PERSPECTIVES on Science and Christian Faith

JOURNAL OF THE AMERICAN SCIENTIFIC AFFILIATION

In This Theme Issue on Astronomy …

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

VOLUME 71, NUMBER 3 **SEPTEMBER 2019**

(US ISSN 0892-2675) (CPM #40927506)

Perspectives on Science and Christian Faith

Perspectives on Science and Christian Faith (USPS 28-3740, ISSN 0892-2675) is published quarterly by American Scientific Affiliation, 218 Boston Street Suite 208, Topsfield, MA 01983. Periodicals postage paid at Topsfield, MA, and additional mailing office. POSTMASTER: Send address changes to: Perspectives on Science and Christian Faith, 218 Boston Street Suite 208, Topsfield, MA 01983.

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The pages of *Perspectives on Science and Christian Faith (PSCF)* are open to original, unpublished contributions that interact with science and Christian faith in a manner consistent with scientific and theological integrity. A brief description of standards for publication in *PSCF* can be found in the lead editorial of the December 2013 issue. This is available at www.asa3.org → PUBLICATIONS → PSCF Academic Journal. Published papers do not reflect any official position of the American Scientific Affiliation.

1. Submit all manuscripts to: **James C. Peterson, Editor, Roanoke College, 221 College Lane, Salem, VA 24153.** E-mail: jpeterson@roanoke.edu. Submissions are typically acknowledged within 10 days of their receipt.
2. Authors must submit **an electronic copy of the manuscript formatted in Word** as an email attachment. Typically 2–3 anonymous reviewers critique each manuscript considered for publication.
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4. While figures and diagrams may be embedded within the Word text file of the manuscript, authors are required to also send them as individual electronic files (JPEG or PDF format). Figure captions should be provided as a list at the end of the manuscript text.

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Working Together across Disciplines

James C. Peterson

A workshop met the first day of the most recent annual meeting of the American Scientific Affiliation. The topic was how to collaborate effectively in interdisciplinary studies. That is near and dear to the heart of *Perspectives on Science and Christian Faith,* in which we seek to bring together the best of the sciences and Christian faith. *PSCF* is well equipped for this work, bringing to the conversation authors and readers from across an unusual breadth of knowledge, who are committed to communicate.

The breadth is seen in dialogue across the full range of the scientific disciplines. The accessibility is pursued when we ask authors to remember that the typical *PSCF* reader is a trained and proven expert in their field; however, that field is probably not the field of the article author. The essay must make an expert contribution to the author's field, while also being accessible to thoughtful professionals outside it. That is why each article is peer reviewed by experts in all the disciplines it addresses. For example, a recent essay on genetics, addiction, and Christian faith was reviewed by a geneticist, a clinician, and a theologian. Each of those fields was part of the argument and so was evaluated by an expert in that field.

It is a challenge to write at the highest level for your own discipline and yet to conscientiously make your work readable for a thoughtful scholar not in your field. It helps when an author already has some experience meeting this difficult expectation from writing grant proposals to organizations in which referees will not be drawn from the author's field alone. Also, many of us these days are in "big science" that requires cooperation. Maybe we can extend some of the lessons we learn there, as well.

To encourage mutual challenge and insight, there are scholars who can speak as experts in more than one discipline that they are bringing into an essay's analysis. Their efforts can be quite fruitful, but it is, of course, much to ask of bright but finite people who naturally struggle to master and keep up with all the developments in any *one* discipline. It would be markedly more manageable, and quite possibly more insightful, if the involved experts on a question could write from the beginning as a team within an article.

Granted, such would be quite contrary to our training. We learn more and more about less and less, in isolated departmental groupings, socialized to individual effort, degrees, and reward, and loaded with the time pressures of myriad responsibilities. For that matter, where does one find scholars who can contribute to an essay that would benefit from a line of thought or discernment in a field that one has not personally mastered?

Current copies of *PSCF* and free indexed archives, the annual meetings of ASA and CSCA, and the activities of local chapters are ready resources and are enjoyed all over North America. If we read each other, meet each other, talk with each other in the pages of *PSCF* and at ASA/CSCA annual and chapter meetings, we might expect, recognize, and develop synergisms by which we can insightfully think and write together. Such would redound to the benefit of all within the kingdom, and beyond. Cases in point include the combination of articles in this theme issue on astronomy, the previous theme issue on artificial intelligence, and future articles in response to the current calls for papers on transhumanism, and on raising food for thought. Collection issues can also do this well: for example, in free-standing articles such as the lead article for the upcoming December 2019 issue on the connection between benefiting from medical radiation and dating the age of the earth. Its authors include a chemist and a philosopher. We have great opportunities in place for working together at ASA: there is much we can learn from each other, and much we can share in interdisciplinary discovery. ☼

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

Susan D. Benecchi

Astronomy, Life, and Our Cosmic Creator

Susan D. Benecchi

The following article was first posted to inform and invite essays for this resulting theme issue on astronomy. It highlights the scientific accomplishments in astronomy over the last decade and invites interaction from our readers. Each section ends with suggested questions for investigation and reflection. It begins with the current focus on understanding the first moments of creation, looking for the source of life, and looking for life outside the earth. In particular, the growing number and characterization of extra-solar planets, planetary exploration within our solar system, and looking back in time toward the moments of creation are highlighted.

> "What the telescope is to the astronomer or the microscope is to the biologist, the names of God are to his children." ~Author unknown

Not long ago, I spent substantial time at Las Campañas Observatory in Northern Chile. Sometimes I used the 6.5-m Magellan telescopes, but much of my time was spent on the more modest 2.5-m du Pont Telescope which is located at the very end of the mountain range and separated from the center of the mountaintop hub of activity. I particularly like this site because the skies are amazingly dark, and I can go out to the catwalk and easily see the Milky Way Galaxy and, often times, the Large and Small Magellanic Clouds as well. These sights were so clear that I could not help feeling as if I were peering into the face and nature of God and seeing his fingerprints all around me. As the Psalmist writes,

> The heavens are telling of the glory of God; and their expanse is declaring the work of His hands. Day to day pours forth speech, and night to night reveals knowledge. There is no speech, nor are there words; their voice is not heard. Their sound has gone out through all the earth, and their utterances to the end of the world. (Ps. 19:1–4, NASB)

In addition to observing, I also teach astronomy to high school students. I try to bring the same awe and excitement into my classroom as we focus on different specialties in astronomy throughout the year, and I seek to engage my students to think about the science-faith dialogues that they might encounter.[1]

Early work in astronomy focused on mapping the grand design of the universe—discovering the basic laws of the universe and how it operates, and making general observations about objects in the night sky as worlds outside our own. More recent work in astronomy has provided exquisite detail on individual objects and has striven to shed light on the earliest moments of creation. Technology in the last approximately twenty years, since the advent of charge coupled devices (CCDs)—a major step forward for digital imaging—has revolutionized our ability to probe the distant past as well as track events in real time. In the last ten years, we have sent spacecraft to Mercury, Venus, Mars, individual asteroids, individual comets, Jupiter, Saturn,

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Pluto, and even a primordial Kuiper Belt Object, 2014MU69, to obtain in-situ measurements of environments outside our own atmosphere. We have designed a wide variety of ground- and space-based telescopes which have allowed us to map the entire universe at different wavelengths, to map the sky to high-positional accuracy (e.g., Gaia[2]) and to look for variations over short and long timescales. We are on the brink of launching even larger ground (the Giant Magellan Telescope [GMT][3] and the European Extremely Large Telescope [ELT][4]) and space-based (the James Webb Space Telescope [JWST][5]) telescope facilities and a number of new, even deeper all-sky surveys (Large Synoptic Survey Telescope [LSST][6]).

Cosmology Revealing Theology

A major thrust of modern astronomy is understanding the first moments of creation, looking for the source of life, and looking for life outside the earth. NASA's goal in astrophysics is to "discover how the universe works, explore how it began and evolved, and search for life on planets around other stars." It is focused on sending spacecraft missions to other planets and having telescope capabilities that allow us to fully explore the question of origins. Likewise, the European Space Agency (ESA), while participating in US space missions, has a direction of its own: focusing on understanding the large-scale evolution of the universe and its underlying physics. Studies which provide revelation about these issues include learning about the nature of black holes, dark energy, dark matter, and gravity. Closer to home it means exploring the origin and evolution of galaxies, stars, and planets. All of these discoveries lead to a grander perspective of the universe which God has created. I wonder, as Christians, how these discoveries broaden our perspective of the nature of God. How do they reveal his attributes? How do they challenge us to think in new ways on the interaction of science and faith?

Extra-Solar Planets

The field of astrobiology was thrust into the limelight in the early 1990s with discovery in 1992 of the first confirmed extra-solar planetary system orbiting the pulsar PSR1257+12.[7] This was followed in 1995 by the first detection of an exoplanet orbiting a solar-like star, 51 Pegasi.[8] Ground-based surveys have thrived, developing detection techniques of radio velocity, direct imaging, gravitational microlensing, polarimetry, astrometry and transit photometry. In 2009 the Kepler spacecraft, which utilized the transit photometry technique—watching a planet pass in front of its parent star—was launched, placed in an Earth-trailing orbit and pointed to a field near the constellations of Cygnus and Lyra.[9] It monitored some 150,000 stars continuously for over four years before the failures in the telescope prevented it from continuing to stare in the same location, and the telescope and mission were repurposed for other astronomical studies. As of 2019, there are more than 3,970 confirmed planets in nearly 3,000 systems with approximately 20% hosting multiple planets. Based on size alone, some 550 of these planets could be rocky in nature and some 16–20 of these are thought to orbit in the habitable zone of their parent star.[10] In April 2018 the Transiting Exoplanet Survey Satellite (TESS)[11] was launched to look specifically for earths and super-earths in the solar neighborhood. This work has revolutionized the general public's interest in space. Countless science-fiction novels have been published over the years, envisioning what our first encounter with an extra-terrestrial species might look like. Likewise, some now propose that life was delivered to Earth from some other place in our universe.

As Christians, the possibility of finding life outside of Earth might raise some interesting theological discussions. The Bible does not describe life in the form of beings other than on our planet—although it does describe angels in the heavenly realm—nor what we should think of such life if we were to encounter it. Some would argue that this is a closed topic: we will not find alien life elsewhere because the Bible does not specify that there is life elsewhere. However, C. S. Lewis in his Space Trilogy describes life on Thulcandra, or Earth, as fallen, but imagines life off Earth as not partaking in the Fall.[12] This sparks the imagination and begs the philosophical questions that would be raised if we indeed find Earth-equal planets orbiting other stars with habitable conditions, which is very likely to be the reality in the coming years. The same questions might be raised from repeated measurements of something like the "Wow" signal—a radio signal anomaly that was found as part of a study that was sweeping the sky looking for extra-terrestrial signals.[13] The question I ask my students when we get to this topic is, "Would finding life—of any form, not just intelligent—shake your faith?" Clearly from a humanistic perspective, it

moves the ball from life on Earth to life elsewhere in the universe, but it does not really change the question. Fundamentally the question to ask is, "Would finding life elsewhere change the way we view God and his relationship with us? Would it change our approach to the great commission (Matt. 28:18–20)? We experienced this, perhaps in part, in the sixteenth century, when new peoples and cultures, quite different from the world of the European explorers, were discovered in the Americas.

Solar System Missions: The Moon, Mars, Saturn, Jupiter, Europa, Titan, and Enceladus

Among recent spacecraft missions to other planets within our own solar system, conditions which are thought to be relevant to life have also been a focus of great interest. The buzz phrase for solar system exploration has been "follow the water." Since the Apollo years (1960s and 1970s), there has been a quiet undercurrent in all missions with the idea that one day humankind will leave Earth and explore our solar system, not just with probes, but with manned missions. The exploration push has been to study places that we could visit, places that have resources that we could use on Earth, or that have the potential for the existence of extraterrestrial life, albeit extremophiles.

One look at the night sky and you are likely to see the Moon sometime in a given month. It is bright, big, and beautiful. Its surface is solid and at times looks as if it would be easy to reach out and touch it. One idea that has been brewing for the last forty years or so is that of a lunar base. However, as in pioneer days, going someplace new is dangerous and unknown. Yet, because of modern technology, we have a huge advantage over colonial times. We can send unmanned probes to map the worlds that we want to eventually settle so that our settlements have a high probability of success. More than seven NASA missions have been to the Moon since the beginning of this century and they have built on the success of tens of missions in the previous century. Most recently, the Lunar Atmosphere and Dust Environment Explorer (LADEE; 2012–2013)[14] was sent with specific goals related to populating the Moon in the future. Some of these goals included determining the global density, composition, and time variability of the tenuous lunar atmosphere, or exosphere, and looking at the dust environment which is important for designing a permanent outpost. The Gravity Recovery and Interior Laboratory (GRAIL; 2011–2012)[15] mission was sent to provide an unprecedented map of the moon's interior structure and composition. And the Lunar Reconnaissance Orbiter (LRO),[16] which was launched in 2009, is still operational and is working to identify safe landing sites, locate potential resources on the Moon, and to characterize the radiation environment.

So although the cost is high, it looks as if a mission to the Moon for humans is again on our horizon with the recent commission of the Artemis program to return humans to the moon by 2024.[17] Beyond NASA, private industry is beginning to investigate ways for the common citizen to be able to make this trip.[18] I wonder how this might affect our witness as believers. Some of the early pioneers to the "New World" went, despite the cost, because they were looking for a place where they could worship freely. Other explorers went as missionaries, carrying the gospel message to the native people they encountered. Obviously, the Moon is different, and we already know that it has no human inhabitants, but I wonder how we can, as believers, play a role for God's glory as humanity moves forward in this endeavor.

In addition to, or instead of, the Moon, many people have their sights on Mars. It is farther away, but it has a thicker atmosphere than the Moon and potentially more resources available for habitation. Since the turn of the century, we have explored Mars in great detail at both single time-step and time-variable regimes through a combination of rovers, including Pathfinder, Spirit, Opportunity, the Phoenix Lander, and Curiosity, which have been able to sample surface materials; there have also been high resolution orbiters, including Mars Odyssey, Mars Express, Mars Reconnaissance Orbiter, Mars Orbiter Mission, MAVEN and the ExoMars Trace Gas Orbiter. The goals for these missions seem to have a dual nature—learn about the environment of Mars for human habitation, and also look for evidence that there has been life on Mars in the past. While the Spirit and Opportunity rovers survived much longer than what they were designed for and found many evidences for water on Mars in the past, the Curiosity rover was sent to look for more-recent evidence.[19] In short, the Curiosity rover has been successful. A key result has been the discovery of hydrated salts

in dark stains on the Martian surface at four different sites which are thought to be the smoking gun for liquid water in the past. It has also found additional evidence for early lakes which existed as recently as 10,000 years ago along with evidence for subsurface liquid water in the current epoch.[20] The atmospheric probe called Maven has measured, for the first time in forty years, the composition of Mars's atmosphere which included a large amount of dust hovering above the planet. The dust is thought to have come from comet and asteroid sources.[21] Maven also found the equivalent of Earth's northern lights caused by high-energy particles exciting the atmosphere unguarded by a magnetic field. And it has provided evidence that solar storms strip particles away from the atmosphere at an incredible rate, perhaps helping to explain why Mars's atmosphere is so thin. The Mars Reconnaissance Orbiter (MRO[22]; 2005) has been involved in monitoring Mars's atmosphere, and, since the arrival of the rovers, has provided invaluable communication support for these missions. In November of 2018, the Interior Exploration using Seismic Investigations, Geodesy and Heat Transport (InSight) Lander touched down to begin the first geophysical investigation of the Martian interior.[23] These are all key aspects to the reconnaissance of planet Mars before sending humans there.

All of the Martian discoveries point to Mars having been a very different place in the past, but mostly hostile to life now without serious protection. However, there is a huge push from within the Mars research community, as well as among the public in general, toward the idea of sending a human mission to Mars. There is already a long list of people who want to be the first on such a mission in spite of the risks involved. As with the Moon, this does seem a next logical step in human exploration. So, one might ask, what drives us to want to inhabit Mars? How much do we really need to know before we launch such an adventure? How much risk is okay for humans to take? Is it okay for humans to terraform the Moon, Mars, or other planets? Are we destined to live throughout the Solar System? What part should Christians play in these missions?

Beyond the reach of human missions at the moment, but clearly in sight tens of years down the road, studies of Europa, Enceladus, and Titan are looking for extraterrestrial life in our own solar system. Studies of different ecosystems on our own planet Earth have revealed that life exists in very extreme environments. These lifeforms, aptly named extremophiles, exist in all the dimensions observed—extremely hot and cold environments, high salinity, high and low pH values, high pressure, and extremely dry conditions. Some extremophiles have even been found in high-radiation environments. Studies of Jupiter's moon Europa by the Galileo spacecraft in the late 1990s and early 2000s revealed it to be the likely home of a large subsurface ocean,[24] and a twenty-year study by Cassini of the Saturnian system (1997–2017) revealed Enceladus to be a fascinating world with active geysers that are composed of nearly 100% water ice.[25] The Huygens's probe that landed on the surface of Titan in 2005 revealed it to have pebbles of water ice scattered over an orange surface resultant from a thin haze of methane in the atmosphere. The decent photos showed a landscape consistent with the presence of many lakes, likely filled with liquid during some seasons on Titan. Continued studies of Titan's atmosphere support the idea that Titan supports a hydrologic cycle akin to Earth's, with the exception that it is driven by methane instead of water.[26]

It seems that some of the life forms encountered by humans as described in Arthur C. Clarke's science fiction known as the Space Odyssey series[27] are perhaps not as far-fetched as they might have been when he first wrote them. What would discovering other forms of life, on places other than Earth, tell us about God and his intentions for us? How might this challenge our interpretations of scripture?

Small Bodies in the Solar System

In addition to looking for life, there have been countless missions to small bodies over the years. Some of these missions have had the inverse goal of protecting life here on planet Earth by identifying objects that might harm us. Large scale Earth-based telescopic surveys have detected tens of thousands of small objects ranging from meters to thousands of meters in size, and residing from orbits near Earth all the way out to the edges of our solar system in the Kuiper Belt and the inner Oort cloud. More than just determining the orbits of these bodies, studies have been done to learn about the orbital interactions and histories of these objects, their shapes, and surface compositions.

Planetary missions such as *Dawn* (which visited Vesta and Ceres), Hayabusa2, and OSIRIS-REx have studied individual asteroids to learn about their cratering histories—how often have these objects been hit and what the impacting population looks like—as well as their compositions. In October 2018, the Mobile Asteroid Surface Scout (MASCOT) spacecraft even landed on the surface of the asteroid (162173) Ryugu.[28] WISE/NEOWISE was a repurposed astrophysics mission that mapped the entire sky in the infrared and subsequently added hundreds of photometrically characterized (with known colors and rotation periods) small bodies to our databases. Finally, in July 2015, the *New Horizons* mission completed our inventory of spacecraft visits to the major planets (as they were listed prior to Pluto's reclassification in 2006 to a dwarf planet), revealing an active environment of surface ices some 34 AU from the Sun. On New Year's Day 2019, this same mission flew past an approximately 30-km Kuiper Belt Object, (486958) 2014 MU69, and found it to be the most primordial object ever studied up close, opening the door to a better understanding of the past and current history of the outer reaches of our solar system.[29] All of these missions have made significant contributions to our current picture of remnant material in our solar system. Theoretical models like the NICE model,[30] using constraints provided by these observations, have been drawn up to provide a potential narrative as to the mechanisms and timing of our solar system's formation out of an original solar nebula.

Although much of the motivation to study close-by objects has been to identify and, if possible, to protect Earth from objects that could destroy humanity as we know it, another motive has been to learn about material in space that we could one day use here on Earth, or for interplanetary travel. Still another motive has been to look for an understanding of our solar system's history and for an origin of life external to Earth (i.e., following the hypothesis that life was delivered to Earth from someplace else instead of originating here) as people have tried to answer the important questions: Where do we come from? What is our purpose here on Earth? Where are we going, individually, as a society, and as a species? If we find aspects of humanity elsewhere in our solar system, what effect might these have on our faith? What insights will they give us into how we interpret scripture?

Astrophysics: Looking for the Moment of Creation

Moving beyond our own solar system to bigger questions of cosmology, astrophysics has made significant progress in learning more about the large-scale structure and early beginnings of our universe including evidence for dark matter, dark energy and dark radiation. In 2016, the Laser Interferometer Gravitational-Wave Observatory (LIGO[31]) announced the first detection of gravitational waves, ripples that stretch and compress space itself and give us the ability to "hear" the universe. In 2017, the first-ever combined gravitational-wave and light-based observatories (from radio through gamma rays) confirmed the observation of two neutron stars colliding (GW170817)[32] and determined mergers like this to be the sources of many heavy elements in the universe.[33] In December 2018, four black holes, swirling toward each other, were detected using the same methodology. This new technique of "multi-messenger" astronomy, with simultaneous observations both in the electromagnetic spectrum and with gravity waves, has the potential to revolutionize our ability to view and understand our universe.[34] Building on these results, in early 2019, the Event Horizon Telescope (EHT), which uses very long baseline interferometry (VLBI), imaged a black hole for the very first time by capturing its silhouette against the glowing region around it.[35]

Likewise, studies to refine the Hubble constant, using the Hubble Space Telescope to look at thousands of Cepheid variable stars and hundreds of Type 1a supernova—two different types of cosmic yardsticks—have led astronomers to conclude that the universe is expanding 5–9 percent faster than previously thought. Reiss, one of the principle investigators on the project, suggests that "this surprising finding may be an important clue to understanding those mysterious parts of the universe that make up 95 percent of everything and don't emit light, such as dark energy, dark matter and dark radiation."[36]

Perhaps related to the questions probed by LIGO and HST has been the pioneering work of the "Conseil Européen pour la Recherche Nucléaire" (CERN) project since its inception in 2011.[37] Focusing on understanding the basic constituents of matter itself, they have built the world's most complex scientific instruments to produce particle collisions at

speeds close to that of light itself, in efforts to gain insights into the fundamental laws of nature. One of the most fundamental questions it has sought to address is, if the Big Bang created equal amounts of matter and antimatter as we understand the physics of it, why is there far more matter than antimatter in the universe?

Because these projects and discoveries take us back in time, they touch on the question of origins and the moment of creation, a question which poses great opportunities for faith interactions. They beg the question, what or who is behind our beginning? Why is there something rather than nothing? At the other end of the spectrum, if materialists are right that the stuff in our universe is all that exists, is the implication of the second law of thermodynamics then that the universe eventually will simply fizzle out and become cold and dark?

Biblical Hermeneutics and the Time Frame of Creation

> We do not draw people to Christ by loudly discrediting what they believe, by telling them how wrong they are and how right we are, but by showing them a light that is so lovely that they want with all their hearts to know the source of it.
> ~ Madeline L'Engle

Lastly, I want to provide an encouragement. I have seen a huge step forward in the last 5–10 years in our ability to dialogue and stand in unity with a distinctly Christian voice.[38] One of the issues that I face in my teaching is the question of time frame—is creation 14 billion or 6,000 years old? In the past I have seen this as a divisive issue inside the church and as a point of disunity with respect to the outside world looking in. Recently, there has been a real effort among the Christian community, and among Christian astronomers in general, to discuss this issue of time frame. What is the evidence from astronomy as to how old God's creation is? How does this evidence fit with our interpretation of scripture? Are there observations and measurements that we should be pursuing scientifically to better address this question of time frame? Are there alternative hypotheses or models, perhaps nonmainstream, that we should be developing?

An Invitation

So, with new astronomical discoveries occurring at an increasingly rapid pace, we are at the forefront of many amazing discoveries which often-times have metaphysical implications. We have an awesome opportunity to learn, and to share, how our life in Christ is related to our life among the stars. I invite you to participate in this dialogue by sharing your own thoughts on some of the questions I have posed or on other questions that have come to mind as you have been reading. May God be magnified as we not only deepen our relationship with him through our studies of his creation, but also seek to build bridges for the outside world to join us in this revelation. And may we effectively do what C. S. Lewis so eloquently exhorted, "Don't shine so others can see you. Shine so that through you others can see Him." ☼

Notes

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Robert J. Marks II

Article

Diversity Inadequacies of Parallel Universes: When the Multiverse Becomes Insufficient to Account for Conflicting Contradistinctions

Robert J. Marks II

The diversity of conflicting contradistinctions available from parallel universes is commonly exaggerated. The number of required universes is shown to increase exponentially with respect to the number of desired contradistinctions. For the commonly cited upper bound of 10^{1000} *universes in the multiverse, only 3,322 binary contradistinctions are possible. What about a countably infinite number of universes? Any finite number of contradistinctions are possible in such a multiverse. If, though, there are a countably infinite number of contradistinctions, all possible cases are not realizable in a multiverse with a countably infinite number of universes.*

Multiple universes essentially existing side by side constitute the multiverse. If a multiverse exists, the number of parallel universes is a question of debate. Serious scientific conception of the multiverse dates to at least 1952 when Erwin Schrödinger suggested their existence.[1] The multiverse was subsequently predicted by string theory, a beautifully elegant model that more and more looks to be unprovable.

Claims of resources available from parallel universes are often wildly exaggerated. Such claims can be used to discount the seemingly miraculous fine tuning of our own universe in order to support life.[2] If there are numerous parallel universes each with different properties, the highly unlikely chance of the existence of our fine-tuned universe is increased.

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The enormous diversity available from parallel universes, collectively called the multiverse, is suggested by the following exchange in the sitcom *The Big Bang Theory* between consummate nerd Sheldon Cooper and Penny, the girl next door.[3]

Penny: Morning, Sheldon! Come dance with me!

Sheldon: No.

Penny: Why not?

Sheldon: While I subscribe to the many worlds theory which posits the existence of an infinite number of Sheldons in an infinite number of universes, I assure you that in none of them I am dancing.

Penny: Are you fun in any of them?

Sheldon: The math would suggest that in a few I'm a clown made of candy. But I don't dance.

Although this dialogue is written as comedy, we can and will analyze its truth using Georg Cantor's theory of infinite

numbers. If there are an infinite number of universes, Sheldon could be right.

Physicist Max Tegmark makes a similar though less powerful statement with a greater degree of seriousness:

> Is there a copy of you reading this article? A person who is not you but who lives on a planet called Earth, with misty mountains, fertile fields and sprawling cities, in a solar system with eight other planets? The life of this person has been identical to yours in every respect. But perhaps he or she now decides to put down this article without finishing it, while you read on.[4]

Many physicists are champions of the multiverse. Others are skeptical of their existence.[5] "Some [scientists] even contend that studying the multiverse doesn't count as science."[6] Our purpose is not to participate in the multiverse existence debate. Nor will we discuss the various theories in physics that purport to support the existence of various models of multiverses. Interested readers can read the well-written article by Tegmark[7] or other tutorials.[8] Our purpose is to examine consequential claims often made concerning the existence of the multiverse.

Appealing to an infinite number of parallel universes lends credence to the contingency claims made by Sheldon. But assumption of anything infinite ultimately leads to logical absurdities[9] such as Hilbert's Hotel and the Tristram Shandy paradox.[10] Mathematician David Hilbert noted,

> The infinite is nowhere to be found in reality. It neither exists in nature nor provides a legitimate basis for rational thought. The role that remains for the infinite to play is solely that of an idea.[11]

There are those who disagree with Hilbert and argue the infinite does exist. Even so, the mathematical idea of the infinite due to Cantor[12] is well developed and allows us to visit Sheldon's infinite universe case later. This author is unaware of any *physical* manifestation of infinity and therefore sides with Hilbert in this philosophical debate.

