Environment

CREATION CARE: A Biblical Theology of the Natural World by Douglas J. Moo and Jonathan A. Moo. Grand Rapids, MI: Zondervan, 2018. 256 pages, index. Paperback; $24.99. ISBN: 9780310293743.

This book is part of the Biblical Theology for Life series, which addresses contemporary issues by answering the question, "What does the Bible have to say about that?" Other publications in this series include books with titles such as *The Mission of God's People*, which addresses God's overarching mission for the world, *Christians in an Age of Wealth*, which answers questions about the place and purpose of wealth in a Christian's life, and *Known by God*, which explores the nature of personal identity. Contributors to this series "seek to straddle both the world of the text and the world in which we live." Each book strives to mine the Bible for theology that addresses a particular topic while also contextualizing this theology in ways that allow the Bible to transform contemporary Christian life.

Each volume in this series has the same basic structure. The first section of each book is entitled "Queuing the Questions." In this section, authors introduce the questions they seek to address. In the second section, "Arriving at Answers," authors develop the biblical theology of their topic by focusing their attention on specific biblical texts. In the concluding "Reflecting on Relevance" section, authors discuss specific ways in which this theology impacts contemporary situations, thus challenging readers to consider how they might live it out in the world today. As stated in the series preface, the hope of the authors is to provide informed insights of evangelical biblical scholarship that will "increasingly become enfleshed in the sermons and discussions that transpire each week in places of worship, in living rooms where Bible studies gather, and in classrooms around the world."

The first two chapters of *Creation Care* ask and then seek to answer three questions: What is our topic? Why write a book addressing this topic? And how can we go about seeking answers from the Bible? The authors answer the first question by explaining their choice of the word "creation" rather than "nature" or "environment." Speaking of creation care rather than environmentalism or nurture of nature provides the foundation for addressing the topic from a Christian worldview. The authors then discuss two reasons for addressing this topic. The first focuses on the challenge of getting Christians on board with creation care, since for many in Christian circles this topic is very much a peripheral issue. The second is to challenge the claim that Christian anthropocentrism is largely to blame for the environmental challenges we face around the world today. The entire second chapter is devoted to the last question and surveys various methods of biblical interpretation. The authors examine three external factors that may influence one's biblical theology of creation care: historical and systematic theology, our contemporary culture, and scientific research. They warn against coming to scripture with an agenda and argue instead for allowing the text to speak for itself.

The "Arriving at Answers" portion of the book is by far the longest, encompassing chapters three through nine. The authors first acknowledge that teachings about the created world are widespread in the Old Testament, but relatively sparse in the New Testament. They admit that this is a problem because most of the preaching and teaching in churches today is from the New Testament and most believers spend far more time reading the New rather than the Old Testament. Since both authors are New Testament scholars, they address this situation by devoting as much space to creation care from the New Testament as they do from the Old Testament. They examine passages of scripture from the epistles in depth and devote one entire chapter to "Jesus and Creation." The last two chapters in this section of the book discuss various aspects of the "new creation." The authors argue convincingly that God's redemptive plan encompasses the whole of reality and that a "transformation" model best summarizes the varied teachings of the Bible about the future of creation. (The passage in 2 Peter 3, which appears to teach a "replacement" model of creation's future, is examined in depth.) While thoroughly covering creation care passages from the New Testament, most, if not all, of the pertinent passages from the Old Testament are also addressed. The result is a genuine "biblical theology of the natural world" that provides a survey of the topic from the entire biblical canon.

The last four chapters contain the "Reflecting on Relevance" portion of the book. One chapter, entitled "Creation in Crisis," presents an overview of the environmental problems that are threatening the health of planet earth. These include the loss of biodiversity, destruction of the world's forests, overhunting, overfishing, the degradation and loss of topsoil, the projected scarcity of freshwater, concerns about our industrial food system, and the ramifications of climate change. The other three chapters propose ways in which Christians should respond. These responses are organized around the acronym "AWAKE" which includes the following: being *Attentive* to the community of creation around us; *Walking* more and considering how, where, and how much we travel;

becoming *Activists* for God's kingdom on earth; rejecting our culture's way of *Konsumerism*; and *Eating* joyfully, thankfully, reverently, and ethically. (Consumerism is misspelled intentionally with the hope that readers will be more likely to remember it.) The authors suggest a number of specific ways in which Christians can become AWAKE, better stewards of God's creation, although they admit that they have provided only "a mere outline of possibilities and suggestions to get readers started." They support their assertions by revisiting their discussion of Genesis, where the "ruling" mandate of Genesis 1 is qualified by the "serving" mandate of Genesis 2. As God's vice-regents, humans must "imitate the nature of God's own rule of the world, which has been powerfully displayed in the servanthood of the incarnate Son of God."

As stated by Richard Bauckham on the very first page, "this book deserves to become the standard work of its kind." The father and son team of Douglas and Jonathan Moo have written a comprehensive introduction to a biblical theology of creation care that is well organized, accessible, and applicable for a wide spectrum of Christian readers. An extensive scripture index is included at the end of the book, along with an author and a subject index. Although there is no bibliography, the book is replete with footnotes that include references to a variety of pertinent books and articles. Anyone who wants to delve more deeply into this topic will find the references in the footnotes most helpful. The authors provide numerous thought-provoking quotations from a variety of sources in the sidebars of many pages, and each chapter concludes with a series of relevant discussion questions, making this book a good choice for adult discipleship classes or study groups. All of these components make this book a welcome addition to the body of literature that addresses the topic of creation care from a biblical perspective.

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Ethics

THE RADIUM GIRLS: The Dark Story of America's Shining Women by Kate Moore. Naperville, IL: Sourcebooks, 2017. 496 pages. Hardcover; $26.99. ISBN: 9781492649359.

In the years preceding WWI, the Radium Girls, teens and young women in their early twenties, gratefully took a job with the United States Radium Corporation (USRC) where they painted watch and instrument dials with radium-containing paint. The exceedingly fine work required precision brushes and the young women were taught to "lip point" their brushes to aid this fine work. Lip pointing was a technique in which the dial painters placed their brushes into their mouths to make the brush tip pointed for the fine work, then dipped the brush into the radioactive paint, painted a number on a dial, and then repeated the process. "Lip, dip, paint," repeat. The USRC assured the dial painters that the paint was not harmful. In fact, in the earliest years following the Curies' discovery of radium, it was believed to have health benefits. Radium was an ingredient in tonics, cosmetics, and more. They could not have been more wrong!

Every time the dial painters pointed their brushes with their lips, they ingested radium. Radium dust rained down on the employees, covering their hair, clothes, and skin. They carried the dust home to their families and walked it out of the plant and onto the sidewalks of their communities with their shoes.

It did not take long for the dial painters to show signs of radium poisoning. Their teeth fell out, their jawbones fractured, and, shockingly, pieces of mandible came out into their mouths. The wounds that were left when they lost their teeth failed to heal. They developed severe anemia, limps, and sarcomas. Doctors and dentists were befuddled. Slowly, doctors, dentists, and the dial painters derived a conclusion. The paint was poisoning them. USRC's behavior in response to the dial painters' illnesses was unforgivable. Through investigation and litigation, as told in this riveting work of nonfiction, it became clear that USRC knew, early on, that radium was making the dial painters sick. In spite of this, USRC actively worked to hide the danger from their employees. USRC began innocently ignorant of the danger of radium, evolved to willful ignorance, and then quickly to an active and malicious cover-up.

The Radium Girls: The Dark Story of America's Shining Women by Kate Moore paints the story of USRC's indefensible actions and failure to act on behalf of their employees. Moore shares the personal stories of several of the dial painters and their suffering due to radium poisoning through their letters, diaries, testimonies, and interviews with living relatives. She recounts the extensive legal battles that ensued to compensate the dial painters (and their families) for the suffering and loss of life they experienced because of their exposure to radium.

The book includes enough of the science of radium and radiation so the average reader can understand why radium causes the kinds of damage the dial painters experienced, but it is not primarily a science book. It covers the evidence, trials, and appeal hear-

ings that led to changes in worker protection laws but is not primarily a book about changing the law. *The Radium Girls*' most compelling feature is the stories of the young women. Moore tells their stories such that they pop from the pages as real human beings with hopes and dreams, experiencing love and loss.

For me, a scientist, the book was a sobering reminder of the responsibility scientists have to do our important work carefully, thoroughly, and ethically. When I am working to make my laboratory OSHA-compliant, I will think of the dial painters and, rather than grumble about the extra work, I will be grateful for the protections we have in labs and industry thanks to the radium girls, whose fierce persistence led to the formation of OSHA and other organizations. The story of the dial painters reminded me that the world was (and unfortunately still is) a place where people who lack power—women, children, people of color, and the poor—also lack a voice. The story compels me to be a voice, whenever I can, for those who lack power; this is an especially important ethical responsibility for Christians.

Who should read this book? Anyone interested in science, law, or business regulations. Anyone who loves a good nonfiction story with sympathetic characters and real-life villains. I will recommend this book to some of the high school students in my church who love science, especially the girls. It is a compelling story of young women who found their voices and made a difference in history.

