconciling the Bible and Science*, 207.

[53]Ibid., 207. They see this analogy as providing help to "overcome any discomfort associated with matter (such as 'dust of the ground'), nature (such as our animal natures, natural relatives, and one-cell beginnings), and natural juices (such as 'slime') that refer to substances associated with the beginning of all life and the beginning of each individual life of every 'kind.'"

[54]Ibid., 211.

[55]Pointing out the work of Conrad Hyers, the authors note that the stories reflect two contrasting life-settings in the history of Israel. The story in Genesis 1, which actually comes after the Genesis 2–3 story in time, reflects an agricultural-urban imagery of civilizations ruled by kings who gave commands, whereas Genesis 2–3 reflects pastoral-nomadic imagery drawn from the experience of wandering herders living on the fringes of fertile plains. Both stories were important in the history of Israel and thus are placed side-by-side. Conrad Hyers, *The Meaning of Creation: Genesis and Modern Science* (Atlanta, GA: John Knox Press, 1984), 41.

[56]Mitchell and Blackard, *Reconciling the Bible and Science*, 213.

[57]The authors remind us of Baptist theologian Bernard Ramm's position that "Few reliable conservative scholars today would state that we can positively identify the Hebrew word *kind* (Hebrew, *min*; LXX, *genos*; Vulgate, *genus* and *species*) with the modern scientific notion of *species* … We judge it improper for the theologian to try to settle specific details about scientific matters by forcing the Bible to speak with a degree of particularity its language does not indicate." See Bernard Ramm, *The Christian View of Science and Scripture* (Grand Rapids, MI: Wm. B. Eerdmans Publishing Co., 1954), 37. This book was the theme of a December 1979 issue of the *Journal of the American Scientific Affiliation*.

[58]Mitchell and Blackard, *Reconciling the Bible and Science*, 224–5.

[59]Ibid., 231.

[60]Ibid., 231. It is a metaphor for baptism as well; see 1 Pet. 3:20–21.

[61]For a naturalistic explanation of the origin of languages, see Quentin D. Atkinson, "Phonemic Diversity Supports a Serial Founder Effect Model of Language Expansion from Africa," *Science* 332 (2011): 346–9.

[62]Theology cannot resolve these questions completely either. Nevertheless, it *can* provide a greater awareness of the mystery, the unfathomable—that perhaps faith in God points in the right direction. The Christian religion is filled with many doctrinal mysteries (the incarnation, resurrection, eschatology, the presence of Christ in bread and wine, how baptism removes sin, etc.) in which human language is incomplete to explain them; however, it is also a faith that has a consilience which holds together to provide a benefit for its believers. Understanding God is the goal of theology, but full understanding is reserved for another time. Like St. Paul, we must remain agnostic in this life and admit that "now we see but through a glass darkly" (1 Cor. 13:12). What is hidden about God is greater than what is known (the apophatic nature of God).

[63]Mitchell and Blackard, *Reconciling the Bible and Science*, 245.

[64]Langdon Gilkey, *Maker of Heaven and Earth* (Garden City, NY: Doubleday & Co., 1959), 54.

[65]The authors claim,

> We believe that God has created a world that contains the capabilities for self-organization and change, such that `an unbroken line of evolutionary development has in fact taken place … meaning that God had a creative plan that included natural consequences and divine governance over a continuing and ever-changing process. The material behavior that we observe, including evolution, is a consequence of God's plan and a continuing expression of His plan for the development of the universe. Natural laws describe this behavior as well as a patterned succession of related phenomena—a succession that demonstrates that God did not act impulsively or on a whim. The glory of creation took place, and the awe it engenders is not diminished by an evolutionary view of how organisms developed from original life. (Pp. 248–9)

[66]For an application to the doctrine of creation, see John B. Cobb and David Ray Griffin, *Process Theology: An Introductory Exposition* (Louisville, KY: Westminster John Knox Press, 1976), chap. 4, "A Theology of Nature."

For an application of process theology that takes evolution seriously as an explanation for original sin, see Daryl P. Domning and Monika K. Hellwig, *Original Selfishness: Original Sin and Evil in the Light of Evolution* (Burlington, VT: Ashgate Publishing, 2006).

For an application that takes evolution seriously in Trinitarian theology, see Denis Edwards, *The God of Evolution: A Trinitarian Theology* (Mahwah, NJ: Paulist Press, 1999).

For a highly accessible and readable introduction that integrates evolution with Christian thought, see John F. Haught, *God after Darwin: A Theology of Evolution* (Boulder, CO: Westview Press, 2001).

[67]For a quick and easy primer on this thinking, see Marjorie Hewitt Suchocki's paper, "What *Is* Process Theology?" at www.processandfaith.org/publications/RedBook/What%20Is%20Process%20Theology.pdf (last accessed June 22, 2011).

Environment

CLIMATE JUSTICE: Ethics, Energy, and Public Policy by James B. Martin-Schramm. Minneapolis, MN: Fortress Press, 2010. 232 pages, index. Paperback; $20.00. ISBN: 9780800663629.

The interrelated issues of energy and climate change are two of the most pressing environmental challenges, or perhaps more accurately, challenging environmental arenas, of the twenty-first century. At the very least, dependence on oil and the impacts of climate change pose fundamental challenges to the economic future of the United States, and, viewed more broadly, they threaten geopolitical stability, human health and welfare, and biodiversity around the world.

Energy and climate change are not, then, merely technical problems; they are, argues Christian ethicist James B. Martin-Schramm, fundamental moral challenges. In *Climate Justice: Ethics, Energy, and Public Policy,* Martin-Schramm urges Christians to engage in serious moral reflection on these issues, connecting the biblical, theological, and Christian social teachings with the relevant natural and social sciences. Energy and climate issues, he argues, "pose grave threats to justice, peace, and the integrity of creation" (p. 21), and therefore, "Christians at the outset of the twenty-first century must respond to this climate crisis by developing a new way of living in harmony with Earth's energy resources and in solidarity with all of God's creatures" (p. 5). The good news is that a growing number of Christians from a variety of theological, political, and economic perspectives are concerned about these issues, and Martin-Schramm provides a useful template for Christians who want to engage public policy debates.

In *Climate Justice*, Martin-Schramm advances an ethic of ecological justice, which is essentially "the social and ecological expression of love" (p. 28) for God's whole creation, both human and nonhuman, and it can be seen in the four derivative norms of sustainability, sufficiency, participation, and solidarity. Applying these norms to complex cases requires additional principles or guidelines, which Martin-Schramm provides for both energy and climate policy. Equity, efficiency, adequacy, renewability, appropriateness, risk, peace, cost, employment, flexibility, timely decision-making, and aesthetics direct his evaluation of energy policy; at the same time, current urgency, future adequacy, historical responsibility, existing capacity, political viability, scientific integrity, sectoral comprehensiveness, international integration, resource sharing, economic efficiency, policy transparency, emissions verifiability, political incorruptibility, and implementational subsidiarity guide his assessment of climate change policy.

With this framework in place, Martin-Schramm devotes most of the book to policy analysis, scrutinizing US policy on energy and climate change as well as international climate negotiations. Fossil fuel energy has led to vast increases in economic productivity, but "this economic wealth has not been distributed very well, and it has only been garnered by undermining the ecological health of the planet" (p. 70). Alternative sources of energy exist, and his guidelines allow for a thoughtful comparison of various options, from solar energy to hydro power, resulting in nine policy recommendations to move the United States away from fossil fuel dependency. Climate policy, he argues, is just as problematic, and "after a decade of delay and obfuscation, we have now reached a point where a decision needs to be made" (p. 158). Once again, the detailed guidelines he advances at the outset of *Climate Justice* enable him to evaluate various issues in the development of new climate policy, both internationally and domestically. He concludes with an account of what his own institution, Luther College, is doing to reduce greenhouse gas emissions by increasing energy efficiency and switching to alternative energy sources.

Climate Justice is an important contribution to both Christian ethics and public policy discussion, and it will serve a wide audience. It provides a valuable model for applied Christian ethics, working from the basic biblical principles of justice and love to the complex world of public policy. This fills a relatively thin area in the literature of Christian environmental ethics, which has focused primarily on either normative ethics or applied ethics at the individual level. Furthermore, Martin-Schramm's command of the science, both natural and social, behind energy and climate debates is impressive, and he guides readers through the maze of relevant information with remarkable clarity. Furthermore, the book is written in a way that is accessible and useful for those inside and outside the church, because the guidelines he develops embody basic elements of prudence that a wide range of people will affirm regardless of their religious identity.

