toms of these iDisorders, which can be exhibited by Christians and non-Christians alike. A common theme of these iDisorders is a person prioritizing relationships with technology and media over relationships with others (and for Christians this includes God). Knowledge of these iDisorders is useful for Christians to evaluate their own behavior. This knowledge may expose a Christian's dependence on technology instead of complete dependence on God. Christians might also discover that they exhibit behaviors which diminish their ability to minister to, have empathy for, and serve others in this technology-heavy world. For example, they may realize they are becoming less able to carry on long conversations with someone, they increasingly evaluate people by their looks, or they are becoming increasingly unable to meet appointments because of excessive time spent online.

The author makes the claim that the use of technology is irresistible. Thus, he never suggests that people avoid the iDisorders by simply getting rid of their cell phones, data plans, or social networking accounts. Calling technology adoption "irresistible" is controversial from a Christian perspective, because Christians are called to exercise freedom and responsibility. With God's help, a person can resist the negative impacts of technology. On the other hand, we Christians are called to engage, reform, and redeem culture, so avoiding all technology may hamper our ability to be witnesses of Christ in this world. Thus, a thorough investigation of the possible impact of technology on our thoughts and behaviors may be very useful, so that technology use does not become an idol but is instead used in service of God in our walk and work in this world.

I recommend this book. It is short and quite readable, apart from occasions when the author lapses into the use of psychology jargon that would not be understood by the average reader. The large bibliography may be a useful reference for anyone interested in exploring this area further.

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History of Science

INFINITESIMAL: How a Dangerous Mathematical Theory Shaped the Modern World by Amir Alexander. New York: Scientific American/Farrar, Straus and Giroux, 2014. 368 pages, biographical summary of key historical figures, timeline, endnotes, index. Hardcover; $27.00. ISBN: 9780374176815.

Five men in flowing black robes convened a meeting in the Collegio Romano to pronounce judgment on a dangerous idea which they feared might plunge their world into chaos. On August 10, 1632, the Jesuit fathers condemned and prohibited the dangerous and subversive doctrine of infinitesimals, the proposition that a continuous line is composed of distinct and infinitely tiny parts. Their opposition to this mathematical theory was based on the belief that the world was an orderly place, governed by a strict and unchanging set of rules. Infinitesimals threatened to undermine the authority of established religious and political order.

In *Infinitesimal*, the author weaves a historical drama, with all the intrigue of an adventure novel, set in the context of the mathematics of the infinitely small. Its key actors include many well-known philosophers, religious leaders, mathematicians, and scientists of antiquity through the Scientific Revolution, from Plato to Thomas Hobbes, Martin Luther to the Jesuits, Pythagoras to John Wallis, and Archimedes to Galileo Galilei and Isaac Newton. It is a fascinating read, connecting the dots between the religious turmoil of the Protestant Reformation, the consequent political upheavals that swept through Europe, and the birth of the modern scientific movement, including the religious ban on the heliocentric astronomy of Galileo and Nicolaus Copernicus, and leading to the development of modern calculus by Isaac Newton and Gottfried Leibniz. The debate over infinitesimals, while relatively unknown in comparison with the controversy regarding heliocentrism, occupied the same historical and intellectual space and involved many of the same religious and philosophical concerns.

The concept of infinitesimals is that, just as a cloth is composed of many layers of fine threads, an object of two-dimensional shape can be thought of as a collection of an infinite number of infinitely small but discrete lines. A solid surface can be considered an infinite number of two-dimensional planes, while a one-dimensional line can be divided into an infinite number of points. For modern scientists and mathematicians, this concept seems obvious because we have grown up with calculus involving the summations of the infinitely small. But in the sixteenth and seventeenth centuries, this concept was the subject of an intense and vigorous debate, with the outcome affecting no less than the stability of the social order and the authority of the church.

Why was this mathematical theory, which is standard curriculum today, considered so dangerous back then? Martin Luther launched the Protestant Reformation in 1517 by posting his Ninety-Five Theses on the door of Wittenberg's Castle Church and openly defended his stand against Catholic authority in 1521 at the Diet of Worms. The Protestant Revolution that followed plunged Europe into a series of religious and political conflicts that seemed to rock the very foundations of the civilized order. In order to counteract the chaos and uncertainty caused by the schisms and to restore alle-

giance to the authority of the church, the Papacy founded the Society of Jesus, known as the Jesuits. Among their missions was a strong emphasis on education; and thanks to the efforts of Christopher Clavius, their mathematical teachings were firmly established on the principles of Euclidian geometry.