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History of Science

THE RHINOCEROS AND THE MEGATHERIUM: An Essay in Natural History by Juan Pimentel, translated by Peter Mason. Cambridge, MA: Harvard University Press, 2017. 364 pages, including contents, prologue, notes, acknowledgments, credits, and index. Hardcover; $29.95. ISBN: 9780674737129.

For a person interested in natural history, the notion of a "fantastic binomial" may bring to mind a favorite plant, animal, or fossil and its uniquely crafted name following the Linnaean nomenclature for a species. But for Spanish historian Juan Pimentel, a "fantastic binomial [is] the combination and setting into motion of two objects or persons who are apparently unconnected" (p. 6). In *The Rhinoceros and the Megatherium*, Pimentel crafts an extended essay that describes the parallel journeys of two marvelous mammals to the Iberian peninsula: one a live creature from the Far East, and the other a fossil from the western hemisphere.

The first three chapters tell the tale of Ganda, a live rhinoceros transported from India to Portugal in 1515 who was named in honor of the native term for the animal. To the Portuguese people, this massive animal represented their perception of the Orient: something unfamiliar, exotic, and dangerous. What was known of rhinoceroses at the time was primarily the stuff of legend, stemming from the works of ancient Greeks such as Strabo and Pliny, and often becoming conflated with stories of the mythical unicorn. The rhino was viewed as a ferocious, brutal creature who was built to destroy its natural enemy, the elephant. Upon coming into contact with animals such as rhinos, many people simply sought to reinforce their preconceived notions about these animals, hence the staged battle between Ganda and a juvenile elephant that was not in any way ready to fight the rhinoceros. Ganda was eventually gifted to Pope Leo X, but tragically died in a shipwreck on his way to Rome. Pimentel contests that no one would remember this tale were it not for Albrecht Dürer's classic woodcut that immortalizes the creature. This image, which would spread around the world, depicts a creature with some of the key traits of a rhinoceros, such as its robust body, stout legs, and the nose horn that gives the animal its name. But it also features what look like overlapping plates of armor, thick reptilian scales, and a small unicorn-like horn perched between its shoulders. Apparently, Dürer actually never witnessed Ganda firsthand, basing his representation on a descriptive letter, an original illustration (which has been lost), and undoubtedly a host of preconceived notions about the animal. Hans Burgkmair produced a woodcut around the same time that more accurately represented the anatomy of the rhinoceros, but it lacked the power of Dürer's chimeric piece that carried the "fables and words of antiquity" about the animal (p. 100).

The next three chapters tell the story of a different beast, whose bones were dug up from the earth near the Luján River in present-day Argentina. The fossil was initially taken to Buenos Aires before eventually being transported across the Atlantic Ocean to the Royal Cabinet of Natural History in Madrid during the summer of 1788. This skeleton was like nothing anyone had ever seen before—it was massive and had an anatomy unlike any modern creature known to science. Initially reconstructed as a pachyderm or large cat, the first people to study it did not really know what to make of it. Juan Bautista Bru and Manuel Navarro collaborated to produce illustrations and engravings of this beast to publicize it, but

it was not until Georges Cuvier got his hands on these images that the mysteries of this ancient creature began to unravel. In 1796, Cuvier produced a paper documenting the anatomy of this creature, placing it in the family tree of mammals, and finally giving it a name: *Megatherium americanum* (which translates to "great American beast"). Through careful comparative work, Cuvier recognized that this animal was new to science, but clearly related to the edentates, a grouping of mammals that includes armadillos and sloths. This work marked the beginning of Cuvier's prodigious career and helped to provide evidence that the ancient world was full of creatures that are not represented in the modern fauna. Additional fossils of related creatures would be found in later years, and after some further debate, the great anatomist Richard Owen would eventually demonstrate that *Megatherium* was an extinct species of giant ground sloth.

Pimentel uses these two stories to explore many topics along the way. While some digressions are more interesting and germane than others, they generally raise intriguing ideas inspired by the tales of the rhinoceros and *Megatherium*. Pimentel recurrently explores topics such as "the role of imagination in the manufacture of scientific and historical facts" (p. 6), the power of images to convey reality mixed with "preconceptions and mental resonances" (p. 103), and the "alliance between art and science" (p. 164) that gave rise to the discipline of scientific illustration. In telling these tales, he also conveys the importance of understanding how our collective knowledge has changed across centuries. He discusses how the discovery of fossils presented a challenge for many eighteenth-century naturalists, who believed in the doctrine of plenitude and the fixity of species. In so doing, he briefly covers the infancy of paleontology, the debate between uniformitarianism and catastrophism, and the tensions that existed between science and faith during this time, pointing out that religion actually played an important role in the development of earth history and science in general.

If readers are in search of a more systematic and thorough history of paleontology or zoology, then they should look elsewhere. However, Pimentel's extended essay about the "circular biographies" (p. 287) of the rhinoceros and *Megatherium* offers plenty of historical illustrations (56 in total) and rich stories that will inspire further thought about the natural world, how we engage with that which is unfamiliar, and the role of imagination and images in helping us see the reality around us.

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Mathematics

A MATHEMATICIAN'S LAMENT: How School Cheats Us Out of Our Most Fascinating and Imaginative Art Form by Paul Lockhart. New York: Bellevue Literary Press, 2009. 144 pages. Paperback; $14.95. ISBN: 9781934137178.

MEASUREMENT by Paul Lockhart. Cambridge, MA: Harvard University Press, 2012. 407 pages, with index. Paperback; $20.50. ISBN: 9780674057555.

ARITHMETIC by Paul Lockhart. Cambridge, MA: Harvard University Press, 2017. 223 pages, with index. Hardcover; $22.95. ISBN: 9780674972230.

You will forgive me if I find it normal for mathematics education to be under attack. That has been my experience since the mid-1960s. I wasn't subjected to "new math" in the classroom (we weren't that up-to-date), but I was privileged to attend a National Science Foundation Saturday course aimed at introducing talented high school students in the Chicagoland area to the modern abstract view of mathematics. The short text we used developed the real number system as equivalence classes of Cauchy sequences, claiming this would help us understand what creative mathematics was really all about. I stumbled out of those lectures in a fog of confusion, none the wiser for the honor, yet still interested in mathematics as I understood it.

I underwent the same anxious muddle about three years later during my first semester of abstract algebra, but this time the haze gradually cleared, and I began to appreciate an abstract formal viewpoint. I was not convinced, however, that imposing a set-theoretic foundation on school mathematics was pedagogically or philosophically sound, nor that it would help catapult the USA ahead of the Soviet Union in the space race. Aspects of the New Math reform appealed to me, but I also resonated with parts of Morris Kline's hyperbolic rant *Why Johnny Can't Add: The Failure of the New Math* (1973). The more concrete heuristic approach taken by British mathematics educators under the leadership of Edith Biggs seemed far more promising than what new math proponents had on tap.

Since the 1960s a host of professional documents by committees and individuals have detailed what's wrong with mathematics education in the USA on all levels and have told us what we should do to fix it. Progress has been made on a number of fronts, but not everyone has clambered aboard one of the reform trains. Paul Lockhart, for instance, begs to differ with how things still typically go—actually, he

stridently excoriates today's mathematics educators, textbook companies, and conventional schooling.

After finishing a PhD in mathematics, Lockhart taught university mathematics but soon became disillusioned with student attitudes and institutional objectives. He therefore shifted down to the high school level and lower, where he hoped he could instill a love for genuine mathematics before students were corrupted by traditional curricula, mindless worksheets, and uninspiring teachers. In 2002, he penned a 25-page stinging broadside against the status quo in mathematics education, which, after Keith Devlin highlighted it in two 2008 *Devlin's Angle* posts ("one of the best critiques of current K–12 mathematics education I have ever seen"), gained increased notoriety and circulation. Lockhart's 2009 book includes this essay as its opening "Lamentation," concluding with a shorter "Exultation" in which he describes his delight in constructing the mathematical world of the mind, where one's hamsters (a favorite metaphor for mathematical entities) can have all the beautiful functionality anyone would ever want, living in a universe subject only to human imagination and logical consistency.

Lockhart's *Lament* ends by exhibiting some examples of what learning mathematics ought to be like: one problem from number theory, solved using Pythagorean-like arrangements of imaginary rocks (why do successive odd numbers add up to a square?); another from geometry, solved using reflective symmetry (what is the shortest linear path connecting two points via an intermediary point on a straight line?); and a third from combinatorics, tantalizingly left for the reader to solve (must at least two people at a party always have the same number of friends present?). Lockhart's colloquial exposition of these problems and their solutions is clear and engaging. His parting advice to students and teachers is to "throw the stupid curriculum and textbooks out the window" and "just play" with the mathematical creations you dream up (p. 139).

So what would such teaching/learning look like? An extended model of how to pursue real mathematical understanding—of how to explore and discover mathematical connections, using elegant arguments—is implicitly presented in Lockhart's subsequent books, *Measurement* and *Arithmetic*.

