PERSPECTIVES on Science and Christian Faith

JOURNAL OF THE AMERICAN SCIENTIFIC AFFILIATION

In This Issue …

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

VOLUME 72, NUMBER 4 **DECEMBER 2020**

(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 St, Ste 208, Topsfield, MA 01983-2210. Periodicals postage paid at Topsfield, MA, and additional mailing office. POSTMASTER: Send address changes to: Perspectives on Science and Christian Faith, 218 Boston St, Ste 208, Topsfield, MA 01983-2210.

Manuscript Guidelines

The pages of *Perspectives on Science and Christian Faith (PSCF)* are open to original, unpublished contributions that interact with science and Christian faith in a manner consistent with scientific and theological integrity.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.
3. Use endnotes for all references. Each note must have a unique number. Follow *The Chicago Manual of Style* (16th ed., sections 14.1 to 14.317).
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 (JPG or PDF format). Figure captions should be provided as a list at the end of the manuscript text.

ARTICLES are major treatments of a particular subject relating science to a Christian position. Such papers should be at least 2,000 words but **not more than 8,000 words in length**, excluding endnotes. An abstract of 50–150 words is required and should be in both the text of the email submission and at the beginning of the attached essay.

COMMUNICATIONS are focused personal examples of how people are living out science and Christian faith. They have ranged from bringing computers to areas with no power, to being married to an experimental physicist, to an astronomer's sermon on the heavens telling the glory of God, to serving as president of a research university.

BOOK REVIEWS serve both to alert readers to new books that appear significant and to engage these books in critical interaction. When a subject area editor selects a book for review, the book is then offered to a scholar with the best match in expertise. ASA/CSCA members who would like to be considered as potential reviewers are welcome to express interest to **Stephen Contakes** (scontakes@westmont.edu) book review editor for inclusion in the reviewer database. Publishers may also contact the book review editor if they are not sure which subject area reviewer would best consider a particular book.

- **Chris Barrigar** (cjbarrigar@sympatico.ca): philosophy and theology.
- **Malcolm Gold** (mgold@messiah.edu): sociology, psychology, and education.
- **Arie Leegwater** (leeg@calvin.edu): cosmology, history of science, mathematics, and physical sciences.
- **Derek Schuurman** (dschuurman@calvin.edu): computers, engineering, and technology.
- **Sara Sybesma Tolsma** (stolsma@nwciowa.edu): biology, environment, genetics, and origins.

The viewpoints expressed in the books reviewed, and in the reviews themselves, are those of the authors and reviewers respectively, and do not reflect an official position of the ASA.

LETTERS to the Editor concerning *PSCF* content may be published unless marked not for publication. Letters submitted for publication **must not be longer than 700 words** and will be subject to editorial review. Letters are to be submitted as electronic copies. Letters accepted for publication will be published within 6 months.

ADVERTISING is accepted in *PSCF*, subject to editorial approval. Please address inquiries for rates or further information to the Managing Editor. The ASA cannot take responsibility for any orders placed with advertisers in *PSCF* and does not imply endorsement by carrying the ad.

James C. Peterson

Let the Authors Say What They Want to Say, Including Running the Numbers

We cited "The Chicago Statement on Biblical Inerrancy" in the March editorial. The authors of the declaration knew from reading the Bible that they had to be very clear about what they meant by without error. Here is Article XIII:

> **Article XIII**
>
> **We affirm** the propriety of using inerrancy as a theological term with reference to the complete truthfulness of Scripture.
>
> **We deny** that it is proper to evaluate Scripture according to standards of truth and error that are alien to its usage or purpose. We further deny that inerrancy is negated by Biblical phenomena such as a lack of modern technical precision, irregularities of grammar or spelling, observational descriptions of nature, the reporting of falsehoods, the use of hyperbole and round numbers, the topical arrangement of material, variant selections of material in parallel accounts, or the use of free citations.

The qualifications are on the list because they are all present in the Bible. Look, for example, at "lack of modern technical precision," "round numbers," and "topical arrangement" in regard to numbering. When the Bible refers to numbers or counting or sequence, it might not be in the same way North Americans generally do now. The Bible is crucial for twenty-first-century English speakers, but do not assume that the people who wrote it were twenty-first-century English speakers. The Bible was written for us too, but it was not written to us. They lived in a desert. Most of us do not. They spoke Hebrew. We do not. They thought the sun goes around the earth. We do not.

Let the authors speak to us what they want to say. Do not try to make them us. They expressed themselves differently than we do. We can still hear and understand them, especially because we serve the same living and active God. But we have to listen carefully to hear them and what God is saying through them. Have you ever sought to understand someone speaking to you in English for whom English is a second language? Even if they get the words and grammar right, they might be speaking from a different cultural situation, so that we miss entirely their intent. The example so often cited is that if an Englishman tells you that he is "mad about his flat," he does not mean that he has been frustratingly marooned by loss of air pressure in one of his car tires. He means he really likes his apartment. And that is a difference between two native English speakers in the same year. Now add thousands of years of different history, languages, and life experiences.

Scripture is ideally like a letter from someone you know and love. You can hear their voice in it. As you come to know God better, you more clearly hear what God is saying, and become more the kind of person who God can reveal more to. Anthony Thiselton calls this a hermeneutical spiral (*New Horizons in Hermeneutics*, 1997): as one listens to the whole counsel of scripture, using scripture to interpret scripture, and recognizing God's consistent character as God reveals more and more about who God is and what God is doing, one can understand more of the scripture to reinforce the process.

So, looking carefully at how scripture does use numbers, consider the sequence of the temptations in Matthew 4:1–11 and Luke 4:1–13. What do you notice? These two passages say this happened, then this, and then this. Same temptations, but they are in a different order. This does not mean that one of the texts is wrong. It means that at least one writer was not trying to tell the sequence in this event. Is Matthew or Luke more concerned about sequence? In Luke 1:1–3, Luke says explicitly that one of his goals is to get the sequence right. Matthew then may have chosen an order that helped to teach a particular point.

Notice also that in this passage, the adversary-Devil quotes scripture. It is not enough to have a text that can be read the way the speaker wants. Jesus replies each time with scripture, but rightly interpreted and applied. Scripture can be abused. It can be twisted. The enemy quotes scripture accurately in terms of the words, but out of context and understanding. The adversary twists the point, using scripture to his own ends, rather than listening to what it actually teaches. Jesus replies with scripture, rightly used.

Another description of sequence. Did Jesus clear the temple at the beginning of his years of ministry or in his last week? See Luke 19:45–46 and John 2:13–22. Luke

describes this event as in the last week of Jesus's earthly life. The Gospel of John reports this at the beginning of his description of the three years of public ministry. John is organized around each chapter describing a different metaphor for who Jesus is. John chapter 6 is about Jesus as the bread of life, chapter 7 as the living water, and chapter 15 as the vine. The Gospel of John cannot tell everything about Jesus at once. The gospel has to present the accounts in an order, but that does not have to be in a chronological order.