This leads, however, to one aspect of *Climate Change* that is not readily accessible. Martin-Schramm roots the four moral norms of sustainability, sufficiency, participation, and solidarity in longstanding work by the World Council of Churches and the Presbyterian Church, USA, yet he provides minimal rationale for the associated guidelines employed throughout the book. As a result, it is not entirely clear how he derived these particular guidelines, and not others, from the four moral norms; this question is important because he ultimately traces the guidelines' moral authority back to the fundamental principles of love and justice. His emphasis on policy analysis also at times obscures some of the necessary work involved in balancing the guidelines, particularly in cases which may indicate different alternatives. For this reason, those interested in greater attention to normative ethics and the transition area between normative and applied ethics may wish to read *Climate Justice* alongside other recent books on ethics and climate change, such as *The Ethics of Climate Change: Right and Wrong in a Warming World* by James Garvey (New York: Continuum, 2008) or *A New Climate for Theology: God, the World, and Global Warming* by Sallie McFague (Minneapolis, MN: Fortress Press, 2008).

Nonetheless, *Climate Justice* is an important step forward. The four moral norms of sustainability, sufficiency, participation, and solidarity and the much longer list of guidelines promise reflection that balances human and nonhuman flourishing, and they will guide essential reform in energy and climate policy if applied by policy makers. *Climate Justice* is therefore an excellent text for undergraduate classes on energy and climate change and

for anyone seeking guidance in these important policy arenas. Given the immensity and complexity of the challenges that lie ahead, *Climate Justice* is a timely contribution and hopefully will improve the depth and quality of public debate.

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GOD, CREATION, AND CLIMATE CHANGE: A Catholic Response to the Environmental Crisis by Richard W. Miller, ed. Maryknoll, NY: Orbis Books, 2010. 150 pages. Paperback; $20.00. ISBN: 9781570758898.

Editor Richard Miller's introduction to *God, Creation, and Climate Change* states,

> The magnitude of the problem of environmental degradation in general and climate change in particular requires a complete rethinking and reorienting of our way of being in the world. Responding … requires not only a conversion of the will but even more fundamentally a transformation of the imagination. (p. vii)

The following essays then seek to encourage such a transformation. The essays originated as talks at the Seventh Annual Church in the 21st Century Lecture Series held in September of 2009. The essayists are theologians, joined by a historian and an economist.

Miller's opening essay, "Global Climate Disruption and Social Justice," is a strong statement and overview of the problem. He focuses on the impacts climate change has and will have on food and water. Miller does a particularly good job of reminding us of a number of very uncomfortable truths, including the following: (1) by every major indicator, climate change is coming faster than any of the climate models have predicted; and (2) as he puts it, the "elephant in the room" is that the "historical climate record shows that abrupt climate change is the norm, not the exception" (p. 16). Especially inspiring, and important, is Miller's closing call to direct action—that people need to start "demonstrating en masse in the streets … especially in the United States" (p. 25).

The following two essays explore theological themes through the lens of present-day ecological concerns. Dianne Bergant looks at anthropocentrism in the Scriptures through a reading of the Book of Job and the Wisdom of Solomon. John O'Keefe then critiques the common understanding of resurrection as a spiritual ascent, a liberation from the body and from the material world. He rightly suggests that such eschatology contributes to a devaluing of nonhuman creation. As a corrective, O'Keefe points to Irenaeus of Lyons' deeply material theology which states that "the incarnation … delivers us from our alienation and restores us to a proper relationship with nature" (p. 63) rather than liberating us from nature.

Both authors make important points. I suspect that, for readers relatively new to "creation theology," their discussions may seem a bit esoteric—or at least leave the reader wondering why the much more common themes of dominion and stewardship are not addressed. However, the book's closing chapter is a transcript of the conference's panel discussion—it is a strong chapter and includes good discussion of these two themes.

The fourth essay begins somewhat repetitively, covering some of the same material that Richard Miller did in terms of the impacts of climate change. In the light of those impacts, author Jame Schaefer introduces the concept of "planetary sin" and argues that the common good needs to include the well-being of nonhuman creation. Her comments raise very important questions, including whether humans can become nonspecies centric; whether we can act as if our "self" is more than a skin-encapsulated ego such that our self-interest not only incorporates the well-being of other humans but other species and living systems as well.

Chapter 5 is entitled "Theology and Sustainable Economics." Including this theme is crucial and recognizes that ecology and economics are intimate partners, sharing the Greek root word of *oikos*, meaning household. Author Daniel Finn provides a good overview of "four problems of economic life" and raises important questions about whether markets address those problems adequately. Significantly, he concludes by asking "what parts of your current definition of well-being would you be willing to give up for there to be a more sustainable future for our lives together?" (p. 110). I wish he would have explored a similar question related to the church (Catholic and otherwise) as a whole: how and where does the church benefit from our current economic system (certainly an unsustainable one and arguably violent), and what would the church be willing to do to actually move the system toward a more sustainable future.

It seems that David O'Brien, the author of chapter 6, reveals his own fatigue with "calls to action" in the very title of his essay, "Another Call to Action." He provides a historical overview of Catholic responses to social injustice, looking through the lens of Catholic social teaching, Catholic social action, and the Catholic social gospel. When asked in the panel discussion (chap. 7) how lay people should build the institutions within the church and society to allow for mobilization around climate change, O'Brien admits that, based on what he sees, he has to assume "there are not a lot of people out there who take responsibility for the politics of the church. They are quite resigned to treat the church like a monarchy" (p. 131). He states emphatically that "people do not do anything"; and though that specific comment was in reference to most Catholics' inaction related to the sex-abuse crisis and the Vatican's inquiry into the Sisters, his comments do not bode well for mobilization to address climate change.

As mentioned, the book concludes with a transcript of the conference's panel discussion. And it is a good discussion. In response to questions from the audience, the speakers respond at some length, allowing them to reveal some of the ways they engage their own imaginations in response to the realities of climate change.

The authors included in this anthology are rooted in the Catholic tradition. They refer to papal encyclicals and Catholic statements throughout the essays; this is one of the book's strengths. They emphasize how both Pope John Paul II and Pope Benedict XVI have taken strong positions and written important pieces on climate change and our related responsibility. I found myself wishing, however, that they had at times challenged the Catholic

tradition on two things in particular, population growth and the position of women in the church.

A number of the essayists discussed population growth in the context of Earth's finite carrying capacity. In addition, Richard Miller cites one of the world's leading climate scientist's careful argument that on our current path (a 5° C increase from pre-industrial temperatures) "the planet could probably support only about 1 billion people" (p. 18). For none of the authors, in this context, to raise questions about the Catholic church's traditional teachings on family planning (for example, condom use) seems a significant oversight.

Eco-feminist theologians have for years pointed out that patriarchal and hierarchical systems tend to associate the feminine with Earth. Both end up being seen as less than capable—and are often treated as such. Though there is not space to discuss this at any length here, an exploration of these themes would have strengthened this anthology.

For the book to not address population growth and the position of women in the church is a missed opportunity because the church plays such a significant role in defining its adherents' worldviews and behaviors. As the author of chapter 4, Jame Schaefer wrote,

> Theologians also need to make some decisions, decisions that focus on ways in which we can contribute to the interdisciplinary dialogue that has emerged over the phenomenon of human-forced climate change … scholars of the world religions can identify teachings that might be helpful in addressing why some climate change-forcing behaviors should be avoided while others should be initiated. (p. 69)

God, Creation, and Climate Change is a worthwhile read. The theological pieces are accessible. Miller's opening and the closing panel discussion are particularly strong. Like many current resources on climate change, this book does not end with a great deal of hope, at least not in the US political process. The book was published when many of us—including a number of the essayists—still had hope that the US Congress would actually pass a climate change and energy bill, however inadequate it may have been. That, of course, did not happen; thus, Miller's opening essay's call for direct action is all the more important.

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GLOBAL WARMING AND THE RISEN LORD: Christian Discipleship and Climate Change by Jim Ball. Washington, DC: Evangelical Environment Network, 2010. 479 pages. Paperback; $25.00. ISBN: 9780982930014.

Global Warming and the Risen Lord is the culmination of two decades of work by Jim Ball focusing on creation care, and frequently specializing on a Christian response to the threat of global warming. Ball was challenged by a fellow graduate student to consider the value of a Christian perspective on the environment in 1990, then went on to do his PhD on theological ethics, writing a primer for Christians on global warming in the process. Few read it, and meanwhile the threat of global warming initially fell on deaf ears throughout much of Christendom. Through his involvement in the Evangelical Environmental Network (EEN), Jim has done much to raise the profile of the issue in Christian circles. His best-known contribution was the "What Would Jesus Drive?" campaign which he conceived in 2002. This was followed by the launching of the Evangelical Climate Initiative in 2006, which also garnered widespread media attention. Now with this book, Ball makes available an in-depth resource for readers seeking to see how Christian faith might best be incorporated into this complex and far-reaching issue of our time.

Ball's comprehensive treatment of global warming and theological ethics is divided into three distinct parts, with each of the three parts comprising seven chapters, followed by a concluding chapter entitled *Walking into the Future with the Risen LORD*. Part 1 describes the challenges posed by global warming to the planet. Ball alternates between painting a picture of the more local impacts to be felt in the United States, and the consequences of climate change for the world's poor, emphasizing that the poorer global regions stand to be impacted the most, even though their contribution to the world's greenhouse gases is less, and it is hard for them to do anything about it. At the same time, Ball acknowledges that it is very hard for people to respond to a crisis that is distant geographically or is predicted to have much greater impact in the future. Although Part 1 is focused on the biophysical aspects of climate change, Ball integrates a Christian worldview into each chapter, developing a major theme of the book that anything is possible if we truly walk with the Risen LORD.