The multiverse offers an explanation to the fine tuning of our universe that materialists readily embrace. Bernard Carr claims, "If you don't want God, you'd better have a multiverse."[13] Why? If there were a large number of parallel universes, the existence of an accidental fine-tuned universe becomes more probable.

The anthropic principle embraced by materialists and others explains fine tuning of our universe with the argument: "If the universe were not tuned for life, we wouldn't be here to notice it." The multiverse diminishes the need for imposition of the awkward anthropic principle.[14] We contribute to this argument in favor of creative fine tuning by noting that as many as 10^{1000} parallel universes come nowhere near to explaining meaningful diversity in the multiverse.

Let's first address the case in which the number of parallel universes is enormous but still finite. We make some simple calculations that reveal that available contradistinctions are not as great as they first might appear.

For a Finite Multiverse

There are many models of the multiverse.[15] A commonly quoted upper bound on the number of possible universes in the multiverse is the enormous number[16] $U = 10^{1000}$.[17] On first viewing, it looks as if there is nothing that we cannot do in this enormous space. A closer look shows that this is not the case.

Consider the case of a single binary contradistinction: Sheldon dances in one universe and does not dance in another. Two universes are required for this. Let's add a second contradistinction: Sheldon has read Max Tegmark's paper in one universe and has not in another. To allow both contradistinctions, four universes are required.

Let's assign a binary assignment of 0 and 1 to distinguish between two contradistinctions: 0 for NO and 1 for YES. For one contradistinction, two universes are needed: one where Sheldon dances and one where he does not.

For two contradistinctions, the four required universes for all possibilities would be tagged 00, 01, 10, and 11 for NO-NO, NO-YES, YES-NO and YES-YES. If a third contradistinction were added, eight universes are required: 000, 001, 010, 011, 100, 101, 110, and 111. Each additional contradistinction doubles the number of required universes. Therefore, if C

binary contradistinctions are desired, we need, at minimum

$$U = 2^C \text{ universes.}$$

If we perform the inverse operation, we find that the maximum allowable number of contradistinctions for universes is as follows:

$$C = \log_2 U \text{ contradistinctions.}$$

So what can be accomplished with 10^{1000} universes in the multiverse? The answer is only

$$C = \log_2 10^{1000} = 3322 \text{ contradistinctions.}$$

That is not a very big number. Making a list of contradistinctions this long is not only straightforward but reveals that we do not have the freedom of diversity initially assumed by Tegmark or Sheldon. This list might be as follows:

1. The actor who plays Sheldon dances. The actor who plays Sheldon does not dance.
2. The actor who plays Sheldon reads Tegmark's paper. The actor who plays Sheldon does not read the paper.
3. Donald Trump becomes president of the United States. Donald Trump never becomes president.
4. Elon Musk's rocket to Mars is successfully launched. The rocket is not successfully launched.
5. Mark Twain grows a moustache. Mark Twain does not grow a moustache.

⋮

3322. Blaise Pascal proposes Pascal's Wager. Pascal does not.

In this list we have used only binary contradistinctions. We could have trinary mutually exclusive contradistinctions such as the following: (1) "The Wizard of Oz" won the Academy Award for Best Picture in 1939; (2) "Gone with the Wind" won the Academy Award for Best Picture in 1939; or (3) "Mr. Smith Goes to Washington" won the Academy Award for Best Picture in 1939. Instead of multiplying the number of universes by 2, we would multiply the number of universes by 3.

Contingencies for a single event need not be binary or trinary. They can be in the millions. Some claim that there are about 10 million colors distinguishable by the discriminating human eye. If we listed all 10 million contradistinctions regarding, say, the currently most common car color on Earth, the number of universes required to cover all cases would be multiplied by 10 million.

The allowable contradistinctions grow logarithmically with respect to the number of universes. This is very slow. For the claims of Tegmark and Sheldon to be credible, the number of universes in the multiverse must be unbelievably large. The figure of 10^{1000} universes does not do it. If the number of parallel universes can be made arbitrarily large, though, all combinations from a finite contingency palate can be painted. Depending on how one defines a universe, Linde and Vanchurin have derived admitted speculative values of $10^{10^{77}}$ to $10^{10^{10,000,000}}$ parallel universes.[18] These are incredible jaw-dropping numbers considering that there are only about 10^{80} atoms in the universe.

The $U = 10^{10^{77}}$ universe count corresponds to about $C = 3 \times 10^{77}$ possible binary contradistinctions. Here is an illustration of how this can happen. Assume atoms in our universe and parallel universes are lexicographically ordered from 1 to 10^{80}. Atom #1 in our universe differs in some manner at any point of time from atom #1 in the parallel universe at some point in time. Possibly it could be displaced by a few million Planck lengths. This requires two universes. An additional parallel universe could have atom #2 likewise displaced, and so forth. Continuing with all the atoms one at a time results in the requirement of 10^{80} binary contradistinctions which cannot be contained in the $10^{10^{77}}$ parallel universes which, as we have calculated, have the capacity for only 3×10^{77} possible binary contradistinctions. And we have not considered, as yet, the contradistinction of whether you are made of candy in some parallel universe or have completed reading Tegmark's paper.

We have implicitly assumed here, as Tegmark and Sheldon did, that all of the parallel universes are similar to ours. This is not necessarily the case. The number of atoms being the same as in our illustration cannot be assumed. Indeed, we have also assumed the existence of time and atoms in the parallel universes. This may not be the case.

We have no corresponding illustration for exhausting contingencies in $U = 10^{10^{10,000,000}}$ parallel universes. If we write a one on an atom and continued to write zeros on all the remaining 10^{80} atoms in the universe, we have written the number $10^{10^{80}}$ which pales in

comparison. Taking the base 2 log of $10^{10^{10,000,000}}$ we calculate the corresponding allowance of a C that is greater than $10^{10,000,000}$ binary contradistinctions. That is a lot! If the number of parallel universes is large enough, you might be, as claimed by Sheldon, a dancing clown made of candy in one of them.

An interesting limitation occurs, though, when the number of universes in the multiverse becomes infinite compared to which the number $10^{10^{10,000,000}}$ now pales in comparison.

An Infinite Number of Universes in the Multiverse

An infinite number of universes allows all possibilities if the list of contradistinctions is finite.

But what if the list of contradistinctions is infinite? Interestingly, allowing for all combinations from an infinite contradistinction list cannot be contained in an infinite universe multiverse.

To discuss whether there is an infinite number of universes, we must first define infinity.[19] The symbol "∞," as used in mathematics, typically is read "increasing without bound." This is not infinity. No matter how large one increases a number, even $10^{10^{10,000,000}}$, the number is infinitesimal in comparison to the truly infinite.

The mathematics of actual infinities was developed by Georg Cantor. He denoted infinities by $\aleph$, the Hebrew letter *aleph*. The infinite set of all counting numbers, {1, 2, 3, ⋯} is said to contain $\aleph_0$ elements. A larger infinity, $\aleph_1$, is the number of points on the line segment between zero and one. Even bigger infinities can be constructed using the set of all subsets of smaller infinities. Since there are 2^N subsets of a set with N elements,[20] we can write $\aleph_{n+1} = 2^{\aleph_n}$. Since we can continue to make sets of all subsets forever, there is no biggest infinity.

As we struggle to intuitively grasp a physical intuitive interpretation of 4, 5, or 6 spatial dimensions, visualizing infinities above $\aleph_2$ is problematic. The set of all counting numbers has a cardinality (size) of $\aleph_0$, and $\aleph_1$ is the set of all points on a line segment between, say, zero and one. $\aleph_2$ can be visualized as the set of all possible scribbles in a square including squiggly lines, isolated points, and solid blobs. Like higher dimensions, infinities beyond $\aleph_2$ have no obvious intuitive interpretation but can be constructed mathematically by taking sets of all subsets.

Scripture refers to "eternal life,"[21] being "alive forever more,"[22] and "forever and ever."[23] We leave the question of whether these terms refer to infinite time, unbounded time, or even timelessness to Christian philosophers and theologians. We do know that Cantor had theological concerns about his results in the development of the so-called transfinite number theory of the infinite and corresponded with the Vatican about the matter. Historian Joseph W. Dauben writes,

> [Cantor] was … keenly aware of the ways in which his work might in turn aid and improve both philosophy and theology. Prompted by a strong belief in the role set theory could play in helping the Roman Catholic Church to avoid misinterpreting the nature of infinity, he undertook an extensive correspondence with Catholic theologians, and even addressed one letter and a number of his pamphlets directly to Pope Leo XIII.[24]

To understand the weirdness of the assumption of infinity, we need to explore the meaning of set cardinality (the number of elements in a set). Imagine a shepherd in the morning counting his flock. The shepherd looks at the first sheep and picks up one pebble. For the second sheep, he picks up another pebble. Repeating the process for all the sheep, the number of pebbles in the shepherd's palm is equal to the number of sheep. The cardinality of the two sets is the same because a one-to-one correspondence can be made between elements of the two sets. At the end of the day, the shepherd compares the number of pebbles collected in the morning to the number of sheep to make sure he has not lost any sheep.

Applying this to a set with an infinite number of elements yields absurdity. For example, the cardinality of the set of counting numbers {1,2,3,4,⋯} is the same as the cardinality of the set of even numbers, {2,4,6,8,⋯}. For every element in the counting number set, there is a single number associated in the even numbers. Like the shepherd, we associate the 1 with 2, 2 with 4, 3 with 6, 4 with 8, and on and on forever. Even though the even number set is a subset of the counting numbers, there are the same number of elements in both sets. The same is true for multiples of 100 in the set {100,200,300,400,⋯}. There are

the same number of elements here as in the set of counting numbers. Both have a cardinality of $\aleph_0$. The math is correct, but the results seem absurd. Cantor[25] famously remarked on such strange conclusions:

> *Je le vois, mais je ne le crois pas*!
> (I see it, but I do not believe it!)[26]

The absurdity of the infinite can be used to argue that the universe must be finite in age. Tristram Shandy is composing his autobiography. One day in Tristram's life takes him one year to chronicle. Poor Tristram falls further and further behind on finishing his autobiography. If the universe is infinitely old, however, there have been, to date, as many years in the past as there have been days. Both have cardinality $\aleph_0$. Therefore, one could argue that given this infinite amount of time in the past, Tristram could have completed his autobiography today! This clear absurdity is typical of that encountered applying Cantor's transfinite numbers to reality. Tristram Shandy's paradox also points to the necessity of a finite-aged universe without an appeal to physics and the big bang.

There are other mind-bending examples of absurdity from the assumption of infinities. For example, the number of points on unit interval from zero to one, $\aleph_1$, can be placed in a one-to-one correspondence with every point in a two-dimensional unit square. For example, consider the point 0.27548294… on the unit interval. Every other digit in this number is taken to define the points X=0.2589… and Y=0.7424…. These values define a unique coordinate on the unit square. Conversely, the value of any two coordinates on the unit square can be shuffled together to give a unique point on the unit interval. Incredibly, the number of points in a square and the line segment are the same: $\aleph_1$.

For such reasons, I believe no serious physicist should be a proponent of an infinite number of parallel universes. Assumption of infinity leads to logical absurdities. Nevertheless, because there are those who support an infinite number of parallel universes, let's perform a thought experiment and see what happens if there are. Clearly, any finite list of contradistinctions can be realized by $\aleph_0$ universes. No matter how large the number of contradistinctions, the corresponding log operation will be finite and therefore less than $\aleph_0$ and we are good to go.

For an infinite number of contradistinctions, however, this is not the case. Suppose we had a list of $\aleph_0$ binary contradistinctions. If we assume all contradistinction combinations can be assigned to a universe, we can make a table as shown (table 1). The infinite ($\aleph_0$) number of universes, *U*, are lexicographically ordered vertically and are numbered **1, 2, 3,** …. The contradistinctions, *C*, are likewise lexicographically ordered and numbered **#1, #2, #3,** ….

$U\downarrow, C\rightarrow$	**#1**	**#2**	**#3**	**#4**	**#5**	**#6**	…
1	<u>0</u>	1	1	0	1	0	…
2	1	<u>0</u>	0	1	1	1	…
3	0	1	<u>1</u>	1	1	0	…
4	0	0	1	<u>1</u>	0	0	…
5	1	1	0	0	<u>0</u>	0	…
6	1	1	1	1	1	<u>0</u>	…
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋯

Table 1. The infinite ($\aleph_0$) number of universes, U are lexicographically ordered vertically and are numbered **1**, **2**, **3**, …. The contradistinctions, C, are likewise lexicographically ordered and numbered **#1**, **#2**, **#3**, ….

In the table, an entry of 1 means the binary contradistinction is TRUE. An entry of 0 means FALSE. Contradistinction **#1** might correspond to finishing Tegmark's paper. In Universe **1**, the entry of 0 in the table means FALSE: you have not finished the paper. Universe **2** has a 1 for contradistinction **#1**. Therefore, the answer it TRUE. You have finished the paper.

From the table, the row for Universe **2** is 100111⋯. In Universe **2**, contradistinction **#1**, reading Tegmark's paper, is therefore TRUE, contradistinction **#2** is FALSE, **#3** is FALSE, **#4** is TRUE, **#5** is TRUE, **#6** is TRUE, and so forth. In making this list, we assume that every possible binary contradistinction combination is possible and is somewhere on the list. Using the ingenious diagonalization argument of Cantor, we can show our assumption is wrong and not all universes are listed in the table. The number of universes is therefore insufficient to include all possible binary contradistinction combinations.[27]

In the table, each element on the diagonal is underlined. Here is a list of the underlined entries: 001100⋯. If each bit is flipped, we get the complement 110011⋯. This sequence is nowhere on the list.

Let's call 110011⋯ Universe X. We know Universe X is not on the list since Universe X and Universe **1** differ on the first bit. Universe X cannot be Universe **2** because they differ on binary contradistinction **#2**. Universe X cannot be Universe **3** because they differ on the third contradistinction. Down the list we go and conclude that the universe corresponding to the bit flip of the diagonal is not on the list.[28]

The interesting conclusion is that an infinite number of contradistinctions cannot be realized by an infinite number of universes. More precisely, $\aleph_1$ universes are required to provide all of the combinations of $\aleph_0$ contradistinctions. Recall $\aleph_1$ is the number of points on a line segment. The points are so compact that given a point on the line, the nearest adjacent point cannot be identified. No matter what point is claimed to be the closest, there is a closer point midway between the points. Such is not the case with $\aleph_0$. In the set of counting numbers for example, the closest elements to 100 are 99 and 101.

Visualizing a continuum of $\aleph_1$ universes to cover all $\aleph_1$ contradistinction combinations is beyond the intuitive comprehension of your humble author.

Here is the takeaway. An infinite number of universes cannot exhaustively represent an infinite number of contradistinctions. The number of contradistinction combinations is limited to $\aleph_0$. The number of contradistinctions not covered by the infinite number of universes is greater than the $\aleph_0$ universes represented in the table and is equal to $\aleph_1 - \aleph_0 = \aleph_1$.[29]

Conclusions

Parallel universes, still a speculation, are a common source of exaggerated claims for simultaneous existence of conflicting contradistinction. A mere 10^{1000} parallel universes in the multiverse do not allow for much variation in terms of contradistinctions. The universe count, though, can always be made large enough to account for any contradistinction tally.

We have shed light on the claim Sheldon Cooper made at the beginning of this article: "While I subscribe to the many worlds theory which posits the existence of an infinite number [$\aleph_0$] of Sheldons in an infinite number [$\aleph_0$] of universes, I assure you that in none of them I am dancing." If $\aleph_0$ contradistinctions are assumed requiring $\aleph_1$ contradistinction combinations, Sheldon could, indeed, be right. There are many contradistinction combinations, including Sheldon not dancing, not realized in an infinite number of parallel universes. ☼

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[19]George Gamow, *One, Two, Three … Infinity: Facts and Speculations of Science* (Mineola, NY: Dover Publications, 1988).

[20]For example, the set {ABC} has three elements. Its subsets are Ø (the empty set), {A}, {B}, {C}, {AB}, {AC}, {BC}, {ABC}. There are therefore $2^3 = 8$ subsets of a set with three elements.

[21]Romans 6:23.

[22]Revelation 1:18.

[23]Revelation 20:10.

[24]Joseph W. Dauben, "Georg Cantor and Pope Leo XIII: Mathematics, Theology, and the Infinite," *Journal of the History of Ideas* 38, no. 1 (1977): 85–108.

[25]Fernando Q. Gouvêa, "Was Cantor Surprised?," *The American Mathematical Monthly* 118, no. 3 (2011): 198–209.

[26]Letter from Cantor to R. Dedekind regarding results of *Theory of Manifolds* (1877).

[27]Roger Penrose, *The Emperor's New Mind: Concerning Computers, Minds, and The Laws of Physics* (New York: Oxford University Press, 1989).

[28]This simple proof, due to Cantor, is referred to as diagonalization. It has many applications, including proof that the set of real numbers is greater than $\aleph_0$ and Turing's halting problem.

[29]A similar example is the set of points on the line segment [0,1] which has a cardinality of $\aleph_1$. We remove all of the points in this interval that are rational. The number of removed points is $\aleph_0$. The number of points remaining remains $\aleph_1 - \aleph_0 = \aleph_1$.

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Matthew C. Fleenor

"Faith Seeking Understanding" as an Intellectual Approach to Twenty-First-Century Cosmology

Matthew C. Fleenor

The credo of Anselm of Canterbury, faith seeking understanding, is examined within the context of twenty-first-century cosmology. To begin, the credo is situated within the varieties of its broad usage, primarily within a Christian context but also within the realm of philosophy. Specifically, the approach is developed that faith is the volitional posture for continued understanding, rather than the idea that faith is the precursor and a forerunner to the higher ground of understanding that replaces faith. While understanding is an aspirational goal, the sustained, mutual presence of volitional "faith" and rational "understanding" are necessary.

Next, the vast gains in understanding within the astronomical sciences are briefly reviewed, leading naturally to the crescendo of the "dark component" discoveries and the unresolved tensions that remain. Specifically, the concept of quintessence is explained as a volitional placeholder that motivationally drives a better understanding of a dark energy mechanism; "understanding" is put forth here as a deeper and more focused set of questions that replenishes and strengthens our volitional posture. Such concepts fall into a pattern and manner of doing science in which "faith" leads to deeper insight and understanding.

Where cosmological sciences are viewed rightly as a complicated process involving an ever increasing set of questions, cosmology always incorporates volitional components in proportion to its established epistemic understanding. In this view, materialistic scientism lacks an all-encompassing scaffolding, and science provides only one means of knowing reality. While Christian faith shares a volitional component with cosmology, it also retains an epistemic faith that is never fully alleviated, nor is it ever fully rationalized.

I. The Credo of Anselm and Its Meaning

Anselm of Canterbury lived and flourished as a Benedictine Father around 1100 in Bec, France. He is best known for the *Proslogion*, *Why God Became Man*, and specifically the "ontological argument" for the existence of God. Another famous statement of Saint Anselm is found in the *Monologion* as *"fides quaerens intellectum,"* faith seeking understanding (FSU). Both ends of the phrase overlap and situate themselves within the realms of theology and epistemology, separately and jointly. Because the idea of reason fits integrally with understanding, and as modern Christianity always hopes to be more reasonable, FSU has become an important phrase within Christian

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theology. Similarly, epistemology finds itself officially as a branch of philosophy, and "faith" and "understanding" both have the acquisition of knowledge within their scope. However, the usage of FSU has a panorama of meanings and interpretations, both originally within Anselm as well as within its modern, Christian context. A few modern interpretations are introduced below and a specific meaning is established for the purpose of this study.

A. Replacement Phenomenon (Understanding Supersedes Faith)

One manner of interpreting the phrase "faith seeking understanding" is that one begins in a state of "faith," in which belief in a proposition has little foundation, and then as reason is applied that original faith is transformed into "understanding." Similarly, as understanding is established and solidified, it replaces faith. Because the arguments of Anselm are developed as a matter of logical deduction, "understanding" is viewed as the higher epistemological ground. Faith is made surer by the establishment of a firmer understanding. In this case, "faith" is viewed as an understudy, an epistemic mechanism for acquiring knowledge until "understanding" is established as a basis for the knowledge. To quote, "faith seeking understanding … is a mode for turning one kind of knowledge into another kind … faith-knowledge into understanding-knowledge."[1] Through reason, "a process of unfolding" occurs whereby knowledge once acquired by faith is matured into a deeper understanding.

Along similar lines, the end of "understanding" is packaged as an "actualization" and/or "realization" of faith. In discussions such as this, it seems that Anselm's arguments satisfied his curiosity for the existence of God and the incarnation of Jesus. Although Anselm's arguments are sound, complete, and logically satisfying, Anselm is not satisfied despite his best efforts to reason for God's existence (see below). This particular view is somewhat muddled by the confusion of the sciences as "positive disciplines in which one arrives at knowledge via sustainable proof."[2] In order to live up to the need for certainty, we view Anselm as the champion of transforming belief into reason. The human longing "to finally arrive at … the ultimate realization of our faith" misconstrues Anselm's faith as well as the epistemic processes of science.

In summary, "faith seeking understanding" is often taken within Christian communities as the process of making surer intellectual commitments through the process of reason. While logical and rational thinking are important and essential to following Jesus, it is not clear that this view fully captures the meaning of the FSU phrase, nor of the typical processes of learning (science, included). While we may wish that the tension and struggle of our doubts would subside, a supplement of faith with reason does not have the magical effect of alleviating the need for faith. Some of the confusion between faith and understanding can be cleared by viewing Anselm's faith as a volitional undercurrent in the search for understanding. This particular idea is now addressed.

B. Faith as a Volitional Posture for Understanding

It is evident from Anselm's writings that the desire to know and understand is uppermost in his thinking. The following excerpt is exemplary and demonstrative:

> Lord, I am not trying to make my way to your height … but I do desire to understand a little of your truth which my heart already believes and loves. I do not seek to understand so that I may believe, but I believe so that I may understand; and what is more, I believe that unless I do believe I shall not understand.[3]

It is the nature of Anselm's believing and the meaning of faith within the FSU phrase that heightens our attention. While it is not prudent to seek to establish the concrete differences between volition and cognition, it may be enough to hold volition as a measure of resolve while cognition signals a level of knowing. In my view, this measure of resolve seems to connect more fluidly with Anselm's "belief" as a measure of his "desire to understand," rather than "belief" as a means of knowing that gives way to solid understanding.

Because the works of Anselm are ubiquitous in both secular philosophy studies and Christian theological works, the volitional nature of the FSU mantra is highlighted by both spheres of study. Within the realm of philosophy proper, this view is addressed most directly by the *Stanford Encyclopedia of Philosophy* (SEP). To provide their full explanation,

> But Anselm is not hoping to replace faith with understanding. Faith for Anselm is more a

> volitional state than an epistemic state: it is love for God and a drive to act as God wills. In fact, Anselm describes the sort of faith that "merely believes what it ought to believe" as "dead" (*Monologion*, 78) … So "faith seeking understanding" means something like "an active love of God seeking a deeper knowledge of God."[4]

Here, "faith" (in FSU), "love" (from the SEP), and "desire" (from Anselm's confession above) are terms that imply a volitional undercurrent not only supporting and guiding one's rational inquiry, but also providing the will in the midst of confusion, paradox, and struggle. This volitional undercurrent as a "drive" will be explored in what follows.

In his book with the same title, *Faith Seeking Understanding*, Daniel Migliore's view of FSU definitely fits the mold of faith as an active pursuit subsisting in the will. For Migliore, "faith" ventures, dares, struggles, fights, and calls. In this context, faith persists through the unresolved questions of Christian theology into new fertile ground, rather than being replaced by assured understanding.[5] In fact, faith of the kind described by Migliore journeys into deeper intellectual water and more-difficult questions. For Migliore, as for Anselm, faith and understanding symbiotically interplay with each other as will and intellect, instead of as competing degrees of intellectual ascent.

Karl Barth's work with the same title (this time in Latin), *Fides Quaerens Intellectum*, lays out a similar scope in its initial claim. Here, Barth goes to great lengths to remind his readers that "the aim of theology cannot be … to deliver their faith from doubt."[6] This statement corroborates the idea that, for Anselm, understanding serves a greater purpose than the replacement of faith. Further within Barth's thought, "according to Anselm's psychology, faith is in effect primarily a movement of the will."[7] Though there is more to Anselm's faith as Barth interprets, this view into Anselm's mind reveals that "faith" collaborates in the process of "understanding" with volitional overtones of guidance.

Specific Anselm studies also draw attention to the volitional tendency within the FSU credo. Eileen Sweeney describes the interplay between faith and understanding as a "double-reliance," in which again both subsist and are strengthened in the interplay in order to address the impossible, to understand the one "which none greater can be conceived." For her also, Anselm activates faith as it motivates reason independently in "an intense desire to know about the subjects he explores by reason."[8] In some of our Christian contexts, perhaps by taking out the active portion of the credo ("seeking"), we have mistakenly associated the terms ("faith" and "reason" are both types of mental processes) instead of keeping them separate as distinct entities, as Anselm intended. In the end, Sweeney sees Anselm's dissatisfaction with the logical ends of his reasoning as the ultimate vindication for the separation of volition and cognition. In the completion of the ontological argument, "[Anselm] has moved to a sense of God as beyond his grasp and has *increased* rather than satisfied his desire" (my emphasis).[9]

In summary, FSU is a mental process not only of varying degrees within the same type (cognition) but also of varying degrees of complementary types that strengthen in degree (volition and cognition). According to several thinkers, both those within Christian theology and those more generally across philosophy, what Anselm refers to as "faith" actually resides in the will and presents itself as a volitional undercurrent. This undercurrent presupposes understanding, is strengthened by the attainment of understanding, and yet extends beyond the present form of understanding. Demonstratively, this type of "faith" exists independently of cognition and does not subside when "understanding" is achieved. In this form, FSU exhibits the qualities of a method of learning rather than a mental process of knowledge acquisition and transformation. Having substantiated the method of FSU, I test the similarities of FSU to science learning in application to twenty-first-century cosmological studies.

II. Twentieth-Century Cosmology Revisited

It is almost unfathomable that less than one hundred years ago the question of whether the Milky Way galaxy stood alone in the universe was debatable. Even the champion of "island universes" in the Great Debate of 1920, Heber Curtis held to an anti-Copernican model that placed our solar system at the center of the Milky Way. Hubble's discovery of Cepheid variables in the Andromeda galaxy not only destroyed Harlow Shapley's single-galaxy universe,

but also revolutionized our picture of the universe as static and evident. Humbled to the outskirts of our own galaxy, we became a mere leaflet in the unconcerned flow of the stream of cosmic time.

Moreover, even in the mid-twentieth century when astronomers had narrowed their studies to the "search for only two numbers" (the precise values of the Hubble and the deceleration parameters), the ghost of Fritz Zwicky and other dark apparitions dealt another slice of humble pie to cosmologists. Astronomers reasoned by the 1970s that the "deceleration parameter" (q_0) was less than one-half, which implied that there was not enough mass-energy in the universe to slow the expansion. This conclusion was in combination with the observation that there was much less matter in the universe than assumed. In fact, even with the amount of "missing mass" (read, dark matter) set at unprecedented levels, there was still no closing the universe, as measurements were still short by a factor of five. In their history of twentieth-century astronomy, Jeremiah Ostriker and Simon Mitton correctly summarize that "the quantitative evidence was simply too uncertain to make definitive statements at this time."[10]

From the late 1970s onward, most cosmological studies considered the possibility of an open universe with a non-zero cosmological constant (Lambda, Λ). As an example, the ingenious and visionary Beatrice Tinsley authored "Accelerating Universe Revisited" in 1978.[11] Here, she surmised various cosmological scenarios that involved contributions from a constant that opposed gravitation, that is, a negative pressure contribution. The resurgence of the cosmological constant, originally assigned the moniker "Einstein's greatest blunder," arose due to the fact that the density of matter was too little (even with the assertion of large amounts of dark matter) but that the universe seemed very "flat" (no curvature). The curvature of the cosmos as flat implies that the amount of matter in the observable universe (that is, the current density parameter, Ω_0) is extremely close to the critical density (ρ_{crit}, the density at which universal attraction and expansion completely balance). As one introductory textbook puts this balance, "our very existence depends on the fanatically close balance (1×10^{-60}) between the actual density and the critical density in the early universe."[12] The flatness of the universe was also observed by microwave probes and remains a fixture in most cosmological models. These two seemingly observational facts (that is, the lack of gravitating matter, yet the persistence of cosmological flatness) imply the existence of some other contribution to the mass-energy budget of the universe. The stage was finally set for the Nobel Prize winning observations of 1998–1999 that brought Dark Energy into the everyday conversation of all who have an interest in cosmology.