Clavius believed that Euclidian geometry held the secret for restoring order to society and re-establishing the absolute authority of the church. He held that Euclid's theorems impose a rigorous order of logical proof that could establish the truth with undeniable certainty, proceeding from simple statements to ever-more-complex questions. This was in harmony with what the Jesuits were trying to accomplish—to impose a true, eternal, and unchallengeable order upon a seemingly chaotic reality—and Clavius believed that geometry held the key to other intractable problems in the scientific and religious debates of the time.

But infinitesimals threatened to challenge that rigid system of logical proofs. By dividing a line into an infinite series of infinitely small points, paradoxes and logical contradictions arose that defied the desired rationality and order of Euclidian geometry. If the parts are infinitely small, then the sum of their lengths should be zero. Or if they are not infinitely small, then an infinite number of them should be infinitely large rather than of a finite size. Comparing "all the lines" making up one shape with "all the lines" of another shape requires comparing infinity with infinity, which had been considered mathematically off-limits since the days of Zeno of Elea in the fifth century BCE. Consequently, in a series of judgments from 1601 to 1651, the Jesuit "Revisors General" denounced and finally banned as anathema the doctrine of infinitesimals.

Although in many ways an exact contrast to the Jesuits, Thomas Hobbes, philosopher and mathematician of the 1600s, also opposed infinitesimals for much the same reason. In Hobbes's philosophy (expressed in *Leviathan* and other works), the disorder in society needed to be brought under the control of an absolute ruler who would maintain and impose the sovereign will of society upon its dissenters. Hobbes opposed religious intrusion into matters of the state and held particular spite toward the Jesuits and the Catholic hierarchy, but agreed with them on the subject of mathematics: Euclidian geometry represented the solution of a rigid, unchanging certainty, order, and stability; but the problems with infinitesimals threatened that order and certainty, because their paradoxical results could just as easily lead one to a false result as to a true one.

On the other side of the question were leading intellectuals of the early modern age, including Galileo, whose final book in 1633 expounded the theory of "indivisibles"; Bonaventura Cavalieri, whose name and books on geometry were often cited by later mathematicians; Evangelista Torricelli, who provided a rigorous defense and series of proofs using indivisibles; and John Wallis, who sparred with Hobbes's philosophies and mathematical claims for several decades through a series of books and pamphlets.

One interesting resolution to the paradox of the infinitely small was proposed by Torricelli. Construct a rectangle ABCD with a diagonal BD. Then construct a series of horizontal and vertical lines intersecting at a point E along the length of the diagonal, forming an infinite series of smaller and smaller rectangles. The number of horizontal and vertical intersecting lines is equal to one another, yet the horizontal or vertical space occupied by the lines in each dimension is different because of the differing length of the sides of rectangle ABCD. Torricelli boldly asserted that the answer to this paradox was that the intersecting lines, although infinitely small, were thicker in one dimension than the other, in proportion to the difference in the sides of the rectangle. He went on to apply this technique by constructing lines intersecting a parabola, enabling him to calculate the slope of the tangent at every point on the infinite parabola. Rather than avoiding the paradoxes, Torricelli sought to understand their mysteries and employ them in the development of a powerful mathematical tool. A generation later, the "method of indivisibles" would be transformed into the differential and integral calculus of Leibniz and Newton, revolutionizing the mathematical foundation of the modern scientific landscape. The book concludes with the establishment of the Royal Society of London and the lengthy intellectual debate between John Wallis and Thomas Hobbes, ending with Hobbes's death in 1679. Appendices provide short biographies of the key players involved in the struggle, plus a timeline of key events.

Although the development of calculus is mentioned in the book, this reader was left hoping for another chapter or two describing in more detail how Newton and Leibniz each used infinitesimally small divisions to finally develop the formal methods of calculus. For instance, what were the differences and rationale behind their approaches? Why did Newton employ infinitesimals but shy away from their use in his formulations, whereas Leibniz made them a central component of his notation? Another concern is that the author characterizes the subject not only as an intellectual controversy, but as an anti-Catholic and perhaps antireligious screed. The reader is left with the impression that Roman Catholic Italy was plunged into intellectual stagnation by rejecting modernity through its insistence on eternal and unchanging truths, whereas England became the bastion of scientific, intellectual, and economic progress

due to its openness to dissent and lack of strict religious doctrine. This caricature of post-Renaissance Italy (and by extension, religious conservatism in general) is certainly lacking in historical and philosophical nuance and may aid in perpetuating the modern "warfare model" of the science/religion dialogue.