Ball is careful to indicate how the scientific data shows that the historic increase in greenhouse gases leads to a potential intensification of natural disasters such as floods, droughts, and storms, and the resulting impacts on humans and the biota, rather than being 100% responsible for these meteorological events. In this way, Ball systematically addresses skepticism spurred by alarmist claims regarding impacts of climate change. However, the reference to the issue being the "next great cause of freedom" in chapter 7 takes the debate to a whole new level. In essence, this is what Ball discusses throughout the extensive theological reflections in Part 2. Ball weaves in his own personal testimony and also attempts to draw parallels from the transformation of historical attitudes on civil rights in the United States, including stories from the hometown of his ancestors. So the question becomes, Can this global, yet complex and intangible, environmental crisis really become "the next great cause of freedom"? I have my doubts, but nevertheless Ball's engagement with the question via a wide-ranging discussion of biblical passages is worth reading.

As might be expected, Part 3 provides the application. To me, this was the most enlightening part of the book. Ball repeatedly tackles the question that paralyzes so many politicians, citizens, and even environmental activists: "What can be done, when the problem seems overwhelming?" In the process, he discusses the spiritual goal of overcoming global warming, overcoming the causes, and overcoming the consequences. Ball says that the spiritual goal is to "become Christian agents of transformation, to be forward-leaning team-builders as we strive with God to work with others in overcoming global warming in this great cause of freedom" (p. 318). "What can I do?" becomes "what can *we* do empowered by the Risen Christ?"

in Ball's vision. The thought that the goal is best pursued as part of a team in itself makes the situation more hopeful, but what provides concrete hope are the chapters that follow in which he describes how recently developed and soon-to-be-developed technologies for increasing energy efficiencies can really make a difference. Furthermore, he provides numerous examples of how governments, companies, and individuals have seized many of these opportunities, generally resulting in economic benefits as well.

This book provides an invaluable resource for believers and even unbelievers to try to grasp the potential for turning the corner on climate change. The multifaceted issue of climate change leads to a myriad of responses, and I doubt whether anyone would agree with Ball's approach on all points. But that is not what it is about, according to Ball. It is about going beyond just thinking about climate change or talking about it, and simply walking deliberately forward with the Risen LORD into a better future not so fettered by materialism, consumerism, and conventional ways of thinking about energy use.

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ETHICS

BONHOEFFER AND THE BIOSCIENCES: An Initial Exploration by Ralf K. Wüstenberg, Stefan Heuser, and Esther Hornung, eds. Frankfurt: Peter Lang, 2010. 183 pages. Hardcover; $57.95. ISBN: 9783631598450.

At first glance, the title *Bonhoeffer and the Biosciences* seems puzzling. What could a man who died over sixty years ago contribute to twenty-first-century discussions of biosciences and bioethics? There are two explanations. First, the book—the third in Peter Lang's *International Bonhoeffer Interpretations* series—is not really about Dietrich Bonhoeffer per se. Most of the essays do not present a thorough reading of his writings (two do not engage Bonhoeffer at all) and few interact critically with contemporary Bonhoeffer scholarship. Instead, the authors explore what they call "the hermeneutics of human life," built upon some keys themes drawn mostly from Bonhoeffer's *Ethics*, in order to frame theologically and ethically the discussion of various issues in the biosciences. As Hans Ulrich nicely puts it in the final chapter, "Bonhoeffer's texts will be primarily fruitful for our ethical work when we do not look for passages in Bonhoeffer's ethics which seem to be immediately relevant for solving moral dilemmas, but when we follow his descriptions of our human existence" (p. 170).

Second, the book does not aim primarily to propose specific solutions to current ethical problems in the biosciences. Its aim is less to teach us *what* to think about current issues than *how* to begin to address them in a way that takes seriously, and in an integrated way, the reality of God, the complexity of human existence, and the integrity of the biological sciences. This reflects Bonhoeffer's emphasis on the Incarnation as *the* event that unites the reality of God with the reality of the world in the person of Jesus Christ. Moreover, as the book's uniting theme, "the hermeneutics of human life," suggests, it reflects the authors' desire to offer not merely abstract principles or simplistic rules, but to prompt deeper ethical reflection based upon a "thick" theological account of human existence in the light of the Incarnation. Before we get to principles and rules, we need an interpretive framework in which they can be contextually and fruitfully employed.

The book comprises a foreword, ten chapters, an index, an appendix, and a descriptive list of the contributors. In the first chapter, Stefan Heuser introduces the book's overarching theme and foreshadows the topics to be discussed in the following chapters. In chapter 2, Christoph Rehmann-Sutter picks up on Bonhoeffer's discussion of the inter-relatedness of all human life and discusses the significance of interpretive decisions about the "beginning" of human life for issues such as stem cell research and IVF.

Next, David Clough (chap. 3) argues against claims that humans are distinct from animals to support ethical arguments. He criticizes Bonhoeffer's tendency to do this in *Creation and Fall* but applauds Bonhoeffer's relational interpretation of the image of God and his reflections on Christ becoming a creature. Clough feels this better affirms all of life, not just human life. However, in my estimation, he makes some questionable claims of Bonhoeffer's views, partly because Clough does not seem to consider Bonhoeffer's historical context in WWII Germany, and thus misses Bonhoeffer's polemical intent.

In chapter 4, Robert Song calls us to reject an idolatrous approach to technology that either views technology as the savior of the human condition or as helping us to become like God *apart from God*. Rather, we should find our likeness to God *in relationship with God* (Bonhoeffer's *sicut Deus* vs. *imago Dei*). Bonhoeffer helps us to avoid what Song calls "posthumanism" and leads us to develop an approach to technology that is more faithful and contextually concrete.

Bernd Wannenwetsch (chap. 5) applies Bonhoeffer's concepts of "responsibility" (in *Ethics*) and "loving the limit" (in *Creation and Fall*) in reflecting upon the delicate tension between patient autonomy and physician responsibility. In place of both "professionalism" and contractualism (focusing on rights, duties, liabilities, etc.), he emphasizes vocation and what he calls "total responsibility."

In chapter 6, Michael P. DeJonge employs Bonhoeffer's argument that "natural life is formed life" to clarify and integrate the relationship between rights and duties in patient-doctor relationships. In this perspective, formed life is both an end *and* a means, correspondingly involving both rights that protect basic dignity *and* duties that serve human purpose. Problems arise when these are separated. Regarding life exclusively as an end absolutizes life, leading to "vitalization" and a one-sided focus on individual rights and autonomy. Regarding life exclusively as a means leads to "mechanization" and a one-sided focus on the duties of individuals to uphold the "common good," whatever that may be. While Bonhoeffer faced the latter danger in his context, DeJonge argues that America presently struggles with the former.

Sigrid Graumann (chap. 7) reflects on the problem that "many disabled people feel discriminated by Prenatal Diagnosis" (p. 124). In dialogue with Charles Taylor, Axel

Honneth, and Nancy Fraser (but not Bonhoeffer), he seeks a more adequate analysis of the social problems linked with prenatal diagnosis.

In chapter 8, Heinrich Bedford-Strohm discusses the role of public theology in relation to biotechnology by reflecting on Bonhoeffer's assertion that the church is called to hold the state accountable when its policies are morally questionable. In order to fulfill this call, Bedford-Strohm argues that the church needs a threefold public discourse strategy: (1) an internal debate about the implications of biotechnologies; (2) an ongoing dialogue with key public figures such as scientists, politicians, and business leaders; and (3) input into public debate indicating both interest and wise reflection concerning fundamental societal questions.

Hans Ulrich (chap. 9) argues that understanding the human condition is the common task of science, hermeneutics, and ethics. No one discipline can claim exclusive ownership of bioethical questions. An interdisciplinary approach is necessary to account for the complexity of the human condition. In the concluding chapter, Ulrich again emphasizes the importance of viewing the human condition as a common field of description and interpretation for multiple disciplines. Where Bonhoeffer is particularly helpful is in providing us with an incarnational theological framework that takes seriously both God and the world, both the spiritual and the biological in the ethical task. Bonhoeffer offers us a "hermeneutics of human life" that can help integrate and orient our ethical questions.

Bonhoeffer and the Biosciences does not provide concrete answers to bioethical questions. Nor does it add significantly to contemporary Bonhoeffer scholarship or even hermeneutical theory. It probably will not attract a wide readership. It will be most helpful to scientists searching for a more nuanced theological framework that integrates theological and scientific knowledge in a way that genuinely respects the integrity and uniqueness of both.

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IS GOD STILL AT THE BEDSIDE? The Medical, Ethical, and Pastoral Issues of Death and Dying by Abigail Rian Evans. Grand Rapids: Eerdmans, 2010. 508 pages. Paperback; $29.99. ISBN: 9780802827234.