III. Dark Energy and Its Proposed Origins

Dark energy is a concept conceived to explain the accelerating nature of the cosmic expansion. It was coined by cosmologist Michael Turner as a means to describe any component of the universe that provides a positive acceleration to the universal expansion.[13] Though it had been known for decades that the universe was expanding, most cosmologists (and astronomers in total) assumed that the universe was "closed," that is, the amounts of gravitating matter were greater than the critical density, and that the universe would re-collapse at some future epoch. When two independent teams of cosmologists in 1998–1999 both observed that distant supernovae were "fainter than would be expected *even for an empty universe*," the results were a "dramatic surprise."[14] Because the supernovae were dimmer than predicted, it was interpreted that the universe had stretched further apart than assumed for constant expansion (no acceleration). In 2011, the Nobel Prize in Physics was awarded to three scientists "for the discovery of the accelerating expansion of the Universe through observations of distant supernovae."[15]

It is now commonly accepted among the astronomical community that dark energy comprises approximately 68% of the mass-energy density universe. Of course, this quantitative accuracy betrays the lack of assurance that this number satisfies the requirement for a cosmologically flat universe (no curvature) because the matter density is 32% (85% of this is dark matter) and the total density of the universe is very close to 1.0 (remember, the critical density). A common expression holds to display this relationship:

$$\Omega_m + \Omega_\Lambda = \Omega_{0_{total}}$$

or in numerical form,

$$0.32 + 0.68 = 1.0.$$

The current situation leaves astronomers in the precarious position of not knowing the physical nature of 95% of the universe's constituents, while being able to explain the influences within the cosmos. What is the nature of dark matter? What is the nature of dark energy? Is there a connection between these two "dark components" of our universe? Being able to accurately account for the effects of the universe does not imply understanding. Certainly, scientists discovering the answer to any of these questions would warrant the receipt of a Nobel Prize in Physics.

The propositions for the origin of and/or the mechanism for dark energy remain plenteous. Although recent measurements from the Planck mission of the cosmic microwave background[16] and the Dark Energy Survey[17] allude to the possible dominance of a cosmological constant, many interpretative models persist.[18] Many proposed mechanisms utilize previously understood concepts in other areas of physics and apply them to the arena of cosmology. For the purposes of this article, I mention only two such mechanisms briefly.

The first is the concept of negative kinetic energy within an equation of state. As you may remember, kinetic energy is required to maintain a positive scalar value due to the squaring of the velocity and the nature of mass (always being positive). However, due to the repulsive nature of dark energy, a model of negative kinetic energy (since the field is dynamic yet repulsive) is sometimes put forth. This is a phenomenological model designed to provide a conceptual picture in order to motivate an equation of state. An equation of state establishes a relationship for characterizing a fluid such as an unknown diffuse field (for example, dark energy).[19] Although scientists are not actually seeking to measure a negative kinetic energy, the term does add meaning and motivation due to the conceptual familiarity of the kinetic energy term.

A second concept that is often used to describe dark energy is that of quintessence. Again, a familiar idea, namely that of a new and unearthly substance in the form of a scalar field, serves as a placeholder until new observations are made and models probed.[20] As the name suggests, quintessence is a specific form of matter that is minimally coupled to gravitation.[21] Quintessence can vary as a function of time in so-called "thawing" (becoming stronger with increasing time) and "freezing" (becoming weaker with increasing time) models. It suffices to show that quintessence is a malleable and somewhat amorphous concept, one that presents a specific picture while also preserving the opportunity for future flexibility.[22]

In summary, persistent observations imply the existence of a repulsive energy term responsible for the accelerating cosmic expansion. Familiar constructs used in new ways stand as surrogates until further data can be gathered. Dark components (energy and matter) beg the existence of new physics, new matter, or even paradigm-shifting revolutions in the way reality is perceived. In the words of the Planck (Telescope) Collaboration, one of the world's authorities on dark energy, "we currently lack any compelling explanation for its value [the cosmological constant], or a natural mechanism to produce it."[23] Despite the lack of foundational understanding regarding the phenomenon of dark energy, cosmological scientists maintain resolve that continued pursuit will produce the understanding they seek. In this way, scientists exert volitional strength in willing cosmology forward without significant understanding currently present.

IV. Cosmological Connections with FSU

While the proposition of attributing "faith" to scientists is usually met with great skepticism, we revisit one aspect of faith as practiced by Anselm. As presented in Section I, the faith portion of FSU was seen as a desire and a volitional undercurrent motivating the search for understanding. Similarly, as scientists face the reality of not knowing what the vast majority of the universe comprises, most are unshaken in their commitment to the proven methods of science in order to reveal greater knowledge. In this case, as is documented by philosophers of science, scientists often proceed with intuition and presupposition even in the face of anomalous data.[24]

Drawing further on the similarity to Anselm, science continues its further search for understanding as new vistas are realized. Science does not have the characteristic of being satisfied once new understanding is achieved. Much like Anselm, greater understanding fortifies the will with a deeper volitional resolve.

Chandrasekhar supports this idea by providing many historical examples in which scientists exhibit anticipatory passion and joy as deeper disciplinary connections are potentially realized.[25] In this way, FSU presents a model for learning and advancing in any intellectual pursuit, including cosmological science.

Cosmology in the twenty-first century exhibits many potential avenues for future development. Aligning the idea of FSU as an able, working analogy for the rhythm of science progression neither diminishes the results of cosmological science, nor hinders the embrace of science as a means for truth seeking. Rather, FSU supplements our traditional views of science as proceeding strictly by the scientific method.[26] In fact, many philosophers of science and history call into question the traditional scientific method as the main method for propagation of our understanding.[27] FSU provides a framework for viewing science as a discipline that proliferates through volition as well as through cognition.

V. What Is the Difference?

In summary, the famous credo of "faith seeking understanding" is presented as a volitional undercurrent supporting and motivating theological inquiry. As was true for Anselm as well as for modern-day theologians, the volitional undercurrent is strengthened and deepened in the achievement of increased intellectual understanding. Therefore, FSU should not be misinterpreted as a progression and culmination of intellectual cognition, in which faith is replaced by understanding. Cosmological science exhibits many characteristics that parallel any field of questioning. Though many achievements have been obtained, the nature of the dark components of the universe is still unknown with any degree of confidence. This situation presents the opportunity to observe FSU as it unfolds within cosmology because science continues with volitional resolve to deeper understanding. Dark energy studies demonstrate volitional resolve as established concepts are re-used for the purpose of new understanding, for example, quintessence.

Yet, differences between the underlying nature of the sciences and theology persist despite the similarities of volitional resolve in both fields. In the sciences, there is expectation that perception becomes clearer as more experiments and observations are made. For example, though the volitional resolve was high regarding the general theory of relativity in the original eclipse experiment measurements and interpretations, repeated and demonstrated observations continue to show support for the veracity of the theory. Therefore, the understanding produced in the sciences is epistemological in nature. Volition subsists but its logic is strengthened through observation and experimentation.

Conversely, in the realm of theology and Christianity, faith remains along with hope and love.[28] Though volition accords with the seeking of knowledge, and understanding results within the life of following Jesus, epistemic faith does not subside or become replaced with logical certainty. Confidence is built as trust increases and understanding forms, but the object of trust continues to be held in faith experientially. Beyond the quotes from Anselm earlier and the reference to Paul above, a few other examples will be offered.

Seen as the birthplace of creativity and courage, vulnerability requires the persistence of epistemic faith in order to grow. If vulnerability depends on uncertainty and risk, then certitude is anticorrelated with this desirable quality. In more explicitly religious contexts, the thought of both Blaise Pascal and Søren Kierkegaard thrive on the persistence of faith and trust in proportion to the growth of understanding. Pascal's "certainty" in his conversion gave way to the clear imperative of "the wager" as it requires an element of faith.[29] Similarly, Kierkegaard's "leap of faith" (as in many other places) reveals the necessity and perseverance of faith despite the emergence of new knowledge and understanding. It is when science and theology are viewed as complementary that the similarities and juxtapositions can be fully appreciated. When polarization and exclusivity are favored, wholeness is impossible. ☼

Notes

[1]Gregory E. Ganssle, "Thinking about God and Time," in *God and Time: Four Views,* ed. Gregory E. Ganssle (Downers Grove, IL: InterVarsity Press, 2001), 11–13.

[2]Luke Lin, "St. Anselm on Faith Seeking Understanding: Transforming the Belief of Faith into the Seeing of Understanding," Pew/Paideia Conference at Dallas Baptist University, April 2, 2005, 5–7, https://www3.dbu.edu/Naugle/PCS_Papers/Luke Lin/2005 PEW Anselm.pdf.

[3]Anselm of Canterbury, *Proslogion*, in *The Major Works*, ed. Brian Davies and G. R. Evans, trans. M. J. Charlesworth (New York: Oxford University Press, 1998), 96.
[4]Thomas Williams, "Saint Anselm," in the *Stanford Encyclopedia of Philosophy*, ed. Edward N. Zalta, Spring 2016 edition (rev. December 21, 2015), https://plato.stanford.edu/archives/spr2016/entries/anselm/.
[5]Daniel Migliore, *Faith Seeking Understanding: An Introduction to Christian Theology* (Grand Rapids, MI: Eerdmans, 1991), 2–5.
[6]Karl Barth, *Anselm: Fides Quaerens Intellectum, Anselm's Proof of the Existence of God in the Context of His Theological Scheme* (Norwich, UK: SCM Press, 1960; reprint, Eugene, OR: Pickwick Publications, 2009), 17.
[7]Ibid., 19.
[8]Eileen Sweeney, "Anselm's *Proslogion*: The Desire for the Word," *The Saint Anselm Journal* 1, no. 1 (Fall 2003): 22.
[9]Ibid., 31.
[10]Jeremiah Ostriker and Simon Mitton, *Heart of Darkness: Unraveling the Mysteries of the Invisible Universe* (Princeton, NJ: Princeton University Press, 2013), 217.
[11]Beatrice Tinsley, "Accelerating Universe Revisited," *Nature* 273 (May 18, 1978): 208–10.
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[13]Ibid., 56.
[14]Saul Perlmutter, "Supernovae, Dark Energy, and the Accelerating Universe," *Physics Today* 56, no. 4 (2003): 53–60.
[15]The Royal Swedish Academy of Sciences awarded the Nobel Prize in Physics 2011 to three scientists (one half to Saul Perlmutter and the other half jointly to Brian P. Schmidt and Adam G. Reiss), https://www.nobelprize.org/prizes/physics/2011/press-release/.
[16]Planck mission summary, European Space Agency (last updated May 13, 2015), http://sci.esa.int/planck/33333-summary/.
[17]The Dark Energy Survey: News and Results, "DES in the News," https://www.darkenergysurvey.org/news-and-results/des-in-the-news/.
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[19]Ryden, *Introduction to Cosmology*, 55.
[20]P. J. E. Peebles and Bharat Ratra, "The Cosmological Constant and Dark Energy," *Reviews of Modern Physics* 75 (2003): 559.
[21]Robert J. Caldwell gives a good but dated overview in "Quintessence," *Physics World Online* (November 1, 2000), https://physicsworld.com/a/quintessence/.
[22]Eric V. Linder, "Quintessence's Last Stand?," *Physical Review D* 91, no. 6 (March 15, 2015), https://journals.aps.org/prd/abstract/10.1103/PhysRevD.91.063006.
[23]Y. Akrami et al., Planck Collaboration, "*Planck* 2018 Results. I. Overview, and the Cosmological Legacy of *Planck*," submitted to *Astronomy & Astrophysics* (July 2018), https://arxiv.org/pdf/1807.06205.pdf.
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[25]Subrahmanyan Chandrasekhar, "Beauty and the Quest for Beauty in Science," *Physics Today* 32, no. 7 (1979): 25–30.
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[27]Niaz, *Critical Appraisal of Physical Science as a Human Enterprise*, 9–26.
[28]1 Corinthians 13:13, *The Hebrew-Greek Key Word Study Bible: NIV* (Chattanooga, TN: AMG Publishers, 1996).
[29]Blaise Pascal, *Pensées* (New York: Random House, 1941), 81–84.

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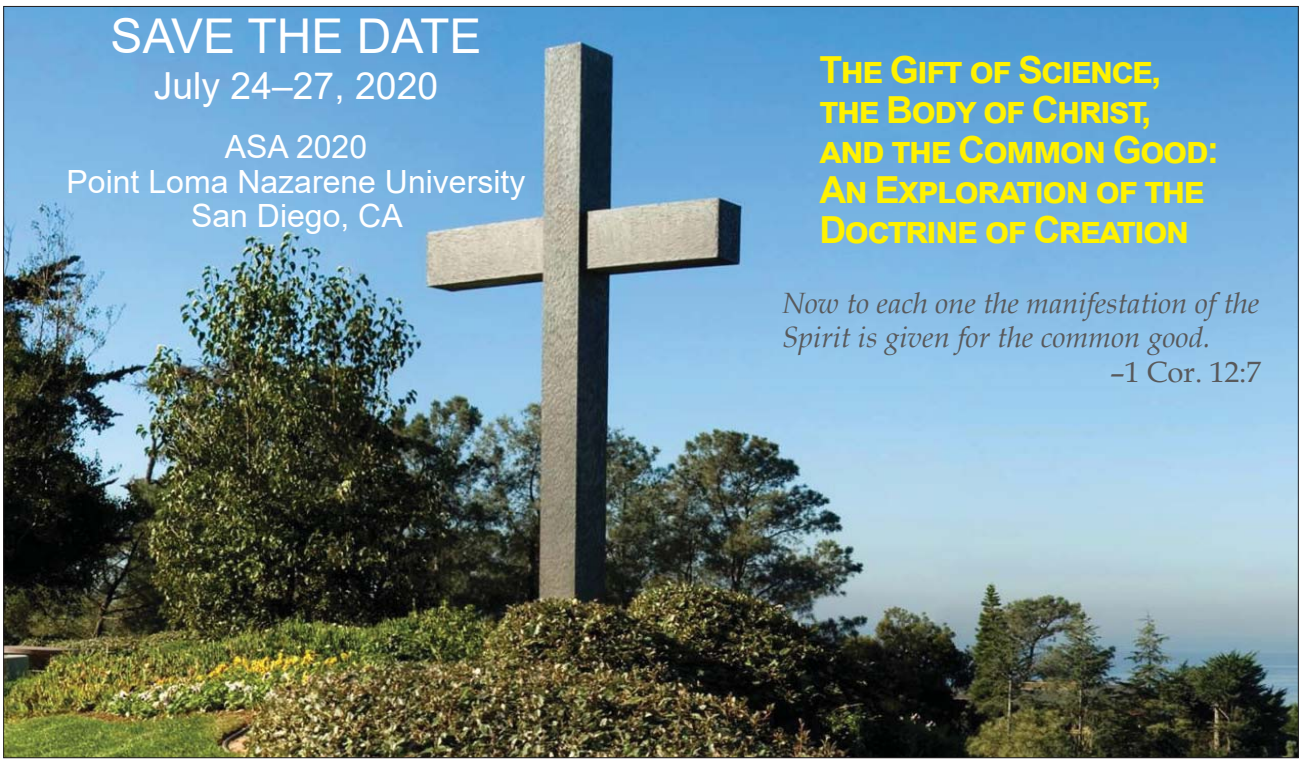

Dwight Hutchison

Article

Matthew's Magi Never Visually Followed a Star Anywhere, But ...

Dwight Hutchison

As we move forward into new discoveries in the heavens, it is also important for Christians involved in science to seek clarity about our ancient scripture texts. Matthew's account of the Magi and the star has been misinterpreted for generations. The star resists attempts to be discovered. One can find dozens of interpretations and speculations. Have we understood Matthew's account in its proper context? Recent archeological discoveries concerning Babylonian astronomy may help us to reimagine the Magi and their famous star.

The ancients marveled concerning the skies. Astronomical studies were done over many centuries by the Babylonians, Greeks, Chinese, Mayans, and others. While the Hubble and Kepler telescopes have been exploring deep space now, archaeologists, mathematicians, and archaeoastronomers have been exploring the world's ancient astronomical history. Some of their research in recent decades may have a bearing on our understanding of several biblical texts.

At the present time, using astronomical software, it is possible to immediately know the present, past, and future positions, brightness, and periods of visibility of a myriad of heavenly objects. However, this knowledge has roots in the ancient world. Mesopotamian astronomers made a detailed observation of the heavens for at least a few thousand years. Originally, their efforts were connected with trying to understand messages from the gods, but as time progressed, the Babylonian astronomers went well beyond that which was necessary simply to "read" omens in the heavens.

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Matthew's account of the Star of Bethlehem largely remains an enigma. Several atheists and agnostics recently have pointed out problems with both modern and traditional explanations of the star.[1] In 2014, at least eighteen of the twenty-two academic papers presented at an international academic colloquium were either formally opposed to Matthew's account of the Magi's star or largely called it into question. Indeed, there are significant problems. Looking at some of the proposals concerning the famous luminous object, one can be sorely tempted to join ranks with the skeptics.

Recent Christian Scholarship concerning the Magi's Star

In 2015, Colin Nicholl published a book entitled *The Great Christ Comet: Revealing the True Star of Bethlehem*.[2] Nicholl has taught at Cambridge University, and he was a professor of New Testament at Gordon-Conwell Theological Seminary. His book was a technical marvel, describing a completely hypothetical comet/star. After an amazing spectacle, the comet/star supposedly was positioned toward the Judean horizon so that it pointed to a certain house in Bethlehem. A huge amount of work went into the book. No

fewer than seventeen Christian academics and other persons solicited by the publisher gave the theory positive reviews on the Amazon page dedicated to the book.

A significant portion of Nicholl's theory relied on a questionable interpretation of the woman in Revelation chapter 12. The text from Revelation should be read with Joseph's dreams in Genesis 37 in mind, not with astrological theories about Virgo. It is regrettable that Nicholl did not even mention the background text from Genesis in his theorizing. If he had done so, he might have developed his ideas in a different manner.

In addition, one of the most important failures of Nicholl's scenario was purely astronomical. This is surprising considering the help that he received from professional astronomers. The author did not seem to realize that a comet that would have appeared to be pointing toward a certain house in Bethlehem could not "guide" anyone. The comet/star would have been pointing to another house or houses if an observer had moved ten meters to the left or right. Any observer approaching Bethlehem would have seen the comet/star pointing toward possibly dozens of homes all along the road. How would one even have had the idea that the comet/star was pointing toward a certain house as the Messiah's location, either on the way to Bethlehem or in the town? How would the men have known on which door to knock?

Much more can be said, but Nicholl should be congratulated for his extensive efforts. He did try to give a viable answer concerning the star enigma. However, Nicholl would have probably done better to insist that the star was only a sign concerning the Messiah, rather than a visual guide pointing to the King.

Questions and Problems concerning the Magi's Star

1. The traditional view of the star involves a mysterious, miraculous star that visually goes ahead of the wise men from the East all the way to Jerusalem and on to Bethlehem. However, ancient astronomers were never known to visually follow stars at any moment. Modern astronomers still adhere to the wisdom of their forebears and never venture out at night to follow any luminous planet, comet, actual star, or the moon. Over the centuries, Matthew's account of the star has most likely been misread.

2. A major weakness of the supernatural theory of the star is found in its lack of an explanation for the eastern manifestation of the star. If the Magi saw a supernatural star above the Messiah's head when they arrived in Bethlehem, what was the star that they saw while they were in their homeland? Was it also supernatural? If it was supernatural, how did the men come to connect it with the Jewish Messiah? Did their knowledge of the heavens count for anything at all in the story?

3. One can ask other questions: How would these men have known that they were supposed to "follow" any star anywhere? The Israelites in the wilderness of Sinai had instructions to follow the "pillar of fire and cloud." Did the wise men receive instructions to follow the star? How did this happen? Many commentators speculate that only the wise men could see the supernatural star. This is also an assumption not spelled out in the text.

Did the Magi travel to Bethlehem from Jerusalem during the night? Greek-speaking John Chrysostom, in the late fourth century, conceived of the star as a brilliant angel that was brighter than the sun.[3] He thought that the wise men visually followed the "star/angel" in broad daylight from the East all the way to Jerusalem and then later on to Bethlehem. He also believed that only the wise men could see the star. Apparently, Chrysostom realized that people generally did not travel at night. Matthew's text does not indicate that the wise men went to Judea or Bethlehem at night, nor does it specifically say they traveled during the daytime. As is evident above, there are a number of unspoken and perhaps unprovable assumptions which underpin the several versions of the traditional miraculous view of the star.

4. Although it is widely acclaimed as a key text concerning the Star of Bethlehem, Balaam's prophecy in Numbers 24:15–19 says nothing about either a natural or a supernatural star over Bethlehem. The text refers to a bright shining leader, a star, who would "come out of Jacob" and "bash through the forehead of Moab." In the gospel account, we read nothing about the Magi's star or Jesus hitting Moab or anyone else. Despite what numerous commentators say

concerning Numbers 24:17, it tells us nothing about either a star seen by men in the East or one over Bethlehem. The best candidate for Balaam's star is King David, who did wage war on Moab, Edom, and other sons of Seth. David's exploits, recounted in 2 Samuel 8:1–15, are a clear fulfillment of Balaam's prophecy. There would have been no scriptural reason for Jews or magi (Babylonian, Persian, Median, or other) to be expecting a star to appear signaling the appearance of the Messiah. One has to find other reasons concerning why the Magi came to associate a star with the Jewish Messiah. Simon ben Koziba, who led the Jewish revolt in the AD 130s, became known as Simon bar Kokhba. Simon, "the son of the star," was associated with King David, not with Moses, Jonah, Ezekiel, or anyone else.

5. The God who is revealed in the Bible does not make his bed with pagan deities. It should be understood that formal or made-up pseudo-astrological explanations concerning the star should probably be excluded from a Christian understanding of the events. The Magi who went to Bethlehem did not receive revelation through occult means. The God of Abraham has never been known to act in such a way.

During the last decades, at least two influential Christians aligned pseudo-astrology with the birth of the Messiah. Both Ernest L. Martin and Fredrick Larson have insisted that the fairly spectacular June 17, 2 BC, evening conjunction of Jupiter and Venus, joining them together as "one," constituted "The Star." For them, the conjunction was symbolic of a "father god" and a "mother goddess" coming together to have a child (the Messiah of Israel, no less!). Their argument should have been rejected, yet literally thousands of Christians bought Larson's DVD or consulted Martin's website (this author included).[4]

Babylonian astronomy was the most influential in the East at the time of the Messiah's birth. According to Babylonian thought, Dilbat, the star of Ishtar (Venus), was a female fertility goddess in the morning sky. In the evening sky, Dilbat (Venus) was thought to be a male war god. In the Babylonian omen catalog we read, "If Venus enters Jupiter, then the king of Akkad will die, the dynasty will change …"[5] Unless Babylonian astronomers had a good reason to think otherwise, the famous conjunction in the evening sky would have signaled a male war god striking the king (symbolized by the king planet MUL.BABBAR/ Jupiter) and overturning his rule. The Babylonians would certainly not have imagined "a father god and a mother goddess" coming together to make a baby on June 17, 2 BC.

A Star Proposal

All Bethlehem star theories involve presuppositions and spoken or unspoken assumptions. Here are important points for the star proposal presented in this article:

- The star was a herald of the Messiah: it was not a guiding light. The wise men witnessed a celestial announcement about a great king. They never visually followed anything, anywhere, at any moment. The star was given to inform, not to guide. Like normal travelers, the wise men probably traveled only during the daytime.
- The star was a natural celestial object. The heavenly signs surrounding the Messiah's coming seem to have been arranged since the time of creation.
- The star was not the brightest heavenly object. It never had a tail. The star was not overly spectacular while it was manifest to the wise men in the East or above Judea.
- The star was symbolically significant, but it did not indicate the specific day or time of Jesus's birth. The star announced the coming of a messianic king. Above Bethlehem, the star affirmed the Messiah's presence in the town.
- The star became symbolic in a context involving other stars, planets, and the sun and moon. It was involved in a series of celestial events centered on kingship.
- The wise men arrived in Judea about a year and a half after the first celestial signs. The young Messiah was probably about one year old. The wise men were not present with the shepherds at the time of Jesus's birth.
- The wise men went to Bethlehem during the daytime, and, over a short period of possibly several days, they made a careful search in order to find the Messiah's family. The men presented their gifts in the context of a private home. Matthew's mentioning of the "house" concerns the private nature of the meeting. The mention of the house is

not meant to localize the star. (See Matt. 13:36–43; 17:24–27, as well as Matt. 17:19–21 and the parallel passage in Mark 9:28–29.)

Babylonian Magi

Men such as Origen, Jerome, and Augustine thought of the wise men as Chaldeans and not as Zoroastrian Medes or Persians. In fact, very little is known about the astronomy and astrology of pre-Sassanian Iran (that is, before about AD 250). The reputation of the Persian astronomers arose from their activities following the third century AD.[6] The only usage of the word "magi" in the Greek Septuagint text of the Hebrew scriptures is in the book of Daniel.[7] The magi in Daniel's context were almost certainly Mesopotamians, not individuals from the Iranian plateau. The words "magi and magus" had come to be applied to many different people by the time the Septuagint was written. Luke uses the word for a Jewish false prophet in the book of Acts.[8] Using the Septuagint version of the scriptures, it would not have been difficult for Matthew to think of the Magi who eventually arrived in Bethlehem as Babylonians.[9] The distinguished Professor Edwin Yamauchi has voiced his judgment in the pages of *PSCF*, that the wise men were Babylonians.[10]

Looking to the Past

Based on the wealth of new archaeological information that has become available, especially in the last thirty years, one could possibly make a new attempt to get fact-based answers concerning the Messianic Star. Who were the Magi in Matthew's account? What were they like? What did they know? The next section of this article will briefly attempt to answer some of these questions.

Still existing, well-organized cuneiform Babylonian astronomical texts detail events in the heavens from about 700 BC to AD 75, but regular records were probably kept for many additional centuries. In recent decades, a series of books has been published containing about 3,000 pages of original Babylonian astronomical documents (one-half of the pages are cuneiform transliterations and the other half are translations).[11] Hundreds of pages of other technical astronomical documents and omen texts still exist as well. Even so, at the present time, there remains only a small portion of the vast corpus of Mesopotamian astronomical and astrological literature. From their observations, the Babylonians were able to understand the solar, lunar, and planetary cycles. They developed procedures and record-keeping systems that replicated the cycles and allowed them to make accurate predictions of future celestial events.