For that matter, how does Jesus use numbers in Matthew 18:21–22? When he says that his disciples should forgive a person that wrongs them "70 times 7 times," does he mean to carefully count 490 offenses, and then on 491, smite him? No, that would miss the point. Jesus is telling his followers not to hold grudges or counts of wrongs. He takes the number of completeness, 7, multiplies it by ten, and then multiplies by yet another 7, to emphasize *not* counting.

When Jesus says in Matthew 12:40 that he will be in the grave for three days and three nights, is he mistaken when he is crucified Friday afternoon and raised Sunday morning? (Matthew 26–27). That is about 36 hours over three days and two nights if you count as meticulously as many do in our clocked society. Even if you are part of such a clock-oriented society and maybe even strap a clock to your wrist or carry one around in your phone, do not assume that two thousand years ago in the Middle East that people were as obsessed with precision time and counting as we are in our society that depends on hyper-coordination. The plane leaves at a certain time whether you are on board or not. The number crunchers among us, the sequence- and number-obsessed accountants, should insist on numerical precision when they are measuring out prescription medication or calculating how many cars, buses, and trucks the highway bridge can carry. We count on them for pinpoint accuracy, but in the biblical text, it would be missing the point. In 1 Corinthians 10:8, we read that 23,000 died from the plague on a particular day, yet Numbers 25:9 says that 24,000 died from that same plague. Is one counting only the primary day of the plague and the other including those who lingered a day or two longer? Are they both giving a precise number that is not plus one or minus one? No rounding allowed?

You may love the potential exactness of mathematics, as I do, but we cannot insist that the Bible talk the way of an English-speaking scientist in the twenty-first century. Let the text say what it wants to say. No more. No less. That is respect for the Bible's message. What is authoritative in scripture is what it is teaching, not what we expect or read into it. ●

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

Stephen L. Reinbold

Pharaoh's Gift: Was Ancient Nubia the Land of Milk and Camels?

Stephen L. Reinbold

Did Abraham receive camels from Pharaoh? Many archaeologists contend that the presence of camels in the Genesis narrative is an anachronism that was added by later scribes. But what if camels were brought across the Red Sea from Arabia to Africa at an earlier date? I will propose a possible camel route from the coastal region to the Nile based on studies of the following: modern and ancient DNA, revealing camel movements after domestication; mutations for adult lactase persistence (LP) that were brought to Africa along with camels or that originated in Africa; and human Y chromosome mutations that can be associated with the LP alleles and the transport of camels. The cumulative evidence allows the possibility of camels to reach Nubia by about 2000 BC. Egyptians could have brought them to Pharaoh who gave them to Abraham.

Did Abraham receive camels from Pharaoh, as recorded in Genesis 12? Did he send them to Aram to buy a bride for Isaac? Did Rebekah ride on one? An article posted on Time.com pronounced that Abraham's camels were "phantoms," an anachronism that was added by later scribes.[1] This announcement was not new to archaeology but was precipitated by an article in the journal *Tel Aviv* in which archaeologists stated that camel remains were found with human remains at a mining site in Israel dated about 1000 BC and not before.[2] When camels became essential to caravan trade is disputed. Most archaeologists already believed that no solid evidence from Egypt or the Levant was known prior to that time.

The existence of domesticated camels in Africa, particularly in Egypt, has been controversial among archaeologists. In the last century, William Albright declared that biblical Abraham could not have received camels from Pharaoh because there was no record of them or inclusion of them in accounts of Egyptian animals.[3] He believed that donkey caravans could have sufficed. Christina Köhler and colleagues explored ancient chert mines in an extremely dry area of Egypt that were dated to the Middle Kingdom. Yet, they believed that donkeys were used for transport despite the difficult logistics of supplying them with water and food, because they did not believe that camels were domesticated then.[4] However, Michael Ripinsky summarized the opposition to this view, including finds in Egypt of a camel hair rope, pottery in the shape of camel heads, and rock art depicting camels.[5] These finds are disputed: for example, did the vague-looking pottery really depict camel heads? How old was the rock art? More convincingly, a camel skull was found in Egypt dating between 2000 and 1400 BC. In his classic book *The Camel and the Wheel*, Richard Bulliet reviewed the evidence, especially the similarities related to the early use of camels for milking in the southern Arabian Peninsula and in the Horn of Africa, and declared that the early second millennium BC arrival of camels on the continent, at least in small numbers, was a possibility.[6]

There are two possibilities for the introduction of camels to Egypt: (1) they may have entered by land caravans through the Arabian Peninsula and the Levant; or (2) they could have been brought across by boat to modern-day Somalia or Eritrea and then to the Nile Valley.[7] Archaeological work has concentrated on the Levant and Egypt. Excavations of early Bronze Age

Stephen L. Reinbold *(PhD, Illinois State University) served until recent retirement as a professor of biological sciences at Metropolitan Community College in Kansas City, Missouri.*

Arad in the Negev Desert revealed a small number of camel bones, interpreted by Ruth Amiran as coming from wild camels dated at about 2700 BC.[8] Camel bones in Jordan have been dated to the third millennium BC by the Camel Bone Dating Project as listed in Oxford AMS System.[9] There has been less archaeological work in the Horn of Africa near the Red Sea, partly because of political instability there for many years. Nevertheless, Bulliet thought that domesticated camels arrived by ship to Somalia between 2500 and 1500 BC.[10]

In this article, I will show that the East African camels were a separate introduction and that this introduction was earlier than that of camels arriving by the land route. I will examine the genetics of camels and the genetics of camel herders, who may have brought camels to Africa, by examining lactase persistence (LP) alleles and Y chromosome mutations.

Genetics of Camels

Camel genetics reveals a history of movement of the animal post-domestication. Faisal Almathen and colleagues refer to pre-Iron Age camel remains as being "intrusive to the chronology" due to doubtful provenance or carbon-14 dating.[11] They do not believe that domesticated camels expanded out of Arabia before about 1500 BC. They believe that the biggest expansion in caravan trade developed after AD 1200 with the growth of the Ottoman Empire. They do, however, point out that East African camels are genetically unique, perhaps due to use (mainly for milk) and long isolation, and that they have a separate origin from the camels of North and West Africa, probably originating from South Arabia. South Arabian camels are more genetically similar to East African camels than to North Arabian camels. Using genome sequences and examining microsatellite diversity by performing coalescent simulations to work backward to discover when the sequences converged in the past, Almathen et al. found a severe bottleneck in East African dromedaries about 8,600 years ago, presumably long before domestication. They found that East African camels had the highest mitochondrial diversity which would be consistent with the shipping of primarily female camels (used for milk) to Africa, along with a small number of male camels. They lumped together North African camels, including Egyptian camels and western Saharan camels.