Most books written in this field are limited to addressing individual subjects. They lack the wider scope any practitioner will need. In this book, Abigail Evans, professor emerita of practical theology at Princeton Theological Seminary and scholar-in-residence at the Georgetown University Center for Clinical Bioethics, writes from a Christian perspective that draws from a variety of disciplines, cultures, and faith traditions to address a wide range of issues in medical ethics and pastoral care in end-of-life decisions.

Evans begins by providing an overview of the current medical, ethical, theological, pastoral, and legal landscape as it concerns end-of-life issues. As she works her way through this terrain, the complexities involved in addressing the needs and concerns of the dying become evident. Early on she establishes her basic assumptions, which include the sacredness and dignity of persons from conception to death. This dignity is rooted in the Divine, she argues, and it in turn gives rise to the sanctity of human life since each of us is made in God's image as an inviolate, unique person. She then turns her attention to the contemporary attitudes toward death in North America and shows how paradoxical these attitudes are. On one hand, we know death is inevitable and in certain circumstances, even welcome it, while on the other, we fear it and wish we could control it but know we cannot. Ultimately we have medicalized it, and thanks to improvements in modern technology and expertise, people today are dying more slowly than ever. However, even here our feelings are mixed because we also recognize the wonderful blessing modern medicine has been, how it has improved, enhanced, and even prolonged life. As an example of this, Evans notes the change in life expectancy in the United States: in 1950, it was 68.2 years; in 2006, 77.7 years.

She then moves into an area she describes as "negotiating death," a term she chooses to reflect the desire of people to retain control over their lives, including the choice of how and when to die. In this section, she sets out the difficult options many of us will face as death approaches. These include complex and expensive medical treatment, various types of euthanasia, heroic self-sacrifice, and physician-assisted suicide. A particular strength of this book is that Evans shows that decisions like these are not made in a vacuum. Rather, they need to be made within a framework of deeper questions, and here is where theology becomes important. It is the discipline that deals with ultimate meaning and purpose and thus can assist us in placing the end-of-life questions we face into perspective. When confronting these questions, we will be helped immeasurably by considering such deeper questions as the following: What is our view of death? How do we distinguish between the process of dying and the state of death? and How does death occur? These are meta-questions and Evans provides helpful explanations of a number of them. Here treatments include the views of such influential thinkers as Roman Catholic moral theologian Richard McCormick, ethicist Tristram Engelhardt, and Edmund D. Pellegrino.

Evans goes on to devote individual chapters to the issues of suicide (including physician-assisted suicide), organ donation, and specific legal questions. In each case she informs the reader of relevant background issues, actual cases, definitions of significant terms, statistics, and contending arguments. Her research is impressive and her knowledge of the discussion reflects a lifetime of immersing herself in these important concerns.

Perhaps the most welcome, albeit unusual, section of the book is section III entitled *The Experience of Dying*. Most books on this subject simply do not delve into the actual experience of dying, the pain, suffering, the knowledge of a terminal diagnosis, or the deep grief at the loss of a loved one. Here Evans' pastoral background becomes evident as she devotes three chapters to exploring this side of the question. They are both practical and informative and virtually all readers will find something there to inform their own journey. For example, she addresses the nature and sources of suffering, and argues that, whereas suffering can be a challenge to one's faith, God can use it

to accomplish good purposes. For example, there is such a thing as "good mourning."

In the final section, Evans builds on this information by turning directly to the intensely practical issue of pastoral care for those facing difficult end-of-life decisions. The issues treated range all the way from a consideration of various types of funeral services to the task of finding ways of giving meaning and hope to the dying.

This book could function well as a university or college text for bioethics courses dealing with end-of-life issues, a manual for practitioners such as physicians, nurses, and clergy, or even as a source of information for families who find themselves in the midst of difficult and traumatic decisions concerning a loved one. Families will especially appreciate the testimonies of people traveling the difficult journey at the end of their lives.

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CHANGING HUMAN NATURE: Ecology, Ethics, Genes, and God by James Peterson. Grand Rapids, MI: Eerdmans, 2010. 259 pages. Paperback; $18.00. ISBN: 9780802865496.

"The question before us is not whether we will shape nature and ourselves but whether we will be aware that we are doing so, and choose well how we do so and to what purpose" (p. 10). As James Peterson observes, we inevitably do shape nature and ourselves; *whether* to shape nature is not the question. Peterson wants us to be aware not only that we inevitably change nature but also that we are responsible to God for the changes we make. The first part of the book argues that God set human beings in the garden to "tend" it, to change it for the better. According to Peterson, human beings have the capacity and the calling to improve nature, including human nature, their bodies, and their genes. The rest of the book focuses on the question how we may "choose well": how to use the new powers of genetic intervention into human nature and "to what purpose." The book's conclusion is that if "an instance of genetic intervention is safe, a genuine improvement, increases the choice of the recipients, and [is] the best use of our finite resources, that genetic intervention may be an expression of our love of God, one another, and the rest of creation entrusted to us" (p. 240).

Human genetic responsibility, according to Peterson, will not be well guided by any romantic suspicion of technology. Nor will it be well guided by prohibitions of "enhancement," of "making children," or of germ-line genetic interventions. It is the burden of the second part of the book to undercut these prohibitions even as it acknowledges that the common distinctions between cure and enhancement, between begetting children and making them, and between somatic gene interventions and germ-line gene interventions can provide helpful cautionary advice.

In the third part of his book, Peterson proposes instead the four guidelines captured in the book's conclusion: (1) genetic interventions must be safe; (2) they must yield real improvement; (3) they must provide increased choice for the recipient; and (4) they must be the best use of finite resources. He acknowledges that these guidelines are not always clear and that different people will see their meaning and application differently. They are, nevertheless, defended as consistent both with Micah 6:8 and with the "Georgetown mantra." Micah's admonition to "love kindness" is taken to entail the requirements of safety and genuine improvement; to "walk humbly" is taken to entail a concern to maximize the freedom of the recipients; and to "do justice" is taken to require the best use of finite resources. That seems to me to be a "thin" (and unlikely) account of Micah 6:8. It is a good deal easier to see the connection of Peterson's four guidelines to the four principles of the Georgetown mantra, "nonmaleficence, beneficence, autonomy, and justice." Along the way, Peterson suggests two other guidelines, namely, that changes wrought by genetic intervention be incremental and reversible. These may be entailed by safety and maximizing freedom, but they are important, and it is regrettable that they are not given the same prominence of the other four.

Because different people can and will interpret and apply these four standards differently, Peterson turns in the final part of the book to the question concerning whose interpretation and application should trump that of others. Peterson wants many people to have a voice in the conversation, but the choice, he insists, must finally belong to those who would receive the genetic intervention (or their parents) "within those limits so universally felt by society to be required" (p. 236).

There is much to ponder in this book. There is much that challenges not only commonplace distinctions but also influential theological positions. (Paul Ramsey, for example, is the most frequently cited author, and Peterson usually disagrees with him.) As an invitation to think again about genetic interventions—and to think about genetic interventions theologically—the book is a welcome addition to the literature. But there are, I think, some serious problems.

One problem Peterson himself identifies as the problem of "thin and thick" accounts of the moral life. Peterson acknowledges that the principles of the Georgetown mantra are "thin" (pp. 164, 225–26), that is, that they are abstract principles susceptible to quite different interpretations. And he declares his intention to provide a "thick" account of the moral life, indeed, a theologically "thick" account, a "theocentric" account. The problem is that he does not make good on that promise; it remains a "thin" account. The Georgetown mantra seems to control the argument.

A related problem is that Peterson gives a "thin" account of the cultural context for decisions about genetic intervention. So, for example, although he cites Gerald P. McKenny's *To Relieve the Human Condition*, he does not attend to the influence that "the Baconian project" (as McKenny calls it) has on our cultural imagination. Indeed, Peterson seems to share that project's confidence, that technology brings human flourishing in its train. Accompanying that enthusiasm for the technological mastery of nature, there seems to be an uncritical adoption of the project of liberal society with its confidence that "maximizing choice" provides the solution to moral diversity. The advocacy of "control" and "choice" is a commonplace of "thin" bioethics, of standard bioethics, but one might expect something more from a "thick" and theocentric account.

One might also quarrel with some of the particular moral judgments defended by Peterson. For example, his discussion of preimplantation genetic diagnosis acknowledges that the moral status of the embryo is a "crucial but controversial point." But his discussion of the status of the fetus is brief and not altogether persuasive. Perhaps that is why he hedges his conclusions here with hypotheticals: "*If* an embryo is not yet a fellow human being, it can be set aside without the loss of any existing person," and "*If* an intervention occurs before a fellow human being is present and helps the person who later does come to be, then it is safe, and by that standard welcome" (pp. 167, 169, italics added). But when he returns to the question of preimplantation genetic diagnosis, it is parental "control" and "choice" that are celebrated (p. 183). He does, in this context, call attention to the moral importance of an "open future" for our children as a (or the) criterion for "improvement," and he uses that criterion to question decisions to select for deafness. But that criterion, too, is pretty "thin," allowing Peterson to conclude, "If genetic intervention and competition combined to bring forward surgeons with unusually precise and steady hands, that would bless them and their patients" (p. 189). One may wonder whether parents who made a child in order to be such a surgeon would really provide an "open future" for the child. And one may wonder as well what would prevent parents from the conclusion that a more "open future" might be secured for their child in their culture if they select for males.