Babylonian astronomers developed detailed astronomical almanacs that gave them much of the basic information which one can now find using a simple computer application. About five hundred pages of transliterations and translations of original cuneiform almanacs have been published in recent years. The following is a typical example from a portion of a Babylonian "Normal Star Almanac" from ancient Uruk for a portion of the Seleucid Era year 150 (162/161 BC).[12] The Seleucid Era is a dating system that was associated with certain successors of Alexander the Great who reigned over Syria, Lebanon, Judaea, and Babylonia. This dating system was used by the Babylonians and others. The year 150 of the Seleucid Era is the equivalent of the year 162/161 BC. (Beginning in the spring, Babylonian and Jewish years straddle two of our years.) The text was predictive, calculated well in advance of the events. Question marks and gaps in the text indicate damaged or unreadable portions.

> Month I, the 1st of which will be identical with the 30th of the preceding month. The 13th?, the first moonset after sunrise. The 27th, the last visibility of the moon before sunrise.
>
> Night of the 5th, the first part of the night, Venus 2 cubits above Alpha Tauri (Aldebaran). The … Saturn stationary in Sagittarius. Night of the 12th?, the first part of the night, Venus 2? cubits below Zeta Tauri. Night of the 13th, the first part of the night, Mars 2½? cubits above Alpha Tauri (Aldebaran). Night of the 17th, the first part of the night, Venus 1 cubit above Tau Tauri. The 18th, Venus will reach Gemini. The 19th, first part of the night, Mercury's last appearance in the west in Taurus. The 21st, first part of the night, Mars' last appearance in the west in Taurus. Night of the 23rd, the first part of the night, Venus 1 cubit above Eta Geminorum. Night of the 25th, the first part of the night, Venus 1 cubit above Mu Geminorum. Night of the 27th, the first part of the night, Venus 4? cubits above Gamma Geminorum (Alhena).[13]

Comments about the Almanac and Babylonian Scholarship

The sample text shows the detailed nature of the Babylonian predictions, indicating the positions of the moon and several planets for many months in advance. There were some errors, but the Babylonian astronomers often succeeded in their predictions. From the fifth century BC onward, the Babylonians could calculate their lunar calendar for many decades in advance without additional observations. Documents exist which demonstrate the specifically measured and projected times for new moons, the full moon, and the last visible moon. Also, beginning in the fifth century BC, the Babylonians divided the path of the sun, moon, and planets into twelve equal parts containing 30 degrees each, forming an unchanging sidereal zodiac. This division of the sky facilitated their calculations.

The synodic cycles of the planets are very prominent in Babylonian observational and predictive documents. One finds first and last visibilities of the planets, their stationary points, and their acronychal risings. In the almanac text above, the reader will note that Mars disappeared into the solar glare in the west during the first month (last visibility/heliacal setting). However, if one looks at the whole document, Mars's calculated position was specifically indicated during months II, III, and IV as it would pass from one constellation of the zodiac to the next, while it was still invisible in the solar glare. Mars was then projected to enter Leo on the third day of month V. The planet was expected to become visible again (a heliacal rising) in the eastern sky the day after entering Leo (the morning of August 4, 162 BC). The days when other planets would pass from one constellation to the next were also forecast. In addition, the Babylonians very often calculated lunar and solar eclipses accurately. In the same almanac, at the end of month V, the astronomers predicted a solar eclipse in Virgo, which would not have been visible in Babylonia. It was to happen during the night of the 29th day of the fifth lunar month (August 28, 162 BC).

In the last three centuries before Christ, Babylonian astronomers developed an advanced mathematical astronomy. In early 2016, Mathieu Ossendrijver, a researcher at the Humboldt University in Berlin, published a paper in the journal *Science* which describes one recently translated calculation tablet concerning Jupiter's daily displacement.

> … Babylonian astronomers construed Jupiter's displacement along the ecliptic during the first 60 days after its first appearance as the area of a trapezoid in time-velocity space. … These computations predate the use of similar techniques by medieval European scholars by at least 14 centuries. The "Oxford calculators" of the 14th century CE, who were centered at Merton College, Oxford, are credited with formulating the "Mertonian mean speed theorem" for the distance traveled by a uniformly accelerating body, corresponding to the modern formula $s = t \bullet (v_0 + v_1)/2$, where v_0 and v_1 are the initial and final velocities.[14]

However, the above comments may give the reader a false impression. In Babylonian planetary astronomy, the synodic phenomena themselves were of keen interest, but not necessarily the daily motion of the planets.[15] Various algorithms are attested in still-surviving Babylonian cuneiform documents for calculating the synodic phenomena of the moon, and all the visible planets: Mercury, Venus, Mars, Jupiter, and Saturn.[16] As we shall see, the synodic phenomena of one planet may be a major key to understanding the star that eventually appeared over Bethlehem.

The ancient discoveries concerning the lunar, solar, and planetary cycles still have a practical role in our everyday lives. The Babylonian astronomers measured time through water clocks (clepsydra). Their basic unit of measure of time/degrees was called an "uš"[17] corresponding to four minutes of our normal time or one degree. Each day the sun, moon, and planets seem to move because the earth turns one degree every four minutes: 24 hours = 1440 minutes or 360° of angular distance (1440 ÷ 4 = 360).

The genius of later Babylonian astronomy is found in a statement made by N. M. Swerdlow, a retired professor of the University of Chicago:

> The very foundation of Babylonian mathematical astronomy is the measurement not of position, but of time, of intervals of months and days between phenomena drawn from records of calendar dates, and visibility times in uš measured with a water clock. The Scribes understood perfectly well that the measurement of location was far less precise than the measurement of time. … It seems clear, in any case, that the measurement of rising and

> setting times in uš lies at the very foundation of both lunar and planetary theory.[18]

One marvels at the ingenuity of ancient astronomers. Few people would dream that Matthew's wise men could have been technically capable of doing the things mentioned in the paragraphs above. Boxed in by what is assumed to be the only possible literal reading of the text, most traditional Christian presentations concerning the Magi and the star make little or no connection with the Magi's astronomy or their wisdom. Mystical church plays and Christmas card images have more or less dictated the church's understanding of Matthew's wise men. But there may be a way of reimagining the wise men, who eventually arrived in Bethlehem, as real scholars and astronomers.

Dating the Messiah's Coming

For various reasons, which go beyond the central focus of this article, many Bibles, commentaries, and godly preachers in the last four centuries have used a 4 BC date for the death of Herod the Great. This dating was first proposed by a Polish monk named Laurentius Suslyga in AD 1605. Suslyga's ideas were founded on a series of logical assumptions, but some of his dating proposals have been seriously called into question in recent decades.[19] These complicated matters have been explored in depth elsewhere.[20] The writings of Emil Schürer are often presented as being among the most authoritative on the dating subject, but most traditional Christians would hardly agree with his fundamental assumptions and arguments.[21] One has to accept the reality that our knowledge of the ancient past is imperfect, and it is often shaped by unprovable assumptions and even speculation.

In the early centuries of the Christian era, almost all of the church fathers believed that Jesus was born sometime during 3 or 2 BC, in the 41st or 42nd year of the reign of Augustus Caesar. A small minority of modern scholars believe that Jesus was born during 3 or 2 BC and that Herod the Great died in early 1 BC. This article adopts more or less the dates of the church fathers. In addition, the oldest church traditions indicate that Jesus was conceived at or near Passover and was born in December or January. The ancient "Feast of the Annunciation" (Gabriel's announcement to Mary) is still celebrated at Easter (Passover). Could anyone imagine a more Jewish date for a conception event than Passover? However, it may be that the skies themselves hold keys for establishing more reliable general dates both for Jesus's birth and Herod's death.

The Star in the East

Identifiable Celestial Kingship Events in 3/2 BC

A key element in the star story involves the star in the "east." It has become popular in recent decades to equate the phrase "saw the star in the east," with an early morning first visibility of a planet, star, or comet as it comes out of the solar glare (a heliacal rising). The "heliacal rising" interpretation of the passage was first suggested by various northern European scholars about one hundred years ago.[22] Franz Boll (1867–1924), a philologist, was once regarded as the world's foremost expert concerning ancient astrology. He rejected the "heliacal rising" translation. In reality, Matthew gives us a nontechnical message; he was not an astronomer. Even though a heliacal rising may have been important to the Magi, the famous phrase probably means that the men saw something while they were in the East.[23]

In Babylonian terms, there were two main royal "stars." The first royal star of importance was the king planet, the so-called "white star" MUL. BABBAR (Jupiter). MUL.BABBAR, the planet/star of Marduk, who was head of the Babylonian pantheon, was associated with messages concerning the king of Akkad in the omen texts used throughout Babylonian history.[24]

The second royal star was LUGAL, also called Sharru (both words mean "king"), which is Regulus in the constellation Leo. The constellation of the lion was also seen as being royal. Several constellations and planets are mentioned repeatedly in Assyrian royal correspondence with Mesopotamian astronomers in the seventh century BC. However, LUGAL (Regulus) was the only individual fixed star that seems to have had central importance to the astronomers who corresponded with the king.[25]

Parthian rulers, who dominated Mesopotamia in the first century BC, issued coins containing a star with the crescent moon (fig. 1).[26] The image on all the coins almost certainly stands for Regulus and the

moon.[27] It is probable that all of Matthew's Magi carried with them coins with the images of Phraates IV and/or his son Phrataaces.

Figure 1. Coins containing a star with the crescent moon issued by the Parthian rulers, who dominated Mesopotamia in the first century BC. Used by permission from www.cngcoins.com.

A monument, known as the Lion Horoscope, found in funeral statuary at Mount Nemrut in southeastern Turkey, is very similar to the coins (fig. 2). The monument portrays the constellation Leo with the crescent moon just beside Regulus. The royal house of Commagene, which commanded the monument, had historical links to all the major royal dynasties in the region. Culturally, the biblical Magi probably would have had the habit of directly associating LUGAL and the moon with kingship.

Figure 2. A monument, known as the Lion Horoscope portrays the constellation Leo with the crescent moon just beside Regulus. Image from "Lowenhoroshkop," an 1883 photo by Carl Humann.

The Danish expert in ancient Mesopotamian astrology, Ulla Koch-Westenholz, gives some indication of the meaning of the presence of Jupiter and Regulus in relation to the moon. This may explain why the Parthian rulers had placed Regulus with the crescent moon on their coins. The presence of Jupiter was also positive in an association of the moon with Regulus.

> In general Jupiter is a harbinger of plenty and peace, except in close connection with the moon (except when eclipsed) when it portends the death of a king and strife in the land, unless it is identified with Mul.LUGAL (Regulus) in which case it brings long days to the king (SAA 8 283).[28]

MUL.BABBAR and LUGAL in 3 and 2 BC

Were there any events involving the royal stars MUL.BABBAR (Jupiter) and LUGAL (Regulus) that might have impressed ancient astronomers in 3 and 2 BC? What happened at the key moments of MUL.BABBAR's 399-day synodic cycle?

Synodic Cycle Sign 1

MUL.BABBAR (Heliacal Rising)—Late July 3 BC

In the summer of 3 BC, when MUL.BABBAR first visibly rose out of the solar glare in the east, the sun was in its annual conjunction with LUGAL. Babylonian astronomers had ephemerides tables and procedure texts which could have indicated the position of the sun in relation to LUGAL (fig. 3).[29] The coincidence of the two events was unique. MUL.BABBAR was more or less in this exact position only every 83 years. Because of MUL.BABBAR's orbit, the mornings of July 28 or 29 in 3 BC were the optimum times in all of Babylonian astronomical history for the coincidence of MUL.BABBAR's rising and the solar conjunction with LUGAL (see statistics in the notes).[30]

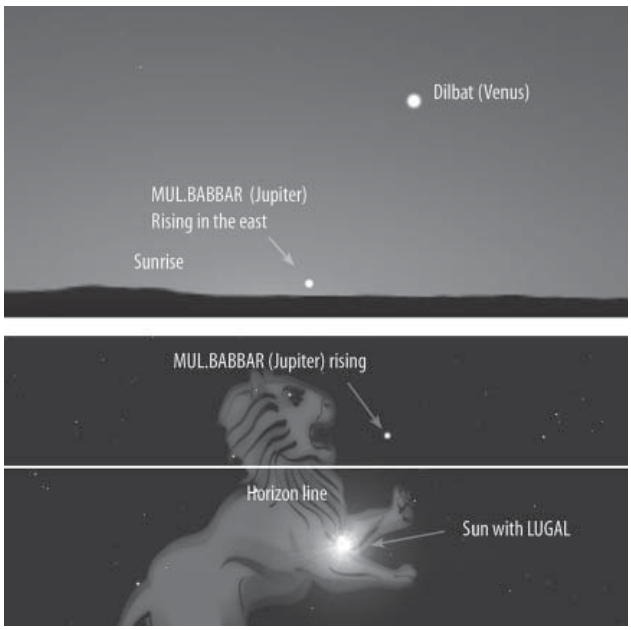

Figure 3. In the summer of 3 BC, when MUL.BABBAR (Jupiter) first visibly rose out of the solar glare in the east, the sun was in its annual conjunction with LUGAL (Regulus).

In Babylonian documents, the ideal rising time for MUL.BABBAR has been described. For example, on November 8, 142 BC, the astronomical diary entry reads: "The 22nd of the month, MUL.BABBAR's first appearance in Scorpius; it was small, the rising of MUL.BABBAR to sunrise: 11°30'" (11.5 uš = 46 minutes).[31] "Ideal first appearance on the 21st." (at 10.5 uš = 42 minutes).

On August 21, 109 BC, we read: "MUL.BABBAR's first appearance in Month V, Day 18, in Leo, rising of Jupiter to sunrise: 11 uš. Ideal first appearance on the 17th." (The previous day, it would appear that the ideal timing was about 10 uš.)[32]

The Almanac for the Seleucid Era year 150 in Month XII (see above) has MUL.BABBAR rising on March 24, 161 BC. From the sighting of the planet to sunrise there were about 10 uš.

The ideal rising in Leo seems to have been either 10 or 11 uš from the actual visual sighting of the planet to sunrise.[33] The planet would not normally have been visible for the first minutes after its rising above the horizon. However, a very bright planet like Jupiter certainly should have been visible within two lunar diameters or less from the horizon (within 1° of the horizon). See Babylonian historical statistics in the notes.[34] Below are the relevant facts for the 3 BC rising:

July 28, 3 BC, at Babylon[35]
Rising of MUL.BABBAR: 04:22:49 LMT (Local Mean Time)
Sunrise: 05:07:23 LMT[36]
Sun center from Regulus at sunrise: 0°31'

Rounding to the nearest minute, there were 44 minutes from MUL.BABBAR's rising above the horizon to sunrise. If one removes one degree to take into account MUL.BABBAR's invisibility toward the horizon, this leaves 40 minutes = 10 uš. On this day the sun was closer to Regulus than on the 29th.

July 29, 3 BC, at Babylon
Rising of MUL.BABBAR: 04:19:55 LMT
Sunrise: 05:08:06 LMT
Sun center from Regulus at sunrise: 0°40'

Rounding to the nearest minute, there were 48 minutes from MUL.BABBAR's rising above the horizon to sunrise. If one removes one degree to take into account MUL.BABBAR's invisibility toward the horizon, this leaves 44 minutes = 11 uš.

The two dates fall within the optimum dates for Jupiter's appearing according to Babylonian standards (statistics in the notes).[37] Ancient pagan astronomers in Babylonia would have understood that something symbolic had happened involving the king star and the king planet whether or not they had any other influences. The sun, known as Shamash in Babylonian thought, was associated with justice and truth. The sun appears to have been a positive celestial object except when eclipsed.

Synodic Cycle Sign 2

MUL.BABBAR's First Stationary Point—End of November 3 BC

On the day when MUL.BABBAR (Jupiter) had reached its first stationary point in Leo, the moon passed directly in front of LUGAL (Regulus) in an occultation (fig. 4). The royal symbolism is evident in that the moon was directly associated with the "king star" LUGAL at the same moment of the king planet's stationary point. Babylonian astronomers would have counted forward about four months from the heliacal rising to determine the date of the stationary point. They did not "eyeball" the station.[38] Counting about four months from July 28 or 29 one arrives in late November. The Babylonian dates were usually written with the first stationary point "around" a certain date in both their records and almanacs. The actual station was on the night of November 27/28.

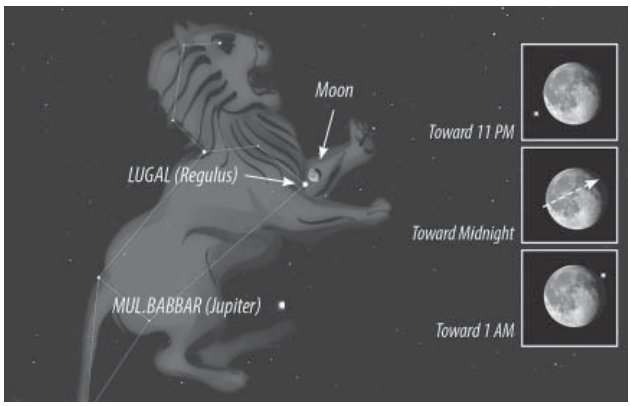

Figure 4. MUL.BABBAR's first station in Leo at the same moment as a lunar occultation of LUGAL.

According to one rough estimation, the coincidence of MUL.BABBAR's first station being in Leo at the same moment as a lunar occultation of LUGAL could

only happen about once in about 2,750 years.[39] Of course, this event brings to mind the Parthian coins and the lion monument. It was an obvious symbolic kingship event.

Synodic Cycle Sign 3

MUL.BABBAR's Acronychal Rising—January 2 BC

An acronychal rising of a planet or star is its last visible rising in the east just after sunset. Afterwards the object is already visible above the horizon in the eastern sky after sunset. The last visible acronychal rising was always several days before the true planetary opposition. It is impossible to actually see the planet rise above the horizon precisely at sunset.

In another segment of the zodiac away from Leo, the Babylonians added 58 days to the date of the first stationary point to get the acronychal rising date for MUL.BABBAR (fig. 5).[40] The planet's actual opposition was on January 26 in 2 BC. But January 24/25, 2 BC, was 58 days after November 27/28, 3 BC (First Station). The acronychal rising was often listed at about the time of true opposition (see the Late Babylonian Text—LBAT 1409).[41] However, according to Swerdlow, Babylonian procedural methods indicate acronychal risings at either 5°, 6° or 2° from true opposition, depending on the method which was employed.[42] The Babylonians usually listed the date of the acronychal rising as "around" a certain date. The Alcyone archaeoastronomy application, using an "arcus visionis" approach, gives the acronychal rising date as January 20, 2 BC.[43]

Figure 5. MUL.BABBAR's visible acronychal rising.

In the early evening on January 20, 2 BC, when seen from Babylon, the full moon passed in front of LUGAL again, making a second occultation in two months. January 20, 2 BC, could have been a possible candidate for MUL.BABBAR's visible acronychal rising.

Again, there was a clear connection to royalty through a simultaneous occultation and a possible acronychal rising. By this point, the men certainly could have been a bit puzzled about the meaning of the synodic cycle events.

Synodic Cycle Sign 4

MUL.BABBAR—Second Stationary Point—Late March 2 BC

MUL.BABBAR's second stationary phase was about four months after the first station. During its first and second stationary phase, the planet Jupiter is visually stationary for about two weeks. The Babylonians called the midpoint of that period the stationary point (fig. 6). Technically, Jupiter's second station was on March 29 in the spring of 2 BC. In their records and almanacs, the astronomers wrote the words "stationary around or about" a certain date. The station was calculated from the acronychal rising or the first station. In this case, the planet stopped its motion about 2.4 degrees west of Regulus.

Figure 6. The stationary point of MUL.BABBAR.

On March 31, MUL.BABBAR set in the west just moments before the moon rose in the east. Minutes later, Regulus set as the moon rose. Could this have been symbolically royal for Babylonian astronomers? Somewhat similar incidents involving simultaneous risings and settings of objects were occasionally mentioned in Babylonian astronomical records. They often spoke of "one god seeing another" when referring to similar incidents with the sun and moon. On March 31, 2 BC, the moon could feasibly have been associated with Jupiter's stationary phase.

Synodic Cycle Sign 5

MUL.BABBAR–Heliacal Setting—Late July, 2 BC

When MUL.BABBAR (Jupiter) finally made its heliacal setting in the west at the end of the planetary cycle, the sun was again in conjunction with LUGAL (Regulus) in the constellation Leo (fig. 7). This would have been about four months from the second station event. The optimum last visibility of MUL.BABBAR seems to have been about 10 or 11 uš after sunset (40 to 44 minutes after sunset).[44]

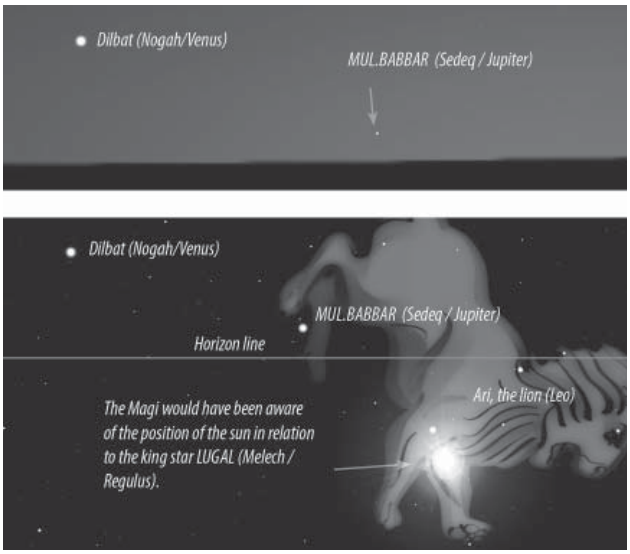

Figure 7. MUL.BABBAR made its heliacal setting in the west at the end of the planetary cycle, while the sun was in conjunction with LUGAL in the constellation Leo.

The events surrounding MUL.BABBAR's setting in 2 BC give almost a mirror image of the planet's rising one year earlier. The Alcyone archaeoastronomy application gives MUL.BABBAR's last visibility on July 28, if arcus visionis altitudes are the following: (MUL.BABBAR: +1° / Sun: -7°16').

July 28, 2 BC, at Babylon[45]
Sunset: 07:03:09 LMT[46]
Setting of MUL.BABBAR: 07:52:50 LMT
Sun center from Regulus at sunset: 0°21'
Sunset to MUL.BABBAR's setting = 50 minutes

If MUL.BABBAR was last visible at 1° above the horizon, it set six minutes later (50 – 6 = 44 minutes or 11 uš).

July 29, 2 BC, at Babylon[47]
Sunset: 07:02:33 LMT[48]
Setting of MUL.BABBAR: 07:49:34 LMT
Sun center from Regulus at sunset: 0°57'
Sunset to MUL.BABBAR's setting = 47 minutes

If MUL.BABBAR was last visible at 1° above the horizon, it set six minutes later (47 – 6 = 41 minutes or 10.25 uš).

Messianic Implications

All the above incidents involved the sun or moon as well as MUL.BABBAR and LUGAL. From a Babylonian perspective, there were royal implications to the extended series of unique celestial signs. These events could have been easily associated with the arrival of a truly great king. But such a series of events, all centered on MUL.BABBAR's synodic cycle, was unknown in their omen catalog. The men may have been surprised and questioning.

However, from a Jewish perspective, the incidents could have also called to mind the Messiah. It would not have been impossible for pagan Babylonians to become familiar with Jewish concepts. The Jewish community was large in Mesopotamia in the first century BC. Aramaic was the common language in the region. Also, scholars and many others would have spoken Greek. The Greek Septuagint text of the Hebrew scriptures would have been available for any who had questions about Jewish beliefs.

At some point in Jewish history, the planet Jupiter came to be called "Sedeq" (Tzedek) meaning "righteousness." The planet probably was commonly referred to by this name by about AD 200.[49] It would not be surprising that it carried the name in much earlier generations. The Jewish Messiah was spoken of as the "Righteous One" by early Christians (Acts 3:14; 7:52; and 22:14). This referred to the prophesied son of David, the righteous king of Jeremiah 23:5–6 and 33:14–17. Associating "Sedeq" with the king of the Jews would not have been difficult.

The Jewish equivalent of LUGAL was the word "Melech" meaning "king." One can see messianic implications by associating the two names Melech and Sedeq (the king of righteousness—Melchizedek). But in addition, LUGAL was in the lion constellation which evokes memories of Genesis 49:8–10 concerning the young lion of Judah and the rule of the Shiloh.

The messianic text of Psalm 89 also mentions the heavens several times. In the later part of the Psalm we read,

> … I will not lie to David. His descendants shall endure forever, and his throne as the sun before Me.

> It shall be established forever like the moon, and the witness in the sky is faithful. (Ps. 89:35–37)[50]

Here the enduring nature of the throne of David is associated directly with both the sun and the moon. Each of the five synodic events in 3 and 2 BC were associated with the sun and moon. In addition, remarkably, during two of the three conjunctions of MUL.BABBAR and LUGAL during this same cycle, the moon was positioned just beside the two "stars" on February 17, 2 BC, and May 9, 2 BC (fig. 8).

Figure 8. Moon positioned beside the two "stars." *Top:* February 17, 2 BC; *Bottom:* May 9, 2 BC.

In addition, during the relatively spectacular conjunction which visually united MUL.BABBAR (Sedeq/Jupiter) and Dilbat (Venus) on June 17, 2 BC, the full moon appeared in the east. The Jewish name of Dilbat is "Nogah," meaning "brightness." Sedeq and Nogah together evoke the "bright Righteous One" in the lion constellation beside the king star LUGAL (fig. 9).

By themselves the five signs connected to MUL. BABBAR's synodic cycle would have been enough to alert any Babylonian astronomer to the probability that something was happening concerning royalty. However, this series of events could have been supplemented by other celestial phenomena and symbolic associations. It may have been many

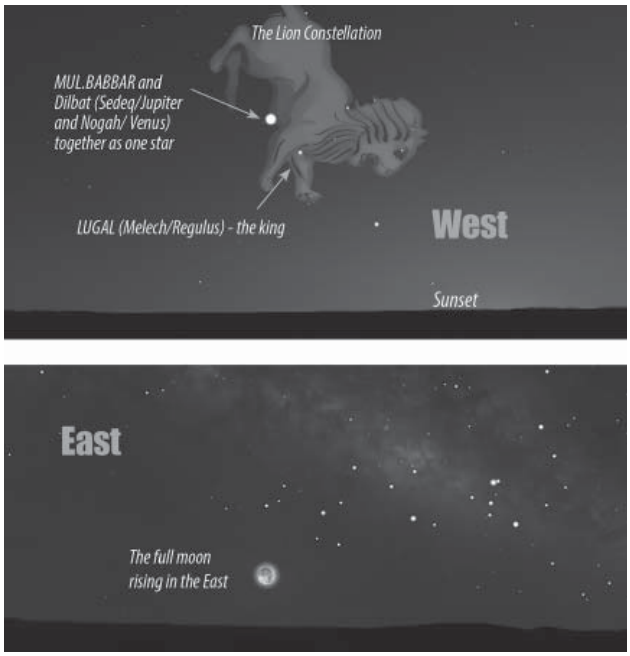

Figure 9. During the relatively spectacular conjunction which visually united MUL.BABBAR (Sedeq/Jupiter) and Dilbat (Venus) on June 17, 2 BC in the west, the full moon appeared in the east.

months before the astronomers came to the conclusion that the unfolding series of celestial events had something to do with the Jewish Messiah.

At the beginning, the Magi may have been complete pagans. However, the repeated and unique celestial signs, along with Jewish prophecy and royal symbolism, apparently convinced the men. A series of royal celestial signs all connected directly with the synodic cycle of MUL.BABBAR would have been completely unknown. Such a series is not found in the omen texts, but the royal nature of at least three or four of the synodic events is hardly disputable.