Of the two books, *Measurement* is the more ambitious and substantial. The material is divided into two equal parts: the first, Size and Shape (topics in classical and projective geometry, as well as trigonometry); and the second, Time and Space (matters handled by coordinate geometry and differential calculus), in which motion plays an important role in generating curves and sweeping out regions as well as being a concept to analyze mathematically.

After explaining that mathematics is simply an exploration of the perfect patterns of things we create with our minds, to find out how they behave and why, Lockhart offers some problem-solving suggestions: solve problems of your own making; collaborate with others; mess around with ideas even if they seem far-fetched; be open-minded and flexible about whether your conjectures are true; review, critique, and improve your proofs; have fun. Not quite Polya's *How to Solve It* (1945) or his two-volume *Mathematical Discovery* (1962, 1965), but some pointers worth heeding.

It is difficult to summarize the contents of *Measurement* because Lockhart occasionally observes his own advice, to follow a problem to wherever it meanders off. His asides are often stated as observations to be tested or posed as problems for further exploration, a feature that may make the book a good choice for group exploration, though readers are on their own with respect to the answers. But his main topics are organized in an interconnected way around the general theme of the title.

Measurement, he notes, is about comparing one measure with another. As geometry has no natural units (with the exception of a full circle for angles), measurements are intrinsically relative—they are ratios, leading to formulas that relate different measures. Shapes are characterized in terms of similar figures, where one is a scaled version of the other, involving proportional measures. Lockhart also compares lengths, areas, and volumes of a wide variety of figures with one another, giving rise to some nicely argued classic results—Heron's Formula for the area of a triangle; the Pythagorean Theorem and its generalization to the Law of Cosines; areas for a circle and an ellipse; the volumes of a cylinder, pyramid, cone, and sphere; and so on.

Fairly early in the section, Lockhart introduces the so-called classical "method of exhaustion," "by far the most powerful and flexible measuring technique ever devised" (p. 70), as a key strategy for extending results about rectilinear figures to curved ones. A circle, for instance, is approximated ever more closely (gets exhausted) by inscribed regular polygons as their number of sides increases. The polygons' areas tend toward that of the circle, giving the circle's area in the end as half the product of its radius and circumference. A similar idea works for volume comparisons: a cylinder is exhausted by a collection of abutting rectangular boxes, a cone by a stack

of cylindrical discs, a pyramid by stacked boxes, a sphere by thin tetrahedra emanating from the center. Using these approximations, Lockhart establishes a number of familiar volume and surface area results known since Euclid and Archimedes. He argues these results informally and concisely, but gives enough details for the reader to follow his reasoning.

Unwilling to admit infinity into mathematics, the Greeks had linked their exhaustion technique to a rigorous double proof by contradiction strategy (a circle's area is neither more than nor less than half its diameter times half its circumference), but this is an idea too complex for *Measurement* to include. Lockhart instead treats the strategy as realized in the infinite limiting process more fully developed in calculus. He also uses the method of exhaustion to argue for the validity of Cavalieri's Principle, which compares lower-dimensional cross sections of figures in order to relate an unknown measure (area, volume) to one that's already known. Lockhart employs this resourcefully in determining the volumes and surface area of a sphere and a torus, the latter result first appearing in a work by Pappus.

Another topic of classical geometry that Lockhart investigates is that of conic sections (first studied by Apollonius), something that has fallen somewhat out of favor in today's streamlined mathematics curriculum. For example, he introduces an ellipse as a dilation of a circle, as a planar projection of a circle, and as a cross section of a cylinder. He then presents an "ingenious argument" using Dandelin spheres for the ellipse's "shockingly beautiful" characterization in terms of foci—"Is that gorgeous, or what!" (p. 145), following this with a discussion of the ellipse's remarkable tangent property—all done without a stitch of algebra or coordinate geometry. The ellipse and other conic sections are then explored using some ideas from projective geometry.

The section on Size and Shape concludes by introducing the helix and the cycloid. As these figures are best understood as traced out by a moving point, Lockhart uses them to segue into the second section of the book, Time and Space. Here he leaves ancient Greek geometry behind to take up seventeenth-century concerns and approaches.

Basic to the modern treatment of shapes is setting up a coordinate system, done to facilitate the use of algebra, including vectors, for analyzing curves. Although at first Lockhart denigrates this—"It's ugly, and should be avoided whenever possible" (p. 214)—he later lauds this way of representing geometric objects, saying that "the connections between algebra and geometry that are revealed by this point of view are among the most fascinating and beautiful results in all of mathematics" (p. 246) and "This viewpoint not only has the benefit of simplicity … but also tremendous flexibility and generality" (p. 295).

Lockhart employs graphed curves to represent and analyze moving points, such as a point on a circle rolling along a line, which produces a cycloid path. Using trigonometric ideas introduced earlier in the book, he determines the parametric equations of the cycloid, later returning to determine its velocity as well as the area and path length for one arch of the curve.

Lockhart adopts a Newtonian view of a curve as traced out by the endpoint of a moving line whose instantaneous velocity $\dot{p}$ is the terminal value of approximating average velocities, attained as time t shrinks to an instant and position p becomes stationary. This is Newton's fluxion, now termed the position's time derivative. After discussing this for motions in more than one dimension, he introduces Leibniz's differential notation dx to denote the instantaneous rate of change of any variable x, making $\dot{p} = dp/dt$. Lockhart next develops a collection of formulas for how the d-operator interacts with various arithmetic operations as well as a simple library of formulas for some basic mathematical functions—a plan familiar to anyone who's taught calculus. He then notes that Leibniz's differential calculus can be used to express and solve "virtually all measurement problems" (p. 319), provided these measures are put into motion: "If you want to measure something, wiggle it" so that "it has a rate of motion" (p. 330) one can calculate with.

A "fantastically beautiful and powerful application of the differential calculus [that is] possibly the most useful" (p. 351) is that of optimization. Differentials can be used, for instance, to determine the largest cone that can sit inside a sphere or the precise shape of a cylindrical can that maximizes the amount of soup relative to the amount of metal in the container. The key principle behind these calculations [an early version of which was known to Kepler] is that "when a variable peaks, its differential must vanish … undoubtedly one of the simplest and most powerful discoveries in the history of analysis" (p. 355).

Putting differentiation into reverse, integrals can be calculated to determine areas, volumes, and lengths, provided the formulas are simple enough—though, like almost all invertible procedures, complications can arise even for some familiar curves. This is the case for most arc length calculations, but it even occurs for area calculations. The area under the hyperbola $y = 1/x$ between $x = 1$ and $x = w$, for ex-

ample, turns out to be complicated, but its properties enable it to be used to define natural logarithms in a rigorous way.

Measurement takes us on a rather impressive tour of various fascinating and significant technical results, visiting many high points in geometry and calculus, whose study would be beneficial for prospective middle school and high school mathematics teachers. The text might also be given to a bright and curious student on these levels, but having a guide familiar with the terrain would be advisable. Lockhart provides a superb big picture exposition of the main contours of introductory calculus, but without all the specifics, terminology, and applications present in today's monstrous calculus texts.

Lockhart's goal in *Measurement* was to demonstrate "What a wild and amazing place mathematical reality is! … a vast, ever-expanding jungle … a meeting place for language, pattern, curiosity, and joy" (pp. 396–97). Those of us interested in making mathematics education attractive can only applaud his effort. Keith Devlin goes so far as to say in his Foreword to *A Mathematician's Lament*, "I will tell you this. I would have loved to have had Paul Lockhart as my school mathematics teacher."

Arithmetic is the latest book in Lockhart's series, focused, as one would expect, on the most basic aspects of elementary mathematics. We need to count, compare, gather together, remove, multiply, and divide up quantities of things in all parts of our lives and then often record the results. Arithmetic is the art humanity has developed for doing these things in efficient ways. While computation was once a practical skill we needed to hone, Lockhart notes that today's calculators and phones are faster and more accurate than we will ever be, relieving us of its drudgery. However, we can still appreciate and enjoy the underlying ideas and methods of arithmetic as an intellectual craft designed to organize and communicate numerical information, as a sort of "symbol knitting."

As a human construct, arithmetic has a rich and varied history, though this isn't typically explored in mathematics textbooks. Lockhart, however, interweaves his explanations of the main ideas involved in doing different sorts of calculations with occasional accounts of how arithmetic developed in various cultures, both real and imaginary.

While numbers don't mind how they are conceptualized or symbolically represented, such choices do affect how we calculate with them. Lockhart highlights the importance of uniform grouping (adopting a number base) as he discusses the counting systems of three fictitious tribes, tally marks, Egyptian hieroglyphic numerals, Roman numerals, and Chinese named-place-value numerals.

The all-important place-value principle, which makes it possible for us to represent numbers of any size whatsoever, was initially embodied in an abacus, in which different columns or rows stood for different group-levels (one, ten, hundred). We know such artefacts were used for making calculations in many ancient cultures, but the first written place-value system was the Mesopotamian sexagesimal place-value system. Lockhart chooses not to discuss this, only recognizing the Babylonians for using sixty as their rather cumbersome base, but without offering any possible reason for their choice. He instead introduces a written place-value system in the context of discussing our Hindu-Arabic numeration system, which originated in sixth-century India.