There may be, however, a discontinuity in Egypt compared to western Africa, such as in Algeria. Youcef Amine Cherifi and colleagues found a differentiation between Algerian and Egyptian camels, despite extensive back-and-forth movements.[12] Egyptian Sudani camels are from Sudan; Falahi camels used in the delta region of Egypt are bred in Upper Egypt and resemble a description of camels from Somalia given by Hellmut Epstein.[13] Ahmed Ould and colleagues found that 91% of variation in Tunisian camels was *within* populations, not between populations, again showing that western camels were relatively homogeneous compared to those in Egypt.[14] According to Bulliet, even the type of saddle used with South Arabian camels is similar to that used in East Africa, in addition to the use of camel milk.[15] He did think that there was a break at the highlands north of the Afar Desert in Eritrea between the East African camels and camels of northern Sudan (Nubia) because he did not think that the Beja north and south of the narrow coastline strip raised camels (fig. 1). However, the Beja of Sudan still rely on camel milk for subsistence during famine.[16]

Genetics of Camel Herders

Methodology

To understand how the populations who depended on camel milk were affected genetically, it was necessary to calculate changes in allele frequencies by generation in order to calculate the date of origin for alleles. The Hardy-Weinberg equilibrium is a general formula ($p^2+2pq+q^2=1$) that calculates allele and genotype frequencies under certain conditions: no selection, no mutation, no migration, random mating, and large population size. Of course, these conditions are not always true. The homozygous recessive genotype is represented by q^2 in the above equation and is the proportion of the population susceptible to negative selection. The formula for changes in allele frequencies when selection is present can be calculated using a selection coefficient s which represents the proportion of homozygotes that is eliminated each generation. If q is the original frequency of the recessive allele, then q can be recalculated for each generation ($q-sq^2/1-sq^2=q'$) to give q′ which is the frequency in the next generation.

The formula was entered into an Excel spreadsheet. The current allele frequency of a population is located by inspection, working down the spreadsheet generation by generation from the original q value. When particular values of q′ are found in the Excel table, the number of generations to reach this point is given. However, what we are really interested in is the number of years to reach the current dominant p allele frequency. The frequency of the particular dominant allele of interest is found by $p=1-q$. Of course, certain assumptions have to be made. I consistently used a selection coefficient of 0.05, well within the range of estimates for lactase persistence in several sources. To estimate the frequency of a particular allele at its origin, a necessary starting point for the calculations, I used the frequency of 0.001. This would indicate a mutation rate of 1 in 1,000 for a large

population over an appropriate range of time, keeping in mind that mutation is always rare. However, when migration does occur, it can introduce a new allele to a population more quickly, and it is expected that a new allele will initially appear at a higher frequency than that of a new mutation.

The above represents the simple case of only two alleles for a gene in a population. A complication enters when there is more than one dominant allele represented in a population. The alleles of interest will be considered to have frequencies of $p+r=1-q$, where p and r represent two alleles, both of which are considered to be dominant to the recessive q. In terms of phenotypes, there will be no difference between the dominant alleles, and they will act as if there is only one dominant allele. It is only by gene sequencing that they can be distinguished. For simplicity, I usually estimated the time of origin for the alleles from the combined current frequencies of the dominant alleles, but the actual separate histories of the two alleles are not resolved. One of the dominant alleles might have entered the population later by migration, as would be expected from a much smaller current frequency. If I know the time when the two populations first came into contact, then I can resolve their separate histories by locating, in the spreadsheet, the number of generations that transpired to reach the date of expected contact. The associated frequency $1-q'$ will be that of the more common dominant allele p of the population when it received allele r from the other population. In this case, the initial frequency of allele r in the recipient population would be less than the frequency in the donor population.

Figure 1. Map of Red Sea Region. Tribe names are in script.

Arabian Lactase Persistence Allele

Most humans after childhood do not produce the enzyme lactase (coded by LCT gene on chromosome 2) responsible for breaking down lactose in milk. Mutations occur in the regulatory region for the lactase structural gene; these mutations allow lactase persistence (LP). An indirect method of examining the arrival of camels in Egypt is by looking for the unique variant of LP (G-13915, "the Arabic allele," showing substituted nucleotide and position) that originated in the Arabian Peninsula in association with the consumption of camel milk. This occurred presumably about 4,000 years ago as dated by Nabil Sabri Enattah and colleagues, using linkage disequilibrium of haplotypes and calculating the rho statistic, which is based on the average distance of a set of sequences from the most recent common ancestor.[17] This allele is found in northeastern Africa in Arabic and non-Arabic tribes (fig. 1).

I examined frequencies of the Arabic allele (G-13915) for LP in non-Arabic tribes in East Africa, including Afar from Eritrea, Beja from northeast Sudan, Tigray from central Ethiopia, Mahas (Nubians) from the upper Nile in Sudan, and Somali from Ethiopia (table 1). I also looked at two Arabic-speaking tribes in the upper Nile valley (table 1): the Gaali who may be Arabized Nubians, and the Shokrya (Juhayna) thought to have migrated from Arabia. These tribes, with already high frequencies of the allele, probably entered Sudan by AD 1000.

Table 1. African tribes with lactase persistence (LP) alleles G-13915 (Arabic allele) and G-13907 (Eritrean allele). The tribes are listed with their location, linguistic association, lifestyle, and total sample size included from research studies.

Tribe	Countries	Language	Lifestyle	Total N
Afar	Eritrea, Ethiopia	Cushitic	Nomadic pastoralist	37[18]
Beja	Eritrea, Sudan	Cushitic	Pastoralist	71[19]
Amhara, Tigray	Ethiopia	Semitic	Agro-pastoralist	40[20]
Mahas	Sudan	Nilo-Saharan	Agriculturalist	69[21]
Somali	Ethiopia	Cushitic	Pastoralist	109[22]
Gaali	Sudan	Arabic	Agro-pastoralist	146[23]
Shokrya	Sudan	Arabic	Pastoralist	40[24]

However, Arabs, bringing camels with them, may have already entered Africa by the Red Sea route earlier, as discussed by Bulliet.[25] Somalia or Eritrea would be the likely part of Africa reached by sailors from southern Arabia. Coastal tribes include the Afar and the closely related Saho who may have interbred with the Arabs. Movement of the Arabic allele at that point could be up the coast through Eritrea among the Tigray. The highest frequency is found in northeastern Sudan, near the coast, among the Beja. This location is near a wadi that gives access to the Nile River Valley in the interior. The frequency found in the Somali from Ethiopia is 5%. The only Somali sample I have is from Ethiopia; therefore, I focused on Eritrea as the initial area of contact.

The difficulty is timing. Based on marker sequences near the LCT gene,[26] Enattah et al. estimated the date of origin at 4,000 years ago;[27] however, the dating method has very broad confidence levels, allowing at least two thousand years difference (rho statistic estimate of 4,091 +/– 2,045). Also note that milk can be used as food when fermented, even by nonlactose digesters, before the LP allele is present. Another LP allele, which may be older, will be helpful here.