To identify one other quarrel with his particular moral judgments, Peterson evidently regards the use of donor gametes in artificial reproductive technologies as a morally trivial matter. He defends this judgment by rendering the biological role of parent as itself a trivial matter, reducing that role to "gene sources" (p. 140) and insisting that the social role of parent is the only role that qualifies one as a "parent." Leave aside the question of the "bad faith" of inviting a gamete donor (or vendor) to treat a biological relation as trivial for the sake of some biological relation to the child conceived by donor seed and the seed of either mother or father. This trivialization of the biological role of parent does not comport with his own recognition of, for example, paternity laws or the common recognition of other responsibilities of biological parents. Let this be a rule: we should not beget without an intention to care for the begotten. The deliberate sundering of the biological role and the social role of parent threatens to reduce the body to mere biology, subject to the control and manipulation of the "real" person with their capacities for rationality and choice. And when Peterson later calls for parental choice and control, if "parent" simply means the social role, he risks the commodification not only of the donor gametes and the embryo but also of the donor himself or herself.

To be sure, there are cautionary words in Peterson's work, especially against genetic reductionism. And to be sure, there is much here to prompt and to reward reflection about genetic control. But it is, on my reading, a "thin" account in spite of its declared intention. It should be read in conversation with some of the literature with which it disagrees, not only Ramsey but also, for example, Oliver O'Donovan and Gil Meilaender.

Reviewed by Allen Verhey, Professor of Theological Ethics, Duke Divinity School, Durham, NC 27708.

MATHEMATICS

THE DRUNKARD'S WALK: How Randomness Rules Our Lives by Leonard Mlodinow. New York: Vintage Books, 2009. 252 pages. Paperback; $15.00. ISBN: 9780307275172.

Mlodinow begins in the prologue and first chapter by demonstrating several situations in which human intuition about probability can be misleading while hinting strongly at the conclusions he will make more explicitly at the end of the book. Having established a need for careful thinking about random events, the author uses several chapters to "present the tools needed to identify the footprints of chance" (p. xi).

While there is nothing new in this probability primer for anyone who has (correctly) learned basic probability, the discussion of the rules of probability is very well written. The style is casual, the stories are engaging. We are introduced to important historical figures, including Fermat, Descartes, Pascal, and Bayes, and to many contemporary situations involving probability: playing the casino, Marilyn vos Savant's Monty Hall Problem, Roger Maris's 61 home-run season, life insurance, and the O. J. Simpson trial, among many others. Furthermore, despite the casual approach, the explanation is precise and careful. The important assumption of independence is duly emphasized where needed, for example, and scenarios in which independence fails are also presented. (Unfortunately, Mlodinow relies on the reader's intuition or previous understanding to know just what independence means—a small weakness in an otherwise masterful presentation.)

Having introduced the fundamentals of probability, Mlodinow turns his attention to statistics, which he views as the inverse problem to probability. Whereas probability quantifies the chances of various occurrences given the "rules of the game," statistics seeks to infer the rules of the game from observed data. The treatment of statistics is briefer and less technical than the discussion of probability, but suffices for the purposes at hand. These include the discovery (by Quételet and others) that "the patterns of randomness are so reliable that … their violation can be taken as evidence of wrongdoing" (p. 156) and that the importance of statistical reasoning will counterbalance our natural tendency for confirmation bias.

In the final chapter, which bears the same title as the book, Mlodinow argues "that in all but the simplest real-life endeavors, unforeseeable or unpredictable forces cannot be avoided, and moreover those random forces and our reactions to them account for much of what constitutes our particular path in life" (p. 195). This argument is supported by a number of historical anecdotes ranging from the events leading to the bombing of Pearl Harbor, to the rise in celebrity of Bruce Willis, to the wealth of Bill Gates, to stock market performance. More interestingly, the argument is supported by reference to several cognitive psychology experiments designed to reveal how humans behave in situations involving randomness. Mlodinow's story is a cautionary tale, exhorting his readers not to overinterpret chance occurrences in their own

lives or in the lives of others, but to correct the natural biases humans have to equate success with ability and failure with inability, to infer rules from perceived patterns, to judge decisions by the particular result that occurred rather than by the spectrum of outcomes that might have resulted, to place more weight on expectations than on evidence, and to attempt to understand all situations in terms of cause and effect.

Mlodinow is a scientist writing for a popular audience, so those looking for a deep philosophical or theological treatment of randomness will need to look elsewhere. But no one should do so without a thorough understanding of the issues discussed in this book, which provides an accessible and enjoyable introduction that is technically sound. Furthermore, the ample references to the primary literature (16 pages worth) provide pointers to additional reading, and the well-constructed index assists in locating the numerous historical and contemporary vignettes.

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Origins & Cosmology

SCIENCE, CREATION AND THE BIBLE: Reconciling Rival Theories of Origins by Richard F. Carlson and Tremper Longman III. Downers Grove, IL: InterVarsity Press Academic, 2010. 141 pages. Paperback; $16.00. ISBN: 9780830838899.

Now and again I come across a book that strikes me for the strategy of its argument. The issue of evolution within evangelical circles continues to be a controversial issue, and physicist Richard Carlson and Old Testament scholar Tremper Longman offer a gentle and academically credible introduction to this volatile topic. This is a short book and does not engage all the topics in origins, but it offers just enough information to captivate evangelicals into reconsidering traditional readings of biblical creation accounts and also the possibility of evolution.

This book assumes the credibility of the modern evolutionary sciences and offers a brief outline of cosmic and biological origins (pp. 27–32). The core focuses on the hermeneutics of Genesis 1 and 2. The authors endorse a "high view" of Scripture as outlined in the 1978 Chicago Statement on Biblical Inerrancy (pp. 15, 35). Their main thesis argues,

> The first two chapters of Genesis, which accurately present two accounts of creation in terms of ancient Hebrew scientific observations and their historical understanding, are neither historical nor scientific in the twenty-first-century literal sense. Instead, the underlying message of these chapters applies for all time and constitutes a complete statement of the worldview of the Hebrew people in the ancient Near East. (p. 14)

The notion that Genesis 1 and 2 include an "ancient Hebrew understanding of science and history" is a novel yet critical concept that assists Christians to step away from concordism and the evangelical tradition of looking for scientific and historical facts in Genesis (pp. 17, 59, 69, 122, 126, 130–1).

To defend their hermeneutical thesis, Carlson and Tremper begin by underlining the fact that truth can be delivered using nonliteral accounts. They offer a courageous and sensitive exposition of the literary genre of myth (pp. 59-61), followed by examples of well-known Christian storytellers; e.g., Tolkien. In addition, Carlson and Tremper appeal extensively to Peter Enns' incarnational hermeneutic (pp. 69–72). Since Jesus is fully God and fully man, so too they argue that the opening chapters of Genesis are both divine and human. In other words, Scripture is accommodated to its ancient audience (pp. 16, 123). One of the best features of this book are the chapters dedicated to the concept of creation outside the Genesis accounts: Isaiah, Proverbs, Job, Psalms, and the New Testament. In these contexts, the emphasis is not on the details of how God created, but that the creation contributes to worship, encouragement, and Christology.

Though this book argues against concordism, it nevertheless slips in places. Carlson and Tremper contend that the creative events in Genesis 1 and 2 "have taken place in a definite historical order. These Genesis accounts depict real history and real science" (p. 120). This is simply not true. For example, the fossil record reveals that flowering plants (creation day 3) do not appear before animal life (days 5 and 6), nor do birds (day 5) precede land animals (day 6). In addition, the authors embrace the historicity of Adam (pp. 122–3) and the cosmic fall (pp. 100–1), failing to identify that Adam reflects an ancient understanding of origins (*de novo* creation) and the cosmic fall, the ancient motif of the lost idyllic age.

Despite these minor inconsistencies, I highly recommend this book, especially as an introduction to assist evangelicals in coming to terms with evolution and moving beyond concordist interpretations of the opening chapters of Scripture.

Reviewed by Denis O. Lamoureux, Associate Professor of Science and Religion, St. Joseph's College, University of Alberta, Edmonton, AB T6G 1H7.

Religion & Science

WHEN FAITH AND SCIENCE COLLIDE: A Biblical Approach to Evaluating Evolution and the Age of the Earth by G. R. Davidson. Oxford, MS: Malius Press, 2010. 288 pages, index, four standard translations of Gen. 1–2, footnotes. Paperback; $12.50. ISBN: 9780982048603.