Over several chapters, Lockhart reconstructs how the usual algorithms that Europeans eventually adopted for addition, subtraction, multiplication, and division can be based both on the meaning of the operations and on the way we symbolize our numbers. This is done mainly for positive integers, but he notes that it can be extended to calculations involving decimal fractions, whose origin he seems to associate with the French Revolution's proposal to decimalize all measures (the metric system) rather than attributing it to Stevin's landmark treatise two centuries earlier or noting its connection with the much earlier sexagesimal system or Chinese decimal notation or medieval Arabic developments. He also devotes a chapter to discussing how these computational procedures were mechanized over time, from using wheels, gears, and carry pins to electronic circuits and LED displays.

Lockhart concludes his treatment of different number types toward the end of the book by discussing the arithmetic of fractions and negative numbers, inexplicably omitting real and complex numbers. He briefly refers to a couple of historical ways of dealing with fractions (Egyptian) and negative numbers (debts), but much more could have been done along these lines to motivate the ideas and procedures involved, which would connect our understanding of them with how they actually arose. In *A Mathematician's Lament*, Lockhart rued the fact that "we have a mathematics curriculum with no historical perspective or thematic coherence" (p. 56), but *Arithmetic* misses some natural opportunities to remedy this deficiency. For example, China's use of red and black counting rods for signed integers and their rules for calculating with negative numbers in the

context of solving linear system problems parallels Lockhart's explanation using sheep and antisheep. Likewise, Arabic and European calculations with subtracted quantities provide a heuristic motivation for multiplying signed numbers. Lockhart's explanations are consistent, however, with his overall perspective on mathematics as a human creation, imaginatively invented. What's most important for him, it seems, is for teachers to reconstruct standard mathematical ideas in ways that charm and entice students to explore them recreationally, even if they involve imaginary hamsters and antisheep rather than practical concerns grounded in historical realities.

Though I very much enjoyed Lockhart's books, I have some reservations and criticisms that go beyond the historical observations just made. These pertain to his basic educational philosophy of mathematics. Lockhart holds that mathematics is ultimately a human mental creation, an art done purely for intellectual enjoyment. He repeats this refrain in a number of contexts, to the point that it gets rather old. Geometry, he insists in *Measurement*, deals with the ideal shapes we define and explore: "none of the things we've been talking about are real … We made up imaginary points, lines, and other shapes so that things could be simple and beautiful—we did it for art's sake" (p. 169). While this seems harder to assert of quantities, which we experience more precisely, he says in *Arithmetic* that he also conceives of numbers as abstract creatures to which we assign behaviors according to our own aesthetic sensibilities (think: negative numbers). Computation has practical applications, but he still claims that "the idea with arithmetic is to have some fun, keep track of a few things, and occasionally enjoy a bit of cleverness" (p. 24). Mathematicians prefer the "purely mathematical realm" for its "sheer intellectual pleasure and entertainment," a universe of exact abstract entities created with "simplicity and abstract beauty" in mind. This may approximate the "fuzzy, random, and inexact" world we live in, but that's not why mathematicians do mathematics (p. 163). Reality provides us with "crude" and "clumsy prosaic object[s]" about which we could never assert any mathematical truths (p. 181). It provides a springboard for humans to create an imaginary world of perfectly behaved objects: "the whole enterprise is a made-up game in our heads" (p. 193).

While I agree that mathematics is not a utilitarian enterprise, this admission does not lead me to ignore its essential connections to a broader reality. A cursory familiarity with the history of mathematics gives the lie to artistic intellectual elitism. Teachers do need to find ways to motivate students to study mathematics, but a practical situation can often do this as well as a game or a whimsical exploration of an idea. Dealing concretely with arithmetic and geometry is important on lower levels, and connecting them with nonmathematical contexts expands students' understanding of the value and interest of mathematical ideas and procedures. Mathematics deals with quantitative, spatial, and kinematic patterns in a given creation already structured by God. Its applicability lies not in humans' brains being part of reality, but in the world being structured as a coherent whole by its Creator. Humans have found ingenious ways to interact mathematically with their everyday contexts, but acknowledging this is quite different from crediting us with creating mathematical reality out of conceptual whole cloth.

Lockhart's antipathy toward real-life applications makes him downplay a side of mathematics that can be helpful to teachers and students. Although I find some of his critique of mathematics education valid, it does not fairly take into account the creative ways some teachers and texts try to connect with students. Lockhart is not alone in wanting to incite a love for mathematics. Regardless, his impassioned advocacy in these books for making mathematics come to life through active explorations of important ideas may inspire such teachers to further improve their own teaching.

Reviewed by Calvin Jongsma, Professor of Mathematics Emeritus, Dordt College, Sioux Center, IA 51250.

ORIGINS

THE INTELLIGENT DESIGN DEBATE AND THE TEMPTATION OF SCIENTISM by Erkki Vesa Rope Kojonen. New York: Routledge, Taylor & Francis, 2016. 226 pages. Hardcover; $150.00. ISBN: 9781472472502. eBook; $50.00. ISBN: 9781315556673.

Writing from a theologian's perspective, Erkki Vesa Rope Kojonen argues that "beliefs about the purposiveness or non-purposiveness of nature should not be based merely on science. Rather, the philosophical and theological nature of such questions should be openly acknowledged." He cogently spells out the landscape of the debate over intelligent design, exploring historical approaches to the fundamental question of teleology in nature and showing the importance of the theological and philosophical aspects of design.

Rope Kojonen is a postdoctoral researcher in the Faculty of Theology at the University of Helsinki. His studies and research interests focus on the general discussion between faith and reason with specific

emphasis on intelligent design. He is the editor of the Finnish science and theology magazine *Areiopagi*.

Rope Kojonen repeatedly emphasizes that he does not wish to take sides in the intelligent design debate. He only wishes dispassionately to analyze the debate and make a suggestion. "I argue that the sidelining of theology and philosophy from the debate is actually an example of the influence of scientism, defined as the belief that science is the only way to gain reliable knowledge about the world" (p. 3). That, in a nutshell, is the summary of the entire book.

Rope Kojonen begins by offering his view of the origin and definition of the contemporary ID movement. Based on a quote from the Center for Science and Culture department of the Discovery Institute, he states that

> ID is three things:
>
> 1. A scientific research programme attempting to find evidence of design in nature
> 2. A community (or movement) of scholars who participate in this research programme
> 3. A theory which holds that there is indeed evidence for intelligent design in nature. (p. 12)

He points to Phillip Johnson's publication of *Darwin on Trial* as the origin of the ID movement, though not of teleological arguments which have a long history. Thereby he seems to ignore the books and articles in *PSCF* published in the 80s. I view the book *The Mystery of Life's Origin: Reassessing Current Theories* by Charles B. Thaxton, Walter L. Bradley, and Roger L. Olsen as a more seminal trigger of the modern design movement with Johnson's work serving as the expansion into public awareness.

Rope Kojonen makes it clear from the outset that he intends to be fair to all sides. He acknowledges the widespread belief in an intelligent creator even by critics of ID when he says, "The basic idea that nature provides some kind of evidence of an intelligent creator has ancient roots and is even shared by many theistic critics of ID." Then he deftly pinpoints the source of the criticism by saying, "ID's defense of the idea is controversial because of its emphasis on the scientific nature of the design argument, and also because of its critique of evolutionary biology" (p. 30). He proceeds to map out an exhaustive articulation of the arguments set forth by advocates and critics of ID while avoiding his own judgment or preference.

Throughout this discussion, Rope Kojonen meticulously seeks to be even handed, supplying a balanced view. Taken to the extreme, he edges perilously close to creating a false equivalence between arguments for and against ID. In reality, virtually the entire scientific community that has assessed the claims of ID has found them wanting while the advocates are a small minority. That overwhelming perspective cannot be gleaned from this book. Nevertheless, the book is valuable for providing a dispassionate description of the arguments for and against ID.

Rope Kojonen's main concern is the emphasis the ID advocates place on scientific evidence for ID. He feels that by downplaying the theological and philosophical aspects ID proponents succumb to the temptation of scientism, despite their expressed opposition to scientism. He feels that ID advocacy would be better served by an open discussion of the pertinent theological and philosophical issues. On the other hand, in my opinion, those perspectives generally do not fare any better than the scientific arguments. Combining several weak arguments does not provide a strong argument. Nevertheless, it is a useful recommendation to the ID community that theologians and philosophers are brought into the discussion more closely, providing a clear linkage to those fields.

The book covers virtually the entire spectrum of topics in the ID controversy, though with disappointingly minimal discussion of the information argument. Better copy editing to correct the numerous missing and extra words would have been helpful but the message comes through clearly. It is a worthwhile source for anyone wishing to delve deeper into the nuances of the ID debate.