Endemic Lactase Persistence in Africa

The G-13907 allele was associated with Afar camel herders by Ingram et al.,[28] but I will henceforth refer to it more broadly as the "Eritrean allele." It has been shown to have LP activity. The allele is not found outside the Horn of Africa region. In addition to the Afar tribe of Eritrea and Ethiopia, it has been reported at high frequencies of about 20% in other Ethiopian tribes and in the Beja of Sudan. Table 2 shows possible dates of origin based on frequencies of the combined Arabic and Eritrean alleles. I used a twenty-five-year generation time and a thirty-year generation time.[29] The most uncertain number is the initial frequency, which affects the date of initial introduction into the population considerably. Enattah et al. used 0.001 as the initial frequency based on mutation in a population of 500, and they used a selection coefficient of 0.05.[30] Here the LP alleles are p and r which are dominant so that $1-q=p+r$. For Beja, the combined frequency for G-13915 and G-13907 is about 0.38, indicating that they originated about 3,375 years before present if the generation time was 25 years, or 4,050 years before present if the generation time was 30 years (table 2). The Beja appear to be a strong, independent tribe set off from the Arabs by language, and the Beja were known to the ancient Egyptians from 2000 BC. The Afar have only one data set, but the data are crucial in understanding when the G-13915 allele first arrived in Africa.[31] If G-13915 and G-13907 are combined, they may have originated prior to 2000 BC.

Table 2. Date of origin of combined Arabic (G-13915) and Eritrean (G-13997) lactase persistence (LP) alleles in African tribes based on selection coefficient s of 0.05, initial frequency q of 0.999 (recessive non-LP allele), and generation times of 25 and 30 years. Tribes are listed with the age of the LP allele in years before present (YBP), where frequency q in next generation q' is found by $q'=q-sq^2/1-sq^2$.

Tribe	LP allele %[a]		Date of Origin YBP Generation time	
	Arabic allele G-13915	Eritrean allele G-13907	25 Years	30 Years
Afar	12.2	29.7	3550	4260
Beja	17.9	20.2	3375	4050
Amhara, Tigray	12.5	20.0	3200	3840
Mahas	12.5	1.0	2475	2970
Somali	5.0	5.5	2375	2850
Gaali	16.8	1.9	2750	3300
Shokrya[b]	27.5	2.5	3250	3900

a = average of independent studies when more than one study
b = European allele G-13910 also present as 2.5%

Table 2 can be used to show possible dates when the Eritrean allele (G-13907) entered the Arabic tribes who migrated into the region. The Eritrean allele is not common in Arabic tribes of the region, which have frequencies of less than 5% (table 2). This suggests a different migration pattern for this allele compared to the Arabic allele (G-13915). In fact, this migration pattern difference suggests the relatively recent acquisition of the Eritrean allele by the Arabic tribes of the region. On the other hand, the roughly equivalent level of the Arabic allele in native Horn tribes, compared to that in Arabs, indicates that the Arabic allele was already present in the Horn tribes when Islam arrived. Muslim Arab conquest of the upper Nile was delayed by Christian kingdoms in Ethiopia and maintained by a peace treaty lasting from AD 700 to 1300.[32] Some of these tribes settled as agriculturalists, but they still retained the Arabic allele at about 17%. Others such as the Shokrya remained pastoralists, and the frequency of the Arabic allele continued to increase to about 27.5%. If the Arabic allele arrived with the Arab Muslims, who mixed freely with the natives despite language differences, then why did the level of the Eritrean allele not increase proportionately in the Arabs? The case is then made that minimal mixing occurred between the Beja and the Arabs, with the Arabic allele already present in African pastoralists independently, who gave a small input of the Eritrean allele to the Arabs (fig. 2).

Two scenarios are possible. First, according to Edita Priehodová and colleagues and other researchers, the Arabic allele arrived in the Horn of Africa, probably through the Levant into Egypt and up the Nile River,

only after the Muslim conquest, and it arrived later than in the north because progress up the Nile was blocked by Christian kingdoms from about AD 700 to 1300.[33] For this Islamic conquest proposal, only after about AD 1000, allowing for some interbreeding with Cushitic tribes during the time before AD 1300, would Arabs likely have introduced the G-13915 allele to these tribes, after which it was selected for along with the endemic G-13907 allele. According to this hypothesis (fig. 2), the high frequency of the Beja for the G-13915 allele was then realized along with the previous high frequency of G-13907.

According to the second proposal, the G-13915 allele had already arrived via the Red Sea by Arabic traders bringing camels and contributing an initially small amount to the gene pools of the Red Sea coastal tribes Afar and Saho. The Arabic allele then passed through other Eritrean and Ethiopian tribes to the Beja in Sudan and minimally to the agricultural Mahas. When the Arab tribes arrived after the Muslim conquest of Sudan, interbreeding had little effect on G-13915 frequency in the local tribes that already possessed it. In the meantime, the G-13907 allele passed minimally into the