Davidson's background as a geology professor and member in a conservative denomination provides the foundation of the book. He affirms a commitment to the inspiration and infallibility of the Bible, the reality of miracles, and the existence of a literal Adam and Eve in a garden until the advent of original sin. The book thus has a much better chance of getting a hearing with conservative audiences than arguments that reject any of those convictions.

He introduces three basic considerations in dealing with an apparent point of conflict between the Bible and science: Does the infallibility of Scripture rest on a literal interpretation of the passage? Does the science conflict with the intent of the passage? Is the science credible?

The rest of the book sets out to address these questions, concluding that a rigidly literalistic scientific interpretation of passages is generally incorrect, that old earth and evolutionary science is not in conflict with the intent of the Bible, and that old earth and evolutionary science is credible, whereas arguments against an old earth or against evolution are generally not credible. Some harmonizing speculation is clearly identified as such. An opening scenario of an ineffective attempt at evangelizing a scientist is matched with a closing appeal not to be a stumbling block. The footnotes provide good documentation for a reader interested in digging further.

The text is well written, with explanations designed to make technical details accessible to a nonscientist. There are very few typos or similar errors, and with print on demand, they are quickly fixed, so a new copy should already correct the few that I spotted. The illustrations are of good quality and illustrate the concepts well. Overall, the book is well suited for a theologically conservative, nonscientist audience.

Reviewed by David Campbell, Paleontological Research Institute, Ithaca, NY 14850.

DARWIN'S PIOUS IDEA: Why the Ultra-Darwinists and Creationists Both Get It Wrong by Conor Cunningham. Grand Rapids, MI: Eerdmans, 2010. 543 pages, notes, index. Hardcover; $34.99. ISBN: 0802848389.

Richard Lewontin once wrote that "a great deal of the body of biological research and knowledge consists of narrative statements."[1] Conor Cunningham, in his new masterpiece, sets out to expose the tacit narratives and the ideological commitments of two great camps in the science and religion dialogue: the ultra-Darwinists and the creationists.

In the first chapter, "Introducing Darwinism—the Received View: Disenchantment," Cunningham outlines Darwin's theory of evolution through a historical and philosophical lens. He recounts the oft-told story of how Darwin completed the supposed loss of human dignity begun with the discoveries of Copernicus and Newton, and then he traces how the disenchantment of nature became entrenched in biological orthodoxy. Outlining the ideological twists and turns of Darwin's theory, the author introduces the reader to several of the main themes that run throughout the book: the problems of essentialism, gnosticism, and reductive materialism. All of these have wound their way into the heart of our essential understanding of the world. Cunningham then challenges these assumptions, asking, "who told you that you were *merely* material or, more importantly, that *matter was mere?*" (p. 23). If the received view from biology is that the world is disenchanted, Cunningham brings the reader on a journey to rediscover just how enchanted, or supernatural, the world really is.

The second chapter, "Units of Resurrection," immerses the reader in the debate of nominalism vs. realism. If natural selection directs evolution, at what level does it select—at the level of genes, of individuals, of groups, or something else entirely? The author shows how the ultra-Darwinists seek to reduce people down to basic dualisms (replicator/vehicle or genotype/phenotype), thereby divesting humanity of any sense of self or personhood. The result is a total ontological nihilism that consumes all meaning in the world. Instead, Cunningham argues that we ought to embrace models of evolution which center around the fundamental reciprocity found in nature. Altruistic models are able to give meaning to higher levels of biological emergence and explain realities that are simply not reducible to genes.

The conclusion of nonreducibility leads straight into chapter three, "Unnatural Selection," in which Cunningham seeks to slay another sacred cow of biological orthodoxy: the primacy of natural selection. While selection (at whatever level) is certainly active in evolution, Cunningham criticizes the ideological commitment that sees natural selection as "all-powerful" in evolutionary development. Natural selection, he argues, cannot account for the formation of traits, and standing alone, it is insufficient to explain the generation of novelties. To do this, we must widen our scope and allow other phenomena, such as occurrences of homology, convergence, and modes of extragenetic inheritance, to shape our understanding of natural selection's role. Indeed, he states that "we must no longer think of natural selection as creative. Rather, it is merely a matter of sorting, much like an editor instead of an author" (p. 105). The compulsion that biologists feel to point at a phenomenon and say, "Natural selection did it" is compared to the creationist who explains the world by saying, "God did it." Both are scientifically vacuous. It is high time, says Cunningham, for biologists to leave behind their ideological commitment to reductionism (driven by physics envy) and admit that natural selection as *the* primary shaper of the natural world is simply insufficient for the complexities of modern biology.

The fourth chapter asks if evolution can make sense of teleology. Cunningham insists that progress is not scientific heresy, but instead, that life is "written into the fabric of the universe" (p. 146). It is only those with ideological hobby horses who attempt to reduce the emergent properties of nature, such as mind and consciousness, and thereby discredit them from value. If life is intrinsic to matter, then meaning returns to the process of evolution. Cunningham shows how a view of rational nature is coherent only within a truly Christian understanding of the cosmos—a view that also leaves humans as distinct from the animal realm through emergence. By reorienting our perspective of creation, God becomes the perfectly natural one, and all creation is derivatively supernatural.

"Matter over Mind," chapter five, unpacks sociobiology and evolutionary psychology which try to make Darwinism a "theory of everything." In Ultra-Darwinism, all morality is relativized, and therefore becomes nonexistent. Cunningham alternately proposes that accepting irreducible emergence allows for the embrace of morality and ethics. A world that rejects dualism and gnosticism is the only worldview in which freewill, and a self to exercise that freewill, actually exist! Instead, human nature is an emergent property that cannot be explained by evolutionary psychology. It is, according to Cunningham, a transubstantiation of being that cannot be reduced.

Chapter six, "Naturalizing Naturalism," wages an all-out war on reductive materialist views. Interestingly, Cunningham includes a short but brilliant critique of

intelligent design here, demonstrating how the movement actually buys into the very reductive philosophies it claims to oppose, and limits the God it seeks to uphold. This longest chapter continues with discussions of many different topics, but argues throughout that any science that claims sole metaphysical veracity will eventually self-destruct. Instead, notions of truth must be expanded to include elements like trust and love. Quoting Gregorious, Cunningham says, "divorced from love and wisdom, science/technology becomes an enemy of humanity" (p. 301).

In the final chapter, "Another Life," Cunningham sets out a theological argument for seeing Christ as the cornerstone of creation. Drawing on various ideas, from the Patristics and Mystics (Gregory of Nyssa, Origen, Irenaeus, Meister Eckhart) right up to the advocates of *Nouvelle Théologie* (de Lubac and Balthasar), he shows how Christ is the fulfillment of the creation narratives. A Christological reading of Genesis, he claims, releases us from reading the creation narrative as a literal, historical event and challenges our traditional views of original sin, death, and salvation. Christ becomes the only Adam, leaving the question of evolutionary origins open and restoring the lost enchantment to the world through a sacramental understanding of the cosmos.

Cunningham's writing is fresh and provocative. He draws on an impressive range of sources, from Monty Python and Shakespeare to the most eminent biologists. The book is massively well researched and represents the cutting edge of discussion in various fields, ranging from psychology to genetics to theology, yet the scholarship does not stiffen the book. While the book is science-heavy, it is accessible to the careful layperson: the writing is rife with similes and engaging examples that help make difficult concepts clear. His analysis of Dawkins' philosophy of science is searing, and his portrayal of modernist ideology in both the ultra-Darwinist camp and the creationist camp is incisive.

Darwin's Pious Idea is already being hailed as one of the most important books of the year by Christopher Benson in *First Things*, and it has received high acclaim from top academics in various fields, such as Holmes Rolston III, Ian Tattersall, David Livingstone, and David Bentley Hart. It will take longer, though, to see if Cunningham's ideas—his biological and theological narratives—will fly or fail in the testing ground of time. For now, however, this book is a must read.

Note

[1]Richard Lewontin, "Facts and the Fictitious in Natural Sciences," *Critical Inquiry* 18, no. 1 (1991): 143.

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THE CONSTANT FIRE: Beyond the Science vs. Religion Debate by Adam Frank. Los Angeles, CA: University of California Press, 2009. 267 pages, notes, index. Paperback; $17.95. ISBN: 9780520265868.

Drawing heavily on the classic William James book, *The Varieties of Religious Experience*, Adam Frank, professor of astrophysics at the University of Rochester, explores the shared properties of science and his word for religion, "human spiritual endeavor" (p. 5). Frank describes himself as a "believer" and what he deeply believes in is "the path and practice of science" (p. 3). In short, Frank is an atheist who is also a spiritual person. A better word to describe him is "nontheist," as the word "atheist" now carries too much baggage.

Given Frank's different worldview from ASA members, is there reason to read this book? The answer is "yes," on two counts. First, it acquaints the Christian reader with a person with whom one can have a profound disagreement and yet respect. Second, it exposes one to an honest nontheist who honestly considered the many stories told by people who have had personal spiritual experiences. Frank points out that these simply cannot be glossed over as coincidences or hallucinations, but must be taken seriously as a part of a body of evidence of something. He writes, "There is … some truth discovered, that is more than simple neurochemistry gone amok" (p. 7). He asserts that he, himself, has had such experiences, some closely connected to his life as a scientist.