Reviewed by Randy Isaac, ASA Executive Director Emeritus, Topsfield, MA 01930.

STANDING ON THE SHOULDERS OF GIANTS: Genesis and Human Origins by Luke J. Janssen. Eugene, OR: Wipf and Stock, 2016. 334 pages. Paperback; $32.00. ISBN: 9781498291408.

Luke Janssen is a professor in the Division of Respirology, Department of Medicine at McMaster University in Hamilton, Ontario. He has a distinguished career as a cell biologist with over 130 peer-reviewed articles. He is also a former young-earth creationist who has wrestled hard with the reality of his faith in light of what he now sees as scientific reality. This clearly written book (his second on the topic) is the result of his thorough examination of both the scientific and theological issues at stake in the human origins discussion.

Given the breadth of the subject matter that extends beyond the author's expertise in the medical sciences, the book would have benefitted from more input from colleagues with expertise in theology and

paleoanthropology. Unfortunately, there are a number of distracting errors that reduce the potential impact of the book.

From the science perspective the book is uneven. For example, fairly early in the book, the author makes this statement:

> Biologists resist viciously any idea that a designer is behind the complex coding found within our cells. We have no examples of genetic mutations giving rise to a significant increase in information or a more complex gene sequence. The only examples of large evolutionary steps via gene mutations that we've been able to document comprise the reduction of information: the inactivation of a gene or the functional neutralization of its gene product. (p. 70)

This is a decidedly pro-intelligent design statement exactly like the argument in books by Stephen Meyer, for example. And yet he does not elaborate on it further at any other point of the book. Indeed, he goes on to write a statement that certainly appears to be an example of the very thing of which he says "we have no examples":

> On a blog which I maintain, I have included a photograph which powerfully depicts how a very small genetic mutation can convey an amazing advantage to an organism and thereby catapult the organisms which inherit the change into a whole new level of competitive superiority. (p. 97)

Intriguingly, the two statements seem to contradict each other. He goes on to show how and why this mutation (it is associated with color vision) is not only highly favorable, but is embedded within a newly duplicated gene. So, the author provides not only a perfect example of a point mutation giving rise to increased information, but also of a duplication event of the sort that is a poignant example of the kind of information-generating machinery that is believed to play no small role in driving the evolutionary process. It is as though he wrote the two sections of his book at two different stages of his own evolutionary journey out of the ID perspective, but he never went back to the manuscript to bring them into concordance with each other. Regardless of whether that is the case, it would have been helpful if the book had attempted to address the apparent dissonance between what appears to be two opposing statements.

The book is also misleadingly vague on some taxonomic issues. For example, it states that "scientists don't believe that humans evolved from apes or monkeys, instead they propose that humans and apes both evolved from a common ancestor" (p. 74). Although what the author means to say, I think, is that humans did not evolve from the species of apes and monkeys we see today, but he doesn't say that. Scientists, in contrast to what the book states, *do* believe that humans evolved from apes (and prior to that) monkeys. It's just that the ancestral species of apes and monkeys from which *Homo sapiens* evolved are not the same as those present today. Similarly, there are several places where the author seems to confuse the genus name with that of a species name. Moreover he gives species names a subspecies moniker (pp. 112, 113, 125, 147). The most disconcerting of these errors is his reference to *Australopithicus* as *Homo australopithicus* (p. 178).

There are other factual misstatements that detract from the value of the book. For example, members of the *Homo erectus* species did not make their initial migration out of Africa less than 800,000 years ago as stated on page 115. Actually, general consensus places the event (or events, perhaps) more than one million years earlier. Similarly, the "pit of bones" in Sima de los Huesos, Spain, does not contain "many fully articulated skeletons, of hundreds of hominins" (p. 119). Scholars believe that the fossils are derived from 28 individuals and that the find includes seventeen complete crania, but no completely articulated skeletons have been documented that I've been able to find (see *Science* 344 [2014]: 1358). Another example of a disconcerting misstatement refers to our common ancestors in Africa. The book states that we "don't know if there were thousands or millions" of these ancestors (p. 128). In actual fact though, genetics has enabled a reasonable estimate: the average population size is believed to be thousands to tens of thousands but not millions (see, for example, *Ancestors in Our Genome* by Eugene E. Harris [New York: Oxford University Press, 2015], 82). One final example of scientific imprecision concerns some of the statements made about Denisovans. The author overstates what we know about this recently discovered group, closely related to Neanderthals. On p. 188, the author states that "Neanderthals and Denisovans also had an appreciation for the aesthetic." Although there is good reason now to think that this is true for Neanderthals, it is not scientifically accurate to extrapolate from them to Denisovans. So far as I am aware, no architectural artifacts have been discovered that are clearly Denisovan-derived. All we have besides their DNA sequence is a finger bone and a couple of teeth fossils—nothing that we can say is clearly a reflection of their culture.

So although the book is thoroughly researched and is a treasure trove of information, the presence of a number of scientific misstatements leaves the general reader in a somewhat tenuous position regarding the factuality of any given piece of information. The errors could easily have been caught in the review

process and corrected, so it's unfortunate that they weren't.

The purpose of the book is largely to present the scientific facts regarding human origins so that we can determine their impact on core theological precepts of the Christian faith. Here, too, I think the author is guilty of overreach. He concludes his discussion of the science by stating, "for those who choose to believe that mankind has indeed evolved, there are going to be tremendous changes needing to be made in their theology" (p. 187). As John Walton (*Lost World of Adam and Eve*), N. T. Wright (*Surprised by Scripture*), Dennis Venema and Scot McKnight (*Adam and the Genome*), and Joshua Swamidass (*PSCF* 70, no. 1 [2018]: 19) have all shown, the changes to theology mandated by the findings of evolutionary biology and paleoanthropology need not shake up theology in any major ways. Science is silent on the issue of a historical Adam and Eve as discussed thoroughly by each of these scholars. It is clear that our species has been created through the evolutionary process, but there are various ways of thinking about Adam and Eve that do not conflict with these data. I am concerned that the author has allowed factors other than science to influence his conclusions. For example, consider also this statement:

> … some will choose to believe that we humans are indeed the pinnacle species in God's creation, and in support of that they will refer to biblical passages like Psalm 8: "What is mankind that you are mindful of them, human beings that you care for them? You have made them a little lower than the angels, and crowned them with glory and honor." They may be right. I won't deny that. But I will point out to them that it was a human that wrote that passage about humans: dolphins might believe they are the pinnacle species. (p. 178)

I think this book is an important example of a highly distinguished scientist who is still on a search to find how best to fit his sophisticated knowledge as a scientist into the Christ-centered, Spirit-filled life he has experienced and found to be real. I think it was published a little prematurely, but it illustrates the journey that all of us in the sciences must take. This is especially difficult for someone who rises to the upper tier of the sciences at a nationally important university where time pressures are enormous as one tries to fulfill responsibilities to family and church, along with those of a high-pressure career. I commend Janssen for doing this so well. This book is an admirable step along the journey that all of us are taking and what is most important of all is that we have mechanisms in place to provide mutual support to one another with each step we take. This is especially important for those whose journey takes them into the cauldron of a first rate research university.

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Science and Religion

THE BELIEVING SCIENTIST: Essays on Science and Religion by Stephen M. Barr. Grand Rapids, MI: Eerdmans, 2016. vi + 226 pages. Paperback; $25.00. ISBN: 9780802873705.

Stephen Barr is professor of theoretical physics at the University of Delaware, fellow of the American Physical Society, member of the Academy of Catholic Theology, and author of *Modern Physics and Ancient Faith* (University of Notre Dame Press, 2003). This book is a collection of twenty-six of his pieces from 1997 to 2013 (11 essays, 13 reviews of 15 books, and 2 unpublished lectures), most of which are previously published (15 appear in the *First Things* journal and/or blog). The pieces range from four to twenty-two pages in length, averaging eight pages each, with only three being over ten pages, making for rewarding piecewise reading. The stand-alone essays can be readily included in undergraduate courses needing to provide engagement with perspectival faith-based reflection and critical thinking. The book adds fifteen pages of notes (mostly contextual explanations and updates) and citations for direct quotations, but lacks an index and any new content.

Chapter 1, "Retelling the Story of Science," is Barr's Erasmus Lecture delivered in New York in 2002 and serves as the introductory essay. As in his 2003 book, he describes five main themes of materialism, and their reversals via "plot twists" in the actual history of science. First, the idea that science overthrew religious cosmology was reversed by big bang theory and the scientific consideration of a beginning. Second, while the idea that mechanism nullifies teleology had growing support in terms of considering laws of physics apart from a lawgiver, many now find the simplicity and aesthetic form of the mathematical principles of physical law evocative of a divine designer. Third, the "dethronement of man" and a universe without purpose, which claimed scientific support in the randomness of events, lost credibility due to the "anthropic principle" and a fine-tuned universe. Fourth, the notion of a closed universe with physical determinism gave way to an open universe upon the rise of quantum mechanics with its uncertainties. Fifth, the view of the human person as machine, with the brain simply running biochemical reactions, is now less tenable due to

both the recognized role of the (human) observer in quantum physics and thus the inability of quantum physics to describe systems including humans, as well as Lucas's argument from Gödel's theorem that humans, unlike machines, can at least sometimes recognize their own internal consistency.