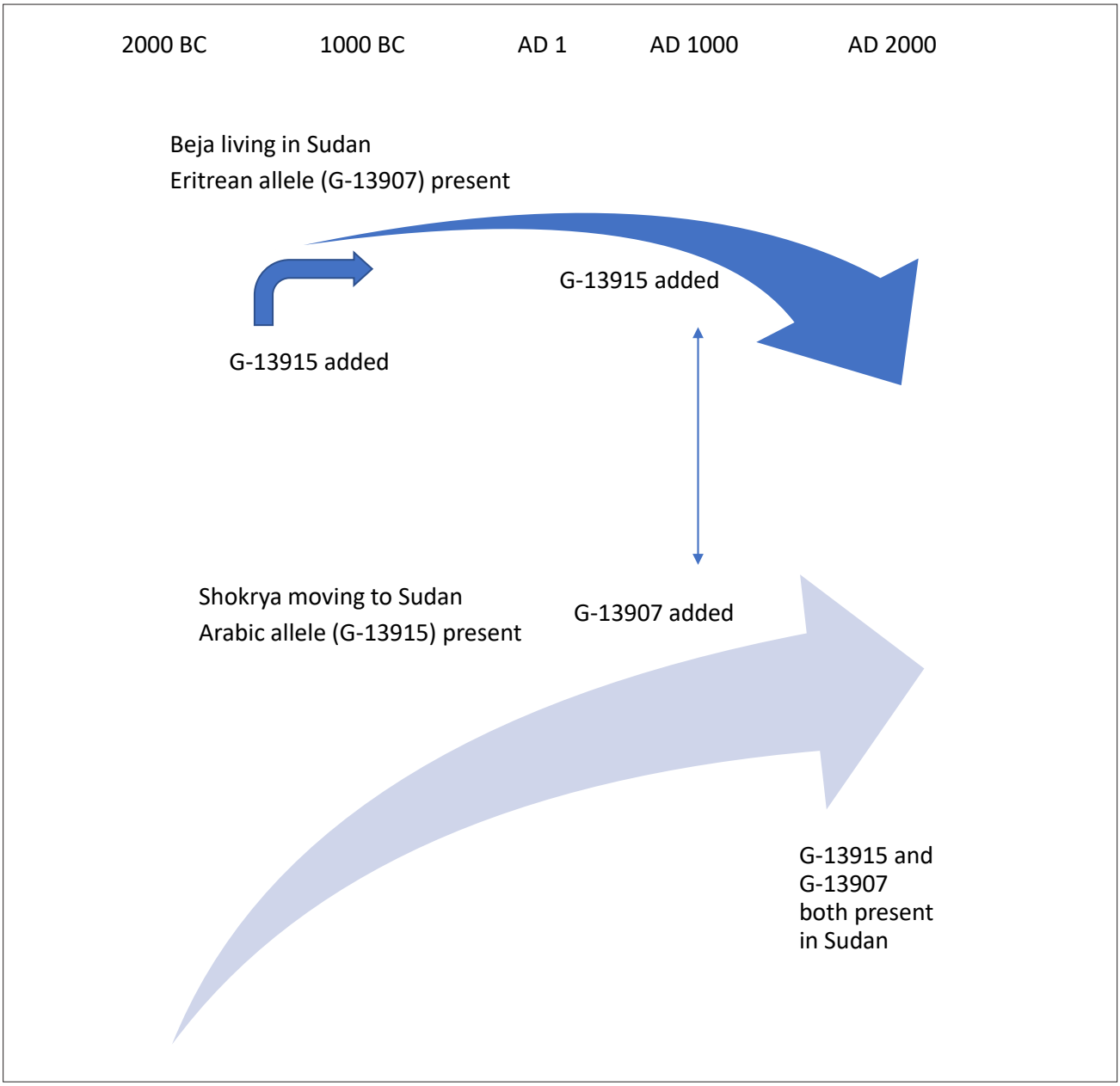


Figure 2. Schematic of Arabic (G-13915) and Eritrean (G-13907) LP allele exchange between Shokrya and Beja tribes in Sudan about AD 1000. Arabic allele must have been added to Beja before AD 1000 as shown on left.

Arabic tribes, including the pastoralist Shokrya and partly pastoralist Gaali. Now we need to look at another line of evidence to choose between these two scenarios.

Y Chromosome Evolution

There are advantages to examining the Y chromosome because it allows tracking of migrating males; mutations are considered random, not directly selected; and ages can be based on estimated mutation rates. Eyoab Gebremeskel and Muntaser Ibrahim examined Y chromosomes in Eritrea and, although they had small sample sizes for some groups, they also summarized data from other researchers.[34] Beniamino Trombetta and colleagues further updated Y chromosome evolution in the Middle East and Northeast Africa (fig. 3).[35] The M123 mutation is important, as one branch (M34, named by mutation), possibly associated with the Arabic allele for lactase persistence (LP), appears to have arisen in Saudi Arabia or Yemen and might have crossed the Red Sea to the Saho (n=11). No LP data are available for the Saho; however, the M34 Y chromosome is also found in the closely related Afar tribe (n=1), which has a high frequency of the Arabic allele. It is to be expected that sailors would be males, and, hence, there would be a one-way flow to the recipient tribe as evidenced by the M34 Y chromosome, at least in the first generations. The nearby Beja (n=22) could have picked up the Arabic allele from the Afar or Saho, although the M34 Y chromosome has not been found in Beja, but any apparent linkage between M34 and G-13915 would be lost because they are not on the same chromosome. After the M123 split, the remaining M123 branch apparently does not associate with G-13915, as the M123 is also found in Italians not known to carry G-13915.

Using genomic sequence differences in Y chromosomes from many African samples to calculate the rho statistic and determine the age of the most recent common ancestor, Trombetta et al. found five African pastoralism-related alleles that originated in newly described clades of the E-V1515 Y group in Africa.[36] The E-V1515 clades split off from sister clades about 12,000 years ago (not shown). Trombetta et al. examined the number of mutations involved in detail. Dates of branch points were estimated from coalescence and rho statistic. These include the E-V1486 subclade associated with LP C-14010 ("Kenyan allele") and the E-V1700 subclade associated with G-13907 ("Eritrean allele"). They worked out details for the newly discovered E-V1515 branch, which they dated to have split into E-V1486 and E-V1700 branches 12,000 years ago. Nine mutations occurred in the E-V1486 branch until, during a span of 8,500 years, it split into three sub-branches about 3,500 years ago. The E-V1700 branch had six mutations

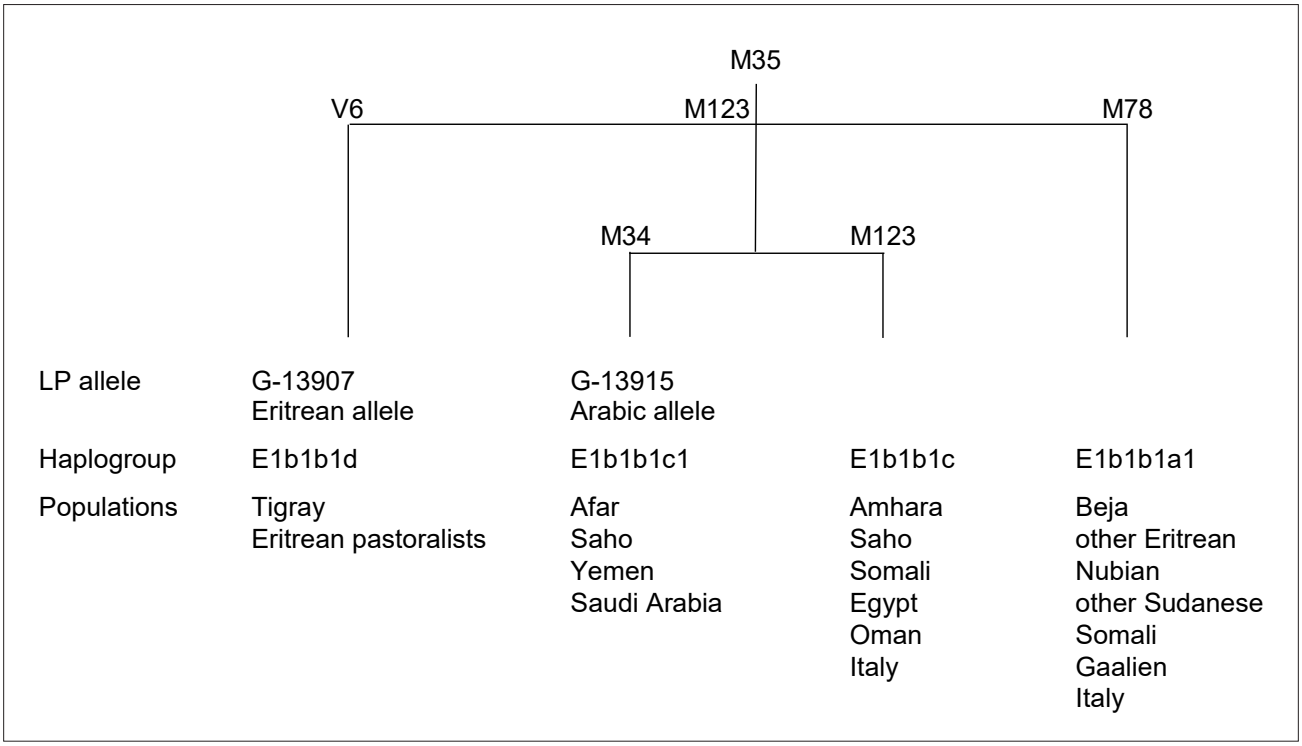


Figure 3. Partial tree of the E-M35 subgroup of haplotype E1b1b of the human Y chromosome. (Redrawn from Gebremeskel and Ibrahim; Trombetta et al.[37]) Haplotypes have standard nomenclature and new branches form at mutations. Two possible lactase persistence (LP) allele associations are shown.

during a span of 7,000 years, before giving rise to the V6 mutation (fig. 3) dated at 5,000 years before present. The V6 branch is also associated with the G-13907 mutation which might have originated at about 4,000 years ago in Eritrea.