Based on this series of unique events, one could affirm that MUL.BABBAR (Sedeq/Jupiter), during this unique planetary cycle in 3 and 2 BC became the Messiah's Star.

The Star in the West—Rethinking the Key Text

Explanations of the Star of Bethlehem rise and fall based on the text of Matthew 2:9:

> When they heard the king, they departed; and behold, the star which they had seen in the East went before them, till it came and stood over where the young Child was. (NKJV)

In recent times, this passage has been interpreted to mean that the star went visually in front of the wise men from Jerusalem to Bethlehem. The eastern church fathers thought that the wise men had visually followed the star all the way from where they had been in the East to Judea and then on to Bethlehem. However, these ideas may not be what Matthew had in mind. In fact, the traditional interpretation of the text of the star as a visual guide may be profoundly in error. There may be an alternate literal reading of the text which can avoid the intellectual, scientific, and mystical puzzles of the traditional reading.

One way of understanding Matthew's text would be to look at other passages in Matthew, which use the same keywords. Matthew uses the Greek verb, προάγω (proago), with the specific meaning of "to precede" or "to go ahead of," in other passages in his gospel.[51]

In Matthew 14:22, we read: "[Jesus] made the disciples get into the boat and go ahead (προάγειν) of Him to the other side, while He sent the crowds away." Jesus then goes up on a mountain to pray and later meets the disciples on the sea. Jesus was not visually following the disciples at any moment, but he had simply sent them on ahead of him.

During the last supper, Jesus made the following statement: "But after I have been raised, I will go ahead of you (προάξω) to Galilee" (Matt. 26:32, see also Mark 14:28). After Jesus was raised from the dead, an angel appeared to some of his followers and said to them: "Go quickly and tell His disciples that He has risen from the dead; and behold, He is going ahead of you (προάγει) into Galilee, there you will see Him …" (Matt. 28:7, see also Mark 16:7).

It is clear that the disciples did not follow Jesus visually to Galilee after the resurrection in the same sense that one usually thinks about the wise men following the star. The disciples arrived chronologically in Galilee after Jesus already had arrived there. Jesus had "preceded" them there. In like manner, the star was waiting for the wise men upon their arrival in Bethlehem, just as Jesus later was waiting for the disciples. The star preceded the Magi to Bethlehem, but not as a visual guide. Matthew 2:9 simply sends the reader back to the East before describing the event in the West.

Bethlehem: A Possible Scenario

While the wise men were in their homeland, the star MUL.BABBAR (Jupiter), in association with other celestial objects, gave several symbolic indications that a great king was certainly arising. The men took this as an announcement about the king's birth. After having received the star's message, the wise men went to Judea. At every moment during their expedition, the men journeyed during the daytime like normal travelers. The way to Judea was well known. They were not looking to the star for visual guidance because the star's purpose had been to give a message. The star was a sign concerning the Messiah. It was not a guide.

Over a period of months, MUL.BABBAR came to be positioned well above the men's heads during a good portion of each night. In the days before the Magi arrived in Bethlehem, the star was near to the zenith in the nighttime skies. The Magi thought that the star had delivered its royal message while the men had been in the East. They were not expecting any other sign in the West. But after their arrival in Bethlehem itself, the men suddenly realized that the star was again in a symbolically significant position "above the place where the child was" (fig. 10).

Figure 10. The star was in a symbolically significant position "above the place where the child was."

On the timeline presented here, the men would have unexpectedly arrived in Bethlehem in late December 2 BC. There would have been no reason that the men should have expected any other celestial signs. They never expected to arrive in Bethlehem. But considering their previous experience in the East, it would not be hard to imagine that Jupiter's stationary point on December 28, 2 BC, could have been symbolically meaningful to them.

Matthew's terminology about the star "standing over the place where the child was" is simply affirming that the star was present in the sky while the men were in the town, it having "preceded" them there. Matthew's terminology about MUL.BABBAR's "standing over" the town (and indeed all Judea in the latter part of the night) was not specifically an astronomical reference to the planet's first station.[52] However, in the context, MUL.BABBAR's first station could have been a symbolically significant celestial event for the Magi while the planet was located over Bethlehem.

While a relatively unspectacular planetary station is not at all impressive for modern skeptics or believers, symbolically it would have recalled the Magi's experience in the East. If MUL.BABBAR's first station was happening at the moment of their unexpected arrival in the town, the men certainly would have rejoiced, thinking that the planet's station was a heavenly sign.

Conclusion

The Messianic Star seems to have been connected to symbolic royal celestial events at the heart of Babylonian planetary science. The star was not discovered through the Babylonian omen catalog or their normal astrology. The star over Bethlehem was not spectacular. It was not necessary for the star to be overly luminous or visually remarkable. However, the star was symbolically significant. The wise men never followed the star anywhere visually, but the star was waiting for them upon their arrival in Bethlehem.

David's throne will indeed be established for ages to come, even as the sun and the moon have endured for ages past. The witness in the sky is faithful (Ps. 89:34–37). ☼

Notes

[1]Webpage https://buff.ly/2HNdDys provides an annotated bibliography of many star interpretations.

[2]Colin R. Nicholl, *The Great Christ Comet: Revealing the True Star of Bethlehem* (Wheaton, IL: Crossway, 2015).

[3]St. John Chrysostom, *Homilies on the Gospel of Matthew,* Homily 7: Matt. 2:4, 5, sections 3 and 4, http://www.documentacatholicaomnia.eu/03d/0345-0407,_Iohannes_Chrysostomus,_Homilies_on_The_Gospel_Of_Matthew,_EN.pdf, 89–92.

[4]Concerning the "father god and mother goddess" theme see Ernest L. Martin, *The Star That Astonished the World,* www.askelm.com/star/, chap. 4, paragraph six, "About the Real Star of Bethlehem"; F. A. Larson, *The Star of Bethlehem,* www.bethlehemstar.net/starry-dance/westward-leading/, first paragraph. I have no personal animus against either man. Martin has died; I wish Larson the best.

[5]Erica Reiner and David Pingree, *Babylonian Planetary Omens* (Groningen, Netherlands: Styx, 1998), 45. Akkad was a kingdom in the third millennium BC in Mesopotamia more or less equivalent to Babylonia.

[6]David Pingree, "Astronomy and Astrology in India and Iran," *Iris* 54, no. 2 (1963): 241.

[7]Daniel 1:20; 2:2, 10, 27; 4:7; 5:7, 11, 15.

[8]Acts 13:6: "… they came upon a certain magician, a Jewish false prophet named Bar-Jesus." ἄνδρα τινὰ μάγον ψευδοπροφήτην Ἰουδαῖον.

[9]It is almost certain that Matthew would not have been looking to Herodotus for any information about magi (Herodotus, *Histories* 1.101).

[10]Kenell J. Touryan, "Dating the Birth of Jesus from the Star of the Nativity," *PSCF* 65, no. 1 (2013): 71.

[11]Abraham Sachs and Hermann Hunger, eds., *Astronomical Diaries and Related Texts from Babylonia,* vols. 1, 2, 3, 5, 6, and 7 (Wien, Austria: Austrian Academy of Sciences Press, 1988–2014). One can access much of this material through: http://www.attalus.org/docs/diaries.html.

[12]Hermann Hunger, ed., and including materials by Abraham J. Sachs, *Astronomical Diaries and Related Texts from Babylonia, Vol. VII: Almanacs and Normal Star Almanacs* (Wien, Austria: Austrian Academy of Sciences Press, 2014), 61–63. The original published text has been somewhat modified for brevity and clarity. A cubit is a distance of about two degrees. Cubits were divided into 24 fingers. An astronomical finger was five minutes of arc in modern terms.

[13]For a limited time, the author is making a few pages of Sachs and Hunger's almanac for SE 150 (162/161 BC) available at https://buff.ly/2qiMf30. To translate the dates into Julian terms use the Babylonian calendar converter: www.staff.science.uu.nl/~gent0113/babylon/babycal.htm.

[14]Mathieu Ossendrijver et al., "Ancient Babylonian Astronomers Calculated Jupiter's Position from the Area under a Time-Velocity Graph," *Science* 351, no. 6272 (January 29, 2016): 482–84.

[15]N. M. Swerdlow, *The Babylonian Theory of the Planets* (Princeton, NJ: Princeton University Press, 1998), 35.

[16]Mathieu Ossendrijver, *Babylonian Mathematical Astronomy: Procedure Texts* (New York: Springer, 2012), 55–109, 207–333.

[17]uš is pronounced 'ush.'

[18]Swerdlow, *The Babylonian Theory of the Planets*, 52.

[19]Frederick M. Strickert, *Philip's City: From Bethsaida to Julias* (Collegeville, MN: Liturgical Press, 2011), chap. 12.

[20]W. E. Filmer, "The Chronology of the Reign of Herod the Great," *The Journal of Theological Studies* 17, no. 2 (1966): 283–98; Jack Finegan, *Handbook of Biblical Chronology*, rev. ed. (Peabody, MA: Hendrickson Publishers, 2015), 279–369—the entire section contains relevant material; Dwight Hutchison, *The Lion Led the Way*, 3rd ed. and expanded (St. Paul-Trois-Chateaux, France: Association Signes Célestes, 2015), 78–104, 298–332; James A. Nollet, "Astronomical and Historical Evidence for Dating the Nativity in 2 BC," *PSCF* 64, no. 4 (2012): 211–19—I do not agree with all of Nollet's ideas concerning the dating of the Roman

governors; Andrew E. Steinmann, *From Abraham to Paul: A Biblical Chronology* (St. Louis, MO: Concordia Publishing House, 2011), 219–56; and ___, "When Did Herod the Great Reign?," *Novum Testamentum* 51, no. 1 (2009): 1–29.

[21]Emil Schürer, *A History of the Jewish People in the Time of Jesus Christ* (Charleston, SC: BiblioLife, 2017), 399–427.

[22]Aaron Adair, "The Star of Christ in the Light of Astronomy," *Zygon* 47, no. 1 (2012): 16.

[23]Ibid.; and Courtney Roberts, *The Star of the Magi: The Mystery That Heralded the Coming of Christ* (Franklin Lakes, NJ: The Career Press, 2007) 120–21. There is at least one clear example from the end of the first century AD of "in the east" (Greek dative, singular) as a geographical area, not a heliacal rising, in the book of 1 Clement 5:5–6.

[24]See the example from Reiner and Pingree, *Babylonian Planetary Omens*.

[25]Simo Parpola, *Letters from Assyrian Scholars to the Kings Esarhaddon and Assurbanipal, Part II: Commentary and Appendices* (University Park, PA: Eisenbrauns, 2007), 420–22.

[26]Mithradates III and Orodes II ruled about 50 years before the birth of Christ. But Phraates IV (38–2 BC) and his son Phrataaces (2 BC–AD 4) ruled at the time of Jesus's birth.

[27]See also the Coins section of the website www.parthia.com.

[28]Ulla Koch-Westenholz, *Mesopotamian Astrology: An Introduction to Babylonian and Assyrian Celestial Divination* (København, Denmark: Museum Tusculanum Press, 1995), 121.

[29]Otto Neugebauer, *The Exact Sciences in Antiquity* (Mineola, NY: Dover, 1969), 121; Ossendrijver, *Babylonian Mathematical Astronomy,* 145; and Michael R. Molnar, *The Star of Bethlehem: The Legacy of the Magi* (Piscataway, NJ: Rutgers University Press, 2013). It should be noted as well that Molnar's entire star theory is built on invisible incidents which took place in the solar glare.

[30]See a table which demonstrates the relative uniqueness of these heliacal rising dates at https://buff.ly/2tzHYd0.

[31]Abraham Sachs and Hermann Hunger, *Astronomical Diaries and Related Texts from Babylonia, Vol. III: Diaries from 164 BC to 61 BC: Texts and Plates* (Wien, Germany: Verlag der Österreichische Akademie der Wissenschaften, 1996), 127. The eighth time is as follows: Jupiter rises (JR): 5:37:21; Sun rises (SR): 6:26:48. Difference = 50 minutes. Sighting took place at 1 US (50 minutes – 46 minutes = 4 minutes = 1 US). 46 minutes = 11.5 US. The seventh JR: 5:40:13/SR: 6:25:51. Difference 46 minutes = 11.5 US. Ideal at 10.5 US or 42 minutes.

[32]Ibid., 359. There is an error in the text. The dates should be the seventeenth and eighteenth of the fifth month, not the seventh and eighth. Earlier Jupiter was invisible, being only about 3 degrees from the sun.

[33]This seems to vary according to the planet's position in the zodiac, the angle of the rising, etc.

[34]The sun and moon are typically about 30 minutes of arc in diameter. The planet could be seen at about 1 US above the horizon. One can download a table with several recorded and estimated ideal risings of Jupiter at the following address: https://buff.ly/2XjTxTk.

[35]The numbers in Babylonian "time/degrees" (uš) are for Al-Hillah, Iraq (near ancient Babylon).

[36]Sunrise is here defined as the lip of the sun crossing the horizon.

[37]See a table which demonstrates the relative uniqueness of these heliacal rising dates at https://buff.ly/2tzHYd0. The Alcyone archaeoastronomy program, using "arcus visionis" concepts, gives similar results although MUL.BABBAR (Jupiter) would probably be visible one day later (the 30th) if one allows exactly one degree of altitude before sighting (default variable setting). At 0.99° of altitude, the planet should have been visible on the 29th, but visibility was unlikely on the 28th (default variable setting).

[38]Ossendrijver, *Babylonian Mathematical Astronomy*, 251, 257. In one part of the zodiac, not including Leo, Jupiter's station was calculated as 123 days from the heliacal rising. We no longer have the exact formula for the station in Leo.

[39]This rough statistical result is the least common multiple of the synodic period of Jupiter (11.86 years) and the lunar nodal period (18.6 years) = 11,029.8. But, also, the moon passes the ecliptic twice near Regulus in 18.6 years. Two stationary phases of Jupiter should fall in Leo every 11.86 years.

[40]Ossendrijver, *Babylonian Mathematical Astronomy*, 257. In their procedure texts, the Babylonians calculated synodic events differently according to Jupiter's place in the zodiac.

[41]Swerdlow, *The Babylonian Theory of the Planets*, 200–201.

[42]N. M. Swerdlow, "Acronychal Risings in Babylonian Planetary Theory," *Archive for History of Exact Sciences* 54, no. 1 (1999): 61.

[43]Result of using the "default variable" settings assuming the planet was visible at 1° above the horizon. The planet was 4°18' below the horizon when the sun was completely set. It was one degree above the horizon 30 minutes after sunset.

[44]For example, MUL.BABBAR's settings in the cuneiform document LBAT 1409 in 147, 146, 144, and 143 BC indicate settings from about 9 uš or less to 11 uš (sunset to the setting of MUL.BABBAR). The setting dates are often much less precise than the rising dates. The word "about" a certain date is often used in Babylonian documents.

[45]The numbers in Babylonian "time/degrees" (uš) are for Al-Hillah, Iraq (near ancient Babylon).

[46]Sunset is here defined as the top lip of the sun crossing below the horizon (sun completely hidden).

[47]The numbers in Babylonian "time/degrees" (uš) are for Al-Hillah, Iraq (near ancient Babylon).

[48]Sunset is here defined as the top lip of the sun crossing below the horizon (sun completely hidden).

[49]Sedeq was the name used by Abba Arikka (AD 175–247), also called Rav or Rab. See "Babylonian Talmud, Tractate Shabbat," www.come-and-hear.com/shabbath/shabbath_156.html#PARTa. (The reader should see Folio 156a and Shabbath 156b.)

[50]All Bible references unless otherwise indicated are from the *New American Standard Bible* (La Habra, CA: Lockman Foundation, 1995).

[51]In judicial contexts, the verb προάγω (proago) can also mean "to lead" individuals before authorities. It is used repeatedly in this sense in the book of Acts (12:6; 16:30; and 25:26).

[52]Babylonian documents often mention planets "standing" in particular locations during lunar and solar eclipses, meaning that the planet was present, it was located, or positioned in the sky during the event.

Mark A. Strand

Communication

Introducing High School Students to Scientifically Faithful Views of Genesis 1–3

Mark A. Strand

This communication describes the process of designing a six-week course on scientifically faithful views of Genesis 1–3 for eleventh- and twelfth-grade Sunday School students in an evangelical church. Students significantly changed their beliefs about science, but changed their beliefs about specific biblical interpretations less. Practices are suggested for introducing challenging science and faith topics to high school students. One church experience has shown that a church with a strong young earth creationist history can be open to discussing scientific evidence about human origins from a biblical perspective.

The creationism movement has used books, videos, and conferences to promote themselves as the *de facto* option for evangelical Christians wanting to understand human origins.[1] Using populist and accessible methods, they have been particularly effective at inculcating this view in the thinking and curricular decisions of Christian school teachers and home schoolers. Consequently, 40% of Americans report to hold a young earth creationist (YEC) viewpoint.[2]

As a consequence, many young people in evangelical churches have grown up taking in young earth creationism materials from organizations such as Answers in Genesis (AIG). This creates intellectual and spiritual conflict when these young people are faced with current scientific understandings on origins, including biblical approaches advocating an old earth and a long process of human origins. This often happens when they begin university studies. What is more, there is evidence that this phenomenon is contributing to young people leaving the church.[3]

In 2015, funded by the John Templeton Foundation, Trinity International University began "The Creation Project" within the Carl F. H. Henry Center for Theological Understanding,[4] to catalyze a field of study around the doctrine of creation that is faithful to scripture and informed by scientific evidence. This became the inspiration for a project to introduce science and faith topics to high school students in a Sunday school class in a midwestern evangelical church.

There were two hypotheses which guided this project. The first was that it is possible to discuss evolution when teaching human origins to young people in an evangelical church with a strong young earth creationist bent without causing extreme conflict. The second was that students' beliefs about interpretations of Genesis 1–3 and science topics could change throughout a six-week course.

This communication will describe the process of designing this course. It also will suggest practices to help churches influenced by YEC viewpoints to open up to a more expansive view of scripture,

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and to the ways in which the findings of modern science inform biblical exegesis and theological conclusions.

Project Description

In the spring of 2017, the author met with the elders of the church to discuss the topic of how to handle differences of opinion regarding the age of the earth and the process of human origins. This included discussion of the denomination's statement of faith and clarifying that belief in an old earth and human evolution was within the parameters of the statement.

This was followed by designing a six-week course for seventeen 11- and 12-grade students (table 1), which was delivered in the fall of 2017. Materials used in the course included the Bible and the following books: *Genesis 1–4* by John Collins; *Evangelical Convictions* by the EFCA Heritage Committee; *How I Changed My Mind about Evolution* by Kathryn Applegate and J. B. Stump, and *When God and Science Meet* by the National Association of Evangelicals.[5] Ten students completed a nineteen-item pre- and post-survey on beliefs and attitudes about issues pertinent to the science and faith conversation. The numerical results are available from the author upon request.

The objectives of the course were to help students to

1. understand that the doctrine of creation is essential,
2. do exegetical Bible study,
3. describe a variety of legitimate scientific interpretations of Genesis 1–3, and
4. see that science is a method and an opportunity for ministry, not an enemy.

The process of delivering the course followed several pedagogical principles. First, acknowledging that the topic is sensitive to many of the students, it was necessary to create a safe learning environment for all students. By "safe" I mean that students were free to disagree with the teacher and with each other, without fear of reprisal, or fear of being stigmatized for holding their viewpoints. Second, while being safe on an emotional level, it was equally important to challenge the students to study the Bible, and to learn the many genres of the Bible and how they affect biblical interpretation. Exegetical Bible study methods were used, including introduction to the historical context of the text and the genre being used. Third, the students needed to learn that there is diversity of opinion among people within evangelical Christian faith who hold to a high view of scripture; therefore,

Table 1. Six-Week High School Sunday School Curriculum

Week	Topic	Objectives
1	Genesis 1:1–2:3—The cosmos The Doctrine of Creation	Creation is an essential doctrine. Genesis 1 is a theological text.
2	Genesis 2:4–25—Creation of man and woman Relating science to the doctrine of creation	Scripture addresses issues to which science speaks.
3	Genesis 3:1–24—The entry of sin When science becomes an idol	Some people place excessive confidence in science.
4	"Why I can say that I believe the Bible, love Jesus and accept evolution." Guest speaker, animal geneticist from the local university.	Science is a methodology. Science and theology can be integrated.
5	"STEM and Biblical Human Flourishing." Guest speaker, engineer from a local engineering company.	Science can be used to serve humanity. Christians serve humanity. Christians are needed in science.
6	Students defend biblical and scientific arguments for both YEC, and for an old earth with a long process of biological development.	Help students reconcile any issues or conflicts.

the students were required to explain and defend both sides of different issues, even those with which they disagreed. They were assisted in this process through the use of a polarity map. Fourth, based on the view that knowledge is personal,[6] and that role models influence one's relationship to knowledge, two scientists from within the church where the course was held were invited to explain the relationship of their faith to their work as scientists.

Lessons Learned

Students entered the course with a variety of incorrect opinions about science. For example, students largely believed that Charles Darwin developed his theory of evolution in order to justify his atheistic beliefs, that human and dinosaur tracks have been discovered in the same rocks, that many scientists recognize that evolution is not a very good theory but still support it, that radiometric dating is not valid, and that there is no evidence for "macro-evolution." These beliefs form a significant part of the YEC position. The students had mastered this information, but when pressed to explain it, they were unable to give either a scientific or biblical explanation defending their position. However, it should be noted that by the end of the course, many students' beliefs about Charles Darwin's atheistic agenda and the co-existence of human and dinosaur tracks, and their skepticism about the evidence for "macro-evolution," lessened with time, demonstrating a willingness to change their opinion on those issues.

Student responses also showed confidence in the possibility for interaction between science and faith. For example, they showed openness to integrating knowledge from science and Christian faith, they recognized that science is not the only avenue to reliable information, and they acknowledged different types of epistemological authority. Students began the course with strong belief that the Bible is a reliable source of scientific information, but by the end of the course the majority of students had changed their minds, reflecting a better understanding of the type of information being conveyed in Genesis 1–3. Belief that "anybody who takes the Bible seriously will believe in young earth creationism" also declined somewhat by the end of the course.

Students showed significant improvement in accepting current scientific truths by the end of the course. For example, student belief that believing the Genesis account requires rejecting evolution declined over time. Student skepticism that scientists are responsible for undermining people's belief in the Christian faith lessened. There was also increased confidence that science is a neutral subject and can be pursued by Christians.

This project showed that it is possible to help students expand their beliefs about science and interpretations of Genesis 1–3 in a six-week Sunday school course. Student views on some issues changed significantly. Bias against Charles Darwin and modern scientists, that they are driven by an atheistic motive, and suspicion that science which points to an old earth is bad science, were both reduced. Confidence that science can serve humanity, that science and the Bible address different issues, and that there is room for interaction between science and faith increased. Throughout the course, students increased their belief that the Genesis account of creation and evolution can both be true. It is surmised that students were willing to change their minds on questions about science and the work of scientists because these ideas were not a direct threat to specific truths of the Bible.

The literature is full of reports and research results confirming the possibility of a mutually beneficial relationship between science and Christian faith.[7] Many scientists who are Christians view their work in science as a Christian calling; this was true of the guest lecturers used in the course.[8] There are many scientists who are Christians who delight in teaching science, including teaching evolution.[9] It has also been shown that there is no evidence that pursuing a career in science moves a person toward atheism.[10] In fact, noted Christian philosopher Alvin Plantinga has successfully argued that science not only is not in conflict with faith, but that, rather, it offers support to theistic doctrines.[11]

Through the process of delivering the course, a few negative outcomes were observed. Although holding adamantly to the authority of the Bible, the students were unfamiliar with the genres of the Bible and exegetical Bible study methods. Consequently, some students had largely accepted certain beliefs about the Bible, such as that the Bible is a source of scientific information, but were poorly equipped to defend or use that information. Therefore, students

seemed ready to expand their understanding of science and scientists in a positive way but were afraid of revisiting absolutist views held about the Bible. It must be remembered, however, that this was one short course, at an early stage in their lives, and there remains sufficient time for these understandings to mature. The testimonies of practicing scientists who have changed their opinions on topics of faith demonstrate that it is possible to expand one's scientific understanding while deepening one's Christian faith.[12] However, this must be done in a manner sensitive to the beliefs of the recipients, as explained by Pastor Mario Russo in his essay "Four Ways Pastors Can Shepherd Their Congregation through Discussions on Faith and Science."[13]

The preceding observations hold the possibility of varying interpretations. On the one hand, reluctance to change some views is a sign that these young people have convictions, and this is good. On the other hand, their convictions may be a sign that they are unwilling to learn, grow, and make the faith their own, preferring to cling to opinions given to them. Commitment to the Bible is commendable, but if held to without evidence or deep understanding, it can lead to a form of bibliolatry. These observations are a reminder of the work that needs to be done to affirm and nurture their devotion to the Bible, while also helping them make that foundation firmer and better able to stand up to the challenges they will face as they move into adulthood.[14] This teaching should be done incrementally, in the same way that spiritual growth occurs, and not imposed upon young men and women as an absolute set of viewpoints that they must accept.

One of the concerns that is sometimes raised is that teaching evolution is a slippery slope, which will lead to sliding toward relativism on other issues such as morals. The argument is that Christian education for youth should increase confidence in the Bible at all costs, even if it means ignoring other forms of information, such as that derived by science. But this is a short-term solution. In time, these young people will be sophisticated enough to see the contradiction, and if they feel that they have been hood-winked, they will likely separate themselves from the one whom they perceive to have misled them.[15] It is disingenuous to use dishonest methods to keep young people believing the Bible. It is far better to introduce them not only to faithful biblical exegesis that takes seriously the many genres of scripture, but also to the evidence provided through the material world.[16]

There were also encouraging process outcomes. Student attendance was good throughout the course. Student engagement was also high, even on challenging or contentious topics. The goal was to teach the course in a scientific way as much as possible. Science is a method of approaching questions more than it is a corpus of conclusions. Therefore, it is important to teach students to think like scientists; this means they are taught how to identify the question being asked, find the information necessary to answer the question, evaluate that information, and then answer the question as best as one is able. Finally, it means accepting that this is not the final answer, but a closer approximation to the truth than one previously held. That is the way of science. It is important to teach in a way that asks students to use facts to solve problems. This shows the importance of epistemology, or the different ways of knowing, which are used to approach theological and scientific questions.

Best Practices

It is hoped that this communication will help readers to effectively introduce science and faith education in their churches.[17] It is beyond the scope of this paper to provide an entire curriculum for teaching science and faith to youth. A five-part course for high school students, created by Denis Lamoureux, is available online.[18] *Toward a Christian View of a Scientific World: Fifteen Topics for Study* by George Murphy could be used in Christian education in the church.[19] The organizations BioLogos (www.biologos.org) and the American Scientific Affiliation (www.asa3.org) also have many good resources.

Some of the practices gleaned from the experience of teaching science and faith to youth, and from the literature, include the following:

- Respect church leaders and secure their support when introducing potentially controversial topics to young people, such as science and faith.
- Inform the parents in advance of the course about what is being taught, in order to minimize controversy and promote multigenerational learning.

- Create a safe learning atmosphere that is open to everyone's opinions, as these are very personal and sensitive issues.
- Seventeen- and eighteen-year-old students need to be pushed out of their comfort zone, as they are rapidly approaching living and learning independently of their parents.
- Students are readier to expand their understanding of science and scientists than they are beliefs about the Bible.
- Convictions about science and faith are formed over decades, not weeks. Therefore, have realistic expectations about the magnitude of the change that can occur in just six weeks. Affirm all evidence of growth, including growth in humility. Sufficient time is needed for these issues to sink in.
- Learning begins with the learner's present knowledge and views, and not with the teacher's. Begin teaching at the place where most of the students are starting from.
- Scientists need to be cautious when passing judgment on creation doctrines, and theologians should be similarly cautious when evaluating the scientific theory of evolution. Humility is needed on both sides.
- Different disciplines lean on different epistemologies—empirical, personal, ethical, and other—which should be considered when teaching topics relating to science and faith. The way of knowing in science is largely materialistic, while the way of knowing in theology is largely based on history and spiritual truths.
- Teaching youth is as much an activity in pastoral care as it is an intellectual activity. Strive to shepherd their hearts as much as you seek to educate their minds.