These themes and plot twists are detailed and addressed in various ways in most of the remaining chapters, which are divided into seven sections: Evolution (7 pieces); Mind and soul (7); The big bang and creation (3); Reductionism (2); Science as a substitute for religion (2); Finding God through science (2); and Mischievous myths about scientific revolutionaries (2). Throughout, Barr criticizes the reductionist, scientistic, and antireligious claims of Dawkins and other public figures, and presents his own perspective offering scientific, historical, philosophical, and theological correctives. His book reviews (on Thomas B. Fowler and Daniel Kuebler, Richard Dawkins, Stephen Jay Gould, Michael J. Behe, David Chalmers, Thomas Nagel, Malcolm Jeeves and Warren S. Brown, John Maddox, Edward O. Wilson, Patrick Glynn, Gerald L. Schroeder, Francis S. Collins, William R. Shea and Mariano Artigas, and Wade Rowland) and other essays are incorporated within these sections.

Barr delivers well-placed, incisive, and often witty criticism of "scientist-atheists" such as Dawkins. He ends his review of Dawkins's *A Devil's Chaplain: Reflections on Hope, Lies, Science, and Love* by writing,

> Dawkins's atheism and materialism … prevent any coherent viewpoint from emerging because they deny the spiritual soul in man. That soul … makes it possible for us to have that hope and love to which the subtitle of Dawkins's book refers, but which are absent from its pages, and about which he has nothing in the end to say. (p. 41)

His review of Gould's *Full House: The Spread of Excellence* includes a few zingers, poking fun at Gould's idea that bacteria are more successful than humans (because there are more of them than us) by asking why this is not the Age of Air, given that there are more air molecules than bacteria, and whether "the fact that cosmic evolution has produced more dust particles than Chinese [persons] tells us something?" (p. 43), and that thus "Gould's ideas could be said to be but a twig on the arborescent bush of human opinion" (p. 44). And noting that Gould's book does not "complete the Darwinian revolution," as Gould aims to do, Barr "recommend[s] it … for those who take pleasure in fossils" (p. 45).

A devout Roman Catholic, Barr refers frequently to, and reminds fellow Catholics of, established Catholic positions. For example, he cites the 1950 *Humani Generis* in which Pope Pius XII affirmed the long-standing Catholic teaching that the theory of evolution is theologically benign, so long as it remains properly a biological theory by not making claims about the human soul. His deference to Catholic doctrine sometimes takes the place of a careful engagement with subjects, such as the challenging issue of divine sovereignty and human responsibility. Similarly, he fails to mention the range of Christian perspectives, such as the nature of the human soul.

Barr's scientifically informed and theologically conservative perspective on randomness is important in chapters 5 and 6, "The Design of Evolution" and "Chance, by Design." The first is a response to Roman Catholic Cardinal Christoph Schönborn's 2005 antievolutionary op-ed in the *New York Times*. Barr points out that the role of randomness in evolution does not, in fact, mean that it is unplanned, uncaused, unguided, or inexplicable, but only uncorrelated, noting that

> if the word "random" necessarily entails the idea that some events are "unguided" in the sense of falling "outside of the bounds of divine providence," we should have to condemn as incompatible with Christian faith a great deal of modern physics, chemistry, geology, and astronomy, as well as biology. (p. 49)

He goes on to point out that "the notion of contingency is important in Catholic theology, and it is intimately connected to what in ordinary speech would be called 'chance'" (p. 51). Further, he quotes from *Communion and Stewardship* (an important Catholic document from 2004) that "true contingency in the created order is not incompatible with a purposeful divine providence" (p. 51). Barr thus places the proper function of chance and biological evolution within the realm of God's providence, concluding with "the clear teaching of the Church that no truth of science can contradict the truth of revelation" (p. 53). Barr further observes that the everyday use of the word "random" differs from its use in science. And he further distinguishes, correctly in my view, between "words used by scientists and words used scientifically" (p. 56), given that, for example, there are indeed many scientists who would claim that the randomness found within evolution points to its being unguided.

Barr engages in hard-hitting criticism of young-earth creationism, calling it a "crackpot idea" (p. 29). He also describes what he calls "The End of Intelligent Design" (pp. 69–73) by noting its "claim … that certain biological phenomena lie outside the ordinary course of nature [is] impossible to substantiate [and

pits] natural theology against science by asserting an incompetence of science" (p. 69). Barr suggests that "the older (and wiser) form of the design argument for the existence of God … did not point to the naturally inexplicable or to effects outside of the course of nature, but to nature itself and its ordinary operations [which reflect] the power and wisdom of God" (p. 70), citing lengthy passages from the Book of Wisdom (c. 100 BC) and the Letter of Clement (c. AD 97).

As a unified collection of pieces published by a believing scientist over a sixteen-year period, this book is a useful resource, and I commend his sometimes provocative thoughts to readers of *PSCF*. I would have found the book more valuable, though, if it had contained sustained engagements with the responses which some of his pieces have garnered over the years.

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BIOLOGICAL INDIVIDUALITY: Integrating Scientific, Philosophical, and Historical Perspectives by Scott Lidgard and Lynn K. Nyhart, eds. Chicago, IL: The University of Chicago Press, 2017. 361 pages. Paperback; $25.00. ISBN: 9780226446455.

The field of biology is a very broad discipline. Etymologically, biology (*bios* + *logos*) means the study of life. But what is it that biology actually studies? Life itself is not a concrete, physical thing; rather, it is a function of living things. The focus of biology is not only the study of life as a function of certain things, but also the nature of living things that display the function of life. How does life as a function of certain things actually come about? Put another way, how do certain things come to display life activity or function? Central to these questions is that of biological individuality. What are biological individuals? What are the boundaries of and for biological individuals? These types of questions have been at the center of biological study, research, and thinking for several centuries.

In this edited volume, Lidgard and Nyhart provide a valuable service in pulling together various analyses of biological individuality. Three foci are distinguished in such an investigation: (1) the fundamental philosophical questions of biological individuality; (2) the historical analysis of how biologists have thought about individuality; and (3) how their reflections have influenced not only their research programs, but also how research programs, in turn, influenced philosophical perspectives on biological individuality and the nature of living things. Edited volumes sometimes suffer from a lack of coordination and a basic central theme, but the editors have dealt with that by providing an integrating introductory chapter, "Introduction: Working Together on Individuality," as well as an integrating philosophical analysis in a concluding chapter, "Philosophical Dimensions of Individuality," by Alan C. Love and Ingo Brigandt. The volume includes thirteen contributors spanning the spectrum of historians, philosophers, biologists, and sociologists.

The editors emphasize that although the concept of individuality is an important concept for biologists, there is no consensus on a definition of biological individuality. They even provide an extensive table (pp. 19–21) outlining the various definitional criteria for biological individuality as well as a graph (p. 23) indicating the year(s) of publications reflecting those definitional criteria and thereby providing a historical perspective.

There are a number of themes that arise in the consideration of biological individuality. One important theme is the evolutionary transitions in individuality (ETI). One such key ETI is that from unicellularity to multicellularity. The case study of the volvocine algae illustrates an attempt to understand this transition. This group of algae provides diverse examples of single-cell forms as well as colonial forms. In some forms, daughter colonies begin to form within the parent colony, raising the question of what constitutes an individual. Are the daughter colonies individuals only after they break from the colonies? In the transition from a unicellular form to a multicellular colonial form, what is the role of cell-to-cell communication and how many different forms of cell-to-cell connections and communications are there? Are such forms of communication fundamental features of the evolutionary transition from unicellularity to multicellularity? In some cases, the daughter colonies are actually clones of the parent colony so that we now have the introduction of levels of organization: one-celled organisms, colonies, and clones, potentially constituting three hierarchical levels. The matter of clones raises the intriguing question of whether all members of a clone, such as a cluster of beech trees sprouting from a single individual beech tree, actually constitute an individual. However, the concept of ETI might also be stretched in questionable ways as evidenced in the chapter by Andrew Reynolds, "Discovering the Ties That Bind: Cell-Cell Communication and the Development of Cell Sociology." Is the use of the term cell sociology a misapplication of the concept of sociology in order to provide some basis for the evolution of animal and human sociology?

The editors also introduce four problems, we might call them themes, related to the question of biological individuality: individuation, hierarchy, temporality, and constitution. Individuation concerns the identity and unity of a living thing. All living things display some form of metabolism and generally also some form of growth. Through all this change of material composition, what guarantees the identity of the individual so that its identity and unity as an individual is retained? Another illustration of individuation is in speciation and the concept of species as individuals. At what point is a species as individual distinct from another species?