Frank's book is most interesting; it is an easy read for those not annoyed by a clash of philosophies. Frank chooses to describe spiritual experiences, both religious and scientific, as "heirophanies," a word first coined by Eliade (p. 81). This allows him to account for reports of religious experiences without having to think of a divine person. This is, of course, a classical "nothing buttery" argument and is unlikely to impress a person who has had a genuine theophany. In my opinion, however, Frank is blowing his dusty horn in a closed room, unaware of a world beyond his vision.

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C. S. LEWIS ON THE FINAL FRONTIER: Science and the Supernatural in the Space Trilogy by Sanford Schwartz. New York: Oxford University Press, 2009. xvi + 240 pages, appendix, notes, bibliography, index. Hardcover; $27.95. ISBN: 9780195374728.

In *C. S. Lewis on the Final Frontier*, Sanford Schwartz has proposed a bold alternative interpretation of Lewis's three science fiction novels. Rather than interpreting the Ransom trilogy as a clash between religious and naturalistic points of view, Schwartz argues that the stories should be read as a much more complex clash "between 'archetype' and distorted 'copy'" (p. 17). Schwartz also argues that even though the Ransom trilogy may have commenced without a master plan, it concludes as an integrated and systematically arranged series. Schwartz sees in the novels the use by Lewis of a literary device Northrop Frye described as an Augustinian strategy to accuse one's opposition of derivative doubling that merely bears a close resemblance or imitation of the real thing. Through his interpretation, Schwartz seeks to make the case that Lewis sought a critical engagement of philosophical interpretations of modern science rather than an antithetical conflict between religion and naturalism.

His argument depends upon three premises that he discusses throughout the book. First, the three novels share a common structure. Second, they describe a developmental paradigm for the modern evolutionary model that

moves "from the 'materialist' assumptions of the first story to the presumably higher 'organic' or 'vitalist' level of the sequel, and then mutates once again into a 'spiritual' principle in the finale" (p. 7). Third, the "providentially governed communities" associated with Ransom represent a "transfiguration" of the phase of the evolutionary model that they oppose.

In his discussion of *Out of the Silent Planet*, Schwartz attempts to demonstrate that Lewis has points of common agreement with the opposing ideas in his novels. Though Lewis critiques the materialistic vision of H. G. Wells, Schwartz argues that Lewis had appropriated much of Wells, including Wells' critique of Western imperialism, racism, nationalism, and disregard for other species. He suggests that the ritual hunt between the *hrossa* and the *hnakra* suggests the common ancestry of the two species and a shared instinct for "mutual challenge" (p. 39). He also finds symbolism to support his thesis such as his suggestion that the Fixed Land of *Perelandra* represents a "surrogate eternity" that offers the Green Lady an escape from "the disappointment and terror of an uncertain world" (p. 72). Actually, the Fixed Lands only represent Fixed Lands. The Green Lady faced no disappointment and terrors of an uncertain world. The floating islands eventually take her to the one Fixed Land where she would find her husband.

In his treatment of *Perelandra*, Schwartz argues that Lewis does not really present a stark contrast between "Christianity and the evolutionary or 'developmental' tendencies of modern thought" (p. 53). Instead, he has built a world whose primary features are based upon a philosophy of continuous flux and perpetual development. Schwartz claims that "Lewis envisions a world in which Becoming is the originary principle and the Creator, who 'never repeated Himself' … has endowed the creation with the potential for perpetually new and spontaneous development" (p. 54). This interpretation sounds much too Aristotelian for Lewis who abhorred "the philosopher of divisions." Schwartz discusses at length Henri Bergson's theory of the élan vital found in *Creative Evolution,* which provides a middle position between religious and naturalistic points of view. Schwartz makes the case that because the young C. S. Lewis appreciated Bergson's ideas of energy and fertility in his youth before becoming a Christian, then *Perelandra* represents Lewis's acceptance of Bergson's vision. Schwartz calls this appropriation a "transfiguration" that involves a redemption of Bergson's position (pp. 63–4). Schwartz's approach appears to be more a case of reader response in which he sees what Lewis did not include in the narrative.

Schwartz's strongest argument against a clear-cut distinction between the religious view and the naturalistic view comes with the third Ransom book, *That Hideous Strength*, in which N.I.C.E. seeks to combine science and the occult. The popular literary device of "doubling" marks much of Schwartz's commentary with doubles formed by Merlin and the tramp, the experiences of Mark with N.I.C.E., and Jane with St. Anne's, Ransom and Wither, and so forth. To advance his thesis, however, Schwartz refers to Ransom's headquarters at St. Anne's as "original" in relationship to the headquarters of N.I.C.E. at Belbury which is merely "the monstrous distortion" (p. 121).

While Schwartz presents an intriguing theory, he fails to take note of the sources for much of Lewis's material. Schwartz does not seem to appreciate that Lewis was a medievalist who did not use modern cosmology or philosophy as his frame of reference. All three books in the Ransom series borrow the medieval conception of the relationship between matter and spirit that made sacramental theology possible. Schwartz attributes Lewis's interest in time and change to Bergson without seeming to realize the extent of the medieval debate over the positions of Plato and Aristotle on these issues. Lewis cannot be understood apart from his first great scholarly work, *The Allegory of Love*, in which the battle between opposing forces lies at the heart of the matter. Schwartz betrays his unfamiliarity with the conceptual world of Lewis on page four with a reference to the cover of *Time* magazine, where Lewis appears with a "pitch-forked tempter" while the "protective wing of a dove" intrudes from the side. The unseen figure that fits medieval allegory is an angel, not a dove. This failure to recognize actual doubles runs throughout the book beginning with the title, for the book is not about "science and the supernatural." Lewis never confused science with philosophy.

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RECONCILING THE BIBLE AND SCIENCE: A Primer on the Two Books of God by Lynn Mitchell and Kirk Blackard. Charleston, SC: BookSurge Publishing, 2009. 266 pages. Paperback; $18.99. ISBN: 9781439240090.

This book intends to address the presumed controversy between God's two books, the book of Scripture and the book of nature, the Bible and science. The authors claim that while the current debate is real, the conflict is only apparent, for faith in God and an acceptance of science are compatible. They write, "Christianity and modern science can co-exist" (p. 13), "if we avoid unwisely mingling or confounding the Bible and science" (p. 145). Thus, the authors' purpose is to reconcile them without confusing them, lest Christians become "de-facto agnostics" or fail to appreciate all that science contributes to our understanding of the universe and its inhabitants. To reconcile the Bible and science is to employ them for different ends. Mitchell and Blackard stress that science can explain how the universe and life developed, but not what life means. The Bible explores the meaning of life sustained by a creator God, but it was never intended to be a science book. It is a book of theology, a collection of documents, each comprising various genres that must be read in the "context of the times and purpose for which it was written" (p. 14).

The statement that "the Bible is not a science book" has become a mantra for me since I recognized that the Bible was not intended to address issues that specifically concern people with worldviews shaped by technology. *Reconciling the Bible and Science* is an effort to stimulate this sort of recognition in its readers by tracing the history of scientific discoveries and the too often lamentable conflict that has been triggered with some Christians. This conflict is based on the literalistic view that the Bible presents accurate science and history at every point. When science reveals something different about the world from how

these Christians interpret a particular text, they perceive science as anti-Scripture and anti-God.

In contrast, *Reconciling the Bible and Science* provides a context for how both books of God should be embraced by believers. It reveals how the philosophical contributions of Plato, Aristotle, Augustine, and Aquinas underpin modern science as well as religious concerns among current creationists, the intelligent design movement (ID), and theistic evolutionists (chaps. 1–2). The book then traces the history of modern astronomy through Copernicus, Galileo, and Newton (chap. 3) before focusing on Charles Darwin and his successors in the field of biological evolution, who have verified, corrected, and expanded upon many aspects of his theory (chaps. 4–6).

The book proceeds to identify the roots of the current debate between those fearful of science because of their faith and those disdainful of religion on account of science, effectively defining important terms such as "falsifiable," "theory," and "myth." The authors then trace the more recent history of the controversy through the court cases involving attempts by ID to place its curriculum in public schools. While the authors agree that God is the intelligent designer behind the universe, its great age, expansion, and the evolution of its inhabitants, they are not convinced that ID is science (p. 248). The authors treat fairly both scientific creationists and ID with whom they disagree, showing how some within those camps have a nuanced acceptance of scientific discoveries, such as the age of the universe, while still attempting to find science in the Bible and to build upon it (chaps. 9–10).