Conclusion

This church with a strong young earth creationist bent was open to revisiting interpretations of Genesis 1–3 and discussing scientific evidence about human origins from a biblical perspective. However, this should be done with the support of the church leadership, and with sensitivity to the prior experience of the participants. High school students' beliefs about the early chapters of Genesis and the relationship between science and faith can be influenced through methodical teaching on the subject. Readers are encouraged to put the warfare metaphor aside and engage with sincere Christians of different persuasions to grow a shared understanding of science and faith issues, and to better prepare young people to embrace and hold on to the faith in an informed way. ☼

Acknowledgments

Thank you to Greg Strand, David Buchanan, and Noel Anderson for their contributions to the design of this project. The results reported here were presented at the 2018 ASA Annual Meeting held at Gordon College in Wenham, MA, on July 27–30, 2018.

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ASA Members: Submit comments and questions on this article at www.asa3.org→RESOURCES→Forums→PSCF Discussion.

Call for Papers

Raising Food for Thought

We all depend on agriculture to provide our food. Further, agriculture is a major player in the quality of our water to drink and air to breath, the only two things we need even more immediately than food. What can the sciences and Christian faith tell us about how we should best raise and consume food? How should we proceed with GMOs, catching or farming fish, eating down or up the food chain, organic or factory farming, vegetarian, locavore, or omnivore …?

Steven G. Hall (PhD, Cornell University) raises a gamut of such questions. As a professor in the Department of Biological and Agricultural Engineering and Director of the Marine Aquaculture Research Center at North Carolina State University, he is well prepared to lead us on this topic. He is past president of the Aquacultural Engineering Society, editor of the *Journal of Aquacultural Engineering*, and a Fellow of the American Scientific Affiliation.

In an essay accessible from both the ASA and CSCA websites, Hall invites consideration of critical technical and ethical aspects of the food system from production to distribution, from biological to environmental resources. Readers are encouraged to take up one of the insights or questions, or perhaps a related one that was not mentioned, and draft an article (typically about 5,000–8,000 words) that contributes to the conversation. These can be sent to Hall at shall5@ncsu.edu. He will send the best essays on to peer review, and we will select from those for publication in a theme issue of *Perspectives on Science and Christian Faith*.

The lead editorial in the December 2013 issue of *PSCF* outlines what the journal looks for in article contributions. For best consideration for inclusion in the theme issue, manuscripts should be received electronically before **January 31, 2020**.

Looking forward to your contributions,
James C. Peterson, *editor-in-chief*

Environment

BLUE PLANET, BLUE GOD: The Bible and the Sea by Meric Srokosz and Rebecca Watson. London, UK: SCM Press, 2017. 208 pages. Paperback; $32.00. ISBN: 9780334056331.

I have been anticipating this book in which two friends, Meric Srokosz and Rebecca Watson, bring part of the results of their "The Sea in Scripture" project together in the book *Blue Planet, Blue God*. You might think it would be a short book. What, after all, does the Bible say about the sea? It turns out, quite a lot!

The aim of the book is straightforward—to examine what the Bible says about the sea. However, in spite of the impression given by their typical British understatement, the authors really want to change our worldview. For most of us, looking out at the sea from a comfortable chair beachside or perhaps eating fine seafood at a quayside restaurant, the ocean appears to be monotonous—much of a muchness. Those who venture out on the ocean know differently, particularly those who don a mask and gaze at the wondrous beauty beneath its surface; the authors want us to share this perspective. They take us on a grand tour examining what scripture and science have to say about the 71% of our planet that is ocean. They challenge us to rethink how we view the ocean, and they show, in great detail and with theological rigor, that the Bible covers a multitude of sea-related topics which are of personal and global relevance. The authors pull no punches in pointing out where humans are to blame for the problems with our ocean. They call to account those unwilling to change comfortable lifestyles that destroy this natural resource. In spite of this, the book's tone is hopeful, continually pointing to a God who cares for and has declared the oceans, along with all of creation, good.

The book reads more like a sea voyage than an airplane trip. Those hoping to get from point A to point Z quickly, will be frustrated. The authors take readers on a journey that draws from the Bible, science, history, poetry, music, and literature. Lengthy quotes will frustrate some. The authors compel readers to discover for themselves the broad relevance of the sea to the Christian life and the critical role Christians play in caring for our beleaguered seas. Chapter 6, "Coping with Chaos and Uncertainty," illustrates this nicely. The chapter begins with a discussion of different uses of the word "chaos" in modern times and then explores human vulnerability through a poem and a hymn by Victorian hymn-writer William Whiting. The science of chaos theory follows, leading from a story about an eleventh-century Viking and the 2004 Asian tsunami, and then to flooding and hurricanes in modern-day Britain and the USA. The authors present a discussion of El Nino weather patterns and impacts. They point out how vulnerable humans and the ocean are to these weather patterns. Srokosz and Watson then return to a biblical analysis of uncertainty among Semitic peoples. At this point, the reader is only halfway through the chapter! Long passages from the Psalms, Isaiah, Jeremiah, and Hosea help the reader to reflect on the fact that "the Bible affirms that God not only stills and confines the sea, but also stirs it up and makes it roar." God is recognized as the Sovereign of the sea—the One in whom we can put our trust when faced with our own vulnerability and fear. The chapter ends with a stark reminder from Isaiah and Hosea that our sin has consequences both for other humans and for the sea.

Srokosz and Watson consistently challenge our ideas about the sea and perhaps even our faith. They state:

> This book, then, touches on some of the most fundamental issues of our time, such as economics, migration, and climate change, but it also offers perspectives on some of the most enduring questions for humanity: those of meaning and purpose, of our place in the world, and the need to allay our fears and seek stability despite threats to the status quo.

Indeed, each chapter ends with a summary of the key messages and then delivers a challenge. Discussion and reflection questions help to unpack and personalize the challenge as well as suggest specific actions, lest the reader not come up with their own.

Returning to Chapter 6 on Chaos, the authors state that "the established order in the world is both dangerous and vulnerable; it cannot be taken for granted, yet through God it is ultimately sustained and overall God's rule prevails." They challenge us not only to trust in God's rule, but also to recognize that much is not in our control. We are indeed vulnerable. We can embrace that vulnerability and even delight in it through experiences in the sea. Reflection and discussion ask us to reflect on the balance of chaos/uncertainty, God's sovereign rule, and whether or not our own "order" might be another's oppression. The action section uses Gaelic folklore to help us to understand, how hard action can be in response to what we have learned, before going on to encourage us to be pro-active in disaster planning/response and to curb behaviors which negatively affect the sea.

Some of the themes examined through these various lenses are awe and wonder, anthropocentrism,

human impacts, the need for restraint, the sacredness of the sea, chaos and order, vulnerability, consumerism, and poverty. The book does not attempt to be exhaustive and some problems which are presently a very hot topics, such as plastic pollution, are given little attention. Yet the main effects of humans on the sea—overfishing, climate change, and pollution—are all examined in sufficient detail and clarity for non-scientists to understand.

One of the key themes of the book is summarized in the concluding chapter:

> Our exploration of the Bible has revealed that a key aspect of God's perspective on the ocean is his delight in his creation apart from any role we as humans may have in it. It has intrinsic value to him and was not created by him solely for the benefit of humanity.

This is an important truth that needs to be taught to both Christians, who can easily see the created world as the stage on which humans act and which provides for humanity, and to the professional conservation community which is increasingly framing nature conservation in instrumental terms. The ocean has value to God, irrespective of all it provides for us. A Rocha, a Christian conservation organization whose Marine Conservation program I direct, is seeking to live out this truth in caring for the ocean. I look forward to many discussions with volunteers, interns, and other scientists after passing them a copy of this book.

If we have a Blue God, how then are we as Blue People to live? The final pages of the book are an important call to action. In light of the science and the Bible, now what? The authors do not give easy answers, as there are none. As much as we should, except in special circumstances, get rid of plastic straws, this will not solve our ocean's problems. Their approach mirrors that of our work with A Rocha, in which both science and theology inform our praxis. The call is to a radical lifestyle that rejects consumerism, moves forward humbly, and is led by Christ's example of a life of self-sacrifice and love.

> We need to live in harmony with God's purposes for his creation, mindful of the "sacredness" of the sea, and seeking not to overstep the limits set for us. It also means recognizing that there is no neutral ground: not making the lifestyle and attitude changes required is an active decision, entailing responsibility (and, yes, guilt), not a passive one. By doing nothing, we are directly contributing to the ruin of God's good earth.

Challenged yet?

Reviewed by Robert Sluka, Lead Scientist, A Rocha Marine and Coastal Conservation Programme, Titusville, FL 32780.

History of Science

A HISTORY OF TECHNOSCIENCE: Erasing the Boundaries between Science and Technology by David F. Channell. New York: Routledge, 2017. 286 pages, index. Hardcover; $155.00. ISBN: 9781138285545.

This is an important book for anyone who is interested in philosophy of science and technology. Although not an easy book to read, it deals with how technology has changed science in the last 150 years into something quite different from what it was before. David Channell is well qualified to write on this subject. He has a BS degree in physics and a PhD in the history of science and technology from Case Western Reserve University. He has received funding from the NSF for research in this area and two Templeton Foundation grants, including a joint Templeton-ASA lecture grant in 1998. Channell is currently a professor of historical studies at the University of Texas at Dallas.

There have been many different attempts to describe a scientific method, but relatively few attempts to describe an engineering method. Many practicing engineers and practicing scientists view their disciplines as being rather different. One of the aims of *A History of Technoscience* is to understand how engineering and science interact today.

Channell's opening paragraph describes the theme of the book:

> In the twenty-first century science and technology are coming to be seen as indistinguishable activities, often referred to by the term technoscience. It is difficult to characterize many of the developments that have come to form the basis of the modern western world as either purely scientific or purely technological. (p. 1)

For someone not familiar with the topic, the most important chapters are Chapter 1: Introduction, and Chapter 11: Epilogue, in which Channell shares his final conclusions. The vast majority of the book is historical, showing how technoscience has developed over the last 150 years. In the introduction he analyzes several different approaches to the relationship between technology and science. These perspectives, in the general order of their historical development include technology as dependent upon science; science and technology as independent; science as dependent upon technology; science and technology as interdependent; and, erasing the boundaries between science and technology.

Channell considers "technology as dependent upon science" to be the oldest approach. He writes, "Since at least the second half of the nineteenth century there has been the widespread view, particularly among scientists and the public at large, that technology is simply applied science" (p. 7). I do not believe this attitude is common among engineers. A practice-based engineering (based on trial and error) has been around long before modern science was developed. It is fair to state that much of modern engineering is now taught using a strong science base. Channell does comment that

> even if one accepts that technology is simply applied science, there is still considerable debate concerning what aspect of science is being applied … to many engineers, applied science meant not the application of scientific theories, but rather the application of a scientific method to the useful arts. (pp. 8–9)

The approach that technology and science are independent of each other is based on historical observations concerning the differences between the cultures of practicing scientists and practicing engineers. A more modern approach is that science is dependent upon technology. The author expands upon this thesis in his historical chapters, which describe the development of what he calls "big science." The interdependent approach accepts the idea that both science and technology have affected each other. Channell writes:

> While the communities of science and technology share many of the same values, those values are reversed in their rank order. The natural sciences rank abstract, general mathematical theories in the highest position and rank practical applications lower; the engineering communities place practical designs in the highest position and rank theories lower. (p. 18)

He then describes a related perspective, which uses the term "engineering science" and an older meaning of science. "These engineers saw science as generalized facts gained through induction based on observation and experimentation rather than deduction based on abstraction and a priori idealization" (p. 18). This approach is consistent with the approach taken by ABET, which accredits engineering programs. They require each program to have a specific number of science/math classes and a specific number of engineering science classes.

The main thesis of the book is that many of these models of how science and technology interact are now outdated. Thus, "by the second half of the twentieth century the long-held distinctions between science and technology were beginning to disappear and, in the place of two individual disciplines, there emerged the new concept of a single integrated realm of knowledge that some have labeled techno-science" (p. 21).

The author then develops this thesis through a series of historical chapters, with chapter titles displaying how Channell develops his thesis. The historical part of the book is divided into two parts: part one addresses the roots of technoscience; and part two, the era of technoscience. Chapters included are as follows:

Part 1: The roots of technoscience:

- Chapter 2—From science-based industry to industry-based science
- Chapter 3—Setting the stage for the military-industrial-academic complex: World War 1
- Chapter 4—Setting the stage for big science: the interwar period
- Chapter 5—The emergence of the military-industrial-academic complex and big science: World War II

Part 2: The era of technoscience

- Chapter 6—The nuclear arms race
- Chapter 7—The space program
- Chapter 8—Electronics
- Chapter 9—Material science
- Chapter 10—Biotechnology

The historical chapters are quite detailed, and some portions of them may be difficult for some readers to follow. As a materials scientist, I most enjoyed the historical chapter about the creation of this discipline in the past 70 years. Materials science grew out of a combination of chemistry and metallurgical engineering. Channell makes an important point when he describes how materials science is different from earlier work:

> Unlike earlier work in mechanical engineering, which focused on dealing with materials from the macro-level, the new materials science approach dealt with designing materials based on knowledge of behavior at the microscopic level. (p. 225)

I have lived through these changes in my career and agree with this conclusion.

In his epilogue, Channell argues that with the development of what he calls "the military-industrial-academic complex," science and technology have merged into technoscience. We have moved beyond the traditional perspectives on science and technology.

> It also goes beyond the old linear model in which universities provide basic scientific knowledge which is then applied by industry. The new model is an interactive model. An important element … is

> that the intertwining of universities, industry and government leads to situations where each one of the threads can take on aspects of the other threads. This can lead to a major transformation of the university … At the same time universities are taking on the role of industry by capitalizing research … the government is taking on the role of both private industry and universities by encouraging certain directions in research through funding and the creating of a regulatory environment conducive to certain types of research needed by industry. (p. 259)

While providing an excellent history of this issue, the author deliberately does not draw any conclusions as to whether

> these changes will have positive or negative consequences and whether efforts should be made to encourage or discourage such changes. While the aim of this book has not been to answer such questions, such answers will not be forthcoming without some knowledge of the history of technoscience. Hopefully this book will provide a historical context in which a debate about the consequences of technoscience can take place. (p. 261)

I am disappointed that the author did not provide us with conclusions about whether the development of technoscience is good or bad. However, he has provided the ASA community with excellent background material about this topic. Hopefully future ASA conferences and *PSCF* papers will delve into the many faith-related aspects of the rise of technoscience.

Reviewed by William Jordan, Professor of Mechanical Engineering, Baylor University, Waco, TX 76798.

THE WARFARE BETWEEN SCIENCE AND RELIGION: The Idea That Wouldn't Die by Jeff Hardin, Ronald L. Numbers, and Ronald A. Binzley, eds. Baltimore, MD: Johns Hopkins University Press, 2018. 358 pages. Paperback; $39.95. ISBN: 9781421426181.

As the teacher in Ecclesiastes declares: "Of the making of books there is no end and much study wearies the flesh." This word of wisdom applies doubly to the genre of books describing the interaction of science and religion. Religion and science matter and they seem to matter ever more in our current tribal society. Each month seemingly presents us with a new exemplar. *The Warfare between Science and Religion* is only the latest, but it is one of the more important and timely additions.

This book stems from a three-day conference held in 2015 at the University of Wisconsin, devoted to the so-called warfare thesis that pits religion and science in an interminable conflict. Twenty-two distinguished scholars, mainly historians and sociologists, contributed to this volume: an introduction by David Livingstone and Mark Noll is followed by seventeen chapters, authored by some of the leading scholars in the religion/science discussions. The book is ably edited by Jeff Hardin, Ronald Numbers, and Ronald Binzley. One reviewer, Edward J. Larson, describes *The Warfare* as the "best single-volume collection of separate-author essays about the history of science and religion in the major modern monotheistic Western traditions" (back cover).

Approaches to this subject have been marred both by polemical intentions surrounding the warfare or conflict thesis and by an inability to grasp and cope with the complexity of the issues involved. What is clear is that a variety of interpretive frameworks have been utilized to depict the historical relations between science and religion. Despite various readings, the conflict model is by far the dominant one, both in the public's mind and for many professional scientists as well. For many hard-nosed proponents, science and religion reflect a tribalism that is set in stone. While fundamentalists cast science as a misguided or even malicious source of information, polemicizing scientists argue that religion is not just wrong or meaningless but also dangerous.

The Warfare is centered on the warfare thesis as classically formulated by Andrew Dickson White and John William Draper in the nineteenth century (chap. 1, "The Warfare Thesis," by Lawrence Principe). What follows is a close analysis of the viability of the warfare thesis as an adequate account of the relation of science and religion in many different historical and social-cultural contexts. First, we look back in time to the most celebrated warfare account, "The Galileo Affair" (chap. 2 by Maurice Finocchiaro). This is followed by an analysis of nineteenth-century developments in the United States, "Rumors of War" (chap. 3, Monte Harrell Hampton), by English "Victorians" (chap. 4, Bernard Lightman), and in "Continental Europe" (chap. 5, Frederick Gregory). Then, successive chapters describe the perspectives of different religious communities on the warfare thesis: "Roman Catholics" (David Mislin); "Eastern Orthodox Christians" (Efthymios Nicolaidis); "Liberal Protestants" (Jon Roberts); "Protestant Evangelicals" (Bradley Gundlach); "Jews" (Noah Efron); and "Muslims" (M. Alper Yalçinkaya). The last six chapters (chaps. 12–17) describe more-contemporary events and persons: "New Atheists" (Numbers and Hardin); "Neo-Harmonists" (Peter Harrison); "Historians" (John Brooke); "Scientists" (Elaine Howard Ecklund and Christopher Scheitle); "Social Scientists" (Thomas Aechtner); and "The View on the Street" (John Evans).

It would take us too far afield to consider each individual chapter. Let me begin with some general comments. Many historians of science have considered the relationships between science and religion. David Livingstone, for example, has identified four relationships: conflict, competition, cooperation, and continuity. John Brooke highlighted three in his insightful book, *Science and Religion: Some Historical Perspectives*: warfare, separation or complementarity, and intimacy. And there are many other descriptions, including Ian Barbour's familiar quartet: conflict, interdependence, dialogue, integration (referenced by Lightman, p. 80). Indeed, there is a broad expanse of relationships on offer: conflict, compatibility, complementarity, harmony (even "discordant harmony"), integrality, and a more holistic model. The first four relationships find expression in one way or another in this book. The latter two are hinted at by Gundlach in his discussion of Bernard Ramm's position regarding the direction of a person's heart in its response to God (p. 179). [For a further delineation describing the gesture of Christian scholarship as complementarity, integrality, and holistic, see Robert Sweetman, *Tracing the Lines: Spiritual Exercise and the Gesture of Christian Scholarship*; Wipf & Stock, 2016, reviewed in *PSCF* 70, no. 2 (2018): 133–34.]

As one examines individual chapters, we encounter increasing complexity in the science/religion relation: The Galileo affair (according to Finocchiaro) "displays various conflicts between science and religion, but also various harmonies between them" (p. 39). English Victorians in Lightman's interpretation often held different conflict theses and frequently opted for a discordant harmony. He also warns us to be sensitive to nuances: John Tyndall pitted theology but not religion against science, a partial philosophical reconciliation not present in Draper's thinking (p. 76). Brooke gives us a superb survey of the past 50 years of historians' accounts of science and religion. Harrison draws on the "neo-harmonists," Rodney Stark, Denis Alexander, and Francis Collins, to display the difficulties in properly describing and understanding a person's take on the science/religion relation. In their chapter, Numbers and Hardin conclude that the new atheists display a remarkable lack of historical analysis in their arguments for the conflict between "organized religion" and science (p. 233). One of the salient contributions of *The Warfare* is to trace what occurred in various communities, including Jewish, Muslim, Eastern Orthodox, Roman Catholic, liberal and evangelical Protestant. In the last chapters in the book, sociologists analyze the response to and perpetuation of the warfare thesis by professional scientists (in different international contexts), by social scientists (particularly sociologists and anthropologists), and by "people on the street."

A final observation: One needs to be concerned about the conflation of religion, theology, and faith that is present in some of the chapters. Clearly, they are not the same. But that is not always clear in the accounts presented. If one holds that religion is a way of life that people engage in with their full existence and at all times, while faith is one of a number of fundamental modes of being religious, a different way of telling the story follows. The socio-cultural endeavor of science can be religious. But could it ever be irreligious? If not, then the question becomes what religion or religions does scientific activity and practice bear witness to. That manner of relating science and religion is much different than seeing religion solely lived out in theology, ecclesiastical and parachurch organizations, or cultic groups. Perhaps there is an opportunity to go beyond trying to live in two worlds at once?

For readers of *PSCF,* this is a book worthy of reading, digesting, and emulating in its close analysis of science and religion. *The Warfare* will give the reader a trustworthy account of the most recent scholarship about the religion science nexus. As Livingstone and Noll conclude in their introduction, *The Warfare* may help "clear the smoke of a battle that has never really existed so that meaningful work can proceed" (p. 5).

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THE GENE: From Genetics to Postgenomics by Hans-Jörg Rheinberger and Staffan Müller-Wille, trans. Adam Bostanci. Chicago, IL: University of Chicago Press, 2017. 147 pages, including contents, acknowledgments, bibliographical references, and index of names. Paperback; $25.00. ISBN: 9780226510002.

Each year, while preparing to teach a course in genetics, I pause when I reach the definition of "gene" in my lecture notes, wondering if the definition accurately captures the concept of the gene as it is currently understood. In *The Gene: From Genetics to Postgenomics*, science historians Hans-Jörg Rheinberger and Staffan Müller-Wille demonstrate that our understanding and characterization of genes is evolving and, furthermore, that "a simple and universally accepted definition of the gene never existed" (p. 4).

The changing concept of the gene is a common theme in genetics, frequently featured as a thread woven throughout textbooks and serving as a source of vigorous discussion among scientists. As a result, many

have noted the multitude of definitions associated with the term "gene"—a heritable unit factor that determines observable traits, a DNA sequence that carries instructions for making a protein, to name just two. This book is unique in its placement of these shifting concepts in a robust historical context. Readers are challenged to consider the ways that contemporary theories and technologies influenced conclusions drawn about the nature and function of genes at different moments in time.

Rheinberger and Müller-Wille describe their book as "a historical survey of the century of the gene." Indeed, readers are taken on a chronological journey that begins in the nineteenth century with Charles Darwin's theories about inheritance and ends in the data-rich postgenomic present. Along the way, the authors summarize the key findings of scientists that have challenged prevailing gene concepts, and they reference prominent science historians and philosophers of science as they consider the context of these findings and their influence on understandings of the gene. Throughout the book, the authors highlight techniques and technologies that were instrumental in advancing the field of genetics. From Mendel's hybrid crosses, to cloning toolkits, to databases that enable storage and retrieval of entire genomes, technological innovations have made it possible for scientists to interrogate and uncover new aspects of the character of the gene.

In the opening chapter of *The Gene*, Rheinberger and Müller-Wille present the primary aim of their book: to reframe the potentially unsettling lack of clarity that characterizes our current understanding of the gene by examining the history of the gene concept and the dynamism that has surrounded this concept throughout the history of genetics.

Chapter 2 describes the various theories of inheritance proposed by nineteenth-century scientists that laid the foundation for the development of the field of genetics. In the next three chapters (chaps. 3–5), Rheinberger and Müller-Wille turn their attention to classical genetics. They describe Mendel's elegant experimental system and findings and explore why their significance was not realized until many decades later. A review of the ways that the rediscoverers of Mendel's work interpreted the result of crossing experiments, indicates that, even among the first generation of geneticists, a uniform gene concept did not exist.

Chapters 6 and 7 describe the transition from classical to molecular genetics and the technological advances that made this shift possible. Biophysical and biochemical techniques were used to identify the chemical nature of the genetic material, decipher the genetic code, and uncover the cellular processes responsible for gene expression. The authors note that while the "molecularization" of genetics initially simplified the definition of a gene, it ultimately added layers of complexity to the gene concept. These chapters also explore the characterization of genes and technical objects and commodities as a result of the introduction of gene-editing technologies.

Chapter 8 examines the relationship between genetics, development, and evolution. Viewed through the lens of molecular genetics, critical linkages are found among these fields of study. Chapter 9 is devoted to a discussion of the postgenomic gene concept. Rheinberger and Müller-Wille suggest that in an era of epigenetics and complex systems biology, the role of the gene as the sole determinant of inheritance and its status as the fundamental unit of life have been deflated.

The book concludes in chapter 10 with a thoughtful discussion of the value of the gene concept in the postgenomic era. Though highly dynamic and lacking definitional clarity, the gene concept will continue to serve an important role as a device that prompts experimentation and thereby advances knowledge.

The last chapter is followed by a 20-page bibliography of history of science and philosophy of science references that will serve as an excellent resource for readers interested in further study. An index of names, found at the end of the book, enables readers to quickly locate mentions of individual scientists in the text.

The authors of *The Gene* assume that readers are familiar with genetics terminology and have a foundational knowledge of genetic mechanisms. Familiarity with ontological and epistemological considerations as they relate to the life sciences are also assumed. As a result, this book would not be appropriate for a general audience. [For a comprehensive and entertaining review of the history and future of genetics that is suitable for general audience, I recommend Siddhartha Mukherjee's book, *The Gene: An Intimate History* (New York: Scribner, 2016)].

For those with an interest in the ever-changing field of genetics, Rheinberger and Müller-Wille's book, *The Gene: From Genetics to Postgenomics*, provides a well-researched account of the history of the gene, and of the scientists and technologies that have continued to challenge and expand our understanding of the term "gene." This book will also serve to inspire awe as readers have the opportunity to consider the ways

that "each new meaning of the gene created an additional dimension along which life could be imagined to vary and unfold" (p. 4).

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Origins

THE TANGLED TREE: A Radical New History of Life by David Quammen. New York: Simon & Schuster, 2018. 461 pages. Hardcover; $30.00. ISBN: 9781476776620.

Many ASA members have spent years and spilled metaphorical blood over this or that detail of the story of evolution and the origin of life, which we all agree is God's marvelous creation. Well, wouldn't it be good to have a book that highlights the debates not among onlookers to the field of biology, but among those actually working and publishing in the field? We now have such a book. *The Tangled Tree* covers humanity's place in the created order of cellular life forms, stretching from the premolecular days of Ernst Haeckel to modern times, when we can quite literally read the instruction book of any and every kind of cell. David Quammen's book is of interest to ASA members as it tackles one of the very biggest questions in biology: "What is the shape of the tree of life?" Such trees have been produced over the years, but the central character of this book, Carl Woese, claimed that he had discovered a more correct, truer tree than had been ever produced before, to the surprise of many in the field. Many believe that Woese deserved a Nobel Prize for his discovery, and yet, most people have never heard of him.

Quammen's skill comes in bringing together key players and voices in the topic at hand and extracting revealing and key quotes in his clear paragraphs and short chapters. We are permitted to go behind the scenes with Quammen as he recollects his own learning experience. The fact that Quammen trained as a writer and not in science helps him render these insights in ways that not only are comprehensible to nonscientists, but are also helpful to biologists (such as me) who have significant background knowledge.