Although the researchers did not find the V6 mutation in the Afar and Saho, the G-13907 allele could have originated in an adjacent Eritrean pastoralist tribe and been passed to them unlinked to the V6 mutation. These tribes are highly dependent on camels. Meanwhile, the G-13915 allele might have originated in the Arabian Peninsula at about that time (4,000 years ago). The M34 Y-branch from M123 might have been carried to northeastern Africa, perhaps modern-day Eritrea, by Arabs crossing the Red Sea with camels. The Saho may have interbred with them and then passed both the M34 Y chromosome and the G-13915 allele to the nearby Afar tribe, who are camel herders to this day. The G-13915 allele reached the Beja through interbreeding between adjacent populations, although the M34 Y chromosome did not. The Y mutation and the G-13915 allele would have drifted apart by then, as they are not linked.

Now let us return to the previous discussion of contact between the Arabic Shokrya and the Cushitic Beja in Sudan (fig. 2). Using the AD 1000 date as a good approximate date for when Arabic and Cushitic tribes came into sufficient contact for interbreeding, the Arabic pastoralist tribe Shokrya was set as having the G-13915 allele frequency of 0.10, by tracing back 1,000 years from its current level, and the Beja initial frequency was set lower at 0.012. The frequency of the G-13907 allele for the Beja predicted for AD 1000 was set at 0.05, and set lower for the same time for the Shokrya, with an initial frequency set at 0.006. Using a hypothetical reciprocal exchange, it was estimated that 100 out of 1,000 Beja, averaging six copies of the G-13907 allele, bred initially with Shokrya so that the latter received the G-13907 allele. The number of Shokrya was also set for 100 out of 1,000 initially breeding with Beja, averaging twelve copies of the G-13915 allele received by the Beja.

From this hypothetical initial frequency in AD 1000, the frequency of the Beja for the G-13915 allele in AD 2000 was calculated and found to be much below the actual current frequency. Using the approximate frequency based on the AD 1000 contact date and starting with the G-13915 allele at 0.012, the Beja would require hundreds of years *after* AD 2000 to reach the current level for the allele (0.18). Therefore, the Beja must already have had a high level of G-13915 when the tribes came into contact. In this example, it was assumed that the Beja had limited contact with Shokrya at AD 1000; otherwise, the Shokrya would be expected to have a much higher level of G-13907 than it now has, if interbreeding with Beja had been more frequent.

There are many uncertainties in this dating method and, to be sure, other reciprocal exchanges are possible, but they will be limited by this constraint in G-13907 frequency. However, nonreciprocal gene flow is possible and must be considered. If the mating had been directional with Arab males carrying G-13915 to Beja, while Beja females did not carry G-13907 to Arabs, then Beja males resulting from Arab fathers would be expected to carry a specific Arabic Y chromosome in substantial numbers. Instead of an Arab-specific Y chromosome, most Beja (fig. 3) share a very widespread Y chromosome (M78) with populations in Africa, west Asia, and Europe who are not associated with G-13915.

Conclusions

Both the genetics of camels and the genetics of camel herders show that East Africa is distinct from North Africa. The camels of East Africa are of the milking variety which is presumed to indicate the original use of the camel that developed on the Arabian Peninsula. Even camels in northern Egypt show some similarity to the East African camels; it was only later that the caravans from the peninsula arrived through the Levant and traveled west across the Sahara.

The camel herders show a similar distribution. The Arabic lactase-persistence (LP) allele (G-13915) arrived on the Red Sea coast from Arabic tribes bringing camels, continued on to pastoralist tribes in what is now Eritrea, perhaps arriving among the Afar or Saho first, coming next to tribes that live along the coast, eventually reaching inland to the Beja and north into Sudan, and then into the Nile Valley, probably traveling through a wadi in northeastern Sudan to the Nubian Mahas. These non-Arabic tribes have the Arabic allele in higher frequency than many of their Arabic neighbors who did not enter Sudan until after AD 1000, thus discounting the need for the Arabic allele traveling by caravans, crossing through the Sinai into Egypt, and then up the Nile Valley. In this same time range, the G-13907 allele appeared in Eritrean pastoralists and was passed into the Tigray and the Afar and Saho, who in turn passed it to the Beja and eventually to the Nubian Mahas and the Arabic Gaali and Shokrya. Cultural evidence for camels in this time period includes rock drawings near Laga Oda in Ethiopia, showing camels on a wall with drawings similar to C-group Nubian drawings.[38] The C-group culture is dated from 2400 to 1550 BC.

Although none of these possible dates for arrival of camels in Africa may be sufficient by themselves,

cumulatively, they point consistently to a date between 3,500 and 4,000 years ago. If pastoralism swept from northeast to southwest as seems likely, it originated in Asia Minor perhaps 8,000 years ago, about the time that dairy culture began with cattle. The arid Red Sea region was not suitable for cattle, but the Arabs may have utilized camels starting at least 4,000 years ago and introduced them to the Afar and Beja. They could have introduced camels to the arid south Red Sea coast of Africa between 3,500 and 4,000 years ago. They may also have contributed to the local gene pool, including both the G-13915 allele and the Y chromosome with the M34 mutation currently found in Yemen, Saudi Arabia, and Eritrean Afar and Saho. Coincidently, the G-13907 allele, being useful when camels arrived and associated with branch V6 of the E-V1700 Y chromosome in the Afar or other Eritreans, may have originated at the same time. Furthermore, based on current combined frequencies of LP alleles G-13915 and G-13907 in African populations, the alleles originated between 3,500 and 4,300 years ago.

About 2000 BC, Egypt had just emerged from the First Intermediate Period of internal strife and weakness toward Nubia and built the Middle Kingdom, which was a period of strength, both internally and externally. Abraham would have encountered a Pharaoh fully in charge and fresh from victories over Nubia and sitting astride the ancient pathway out of Africa into Asia. Abraham trod the path that was used back and forth between great civilizations.

Since the Egyptians received their meat, milk, and transportation needs from cattle, goats, sheep, and donkeys, camels would have been a mere curiosity to Pharaoh—perhaps received as tribute from the conquered Nubians or from a trade for exotic animals. Even if there was no extensive caravan trade between the southern Red Sea and Egypt, Nubians might have occasionally received camels from the Beja, their neighbors along the desert coast on the Red Sea. The Beja might have immediately utilized camels as a source of milk, just as the Arabs who brought them to their coast did. The Egyptians could have received camels directly from the Beja, who were known to them as early as the twelfth dynasty about 2000 BC. Egypt was in a period of Imperial equilibrium toward Nubia at the time, wherein Egypt interacted through trade with the native C group, including trading for exotic animals, but Egypt did not settle or form an integrated system of state control.[39] Abraham from Mesopotamia may have already been familiar with two-humped camels used as pack animals, in that camel rations are recorded by carvings on a Mesopotamian cylinder dated from 3800 YBP, and he may have gladly received similar one-humped camels as a gift from Pharaoh.[40]

The biblical uses of camels during the Patriarchal period included transporting light loads (gifts for Rebekah's family, and later for Rebekah and Rachel to ride on). Camels may not have been common in Nubia, and certainly not in Egypt, but warfare in Nubia previous to Abraham's arrival in Egypt could have netted Pharaoh tribute—including camels. It would have been natural for him to re-gift these to Abraham as tribute in order to find favor in pursuit of Sarah for a wife. ●

Notes

[1]Elizabeth Dias, "The Mystery of the Bible's Phantom Camels," February 11, 2014, https://time.com/6662/the-mystery-of-the-bibles-phantom-camels/.