But despite these relatively minor complaints, I would highly recommend this intriguing book to all who are interested in mathematics or the history of the modern scientific era.

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EARTH'S DEEP HISTORY: How It Was Discovered and Why It Matters by Martin J. S. Rudwick. Chicago, IL: The University of Chicago Press, 2014. 315 pages plus glossary, a section "for further reading," and bibliography. Hardcover; $30.00. ISBN: 9780226203935.

In 1972, British brachiopod paleontologist Martin Rudwick penned a judicious and revelatory volume, *The Meaning of Fossils: Episodes in the History of Palaeontology*. This book (now 2nd ed., University of Chicago Press, 1985) remains a treasure store of insight into the impact of discovery—as well as the communication of discovery—upon many individuals of talent during the sixteenth through nineteenth centuries. Many of these historical protagonists were devout Christians (for example, Conrad Gesner, John Ray). Rudwick explored their ponderings and their fraternal debates as to just what these remains meant.

More books followed; I count nine, including the volume under review. These included a volume of translation, from the French, of Georges Cuvier's work on fossils (*ossemens fossiles*)—arguably the birth of vertebrate paleontology—and also a volume (*Scenes from Deep Time*, 1992) analyzing the impact of illustrations of "former worlds" revealed by these exhumed remains, during the eighteenth and nineteenth centuries. The scope of Rudwick's coverage broadened, to include the history of fieldwork and deliberation upon the history of Earth as well as that of life. Collectively, his writings now comprise the most significant single-author corpus analyzing the history of the earth sciences. Rudwick brings his Christian faith to his scholarship.

The present volume, *Earth's Deep History*, summarizes the development of a history of Earth. It is written in an accessible style and sparkles with nearly one hundred illustrations, mostly reproductions of original illustrations or text pages from significant individuals ranging from James Ussher to contemporary astrogeologists. Along the way, the geological time-scale develops until it reaches its current scope and detail.

Rudwick painstakingly demonstrates why historical thinking is an essential component of Earth comprehension. Earth and its parts are four-dimensional objects. Rudwick cleanly narrates the step-by-step realization that Earth was an object with a long history. The explanatory power and practical utility of time in analyses were appreciated for two centuries prior to the development of radiometric dating techniques. In fact, through several incidents, Rudwick explicates how spatially—and geometrically—commonsense interpretations of the rock record demanded large volumes of time, and this in the face of opposition based on the "absence of a mechanism." An example would be the development, over the course of several decades, of what would eventually become known as "plate tectonics" prior to the acceptance of the driving mechanism, mantle convection.

The apprehension of deep time during the eighteenth and nineteenth centuries, far from presenting obstacles to faith, was regarded as an ally:

> Closely related to this sense of the providential designfulness of the natural world was a sense of wonder at the romance of vanished deep past that the geologists' research was disclosing. So, for example, Mantell—who had discovered the *Iguanodon*, the first of the fossil reptiles to be classed later as a dinosaur—exploited a profitable vein of popular science by describing the *Wonders of Geology* (1838). The sheer scale and unanticipated strangeness of the earth's long history was often treated as welcome evidence for the grandeur of God's creation. Far from geology being in intrinsic conflict with religious faith, the science was widely regarded in the early nineteenth century as its ally and supporter. (p. 163)

A thread running through *Earth's Deep History* is the participation of earnest Christians in the development of the historical Earth sciences. Contrary to the wishes of some contemporary vocal atheists as well as some equally vocal Christians, faith and science have never been at war.

> What is certainly untenable is any claim that the discovery of the Earth's deep history has in the past been retarded or obstructed by "Religion" … In the history of the discovery of the earth's own history, as in the history of many other aspects of the sciences, the idea of a perennial and intrinsic "conflict" between "Science" and "Religion"—so essential to the rhetoric of modern fundamentalists, both religious and atheistic—fails to stand up to historical scrutiny. (pp. 306–7)

At several points during *Earth's Deep History*, Rudwick takes fellow geologists, or popular science writers, to task for falling prey to the temptation to frame a historical narrative in terms of a manufactured conflict metaphor.