I recall teaching on the relationship between bacteria, archaea, and our own types of nucleated cells, and referencing Carl Woese (pronounced "woes") and his colleague Norm Pace, who first identified the third branch of life now known as archaea, previously assumed to be bacteria based on appearance. It is no surprise within the life science field to be teaching material that was totally unknown during one's own training, and this book serves to highlight the pace of change. The 1970s seem like ancient history, and in a sense they are. However, it is still possible to interview primary players in the field, and so Quammen does a great service in stirring up these waters. As far back as I can remember, I have always emphasized to my students that the group that textbooks call "prokaryotes" is really not a "true" group, being made up of bacteria and archaea; that the archaea are in many key ways more closely related to humans than to bacteria. And so, using "prokaryote" is directly analogous to grouping butterflies, birds, and bats into a single group. Sure, it might at times be useful to have a group called "flyers," but that name tells nothing of their true relationships, which is what biologists and scientists should strive to ascertain. Further, it creates new problems. Where do penguins fit? What about flying squirrels? Another topic of great interest to my undergraduate students is the concept of endosymbiosis: mitochondria once existed free-living in the bacterial branch of life's tree; and at a time in the impossibly distant past they became symbiotically, irreversibly associated with another cell. As many biologists know, Lynn Margulis is credited with this big hypothesis, which was quite controversial at the time and was not readily accepted by the mainstream of scientists who favored other explanations.

So, what a pleasure it has been for me to peek behind the curtain and learn that it was not Lynn Margulis who originally had the idea of endosymbiosis, and to learn much more about the central character of the book, Carl Woese, who doggedly pursued the big questions of biology without getting lost in the minute details. Quammen spends the first third of the book setting the stage for Woese's entry by a concise retelling of the discovery of the gene by Watson and Crick, and of Crick's prescience in speculating that the sequences of long molecules (DNA, RNA, protein) might provide insights into ancestral relationships among living organisms. Yes, from the earliest days of obtaining sequence information, some forward-thinking scientists realized that the order of subunits within our long molecules, since they are inherited, provide a window on the past—a remarkable insight.

And so Quammen's book is actually a book about molecular phylogenetics. It is a book about a field which provides, many would argue, a truer picture of how living species are connected to each other, based on inherited sequence information. It relates the story of how Woese and colleagues selected one particular molecule to focus on, and based on that choice, produced what Woese argued was the true tree of life with three ascending branches: bacteria, archaea, eukarya. And yet, this is a scientific

hypothesis, the truth of which will be decided on the evidence. And the evidence is, in some respects, confusing.

There is no doubt that the big tree with three branches is what you get using the large ribosomal RNA (the long molecule Woese selected), but in fact each gene has its own history, and trees do not work with the microbial world very well (that is the confusing part). I do not want to give away too much in this review, but Quammen's discussion of gene sharing among organisms is remarkably well done. Along the way he explores the truly "Lamarckian" aspect of the CRISPR system of bacteria and archaea, wherein they purposefully store part of their environment within their genome as part of a highly advanced (not at all primitive) microbial immune system. The final third of the book focuses on this phenomenon of horizontal gene transfer (HGT). It is hard to deny that such processes have contributed a tremendous amount to the human nuclear genomes we adore so much. But does this diminish our humanness? What does it mean to be human? What is a species? These questions are addressed only from a biological perspective in this book, and while some Christian readers may find this a limitation, Quammen appropriately focuses on scientific questions, not theological ones. The final section of the book is "E. Pluribus Human," which readers should realize is speaking simply of our biological origins, not our spiritual natures as described by scripture.

It is noteworthy that Carl Woese apparently believed in the existence of a personal deity at some level, even kidding his long-time atheist assistant that she might be blessed by "the God you don't believe in." As a working biologist, I am continually amazed at the amount of antievolution material produced by the Christian community. I realize that, for many, the term "evolution" equates with atheism, and I have been asked if I am a "Darwinist" multiple times, whereupon a lengthy discussion usually ensues. But much like the term "prokaryote," we really ought to use more precise language to avoid misunderstanding. Can we start to call this natural process what it is: biological evolution? It is science, neither a worldview nor a philosophy. It is genetic change over time. It is complicated, and we can now read the information as never before. The fact that our very cells record a history of how God has used the atoms and molecules (whose very existence we believe he upholds) to accomplish his ultimate ends, somehow with an openness and freedom, is a truly breathtaking realization.

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Science and Religion

CHRIST AND THE CREATED ORDER, Vol. 2 of Perspectives from Theology, Philosophy, and Science by Andrew B. Torrance and Thomas H. McCall, eds. Grand Rapids, MI: Zondervan, 2018. 304 pages. Paperback; $36.99. ISBN: 9780310536086.

Christ and the Created Order is the second volume of "perspectives from theology, philosophy, and science." (The first volume was reviewed in the June 2019 issue of this journal.) As the title indicates, this collection of essays brings together distinctively Christian insights on the subjects of creation and science.

The selection was slightly more wide ranging than the first volume, and the quality and relevance of articles oscillated. Three or four seemed overspecialized and out of place for a broader interdisciplinary theological conversation, while others more directly addressed pertinent issues relating to Christology and the doctrine of creation.

Some of the narrow subtopics addressed, however, effectively enlighten readers to reconsider our understanding of "science," the "natural" world, and the nature of religion in general. For example, Murray Rae discusses one of Chopin's symphonies as a case study for the interpretation of real, meaningful phenomena, even though the "utility" of all the details that gave rise to the piece "cannot be proven" (p. 28). Various fields of knowledge, whether religion or otherwise, are providing an interpretation of a slice of our experience. We can debate meaning, but we cannot debate that there is more going on than we may be able to put to words. What we are "hearing" in the symphony of creation is *something* indeed.

> The sciences contribute their expertise to examine and explain how the world is ordered; poets and visual artists and musicians help us see in a different light the complex interdependence of things; economists, political theorists, and social scientists give insight into the working of human culture and society, while historians provide a further means of contemplating the realms of human action and discerning the consequences of what we do. All these disciplines and more contribute to our understanding of the world. (p. 28)

Part of the distinctively Christian view of the world is that God in Christ is behind it all. All the above disciplines "go about their business under the assumption, repeatedly confirmed by experience, that the world does have an order and a coherence that is intelligible, at least in part, even if its ultimate basis in Christ

is not seen or acknowledged by all enquirers" (p. 29). The claim that Christ is behind everything is rejected by many. "It is rejected by some who, for reasons of their own, simply refuse to entertain the possibility that theological explanation might have something to contribute to our understanding of reality" (p. 32). Such skeptics "do not see in Christ's healing of the sick, in his compassion for the despised, in the forgiveness he extends to sinners, or in his feeding of the hungry, any hint of the way creation itself is ordered" (p. 39). In this way, the hegemony of modern science (and scientism) is rightly questioned as not being as pluralist as it should be.

In an equally thoughtful article, Norman Wirzba masterfully connects the life and work of Christ to the big picture of cosmology and human purpose. As scandalous as it has always been to claim such, "… Jesus expresses in his daily, practical mode of life how life should be for all creation because his embodied life is the exact, material imprint of the divine power that daily creates the world" (p. 40). He later discusses the significance of how we might be able to reconceive the world in terms of a "field of verbs" instead of a "collection of nouns" (pp. 51–53), the latter being an outgrowth of Aristotle's immeasurably influential ontology. "A collection of nouns," Wirzba concludes, "much like a container of objects, stresses distinctions between things. A field of verbs stresses the entanglements of lifeways that in their development continually challenge, shift, and penetrate the 'borders' that keep things apart" (p. 51).

In the third chapter, Brian Brock revisits "sin" in light of modern scientific discourse: "Human sin is thus to be defined as moving back into a state of competitive self-promotion that was once nonmoral but now in the postlapsarian state constitutes a self-induced moral and religious deafness" (p. 72). Brian Curry then looks at the meaning of "the powers" in New Testament and theological discourse: *"So by 'powers' Paul means to name structures of the world that were at least to some extent part of a good creation but threaten to ruin our lives and life of the world more generally"* (p. 86, emphasis original). Why is this topic significant? "Without a robust doctrine of the powers, Christians can all too easily think that it is their responsibility to put forward a flat-footed theodicy, defending the status of the present world as really good even though the New Testament does no such thing" (p. 89). Curry then quotes from David Bentley Hart's *The Doors of the Sea* (a work on theodicy) and controversially concludes that "Evil" is not part of "God's good plan" and exercises no necessity upon the divine purposes in creation. It is "wholly parasitic, wholly unnecessary to the flourishing of all things in fellowship with God" (p. 90).

N. T. Wright then examines the cosmic implications of the incarnation. Similar to cases made by others (I am thinking of Daniel Migliore's *Faith Seeking Understanding*), Wright argues that

> When the New Testament says that "all things were made through him," we don't start with a view of "how God made the world" and insert Jesus into that. We start with Jesus himself, as I have tried to do in this essay, and we therefore reflect on creation itself not as a mechanistic or rationalistic event, process, or "fact," and not as the blind operation of impersonal forces, but as the wise, generous outpouring of the same creative love that we see throughout Jesus's kingdom-work, and supremely on the cross. (p. 109)

The next few chapters comprise some technical and/or (in my opinion) somewhat off-topic articles (i.e., their relation to the book's theme is indirect or obscure). Then, readers are refreshed with Adams's more straightforward, clear, and realist article, "For Better or Worse Solidarity." As with her previous essay in volume one, a quick journey across provocative and interesting topics, from the process of psychological development at the hands of "neurotic adults" (p. 175) to the ethnic cleansing of Rwanda (pp. 175–76), re-centers questions about the basic nature of creation: "What God wants is for material creation to be as godlike as possible while still being itself" (p. 177). James K. A. Smith's article, likewise, zooms out to assess secularism at large (leaning on the work of Charles Taylor) and the real nature of "conflict" between "science and religion."

In a later chapter, Deb and Loren Haarsma turn the reader's attention toward the stars, themselves being in "Christ and the Cosmos." However one conceives of the Christ-stars relationship, it is clear how we engage the dark and dangerous elements:

> Jesus Christ gives us the ultimate example of how we should respond to the wild, destructive aspects of creation when they cause suffering: Jesus calmed the storms and healed the sick. He worked to ease the suffering of others, whatever the cause of their suffering. We are called to do the same. (p. 233)

Greenway and Barrett then discuss the nature of religious belief from a cognitive and evolutionary-psychology perspective, relating Calvin's *sensus divinitatis* to such ideas as agency detection and belief in the supernatural. The book concludes with an article on what it looks like, concretely, for the Christian to practice science.

In my reading, this second volume was not as engaging as the first, and felt as though several contributions were little more than (needless) academic recycling. However, *Christ and the Created Order* does contain thoughtful contributions for the doctrine of

creation and Christology. Readers can expect helpful elaboration on what a first-century Jewish carpenter has to do with the universe, nature, and the meaning of life.

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THE EMERGENCE OF SIN: The Cosmic Tyrant in Romans by Matthew Croasmun. New York: Oxford University Press, 2017. 190 pp. + notes, references, and index. Hardcover; $74.00. ISBN: 9780190277987.

SIN is a person, a being, an entity exercising tyrannical dominion over all human persons since the dawn of humanity's emergence. This is the provocative claim that Matthew Croasmun, Associate Research Scholar, Director of the Life Worth Living Program at the Yale Centre for Faith and Culture, and Lecturer of Divinity and Humanities at Yale University, advances in his book *The Emergence of SIN*. Based on his doctoral dissertation (which won the 2015 Manfred Lautenschläger Award for Theological Promise), Croasmun masterfully weaves together interdisciplinary research from the fields of biblical studies, theology, ancient Greco-Roman culture, and scientific and philosophical contributions to emergence theory. He puts forth a case that is stimulating, enlightening, and, for the most part, clear and convincing, with important implications for theological anthropology, ecclesiology, ethics (social and personal), politics, and the dialogical, mutually enriching relationship between science and Christian faith.

The context giving rise to his thesis is Paul's discussion of sin in Romans 5–8, and more specifically Paul's personification of sin as Sin, a cosmic agent exercising power and control over the human beings it enslaves. His question is whether "Sin as a cosmic agent" has "a basis in fact" for Paul. He then surveys three ways of answering this question in modern theological literature.

The first option, represented by Bultmann and existentialist interpreters, is that personified Sin is a literary device, not to be taken literally but pointing to a deeper truth that confronts the reader with questions about human existence. The claim is not so much that Paul intentionally employs personification in strictly a literary sense, but that modern readers (who know they must separate myth from kerygma) must read Paul this way to read the text responsibly (reasonably). This idea is the result of "Bultmann's assumption that Sin as a cosmic power does not correspond to 'the actual state of affairs'" (p. 8), whether or not it has a "basis in fact" for Paul. Bultmann is suspicious of mythical interpretations not only for epistemological reasons, but also for ethical reasons. He is concerned to preserve the culpability of the sinner (emphasizing the point of decision), which he believes is compromised by accounts that lean toward cosmic determinism. Thus, Bultmann argues that Paul's position is that sin *came into the world by sinning*; it is inherited socially, not biologically or spiritually. "Original sin" is a pre-Pauline gnostic myth that Paul accommodates.

The second option, represented by Käsemann, is that by personifying Sin, Paul is claiming that human beings are under the dominion of real spiritual powers that transcend human beings ontologically. For Käsemann, Paul's mythological language cannot be fully explained away; it is not "just" metaphor. Quoting Käsemann, a person "is in the grip of forces which seize his existence and determine his will and responsibility at least to the extent that he cannot choose freely but can only grasp what is already there" (p. 11). Thus, for Käsemann, Sin "is a very literal demonic power" (p. 12). Croasmun points out that both Bultmann and Käsemann make legitimate points and that the biblical text has room for elements of both views. Paul makes two claims that seem paradoxical to the modern reader: sin is both something that human beings commit (thus, confirming Bultmann) and yet Sin is a transcendent entity, acting upon humans who are thus enslaved (as per Käsemann).

A third option, represented by various liberation theologians, is that personified Sin refers to social and political structures that perpetuate evil and oppression in human societies. For Oscar Romero, such structures "are sin" because they produce the characteristic fruit of sin, namely death. Elsa Tamaz points out, in light of Romans 7, that "sin needs the law to hide its wickedness with legitimacy." As such, Sin is both "a personified and enslaving power" and a structure "constructed by unjust practices of human beings" (p. 16). Similarly, according to José Ignacio González Faus, "When human beings sin, they create structures of sin, which, in their turn, *make human beings sin*" (p. 16, emphasis original). Juan Segundo likens Paul's language of Sin to the demonic in the gospels, specifically in that sin "is a condition that subdues and enslaves me against my own will" (p. 17). Yet, these powers operate through sinful social and political structures. For Bultmann, Sin is a myth pointing existentially to the culpability of the individual and leading the importance of individual decision, and, for Käsemann, Sin is a spiritual entity influencing individual human beings; for liberation theology, Sin points to the fact that individual human

sinners participate in corporate structures of sin, not only committing sin but also becoming socially conditioned by such structures to commit sin.

Croasmun touches briefly on two attempts to synthesize individual-corporate and mythical-existential dimensions of Sin (Jerome Murphy-O'Connor and Derek Nelson), but he finds that both lapse back into reducing one side of the duality (e.g., individual or corporate) into the other (pp. 18–20). These attempts at synthesis share the same basic problem of all previous proposals: they all struggle to articulate an adequate ontology of social entities.

From his survey of the three main options, Croasmun argues that each makes important contributions and that all three can fruitfully describe Romans 5-8 and coexist, but only with the addition of an appropriate ontology that they all currently lack. What is needed is not simply a middle ground (an attempted synthesis or compromise), but "a both-and solution, an ontology that permits us to conceive the 'actual state of affairs' in a rich enough way to hold the various entities and various agents in Paul's language together, all at once" (p. 21).

In the next two chapters of the book, Croasmun turns to emergence theory to help him construct an ontology of social entities that can fruitfully make sense of Paul's personification of Sin in the "both-and" kind of way just described. Thus, for Croasmun, emergentism "provides the framework we need to hold together the multilevel picture of Sin which Paul paints for us" (p. 23).

In chapter 2, Croasmun offers a fairly standard account of emergence theory as it has arisen in several scientific and social-scientific disciplines. As is common, he presents emergence as a theory that opposes various forms of reductionism (ontological, methodological, epistemic) and substance dualism (mental and vital). Regarding the latter, he writes that for emergentists "there is only one kind of stuff in the universe; there are no special 'mental' or 'vital' substances … [on] this point, emergentism and reductionism agree" (p. 28). Moreover, he claims that "ontological monism—the belief that the universe consists of only one kind of substance—is scientific (and, to a lesser degree, philosophical) orthodoxy" (p. 27). This naturalism, it seems to me, is overstated. For one thing, while it can accurately be said that monism tends to be popular at the moment, it is quite another thing to claim that it represents a new orthodoxy (Croasmun cites John Searle as a philosophical authority, but there are important philosophers who remain convinced of dualism—for example, Richard Swinburne, Alvin Plantinga, and Eleonore Stump).

In addition, it is not clear to me precisely how emergence theory definitively rules out nonphysical substances as such (i.e., as part of one's overall worldview, including metaphysical considerations). At the very least, orthodox Christians must affirm that some nonphysical entities exist—most importantly, God, the divine nature of Christ, and angels—and that these nonphysical entities can interact with the physical world (though we do not understand how, given that we have no unmediated access to God's essence or purely spiritual entities). Perhaps Croasmun only means that human beings, more specifically, are composed of "one kind of stuff." Well, perhaps. But I do not see how emergence theory can know this so confidently. Of course, it is appropriate that, in the context of scientific study, emergence theory is researched within the confines of methodological naturalism; but it also seems obvious that within these confines, emergence theory will necessarily bracket out nonmaterial factors and explanations such as souls and other immaterial substances or powers. But the outcome here is determined in advance by the method, not by the nature of Reality as such, which is only partially accessible to the methods of science. I find the critical realism of Christian Smith (see his *What Is a Person?*), and the epistemic humility it entails, instructive on this matter: we must hold together as related, but not conflated, what we personally experience through our senses (the empirical), all that happens (the actual), and all that is (material and nonmaterial; the real). "Thus, what we observe (the empirical) is not identical to all that happens (the actual), and neither is identical to what which is (the real)."[1] If we limit our methods of inquiry to the first two domains, philosophically not just scientifically, then we remain open to the charge of reductionism.

Croasmun continues chapter 2 with a survey of the history of emergence theory, including a lucid and helpful discussion of supervenience, downward causation, and "weak" and "strong" forms of emergence. The chapter includes an incisive case study to show how an emergent account of social entities illuminates the insidiousness and complexity of racism in America, thus providing theoretical and scientific substance to the claim that racism can exist without racists.[2] Sound provocative and paradoxical? Let this be a teaser to entice you to read his insightful analysis.

In chapter 3, Croasmun employs emergence theory in order to rethink the meaning of "person" such that it can be capable of describing entities that transcend individuality. He argues that since corporate entities can exercise "agency" and demonstrate the operations of "mind" (superorganisms and group minds—e.g., bee hives, altruism operating at the group level, insti-

tutional persons, multi/many-authored scientific experiments), they can legitimately be considered as "persons" in some sense, from an emergentist perspective. Croasmun's discussion is fascinating and illuminating in many ways, pushing at the boundaries of individualistic and atomistic notions of personhood. However, questions remain. Croasmun describes complex corporate entities as persons; why then does the evil we experience from corporate entities seem so impersonal? And it is precisely the *impersonal* nature of the evil (whose source we can broadly identify but not specify) that makes it so dehumanizing. I also wonder if superorganisms or group minds that are emergent from individual human beings bear the image of God. Do they possess inherent and inalienable dignity? Human rights? Is the ontology of a social structure as real as human consciousness (or the human "self/soul")?

In chapter 4, Croasmun seeks to provide an emergent account of Sin in the book of Romans to address the question,

> How does this understanding of the self reframe not only our questions about the personal language Paul employs with regard to [Sin], but also our questions about the overlapping agencies at the individual, social, and mythological levels? (p. 103)

He suggests that emergence illuminates what Paul signifies when he describes Sin as entering the world (Rom. 5:12), increasing (5:20), exercising dominion (5:21; 6:12,14), producing desire (7:8), and reviving (7:9) and dwelling in the bodies of sinners (7:17, 20). It does so as an emergent person, specifically a cosmic tyrant that enslaves the human race. This account is emergent, because "Sin not only gains power over people's lives through their cooperation, but also, Sin depends ontologically on this cooperation, as Sin's supervenience base consists precisely of this cooperation" (p. 111). Co-opted by Sin, human beings are drawn collectively into constituting the Body of Sin ("in Adam") that Paul contrasts with the Body of Christ, another emergent entity created by the redemptive and sanctifying work of Christ and the Spirit and constituted by the supervienence base of redeemed human persons. Thus, to summarize the effects of Sin's emergence: "The primary role Sin plays in the cosmic drama of Romans is that of exercising dominion over the members of its Body" (p. 124). In the final pages of the chapter, Croasmun returns to the issues of race, the law, and the dominion of Sin, as well as a brief discussion of original sin and the transmission of sin. His proposal is that only an emergent approach that accounts for the ontology of Sin at the individual, social, and mythical levels is capable of adequately explaining the mechanism of the transmission of sin in a way which eludes Augustinian, Liberal/Ritschlian, and scientific/epigenetic proposals.

In the final (and probably, most controversial) chapter, entitled "Sin, Gender, and Empire," Croasmun seeks to specify in greater detail the identity that Paul attributes to Sin in Romans. In dialogue with first-century Greco-Roman scholarship (especially concerning devotion to the goddess Roma) and gender and post-colonial theory, Croasmun presents Sin, or Hamartia, as a goddess that subjugates and dominates human beings in a way that violates the "natural" order of things (sexual connotations of tribadic penetration are present here, in line with the kind of "unnatural" sexual expression Croasmun thinks Paul has in mind in Romans 1). Thus,

> Paul exploits the identification of effeminating conqueror and effeminate conquered in Roman imperial ideology manifest in tribadic Roma (that is, Roma-read-as-tribas). The implication is this: perhaps the imperium of Roman ideology is not the paradigm of an impenetrable masculinity, but rather the natural consequence of greater and greater degrees of enslavement to feminine desire. (p. 165)

In contrast, Paul, through parody and irony, presents Christ (via the cross) and the life of Christ's Body (the church) as subverting this oppressive vision of (apparently) successful worldly power.

> Ironically, it is within this effeminate Body of Christ that true masculine self-mastery is possible … The effeminate Body of Christ delivers what the tribadic Body of Hamartia could not: mastery of the passions (Rom. 6:12, 13:14), the renewal of mind (12:2), and the establishment of imperium (5:17). Obedience in imitation of the "dominated," "effeminate" Christ yields everything that the masculine Roman ideology was supposed to deliver. (p. 170)

It is difficult to know what to make of Croasmun's final chapter. On the one hand, he offers an interesting and creative (too creative?) case that Paul accommodates Roman mythology (combining religious and sexual themes) as a subversion of Roman imperial ideology. On the other hand, he appears to assume a very Roman (not Jewish) audience for Paul's readership. For example, this reading seems quite disconnected from the rest of the canon generally and the Old Testament and its own ancient context in particular (he seems to interpret Paul as reading the Old Testament exclusively through Philo and other select Hellenistic sources). It also leaves unaddressed the overarching concerns of Romans, especially the relationship between Jews and Gentiles and the resolution of God's covenant promises given Gentile inclusion. I am left wondering how Croasmun's arguments on Sin, gender, and empire fit within Paul's broader purposes and narrative in

Romans. I raise these concerns tentatively, leaving their adjudication to experts in New Testament and Pauline studies.[3]

Croasmun's aims in *The Emergence of Sin* are ambitious and, by and large, successful. The book invites and stimulates interdisciplinary engagement and discussion from scientists, social scientists, biblical scholars, theologians, and cultural critics. Perhaps most helpful is the clarity, lucidity, and accessibility with which Croasmun presents emergence theory (I plan to assign one of his chapters to my theological anthropology students), both in its own right and as insightful and illuminative in drawing out more fully than past interpreters the full significance of Paul's personification of Sin in Romans. This, in turn, allows for incisive analysis and critique of social evils, such as racism, going beyond approaches that fall into reductionism due to their inadequate (or lacking) ontologies of social entities. While I have reservations about some of the claims Croasmun makes as discussed above, I heartily recommend his book to all *PSCF* readers and look forward to seeing more critical engagement from biblical scholars.

Notes

[1]Christian Smith, *What Is a Person? Rethinking Humanity, Social Life, and the Moral Good from the Person Up* (Chicago: University of Chicago Press, 2010), 93; cf. 90–98 for the larger discussion.

[2]Eduardo Bonilla-Silva, *Racism Without Racists: Color-Blind Racism and the Persistence of Racial Inequality in America*, 3rd ed. (Lanham, MD: Rowman & Littlefield, 2010).

[3]Scot McKnight, for one, is not convinced by Croasmun's final chapter (especially his presentation of Sin as Roma-tribas), though he is quite impressed with the first four chapters of the book. See his review, posted on his blog on June 11, 2018, https://www.patheos.com/blogs/jesuscreed/2018/06/11/sin-as-tyrant/.

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COSMOLOGY IN THEOLOGICAL PERSPECTIVE: Understanding Our Place in the Universe by Olli-Pekka Vainio. Grand Rapids, MI: Baker, 2018. 224 pages. Paperback; $26.99. ISBN: 9780801099434.

There has been a growing market for books that discuss the intersections of science, theology, and philosophy, as evidenced by the popularity of writers such as Paul Davies and John Polkinghorne. Writing about the intersections of these apparently disparate fields is a true challenge that should not be taken lightly, and requires honesty about one's limitations in learning about the fields in which one has not received vigorous training. In *Cosmology in Theological Perspective: Understanding Our Place in the Universe*, Olli-Pekka Vainio makes an attempt to contribute to this rich field. The intention and desire to understand the study of science from a theological perspective is clear from the onset. However, a careless approach to studying science and the lack of humility in subjects for which he has not deeply studied in the traditional sense results in a jarring and unsatisfying conclusion.

The book begins with an overview of the history of the Western concepts of cosmology. Vainio focuses primarily on the Judeo-Christian perspective that shaped the understanding of the universe in the ancient world. Additional pagan viewpoints are occasionally brought in; however, the main focus is first on Jewish philosophical thought and later on a Christian perspective. Vainio continues this discussion of the philosophical/theological influences on science through the modern era, discussing periods of conflict such as in the time of Galileo and identifying instances such as Newton's discoveries, in which the drive for scientific knowledge has furthered the pursuit of a more complete theological understanding of the universe. These chapters are surprisingly thorough for their length and cover the key points for those who are interested in the history of Western science. It is clear that Vainio has studied scientific history and theological history of the Western world deeply. These chapters could have benefited, however, from more comparisons to other theologies that drove ancient discoveries.

After this history, Vainio abruptly switches to the real purpose of the book, which is to examine theological perspectives on astrobiology and questions of life on other planets. Here his lack of scientific study is evident. Vainio includes a discussion of the multiverse, proposing that in a reality in which every possibility is its own universe, there would be many with and without life. These would include evil universes that are antithetical to the notion of a good God. This discussion is intertwined with discussions of fine-tuning and the Drake equation for the improbability of a space in the universe having the right conditions to sustain life.