[2]Lidar Sapir-Hen and Erez Ben-Yosef, "The Introduction of Domestic Camels to the Southern Levant: Evidence from the Aravah Valley," *Tel Aviv* 40 (2013): 277–85, https://doi.org/10.1179/033443513X13753505864089.

[3]William Foxwell Albright, "Abram the Hebrew: A New Archaeological Interpretation," *Bulletin of the American Schools of Oriental Research* 163 (October 1961): 36–54, https://doi.org/10.2307/1355773.

[4]E. Christina Köhler, Elizabeth Hart, and Michael Klaunzer, "Wadi el-Sheikh: A New Archaeological Investigation of Ancient Egyptian Chert Mines," *PLOS ONE* 12, no. 2 (2017): e0170840, https://doi.org/10.1371/journal.pone.0170840.

[5]Michael Ripinsky, "The Camel in Dynastic Egypt," *The Journal of Egyptian Archaeology* 71, no. 1 (1985): 134–41, https://www.jstor.org/stable/3821718.

[6]Richard Bulliet, *The Camel and the Wheel* (New York: Columbia University Press, 1990).

[7]In this article, I am referring to dromedaries or one-humped camels unless I say otherwise.

[8]Ruth Amiran et al., *Early Arad: The Chalcolithic Settlement and Early Bronze City. Vol. 1, First–Fifth Seasons of Excavations, 1962–1966* (Jerusalem, Israel: Israeli Exploration Society, 1978).

[9]R. E. M. Hedges et al., "Radiocarbon Dates from the Oxford AMS System: Archaeometry Datelist 6," *Archaeometry* 29, no. 2 (1987): 289–306, https://onlinelibrary.wiley.com/doi/pdf/10.1111/j.1475-4754.1987.tb00421.x.

[10]Bulliet, *The Camel and the Wheel.*

[11]Faisal Almathen et al., "Ancient and Modern DNA Reveal Dynamics of Domestication and Cross-Continental Dispersal of the Dromedary," *Proceedings of the National Academy of Sciences* 113, no. 24 (2016): 6707–12, https://doi.org/10.1073/pnas.1519508113.

[12]Youcef Amine Cherifi et al., "Weak Genetic Structure in Northern African Dromedary Camels Reflects Their Unique Evolutionary History," *PLoS ONE* 12, no. 1 (2017): e0168672, https://doi.org/10.1371/journal.pone.0168672.

[13]H. Epstein, *The Origin of the Domestic Animals of Africa,* vol. 2 (New York: Africana Publishing, 1971).

[14]Ahmed M. Ould et al., "Genetic Diversity in Tunisian Dromedary (*Camelus dromedarius*) Populations Using Microsatellite Markers," *Livestock Science* 132, 1–3 (2010): 182–85, https://doi.org/10.1016/j.livsci.2010.05.016.

[15]Bulliet, *The Camel and the Wheel,* 41.

[16]Gudrun Dahl, "The Beja of Sudan and the Famine of 1984–1986," *Ambio* 20, no. 5 (1991): 189–91, https://www.jstor.org/stable/4313820.
[17]Nabil Sabri Enattah et al., "Independent Introduction of Two Lactase-Persistence Alleles into Human Populations Reflects Different History of Adaptation to Milk Culture," *The American Journal of Human Genetics* 82, no. 1 (2008): 57–72, https://doi.org/10.1016/j.ajhg.2007.09.012.
[18]Catherine J. E. Ingram et al., "Multiple Rare Variants as a Cause of a Common Phenotype: Several Different Lactase Persistence Associated Alleles in a Single Ethnic Group," *Journal of Molecular Evolution* 69, no. 6 (2009): 579–88, https://doi.org/10.1007/s00239-009-9301-y.
[19]Hisham Y. Hassan et al., "Genetic Diversity of Lactase Persistence in East African Populations," *Biomed Central Research Notes* 9 (2016): article no. 8, https://doi.org/10.1186/s13104-015-1833-1; Alessia Ranciaro et al., "Genetic Origins of Lactase Persistence and the Spread of Pastoralism in Africa," *The American Journal of Human Genetics* 94, no. 4 (2014): 496–510, https://doi.org/10.1016/j.ajhg.2014.02.009; and Sarah A. Tishkoff et al., "Convergent Adaptation of Human Lactase Persistence in Africa and Europe," *Nature Genetics* 39, no. 1 (2007): 31–40, https://doi.org/10.1038/ng1946.
[20]Hassan et al., "Genetic Diversity of Lactase Persistence in East African Populations," article no. 8.
[21]Ibid.
[22]Ingram et al., "Multiple Rare Variants as a Cause of a Common Phenotype," 579–88.
[23]Enattah et al., "Independent Introduction of Two Lactase-Persistence Alleles into Human Populations," 57–72; Hassan et al., "Genetic Diversity of Lactase Persistence in East African Populations," article no. 8; and Ingram et al., "Multiple Rare Variants as a Cause of a Common Phenotype," 579–88.
[24]Hassan et al., "Genetic Diversity of Lactase Persistence in East African Populations," article no. 8.
[25]Bulliet, *The Camel and the Wheel*.
[26]"The LCT gene provides instructions for making an enzyme called lactase. This enzyme helps to digest lactose, a sugar found in milk and other dairy products." MedlinePlus: Trusted Health Information for You, updated August 18, 2020, https://medlineplus.gov/genetics/gene/lct/.
[27]Enattah et al., "Independent Introduction of Two Lactase-Persistence Alleles into Human Populations," 57–72.
[28]Ingram et al., "Multiple Rare Variants as a Cause of a Common Phenotype," 579–88.
[29]Juan Sanchez et al., "High Frequencies of Y Chromosome Lineages Characterized by E3b1, DYS19-11, DYS392-12 in Somali Males," *European Journal of Human Genetics* 13 (2005): 856–66, https://doi.org/10.1038/sj.ejhg.5201390; and Jason A. Hodgson et al., "Early Back-to-Africa Migration into the Horn of Africa," *PLOS Genetics* 10, no. 6 (2014): 1–18, https://doi.org/10.1371/journal.pgen.1004393.
[30]Enattah et al., "Independent Introduction of Two Lactase-Persistence Alleles into Human Populations," 57–72.
[31]Ingram et al., "Multiple Rare Variants as a Cause of a Common Phenotype," 579–88.
[32]Ahmad Alawad Sikainga et al., s.v. "Sudan," *Encyclopaedia Britannica* (January 29, 2020), www.britannica.com/place/sudan.
[33]Edita Priehodová et al., "Lactase Persistence Variants in Arabia and in the African Arabs," *Human Biology* 86, no. 1 (2014): 7–18, https://doi.org/10.13110/humanbiology.86.1.0007; Ingram et al., "Multiple Rare Variants as a Cause of a Common Phenotype," 579–88; Hassan et al., "Genetic Diversity of Lactase Persistence in East African Populations," article no. 8; Ranciaro et al., "Genetic Origins of Lactase Persistence and the Spread of Pastoralism in Africa"; and Tishkoff et al., "Convergent Adaptation of Human Lactase Persistence in Africa and Europe," 31–40.
[34]Eyoab I. Gebremeskel and Muntaser E. Ibrahim, "Y-Chromosome E Haplogroups: Their Distribution and Implication to the Origin of Afro-Asiatic Languages and Pastoralism," *European Journal of Human Genetics* 22 (2014): 1387–92, https://doi.org/10.1038/ejhg.2014.41.
[35]Beniamino Trombetta et al., "Phylogeographic Refinement and Large Scale Genotyping of Human Y Chromosome Haplogroup E Provide New Insights into the Dispersal of Early Pastoralists in the African Continent," *Genome Biology and Evolution* 7, no. 7 (2015): 1940–50, https://doi.org/10.1093/gbe/ew118.
[36]Ibid.
[37]Gebremeskel and Ibrahim, "Y-Chromosome E Haplogroups," 1387–92; Trombetta et al., "Phylogeographic Refinement and Large Scale Genotyping," 1940–50.
[38]Pavel Cervicek, "Rock Paintings of Laga Oda (Ethiopia)," *Paideuma: Mitteilungen zur Kulturkunde* 17 (1971): 121–36, https://www.jstor.org/stable/40341510.
[39]Stuart Tyson Smith, "Nubia and Egypt: Interaction, Acculturation, and Secondary State Formation from the Third to First Millennium BC," chap. 12 in *Studies in Culture Contact: Interaction, Culture Change, and Archaeology,* ed. James Cusick (Carbondale, IL: Board of Trustees, Southern Illinois University, 1998).
[40]Mark W. Chavalas, "Did Abraham Ride a Camel?," *Biblical Archaeology Review* 44, no. 6 (November/December 2018): 52, 64–65, https://www.baslibrary.org/biblical-archaeology-review/44/6/11. Chavalas thought that Abraham brought two-humped camels with him from Mesopotamia, but Genesis 12 is clear that Abraham received camels from Pharaoh as a gift to gain Sarah as a wife.