Hierarchy is another important theme that reflects the nature of the levels of organization of living things. During the nineteenth century, there was a very active debate between two basic schools of thought: vitalism and reductionism. Vitalism emphasized a holistic view of living things whereby the whole individual is greater than the sum of its parts. Reductionism emphasized the view that the individual can be understood by examining the mechanistic functioning of the constituent parts. This debate was continued in the twentieth century by organicism and systems thinking in biology, which emphasized a holistic view replacing the earlier vitalist views. Central to this discussion is the question of how the entities of one level are related to the entities of a higher level. Are the entities at each level to be considered as integral wholes or are the entities merely part of a higher level? Expressed another way, are we dealing with part-whole relationships or with whole-whole relationships as in enkaptic hierarchies? Olivier Rieppel in his chapter, "Biological Individuality and Enkapsis: From Martin Heidenhain's Synthesiology to the *Völkisch* National Community," lays out how the theory of enkapsis was used by some to argue for individuals to sacrifice themselves for the good of the whole national community in Nazism. Ingo Brigandt, in the chapter "Bodily Parts in the Structure-Function Dialectic," makes a case for considering functions or activities as entities that were proposed to become integrated into the levels of hierarchies. However, doing so would bring into question whether functions can really be independent of entities and whether this would obscure the fundamental meaning of hierarchical levels of structure.

Temporality is another theme that addresses the evolution or emergence of biological individuality. How do individuals at one stage of evolution relate to subsequent stages of evolution? A further issue concerns the units of selection and whether species are individuals, and thus, are possibly considered to be subject to selection. Temporality also relates to developmental stages and how stages relate to the identity of a biological individual. One very intriguing and significant historical discussion concerns the alternation of generations. For living things that display a remarkably distinct alternation of generations such as between haploid and diploid generations, to what extent are we dealing with distinct biological individualities? Are the alternate generations a single biological individual or are they separate biological individuals?

A fourth theme is that of constitution: what constitutes a biological individual? This is also related to the questions of part-part, part-whole, and whole-whole relations that are important considerations of hierarchical levels of structure. Additional fascinating aspects to this theme include parasitism and symbiotic relations. Parasitism involves intimate relations between host and parasite such that the parasite typically exists within the boundary of the host organism. In such a relationship, what constitutes the individual? Are they to be seen as a single individual or as two distinct individuals that are at least for a time intimately connected to each other? This is perhaps even more complex with regard to symbiotic relationships, especially with regard to obligatory symbiotic relationships. One clear example is the case of intestinal bacteria in human digestive systems. It is reported that 30% of our blood metabolites are bacterial products. Without such beneficial intestinal bacteria, human survival is at stake. The bacteria are considered to be biological individuals in their own right. So how does that affect human individuality? Another example is lichens, which are obligatory symbionts of specific fungi integrated with a specific form of algae. We intuitively recognize lichens as biological individuals. Is this perhaps an example of a whole-whole relationship?

This introduces a new concept of biological individuality, that of holobionts. Holobionts are biological individuals that encapsulate autonomous or semi-autonomous individuals into a functioning organism, as illustrated in the examples of symbiosis given above. Perhaps the process of endosymbiosis in which prokaryotes became incorporated into other eukaryotic cells is an early form of holobionts. Holobionts may also have impacts on genetic activity (viral insertions into a host's genetic makeup) and immunological recognition of self and nonself.

In short, this book on biological individuality is relevant to biological research and helps one develop a richer philosophical understanding of the nature of living things. It may also assist in reminding readers of the limits of reductionist and mechanistic understandings of the nature of life as a function of living

things. Reductionist and mechanistic views are heavily dependent on a philosophical materialism, which is opposed to a deeper Christian, theistic view of reality.

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TECHNOLOGY

RE-ENGINEERING HUMANITY by Brett Frischmann and Evan Selinger. New York: Cambridge University Press, 2018. 295 pages + foreword, five appendices, detailed notes, bibliography, index. Hardcover; $29.95. ISBN: 9781107147096.

In his 1954 classic, *The Technological Society*, Jacques Ellul explored the concept of "technique," a way of thinking in which optimizing productivity and efficiency becomes an end, not a means. Joseph Weizenbaum's 1976 book, *Computer Power and Human Reason,* introduces the "imperialism of instrumental reason," a way of thinking that seeks to frame all problems in the language of computation. Weizenbaum argues that not all problems can be framed in this way—justice, for example—and that it is not the case that all things that matter are amenable to measurement. *Re-Engineering Humanity* belongs to this same literary genre (critiques of technological thinking). It explicitly seeks to extend Weizenbaum's analysis to the impact of the internet.

Frischmann and Selinger develop two key concepts. The first concept, "techno-social engineering," consists of processes in which technologies and social forces align and affect how people think, perceive, and act. "Engineered determinism" is the second concept and "entails techno-social engineering of humans, often through the construction of smart techno-social environments that render humans within the environments increasingly predictable and programmable" (p. 220). They add that engineered determinism is "… the grand hubris that we can socially construct a perfectly optimized world if we only have the data, confidence in our tools, and willingness to commit" (p. 53).

The book is primarily a warning against techno-social engineering. Frischmann and Selinger assert that "as we collectively race down the path toward smart techno-social systems that efficiently govern more and more of our lives, we run the risk of losing ourselves along the way" (p. 1). They add that their "concern is with the social costs associated with rampant techno-social engineering that diminishes and devalues human autonomy and sociality" (p. 62). They argue that our humanity can be taken away, that it is at risk of deterioration by pervasive techno-social engineering. The basic capabilities at risk are thinking capacities, the ability to socialize and relate to each other, free will, autonomy, and agency.

These are strong assertions and the authors develop the case for them with some care. They examine a number of examples. For instance, to some people iPhones become part of themselves, yet the phone is designed to give access and control privileges to others; Facebook's algorithms determine who can see a post; global positioning systems can be used so easily that people lose a sense of where they are; furthermore, the data such systems generate can be exploited. The authors also point out that the internet has vastly increased the reach, interconnection, and continuity of techno-social engineering into homes and public places. They examine the internet of things, a means for ubiquitously distributed sensors to gather, exchange, and act on data. It can enable the providers of those sensors to engineer people's beliefs, preferences, and emotions.

They are careful about the structure of their argument. For instance, they acknowledge that they are making a slippery slope argument and devote most of one chapter to exploring the question of when such arguments might be legitimate. Since they assert that our humanity is at risk, they take time to examine what it means to be human and how one might detect that our humanity is being lost. To do that they reverse the classic Turing test for whether a machine can think like a human and ask how we might detect that a human is thinking like a machine.

Re-Engineering Humanity presents a dire picture of our current situation. So, the authors strongly argue for the "freedom to be off." They suggest three strategies toward this end. First, engage in critical analysis. For instance, Weizenbaum said that things that matter normatively are not necessarily amenable to measurement. Frischmann and Selinger extend that by pointing out an additional assumption often made, namely, that a common denominator for such measurements exists. Second, create friction on the slippery slope. Suggested methods include preserving net neutrality, using air gaps (places in software that are intentionally not optimized), using obfuscation techniques to disrupt surveillance, and anonymizing data. Third, challenge the logics of minimization and maximization.

It's hard to know how to evaluate a warning as serious as this. On one hand, the argument is carefully developed and the response strategies are worthy of consideration. However, the experience of reading the book is like looking at a room through a key hole

and seeing things that seem to be major concerns. One would like to see the rest of the room. There are good reasons for skepticism about the perspective the keyhole provides. For one, Frischmann and Selinger point out that humans possess a basic resistance to being manipulated and conceivably could successfully resist the kind of control they warn against. But they do not develop this point. Also, they do not engage existing empirical research on the impact of internet usage. Anyone who has programmed computers or worked much with them knows that doing so can be a source of great joy. Such work need not be manipulative or controlling and can be done with an aim of helping others. But joy and service never make an appearance in *Re-Engineering Humanity*. As a result, the book comes across as too much of a jeremiad.

What is needed in the face of such a serious challenge is a view of the big picture as well as careful attention to the particular concerns Frischmann and Selinger address. To their credit, the authors do a normative analysis, employing a consequentialist approach. However, for Christian scholars, a more comprehensive, more principled theory is not out of reach. Here are some components such a theory might include: (1) an affirmation that the capacity for technology is God's creation, a gift to humanity, and part of the cultural mandate—as such it is good; (2) a broader scholarly context that would include more studies by more critics of technology than this book includes; (3) a sense of the joy of technology, of both making it and using it; (4) a recognition of human sinfulness and hence the seriousness of dangers such as the one the authors highlight; and (5) a framework of guiding principles for developing technology in ways that are constructive and that include checks and balances for protecting against evil consequences.

Perhaps some reader(s) of *PSCF* can articulate such a theory. In the meantime, we can listen seriously to the warning Frischmann and Selinger offer.

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Note to ASA/CSCA Members

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

Theology

THE LOST WORLD OF THE FLOOD: Mythology, Theology, and the Deluge Debate by Tremper Longman III and John H. Walton, with a contribution by Stephen O. Moshier. Downers Grove, IL: IVP Academic, 2018. 192 pages. Paperback; $16.20. ISBN: 9780830852000.