Mitchell and Blackard reveal early on their stand with theistic evolutionists, and then demonstrate why in Part II (chaps. 11–14). Although they are sympathetic to Stephen Jay Gould's "non-overlapping magisteria," they prefer theistic evolution's recognition of God as the creator who works through evolution (p. 145). They believe the latter involves more dialogue between "scriptural revelation and the testimony of the created universe" (p. 149). They boldly assert that biblical literalism "turns attention away from the central religious concerns of the Bible's authors. Much religious language was not intended to be read literally …" (p. 172). Indeed, to expect the ancient Scriptures to reveal or to be concordant with modern science is a cheerless failure of the imagination.

Knowing when, where, and how the perceived science-theology conflict arose and mutated is crucial to realizing that the conflict does not have to be. Nonetheless, some readers may find tedious the sheer length of material leading to the discussion of biblical interpretation in chapters 12–14. The material in chapter 12, which includes the section "Reading the Bible for what it is," could have come much earlier in the book.

Also, the authors may have feared that further citations would have made *Reconciling the Bible and Science* less accessible, but readers would benefit by more of them, as well as a short list of resources for further study at the end of each chapter. For example, what is the textual evidence for their claim that, at the beginning of the seventeenth century, people began to see the Bible as an infallible source of information about science, and that the Bible had been "dictated" by God? (p. 49).

I have a few other quibbles. The authors repeat that the purpose of the biblical creation stories is to oppose polytheism (p. 25), but the accounts have other functions. They are etiological; they explain the world as we see it—farming, marriage, shame and modesty, the trials of parenting, and adversarial relationships between spouses and between brothers. Regarding the order of the Hebrew Bible, the authors assume that Malachi is the last book and that between Malachi and Matthew were "silent years" (p. 23). Actually, Chronicles is the last book in the Hebrew Bible and 400 BC to 0 were anything but silent in terms of Jewish literature. Daniel was, in fact, written during these years, and seemed for a time to reside in the prophetic division. In addition, regarding the New Testament canon, Mitchell and Blackard claim that "Marcion began the process," but this gives him too much credit. Scholars of the New Testament canon know that Marcion created a canonical list around AD 140, but most of the books of the New Testament were already being transmitted as authoritative at that time, or else Marcion would have had no books to excise from his list, even though, as they note, a list identical to the present New Testament is not found until the late fourth century.

All in all, I recommend this book to all who cannot ignore the wonder of God's universe as revealed through science; who are convinced that Scripture permits us to hear how our ancestors in the faith met God; and who recognize that it is the means by which our walk with God is illuminated.

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Letters

Humans: The Supernatural in Nature

Michael L. Peterson, "C. S. Lewis on Evolution and Intelligent Design," (*PSCF* 62, no. 4 [2010]: 253) presents a comprehensive study of C. S. Lewis on the theory of evolution, the argument from intelligent design, and how Lewis would distinguish the philosophical arguments for a Transcendent Mind from the current claims of the intelligent design (ID) movement.

The central issue in all arguments and discussions regarding the scope of science is based on the distinction between the notions of methodological naturalism in science from those of philosophical naturalism. Methodological naturalism is the scientific approach of restricting the explanation of *natural phenomena* to *natural causes*. Philosophical naturalism, on the other hand, is the metaphysical view that nature alone is real, that the supernatural does not exist. However, it is not often clear what one means by "natural phenomena" and "natural causes." For instance, is human reasoning a natural phenomenon based on natural causes? Lewis considers human reasoning to be supernatural.[1] Therefore, it seems that methodological naturalism presupposes physicalism, which can only deal with the physical aspect of human beings, and so can never give a complete description of what a human being is.

Note that physicalism implies that purely physical devices can collect, in principle, all the data that form the assumed reality. Therefore, methodological naturalism equates the real with the physical. Of course, what is real ought to be the totality of all that can be "detected" directly by human beings together with data collected with the aid of purely physical devices, the latter data encompassing only the subject matter of science and not the whole of reality.

In evolutionary theory, one applies the results of the experimental sciences to construct a temporal development, connecting cosmic evolution and biological evolution supporting the appearance of human beings. However, it is hard to understand how Lewis would subscribe to such a theory that leaves out the true essence of human beings, namely, their ability to "detect" God, which is Lewis's "argument from reason." The "detection" is based on the supernatural nature of human reasoning in which the inferior supernatural being "detects" the infinitely superior supernatural Being. Purely physical devices cannot accomplish that. Accordingly, one can do experimental science and develop theories summarizing the data without invoking God; however, the true nature of humans, who are the doers of science, will remain hidden from studies that assume methodological naturalism.

Peterson indicates, "ID views itself as reviving and updating the eighteenth-century argument for God which assumes that science can discover traces of a designing intelligence in the natural world" (p. 256). The enterprise of science involves using collected physical data together with prior information that allows humans to make Bayesian inferences. Of course, if one begins with physical data, then such inferences relate to the physical aspect of reality only and not to the supernatural aspect. The whole of reality, that is nature, involves, in addition to the purely physical data, nonphysical data "detected" by humans. Note that human (supernatural) reasoning is used to make scientific inferences from purely physical data, that is, the doing of science itself requires the supernatural.

It is clear that attempts to answer questions of what constitutes nature must be based on the kinds of knowledge one uses to make sense of the whole of reality. William Oliver Martin characterizes kinds of knowledge as being autonomous or synthetic.[2] The latter are reducible to two or more of the autonomous (or irreducible) kinds of knowledge. Martin considers six autonomous kinds of knowledge: history (H), metaphysics (Meta), theology (T), formal logic (FL), mathematics (Math), and generalizations of experimental science (G). Metaphysics and theology constitute two domains of the ontological context. Martin indicates the role that autonomous kinds of knowledge play in synthetic kinds of knowledge, namely, instrumental, constitutive, and/or regulative. For instance, historical propositions are constitutive of G, metaphysical propositions are regulative of G, and propositions in formal logic and mathematics are instrumental to G. Theological propositions are not related to G.

Notes

[1]C. S. Lewis, *Miracles* (New York: The Macmillan Company, 1971), Appendix A.

[2]William Oliver Martin, *The Order and Integration of Knowledge* (Ann Arbor, MI: The University of Michigan Press, 1957).

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Taking Neuroscience Seriously

Mihretu P. Guta accuses me of neuroscientism, claiming that I assert that the proper knowledge of human nature is only attainable via neuroscience (*PSCF* 63, no. 1 [2011]: 69–70). This was most certainly not the intention of my article ("Peering into People's Brains," *PSCF* 62, no. 2 [2010]: 122–32), and I am surprised that he considers this to be my position. More importantly though, we cannot dismiss neuroscience and the role of the brain in human life as readily as Guta does. The thrust of the developments outlined in my article is that neuroscience, in some circumstances, is beginning to claim that it can provide something akin to first-person descriptions. The adequacy of these is a matter for debate, and I questioned some of the claims.

However, Guta's example of the hurtfulness of pain is not entirely convincing. I readily accept that neuroscience can tell us only a limited amount about how I (or someone else) experience pain. Nevertheless, when sitting in the dentist's chair, it is comforting to know that the dentist has an intimate knowledge of nerves such as the inferior alveolar, when injecting an anaesthetic into the appropriate one prior to working on my tooth. Pain is objective, regardless of whether my experience is slightly different from yours, and neuroscience is indispensable in understanding some aspects of it and controlling it, at least to a degree.

The dramatic, and sometimes appalling, pathologies that result from brain injuries or drug-based manipulations of the brain, show that the gulf between first- and third-person descriptions can become exceedingly murky and ill defined. Whether we like it or not, neuroscientists can peer into ever more intimate aspects of our thought life, and on occasion, can even manipulate it. Christians should not close their eyes to what is going on all around them in neuroscience laboratories.

Similarly, my description of the color "blue" may or may not be the same as someone else's, but this does not make redundant attempts to determine which parts of the visual cortex are responsible for the perception of color. There is a powerful personal element to all our conscious responses and reactions, but this in no way invalidates the point I made in my article about the centrality of the brain (and other parts of the nervous system) for many facets of what makes us what we are.

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American Scientific Affiliation

The American Scientific Affiliation (ASA) is a fellowship of Christians in science and related disciplines, who share a common fidelity to the Word of God and a commitment to integrity in the practice of science. Founded in 1941, the purpose of the ASA is to explore any and every area relating Christian faith and science. *Perspectives on Science and Christian Faith* is one of the means by which the results of such exploration are made known for the benefit and criticism of the Christian community and of the scientific community. The ASA Statement of Faith is at www.asa3.org/ASA/faithASA.html

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Canadian Scientific & Christian Affiliation

A closely affiliated organization, the Canadian Scientific and Christian Affiliation, was formed in 1973 with a distinctively Canadian orientation. The CSCA and the ASA share publications (*Perspectives on Science and Christian Faith* and the *ASA/CSCA Newsletter*). The CSCA subscribes to the same statement of faith as the ASA, and has the same general structure; however, it has its own governing body with a separate annual meeting in Canada. Contact CSCA by writing to: Canadian Scientific and Christian Affiliation, PO Box 63082, University Plaza, Dundas, ON L9H 4H0 or visit their website at www.csca.ca

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