After discussing these theories, Vainio questions the Christian theological perspective on astrobiology, primarily using C. S. Lewis's works of fiction to describe the Christian perspective. His insights on the Christian perspective on astrobiology are certainly fascinating, but they are not novel. He is in line with most Christian scientific organizations, Christian philosophers, and theologians, concluding that the existence of alien life does not preclude the existence of the Christian God. Nor does it pose problems for Christology. The primary example given for this comes from C. S. Lewis's space trilogy, with beings at different stages of pre- and post-Fall,

each with a unique revelation of salvation from the one God. Vainio concludes that Christians should approach the study of science and theology with a sense of awe and an awareness of what is not known. This is an unnecessary conclusion as most scientists and theologians in the field, Christian or otherwise, take exactly that approach. His statement reveals his ignorance toward what it means to pursue scientific study. Perhaps this statement was intended for readers lacking in both scientific and theological academic pursuits, but this would not be in line with the book's apparent intended audience.

This book suffers from being mistitled. While it is true that the definition of cosmology in a literary sense includes the human perception of the totality of knowledge, most modern readers will think of the scientific field of physical cosmology. This is the scientific study of the origins and ultimate fate of the universe, which are typically not studied from a life science perspective. On the topic of scientific physical cosmology, Vainio says very little. As a physicist, looking forward to expanding my understanding of philosophy relating to my field, I was disappointed. It is clear that the main purpose of this book is to discuss the philosophical implications of astrobiology, another deeply important and nuanced field. A more accurate title, emphasizing the astrobiology focus, would have set a better perspective and drawn the intended audience.

While there are many minor issues with this book, the most grievous is the author's clear lack of scientific understanding. In analyzing different scientific theories such as the multiverse, Vainio cites primarily science philosophy books that have summarized these papers. There is no sense that Vainio has read the original research or done the equational analysis needed to deeply understand the physics theories that he is attempting to discuss. I am reminded of reading works by William Lane Craig, such as *Theism, Atheism, and Big Bang Cosmology*. In this work Craig has rightly been criticized for having a clumsy grasp of the physics for which he is trying to offer philosophical perspective. The difference is that Craig is deriving his physics knowledge from original scientific sources and makes a valiant attempt to wrestle with the theories and equations. Vainio does no such thing. All of the science Vainio presents in both the fields of physical cosmology and astrobiology is coming from science philosophy or popular science books. This is not an acceptable substitution for learning scientific theories at the level needed to offer insightful analysis. The reader is left with the perception that he does not have a real understanding of the science, and as a result most of Vainio's conclusions are weak.

The book, despite its flaws, does have some redeeming qualities which some readers may find beneficial. The summary of the western perception of universal understanding is surprisingly thorough for its short length. Those who are fans of C. S. Lewis and his writings on theological issues of astrobiology in his fiction works will appreciate how these discussions provide a guiding force in the philosophical analysis of extraterrestrial life in this book. This may be an interesting read for those pondering the implications of life outside of Earth from a somewhat Christian perspective. The discussion on Christology and astrobiology is an effective counter argument for anyone (secular or theistic) who holds the belief that the discovery of extraterrestrial life would compromise Christian belief. These sections alone may make it worth a skim. However, with the wealth of available books on the topics of science and faith as well as on the Christian perspective on astrobiology, this one falls flat.

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READING GENESIS AND MODERN SCIENCE: A Study Guide by Frank De Haan and David De Haan. Grand Rapids, MI: Credo, 2018. 112 pages. Paperback; $9.99. ISBN: 9781625861177.

Reading Genesis and Modern Science is a relatively brief work produced by a father-son team of Christian chemists. Both have earned PhDs and have spent their careers teaching, researching, and ministering among college students at major universities. One is now retired from Occidental College in Los Angeles and the other is working at the University of San Diego. The authors confess a biblically based Christian faith, with deep roots in the Reformed tradition, and a confidence that modern conventional science is not at odds with the authority and truth of scripture. A love for the church and for God's natural creation prompted the project.

The book is intended to be used as a study guide for Sunday School classes or small group discussions to introduce scientific topics with which many Christians struggle. The authors acknowledge that there are risks on either side of positions taken on these topics. Taking an overly skeptical approach to science may lead to rejection of good science and loss of benefits that progress in those fields could bring. On the other hand, rejecting parts of the Bible that seem inconvenient may result in an anemic, ineffective, and misdirected faith. With the risks in mind, their position unabashedly favors an embrace of scientific findings related to the age of the earth, evolution of life including humans, and human-induced or exacerbated climate change.

The book's stated objectives are to appreciate the strength of scientific evidence; critique young-earth creationist methods; utilize alternate ways to understanding Genesis; express why this really matters; understand the causes and seriousness of climate change; and consider how to be stewards of the earth.

The book is divided into eight lessons, with short descriptions or vignettes designed to facilitate discussion. The authors take a novel approach of shifting a significant portion of their own arguments to the back of the book. This final section, "Answers and Comments for Discussion Questions," fills the last one-third of the book.

The strengths of the book, considering its purpose, start with its relatively small size. The book is not an intimidating tome on the subject of science and faith. It is not intended to be a thorough defense of the chosen topics, but to be a starting point for discussions. Participants interested in more-thorough coverage of subjects are directed to other sources. Descriptions of scientific understanding and biblical hermeneutics are generally accurate, though oversimplification in some places is an inevitable artifact of the book's brevity. The tone of the book attempts to draw participants together in discussion rather than to preach, though the authors do make a strong case for their viewpoints.

The brevity is also a drawback, given the complexity of the subjects addressed. Readers or group leaders looking to go deep with a discussion group may find the material falling short of expectation, with some lessons less than two pages in length leading up to the questions. Given the beginning of the book title, *Reading Genesis …*, readers might also expect more discussion of the Genesis text than is found. Chapters do ask readers to consider the meaning of many Bible verses, though mostly verses outside Genesis. If using the book in a Sunday School setting, leaders will need to forewarn participants that questions dealing with specific verses are saved for lesson three and beyond. Finally, while the questions are good, they are not always obviously tied to the stated subject of the chapter.

Lesson one covers plate tectonics. Readers are provided with a brief history of Wegener's theory of continental drift and its eventual confirmation based on alternating bands of iron-mineral orientation on the ocean floor. The lesson ties in an explanation of how earthquakes happen, and even how human activity can cause smaller earthquakes in some parts of the world. There is no biblical discussion in this lesson, though questions ask participants to think about whether earthquakes started only after sin.

Lesson two focuses on dating. A simple description of radioisotope dating is provided, with a good example of a method scientists use to determine the starting composition of minerals being dated. The lesson does not address the challenges raised by young-earth advocates or how scientists respond to those challenges. Apparent conflicts with biblical ages is saved for later chapters.

Lesson three covers the age and origin of the universe. This is a short chapter, with fewer than two pages of discussion leading into the questions (though the "Answers and Comments" section at the end offers more). One example of a method for estimating the age of the universe is provided, based on the current position of galaxies in the universe and the rate of expansion. Questions begin to draw participants into scripture here, addressing subjects such as the understanding of the original audience and whether God speaks through his natural creation.

Lesson four concentrates on the question, "Where Does the Idea of a Young Earth and Universe Come From?" The authors provide a brief history of modern thought on the age of the cosmos, noting that many conservative theologians of the 1800s did not consider Genesis to constrain the age of creation. Half the lesson is an extended quote from *The Bible, Rocks, and Time* by Davis Young and Ralph Stearley. Questions ask participants to consider whether science and faith have always been in tension and why some scientists try so hard to dismiss God.

"An Alternate Way to Understand Early Genesis, Especially Genesis 1" is the focus of lesson five. This lesson draws largely from John Walton's work in *The Lost World of Genesis One*. A brief case is made that Genesis was effectively a love poem: God telling God's people that they need not fear darkness, or the sea, or monsters, or the unknown, for he has made the creation to function for their benefit. This lesson is the first time participants are asked why some feel the Genesis story must be taken literally and whether there was death before sin.

Lesson six explores "Why This Really Matters." The authors reiterate material from lesson three, reminding participants that insisting on a young earth in spite of overwhelming evidence can place stumbling blocks to faith in the path of Christian youth and adults considering the Bible. They also note that some powerful apologetic arguments are undermined by the young-earth position. Questions range from exploring why people believe in a multiverse to whether God could have created by evolution.

Lessons seven and eight both focus on "Topics for Further Study and Discussion." The seventh chapter

probably should have been titled "Climate Change and Christian Stewardship," as this is the subject addressed. An overview is provided for the science of human-induced climate change, how the discussion is often derailed by political polarization, and what we should be doing as stewards of God's creation. Some will argue that the acceptance of human agency in the earth's warming trend is overstated, though a good case is made for seeing ourselves as caretakers of the earth, rather than simply as users. The final chapter probably should have been wrapped into the previous one, for it continues the subject of stewardship. The lesson is just two questions, both tied to climate change. An appeal is made for churches to be more active in discussing the impact of human activities on the earth's climate, and recommending active participation in solutions.

I recommend the book for groups already comfortable with the possibility that science may have something to say about our understanding of scripture or earth stewardship. It will not be as useful for groups looking for a strong scriptural defense before giving science an ear.

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Social Science

MINDS MAKE SOCIETIES: How Cognition Explains the World Humans Create by Pascal Boyer. New Haven, CT: Yale University Press, 2018. 376 pages. Hardcover: $30.00. ISBN: 9780300223453.

Encompassing updated research findings from evolutionary anthropology, history, economics, and social psychology, Boyer has embarked on an arduous and audacious task to provide psychological and cognitive underpinnings of a wide range of human social behaviors. Within the framework of evolutionary psychology, Boyer frequently provides comparative as well as historical accounts of human social behaviors to explain how such behaviors have evolved. While doing so, Boyer emphasizes the importance of cognitive underpinnings of social behaviors and explains how cognitive systems played a role in shaping and influencing various social behaviors.

Boyer suggests that at the core of understanding various social behaviors lies the functional capacity of human mind. This implies that we need a set of cognitive capacities or detection systems that enable people to extract information from the social world—termed as the "intuitive inferences systems." Boyer argues that there exist a plethora of these intuitive inference systems shaping, guiding, and directing cognitive processes of information pertaining to specific social contexts. These intuitive inference systems share some common properties: (1) they operate outside consciousness; (2) they are specialized; and (3) the operation and function of these systems can be best understood from the evolutionary perspective. Under such assumptions, Boyer presents how these systems operate and function in group formation and conflict (chap. 1), junk culture, including odd belief, rumors, and conspiracy theory (chap. 2), religion (chap. 3), family (chap. 4), societal cooperation and justice (chap. 5), and human society (chap. 6).

In the first chapter, Boyer focuses on the operation and function of the cognitive system in group identity and group formation. He begins the chapter by describing one's inherent tendency toward group formation and antagonism toward out-group members (group conflict). Coalitional psychology emerged to understand the psychological and cognitive underpinnings of human alliance that enable people to form a group. Cognitive systems shape and reinforce the coalition by playing a vital role in recognizing in-group members in order to build solidarity and identifying out-group members based on accent and phenotype. For example, race is one of the most salient and explicit ways to predict social alliance. Furthermore, the system makes implicit statistical estimations of different out-group members, which have significant impacts on people's physical health as well as attitude. As such, one's survival and well-being hinges upon group cohesion and continuity, and cognitive systems play a vital role in group solidity and conflict.

In the second chapter, Boyer focuses on the functional role of cognitive processes involved in seemingly unreasonable and odd belief with little value—termed "junk culture." In chapter 3, he defines religion as a subset of supernatural concepts systematically structured and codified. In light of evolutionary psychology, religion is adaptive and enhances fitness by promoting one's commitment to a group and cooperation with others. Boyer proposes three cognitive representations of religion: (1) an interesting fiction; (2) a way to cultivate spiritual self; and (3) a way to promote group solidarity and intergroup hostility.

In chapter 4, Boyer presents the cognitive computation underpinning sexual preference, identity, and behavior. Sexual psychology has heavily relied on the theory of evolution, which is supported by a wealth of evidence. However, according to Boyer, this explanation also poses a challenge because the notion of fitness is difficult to measure and it takes a

long time to evaluate its effect. As a result, people are more likely to rely on cognitive proxies to observe one's adaptability to the environment. For example, we have specialized learning systems that allow us to compute a kinship index, a measure of relatedness, to avoid incest.

In chapter 5, Boyer examines cognitive capacities involved in cooperation and fairness. Cooperation relies on cognitive capacities to keep track of previous social interactions with different partners for future reference. Such cognitive capacities enable people to remember partners who make fair deals for future reference as well as noncooperators for the purpose of inflicting punishment. In addition, these cognitive systems provide intuitive understanding of fairness, justice, and distribution, which shape people's attitudes and behaviors. Chapter 6 then addresses how people evolved to live in societies without fully understanding the underlying mechanisms of society. Boyer borrows the term "folk society" and expands it to describe the layperson's understanding of how societies work, what constitutes societies, and how these components are related.

The underlying assumption of Boyer's argument is that the human mind is "an efficient learning machine" (p. 67) that is capable of detecting useful information in the environment. Following the framework of the evolutionary theory, Boyer assumes that the human mind is functional and adaptive to enhance fitness. However, Boyer often encountered evidence that suggested otherwise. For example, people readily change their opinion to conform to the group as seen in Asch's experiment. Or, people's memory is malleable, fallible, and easily altered. Thus, Boyer presents selective data to justify his arguments. For example, to provide evidence that the human is not gullible, he provides an example of repressed memory and comments that "they did not show that people's memory was easy to fool—quite the opposite" (p. 73). However, research in cognitive psychology has provided compelling evidence showing that human cognitive function is far from being perfect and is susceptible to errors and failures in various stages of information processing—from perception to memory. For example, there is extensive evidence suggesting that our sensory and perceptual systems are highly susceptible to misperception, measurement errors, or visual illusions.[1] In fact, perceptual illusion occurs so frequently that it has been construed as an unreliable source for knowledge by itself.[2] Other troubling research suggests that our attention system has such limited capacity that we have to pay attention to some aspects of stimuli or environment and ignore or exclude others—termed selective attention.[3] Limited attentional capacity constrains our ability to perceive objects, stimuli, or changes occurring in environments.

Furthermore, a wealth of evidence in memory research suggests that human memories are easily altered, distorted, or reconstructed by misinformation, beliefs, moral concerns, and stereotypes.[4] The fragility of memory is well illustrated in the misinformation effect, which refers to the phenomenon that exposure to misleading information after an event distorts and changes how an eyewitness describes the event later.[5] Moreover, it is possible to suggest or implant an entirely false memory that had never happened before.[6] The prevalence of memory failure or distortion has been widely recognized and well documented by prominent memory researchers. For example, Daniel Schacter, a famous memory researcher at Harvard University, identified and described common "sins" of memory.[7]

Boyer made significant efforts to justify seemingly dysfunctional cognitive systems by presenting their roles in satisfying another evolutionary goal. For example, Boyer suggests that one's susceptibility to information that feeds "junk culture" can be attributed to negativity bias, which describes one's tendency to readily receive and accept negative information. Negative bias can be explained by a built-in threat response system that operates to detect potential threat. Indeed, negative bias can be adaptive from the evolutionary perspective because accepting precautionary advice against potential danger allows one to identify the source of danger without extensive, yet potentially costly, processes of testing. In particular, when threat information is moralized, it can serve an important role in recruiting in-group members by motivating and persuading people to participate in an action to achieve a collective goal. As such, information that feeds "junk culture" can be functional and adaptive to the social world, though it may not always be philosophically or scientifically true. As a result, human minds are susceptive to such information, thereby enhancing fitness. However, cognitive models of psychopathology posit that negativity bias in information processing may play a critical role in the etiology and maintenance of a wide range of anxiety disorders and depression.[8] It has been well documented that people with anxiety disorders demonstrate prioritized attentional processing favoring emotionally negative information; similarly, people with depression demonstrate memory bias favoring emotionally negative events. Thus, what is defined as functional can be a source of problems that produces aversive results.

On the other hand, Christian worldview has provided some explanations and implications for cognitive

limitations and constraints. God made humankind in His image with an ability to learn and to think. In fact, humankind was created with the superior intellectual capacity to perceive and pay attention, think creatively and logically, use complex language, and govern the physical world.[9] Furthermore, humankind was capable of moral reasoning—an ability to determine right from wrong—by God's moral standard.[10] Many Christian traditions emphasize the importance of human cognition (mind) in forming and developing the Christian faith. However, the Fall has brought devastating results on the human mind. The "total depravity" of man means that every part of the human constitution, including human mind, has been corrupted. Scripture depicts the human mind as being "darkened": our thinking becomes "futile" and we become hostile to God and his law. For instance, Mark 8:8 ("You have eyes—can't you see? You have ears—can't you hear? Don't you remember anything at all?," from New Living Translation) truly echoes cognitive limitations that we have. Indeed, a wealth of research in cognitive psychology has provided empirical evidence of functional difficulties and challenges in human cognition.

Such cognitive constraints and limitations significantly interfere with our ability to gain knowledge about the world and may pose serious challenges to psychological and social function. General revelation refers to the knowledge of God's existence, nature, and moral law through creation, which is bestowed upon every person.[11] However, limited and distorted cognitive capacity prevents people from correctly sensing and interpreting natural laws. For example, Einstein's groundbreaking work illuminated that time is experienced relatively, and also that time and space depend on each other.[12] However, to this date, we tend to consider space as being immutable and independent from time. As such, we have limited ability to perceive and understand natural law and God himself revealed in nature. Similarly, limited cognitive capacity sometimes hinders our understanding of God revealed in specific revelation. Specific revelation refers to God's Word, including prophecy, scripture, and the direct communication with the Holy Spirit, given to specific people.[13] Challenges in specific revelation may occur because of cognitive constraints imposed on hermeneutics and exegesis of scripture. For example, people, even theologians, find it difficult to conceptualize the role that human free will plays in the context of traditional predestination within Calvinist theology.[14] In an attempt to interpret and understand difficult concepts, people may rely on their intuition, presuppositions, and prior knowledge to make sense of apparently conflicting concepts, thereby turning exegesis into eisegesis. This may explain people's confusion of theological concepts, which confusion is observed in "theological correctness" (p. 107).

Although sin has seriously constrained and distorted cognitive function, it did not irreplaceably destroy one's capacity to exercise cognitive function and to grasp truth. Humankind in the fallen condition is capable of understanding some truth and processing information from the external world. In fact, people are capable of utilizing and processing information to engage in effective social behaviors. Some people have high intelligence and superior reasoning in that they are capable of understanding ideas and theories and making incredible discoveries and inventions.[15] I enthusiastically support Boyer's idea about the importance of cognitive systems in various social behaviors and their vital role in social function. The cognitive systems are adaptive and functional to a certain extent. However, at the same time, I humbly acknowledge that our limited cognitive capacity misguides psychological processes and poorly directs social behaviors; these unfortunate results contribute to the various individual and societal problems we encounter.

Notes

[1]E. B. Goldstein, *Cognitive Psychology: Connecting Mind, Research, and Everyday Experience,* 3rd ed. (Belmont, CA: Wadsworth, Cengage Learning, 2011); and R. L. Gregory, "Knowledge in Perception and Illusion," *Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences* 352, no. 1358 (1997): 1121–27.

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TECHNOLOGY

MODERN TECHNOLOGY AND THE HUMAN FUTURE: A Christian Appraisal by Craig M. Gay. Downers Grove, IL: InterVarsity Press, 2018. 233 pages plus preface and acknowledgments; includes epilogue and author, subject, and scripture indices. Paperback; $22.50. ISBN: 9780830852208.

If someone asked me what I regard as the seminal works of the last century or so that critique technology and technological thinking, I would point that person to the works of Max Weber, Lewis Mumford, Jacques Ellul, and Joseph Weizenbaum. But if they asked me to point them to a book that made the best thinking about technology accessible to people who are broadly educated and eager to learn but who are not specialists, I would point them to Craig Gay's book, *Modern Technology and the Human Future*.

Gay has written a very helpful book. It is carefully thought out, well organized, thorough, deals with substantive and critically important ideas—and it is readable!

Gay begins by arguing that there are serious problems with the direction in which modern technological development is heading; he does this by treating a number of important and comprehensible examples. He then analyzes the economic dynamics that drive such development and follows with a clear analysis of the historical and philosophical roots of that development, most notably the mechanistic model of the universe commonly associated with Descartes. He then steps aside for a chapter to discuss the Christian view of human nature, especially "embodied human existence," through the lens of the creation-fall-redemption-consummation model. The argument culminates with a discussion of what Christians can reasonably do in the face of this situation. He concludes with some personal reflections on technology and employs the concept of the eucharist to tie all of his threads together in a coherent and compelling way.

Gay's book is a tale of two views of the universe: as fundamentally personal or impersonal. From a Christian perspective, everything in the universe is created by a personal God. Thus, it is endowed with qualities given by a person, such as meaning, purpose, and value. It is undergirded by a transcendent moral system. Human beings have a purpose and direction, to be shaped into Christlikeness, and this provides a basis for evaluating the worth of all human endeavors. Our bodies are not prisons for our minds, but temples worthy of honor. Our relationship with the created world ought to be characterized by appreciation and, when appropriate, love.

If, however, the universe is an impersonal machine, governed solely by natural laws with no transcendent meaning, humans are free to master those laws and shape nature to their own ends. Nature's only purposes are those that people give it. Our culture seems to have adopted the perspective of an impersonal universe and the consequences are extensive. There are surface problems that flow from this perspective and that have been widely discussed; for example, algorithms that have replaced human judgment in harmful ways, narrow specialization, the confusion of means and ends, and the loss of skills. But there are deeper problems. Gay argues that automated machine technology is pushing society and culture away from ordinary embodied human existence at considerable speed and we are becoming more machine-like. Furthermore, technology seems to be interfering with our ability to enter into "I-Thou" relationships. In short, given its current trajectory, modern automatic machine technology is more likely to detract from our ordinary embodied experience of the world than it is to enhance it.

The author is no technophobe. Following the last chapter, he includes a personal conclusion in which he discusses his enjoyment of high-performance bicycle technology. However, he identifies a significant problem with the direction contemporary technology is heading and asks why we are so unconcerned. His answer is that western culture has thoroughly assimilated the mechanistic worldview.

What can Christians do to respond to a culture that, in its understanding of the nature of the universe, is antithetical to the personal perspective that Christian belief affirms? We intuitively recognize that aspects of our lives—friendship, marriage, family—are not to be surrendered to rationalized techniques based on productivity, efficiency, cost/benefit analysis. Thus, Gay urges taking an inventory of the physical places

where technologies are located in our homes and the roles they play in our lives. He then suggests some practical means we could use to limit those roles appropriately. Moreover, churches, schools, and community organizations—any association whose primary purpose is human formation—should not be surrendered to rationalization. He writes, "… personal ends cannot be achieved through exclusively impersonal means." On a broader scale, he points out that automated machine technology has developed a momentum of its own that seems immune to critique, driven by powerful economic forces (which Gay discusses with some care). Nevertheless, Gay points to the necessity of a more extensive cultural change, including the need to repent of hubris and the desire for autonomy and to turn from the mechanistic way of enframing the world that reflects that hubris.

Gay is not an alarmist, but he makes a compelling case that modern culture is heading in a dehumanizing direction. He analyzes how that course was set and shows how it needs to change. I heartily recommend this book for perspectival courses on technology in Christian colleges and universities and for anyone whose professional work is in a technological field. But it could be read with profit by anyone concerned with issues of technology and society.

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DEEP MEDICINE: How Artificial Intelligence Can Make Healthcare Human Again by Eric Topol. New York: Basic Books, 2019. 341 pages. Hardcover; $32.00. ISBN: 9781541644632.

Artificial intelligence (AI) will not be replacing human doctors anytime soon, but it will have profound impacts on the way medicine is practiced. This is according to Eric Topol, MD, the author of *Deep Medicine*. Topol vacillates between the voices of a historian and a prophet as he details the history of AI and its incorporation into the medical field, and then speculates about the future medical roles of AI. This is the author's third installment in a series of books describing the changing landscape of medicine in a society amid a technological revolution (see also *The Creative Destruction of Medicine* and *The Patient Will See You Now*). As a cardiologist, professor of genetics, and director of the Scripps Translational Science Institute, Topol is well qualified and uniquely positioned to take on the formidable task of translating the fields of AI, genetics, and medicine into prose understandable to the lay reader. He largely succeeds at creating a balance of a comprehensive description of each topic without overwhelming the reader with too much detail.

In the first two chapters, Topol whets readers' appetites with anecdotes describing potential ways that AI could improve medicine. He also chronicles some of the shortcomings of "shallow medicine," which is described as medicine practiced with "insufficient data, insufficient time, insufficient context, and insufficient presence" (p. 31), which he suggests is often the way medicine is currently practiced. Chapter 3 details some of the shortcomings of using AI for diagnoses in the past and describes some of the most promising fields of medicine in which AI is currently improving diagnostic power.

Chapters 4 and 5 take a step back to define what AI is, survey some of the history of its development, and explain how deep-learning algorithms work. Potential problems with AI are also discussed, from designing human bias into learning algorithms to sentient machines turning on humanity. The latter scenario is decidedly unlikely in the near future. Yet AI will undoubtedly change society profoundly, so, Topol cautions, it behooves us to be aware of this and direct its uses to ways that benefit humanity.

The remainder of the book focuses on specific facets of medicine and how AI is being used in each arena. Some of the topics include analyzing images (MRI and X-ray, for example), mental health, drug discovery, personalized diets, and the healthcare system itself. For each of these subjects, Topol offers a realistic description of the current state of AI incorporation and a distinctly optimistic look at how AI will transform that field in the future. However, a common refrain in these chapters is that the use of AI will always be limited by its inability to replace the human and relational aspect of the practice of medicine.

This leads to the last chapter, called "Deep Empathy," in which Topol offers an impassioned call for a paradigm shift in medicine away from an assembly-line mentality to a focus on developing uniquely human characteristics of medicine for which AI, in his view, will never be a satisfying substitute. He notes that in recent years it is these very characteristics that have been pushed aside as medical professionals are required to spend more time behind a computer screen, care for an increasing number of patients, and spend less time face to face with those in their care. As business interests have taken over medicine, profitability is favored over building relationships with patients. AI, he notes, "could be used in two very different, opposing ways: to make things much better or far worse" (p. 285). We still have the capability

to control the direction of the evolution of medicine, but it will take intentional effort by medical professionals, the government, and society to reclaim the humanity of medicine.

This is not the first time that society is faced with a technology that has the power to either greatly benefit or greatly harm, depending on its application. Impacts cannot always be reliably predicted. Therefore, Topol urges that these technologies must be closely monitored to mitigate negative impacts.

Christians should be integrally involved in this, both at the societal and policy level, to encourage equitable and ethical use of AI in the medical field. For example, this technology truly could, Topol suggests, increase the time that medical professionals have available to spend with each patient, allowing them to form human connections and develop true empathy. Humans are created as relational beings, so technology that frees time for deeper relationships should find widespread support.

However, equally possible is that business interests will dictate an increase in the number of patients seen, rather than the time spent with each patient. Similarly, AI may decrease costs associated with medicine, making medical care more accessible to marginalized groups in society who currently experience poor access to medicine. However, it may simply increase profit margins, enable discrimination based on risk factors, and "exaggerate the profound gap that already exists between those who have much and those who have less" (p. x). AI has the potential to narrow in on a diagnosis more rapidly than ever before, decreasing wasted spending on unnecessary tests and leading to better societal stewardship of monetary and medical resources. However, it could also increase spending and waste if individuals demand more tests and continuous medical screening because of their ready availability.

These issues must continue to be carefully considered while AI is being implemented, in order to guide our medical system to become something better, rather than worse, than its current state. In making these matters accessible to lay readers, Topol provides the information required for everyone to join in the discussion.

Reviewed by Kelly N. DuBois, Professor of Biology, Calvin University, Grand Rapids, MI 49546. ☼

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