In *The Lost World of the Flood*, Tremper Longman and John Walton put forward an interpretation of the Genesis flood narrative that treats it as an inspired, authoritative, and purposeful theological story of a real event. In so doing, they promote a serious view of the Bible while also alleviating unnecessary conflicts with science.

Structurally, the book's seventeen chapters are sorted into four parts and titled as propositions, a trademark of the Lost World series. Part 1 (propositions 1–6) addresses the "cognitive environment" and literary character of the Genesis flood story. Worldview, genre, and rhetoric are central concerns. Longman and Walton argue that ancient worldviews framed ancient genres, such that the modern categories "myth" and "history" are inadequate for the flood story. Genesis 1–11 is "history" in the sense that it refers to events that really happened (signaled in part by the use of the Hebrew word *toledot*, pp. 16–17). But the flood story is a *theologically interpreted* and *rhetorically shaped* story about a real flood. To express this idea, Longman and Walton propose "theological history" as a more accurate and faithful genre-label than "myth." As for rhetorical shaping, the flood story and its larger literary context (Gen. 1–11) bear the marks of figurative language (pp. 24–28), anachronisms (pp. 28–29), and hyperbole (pp. 36–50).

Part 2 (propositions 7–8) summarizes three Mesopotamian flood stories and compares them to the Genesis story. The Mesopotamian stories summarized are Eridu Genesis (Sumerian), Atrahasis (Babylonian), and Gilgamesh (Babylonian) (pp. 53–60). In their comparison to Genesis, Longman and Walton discuss theologies, portrayals of humans, details of the flood plot, descriptions of the rescue boat, and the roles of the key protagonists (pp. 61–87). They argue that readers should understand the Israelite story "not in terms of borrowing but rather in terms of Mesopotamia and Israel floating in the same cultural river" (p. 85). Even so, the authors alert readers to a fragment of the Gilgamesh Epic found in the land of Israel (p. 63, n. 3) and to words in the Genesis flood story that were probably borrowed from Akkadian, the language in which the Babylonian stories were

written (pp. 77–78). All four stories are said to preserve a memory of a real flood in the past, though interpreted to communicate significantly different messages. In the case of Genesis, "what is inspired and thus the vehicle of God's revelation is the literary-theological explanation that is given by the biblical author" (p. 85).

Part 3 (propositions 9–13), then, lays out the biblical author's literary-theological explanation of the flood. According to Longman and Walton, the Genesis story presents God responding to two distinct, but still related, concerns: (1) sin; and (2) disorder. The sin-judgment interpretation fits patterns of sin, judgment, and grace found throughout the book of Genesis (pp. 100–111), as well as interpretations of the flood found in Second Temple Jewish writings and the New Testament (pp. 96–99). Longman and Walton next argue that Genesis and its flood story have an even greater theological concern with God's presence in, and continued ordering of, the creation. Appeal is made to every major narrative constituting Genesis 1–11, including stimulating discussions of the "sons of God" (pp. 122–28) and the Tower of Babel (pp. 129–36). Both readings of the flood story—the sin-judgment interpretation and the presence-and-order interpretation—are shown to have intimate, purposeful connections to the patriarchal narratives (Gen. 12–50): the call of Abram is God's act of grace amid the sin and judgment that occur after the flood (pp. 109–10), and "the covenant [with Israel's patriarchs] can now be recognized as having its focus in the reestablishment of access to God's presence on Earth" (p. 140).

Lastly, Part 4 (propositions 14–17) summarizes scientific evidence relevant for claims about the flood that is narrated in Genesis, and follows this summary with an assessment of the value of science and Christianity for each other. The central sciences consulted are archaeology, geology, and anthropology. Longman and Walton discuss evidence of actual prehistoric floods in the Mesopotamian world, helping readers imagine the kind of flood that could have generated the stories found in Mesopotamia and Genesis. Guest writer and Christian geologist Stephen Moshier takes seriously the claims of flood geologists to demonstrate that Earth's geologic record simply does not preserve evidence of a global flood. Longman and Walton then return to discuss proper ways of understanding the proliferation of flood stories in cultures from around the world. All of these scientific insights, they go on to argue, help Christians clarify the word that God intends to convey through the Bible, even as Christians profess a faith that is poised and tooled to participate in scienc—both to learn through it and to challenge it when it becomes a pretentious philosophy and religion of its own.

The Lost World of the Flood has numerous strengths. Its style, structure, and content are accessible and manageable. Complexities are managed effectively and with nuance. The theological insights are thought-provoking, even for seasoned interpreters of the Bible. Science is handled respectfully, and so are the Bible and the concerns of sincere Christian readers, such as the Bible's inspiration, authority, and perspicuity. The virtue of humility pervades the book, and is most evident in the book's tone, in the way the authors offer suggestions instead of dogmatic, only-way solutions, and in their use and crediting of the interpretations that their own students have proposed.

Although few in number, the book's shortcomings are still noteworthy. When Longman and Walton argue against the view that the flood was actually local but was universal from the *perspective* of the survivors, reporters, and author(s), they say,

> The language used in the flood story does not support the idea that the flood was only a local, even if widespread, flood. And this conclusion is, in our opinion, inescapable whether the author of the account was describing it as local or the initial reporter … thought a local flood was actually a worldwide flood. (p. 48)

But if the initial reporter thought a local flood was actually worldwide, wouldn't this perspective precisely generate the universalistic language that appears in the Genesis story? And couldn't perspectivally universal language undercut the claim that the story's author(s) used hyperbole? The actually-local-but-perspectivally-universal flood theory is not adequately answered.

Second, the excurses, while informative, fall flat and are not integrated into their propositions. The excursus "Genealogies" (pp. 107–9) shows that ancient genealogies are referentially historical, factually fluid, and ideologically purposeful, but then ends without making clear how these insights inform the proposition that "the flood account is part of a sequence of sin and judgment serving as a backstory for the covenant" (pp. 100–111). The excursus "Modern Quests for Noah's Ark Are Ill-Founded" (pp. 165–66) is not integrated into its proposition about flood stories from around the world, and would actually seem to suit better the purposes of Proposition 14: "The Flood Story Has a Real Event Behind It" (pp. 145–49).

Third, since the origin and development of the Genesis flood story is a central concern of the book, it is surprising that Longman and Walton do not at

least discuss the widespread belief among biblical scholars that the Genesis flood story bears the marks of originally different stories that have been stitched together and reworked before taking a final form as a single story in the theological history of Genesis 1–11.

Fourth and finally, since the book insists that the Genesis flood story refers to real events in a real past, and since Longman and Walton show themselves highly alert to the concerns of evangelical and fundamentalist Christian readers, it is surprising that there is not a more direct and thorough discussion of human ancestry. Many Christian readers in the target audience will believe that all humans today have descended from Noah. If they are to entertain a different reading of the flood story, whereby a local flood is rhetorically and theologically reworked, then how should they go about rethinking the story of Noah's descendants, which is itself part of the flood story?

These criticisms notwithstanding, *The Lost World of the Flood* is a recommended read. It fills a niche in the library of Christians who care about Bible-science relationships. It educates in accessible ways. It models humility, inquisitiveness, and open-mindedness. It acknowledges complexity and elucidates nuance. It is ideal for Christian readers who see themselves as Bible-believers, but who need guidance that is wise and sound, at once committed to Christian faith and truthful with scientific findings. This reviewer has gained much in the way of content knowledge, resources, and theological insights. Readers are fortunate to be beneficiaries yet again of Tremper Longman and John Walton's ongoing work in the important field of science and Christian faith.

Reviewed by Daniel Gordon, McClure Professorship of Faith and Science, Lipscomb University, Nashville, TN 37204. ✧

Letter

Know, Believe, Understand

As a member of the Atheist Society of Denver, I would like to comment on Walter Bradley's article, "The Fine Tuning of the Universe: Evidence for the Existence of God?" (*PSCF* 70, no. 3 [2018]: 147–60), and the letters to the editor that it triggered. The argument from nature for the existence of design and hence a Designer, is an argument I almost always use as a starting point, to drive home the fact that atheists are not willing to go where the evidence leads them. This is articulated by the former atheist Antony Flew in his book *There Is a God: How the World's Most Notorious Atheist Changed His Mind*.

The quote Bradley used from John 20, where Jesus emphasizes the signs he performed to lead skeptics to accept his words, can be expanded further by checking on a few more scriptural references that address the question of which comes first, faith in God followed by confirmation of his existence using arguments such as the fine-tuned universe, or using arguments from design in nature, to whet the interest of an unbeliever for considering faith in God. Isaiah 43:10 reads, "… that you may know and believe me and understand that I am he." Also, the more commonly quoted passage of the same is Romans 10:14. Both imply that knowledge comes before faith, which then leads to faith, and eventually to understanding who God is. This is an important sequence (know-believe-understand) to get an unbeliever to start thinking.

Ken Touryan
ASA Fellow ✧

How, then, can they ***call***
on the one they have not believed in?
And how can they ***believe***
in the one of whom they have not heard?
And how can they ***hear***
without someone preaching to them?

~Romans 10:14