Erin I. Smith

Article

The Role of Psychology in Advancing Dialogue between Science and Christianity

Erin I. Smith

Those interested in the intersection of science and Christianity, rightfully pay attention to specific issues in the landscape of science and religion. Despite progress made in science-religion scholarship, asking and answering thorny questions and unearthing new ones, it sometimes appears that these advances make little progress shifting the narrative in individuals or culture. In this article, I argue that for progress in difficult conversations, such as those between science and Christianity, we must acknowledge and account for the psychology of the individuals engaging in these conversations. This article discusses how normal psychological processes involved in reasoning may influence engagement with science-religion material. I conclude by offering several suggestions to increase the fruitfulness of these conversations.

A review of recent articles published in *Perspectives on Science and Christian Faith* indicates topics including cosmology, artificial intelligence, origins, mathematics, and addiction. Psychology is rightly represented in this list, as research in psychological science has implications for, and can be informed by, Christianity.[1] This article, rather than engaging a specific piece of scientific content with theology, seeks to ask a more fundamental question: *what can psychology contribute to how ongoing conversations in science and religion unfold?*

The need to bring together experts in diverse areas is evident and, as the study of people's thinking and behaving, psychology has much to contribute to understanding how to do that well.[2] One of the goals of science-religion conversations across disciplines is to better understand and evaluate evidence, with the hope that subsequent scientific and theological beliefs will better align with reality. The implication is that, with the engagement of evidence, some people will need to revise and change some of their beliefs.

Erin I. Smith *(PhD, University of California Riverside) is an associate professor of psychology at California Baptist University. Trained as a cognitive developmental psychologist, her research focuses on Christian engagement in science, religious and scientific cognition, and effective practices in children's church ministries.*

Research in psychology—examining how people develop, maintain, and change their beliefs and attitudes—converges on the conclusion that humans are not objective or neutral processers of information.[3] Data, as it were, are not self-evident, and beliefs are not so easily changed. There are many influences on how people engage with information, especially when this information is inconsistent with current beliefs. The goal of this article is to provide a brief review of the research highlighting several influences on human reasoning in order to provide empirically supported suggestions for how to better navigate the difficult conversations at the intersection of science and religious faith. If these conversations intend to move the participants closer to the truth, then understanding how people process information that challenges their beliefs is crucial. Furthermore, if conversations in science and Christianity are successful in shifting beliefs to be more consistent with reality, then they will have the potential to be important both academically and in transforming cultural narratives and people's daily lives.

Human Reasoning

Reasoning refers to the process by which humans consider available information, putting various bits of experience,

perspectives, and data into proper relation. Engaging with information—including information emerging from science, theology, and religious tradition—involves reasoning. Fundamentally, for many religious believers, disagreements about contentious issues emerging from science are disagreements about the reasoning process prior to the conclusion.[4] These disagreements are complicated by aspects of the human reasoning system, including the difficulty with which we process large amounts of information and the fact that accuracy is only one of many competing goals of reasoning.

Keith Stanovich and Richard West introduced a two-system metaphor for understanding human reasoning, a metaphor subsequently adopted by Nobel Laureate Daniel Kahneman and his longtime collaborator Amos Tversky.[5] Each of these systems represents a different way of engaging information, with engagement patterns influencing the quality of the subsequent reasoning outcome. System 1 represents reasoning based on intuition, emotions, or gut feelings. This system is quick, efficient, automatic, and, as a result, prone to errors. By contrast, System 2 processes information explicitly, rationally, and according to an analysis of the data. As a result, System 2 is difficult, time consuming, and relatively slow; however, it is also more likely to lead to a more rational, thoughtful, and logical conclusion, given the available data. Although these systems are discussed often, sometimes by alternative names such as emotional / rational systems, it is important to keep in mind that the two-system idea is a useful *metaphor;* the actual functioning of human cognition, rooted in multiple competing neurological processes, is much more complex.[6]

Given the sheer quantity of information impinging on our sensory systems at any given moment, we are prone to use System 1-based heuristics for much of our daily reasoning. In many circumstances, these mental shortcuts offer a quick and reliable means to navigate the complicated—and potentially incomplete—information in front of us.[7] However, the tradeoff for the speed and efficiency offered by System 1 is decreased accuracy, as evidenced in cognitive biases.[8] Cognitive biases are systematic errors that arise from the inappropriate use of System 1 (i.e., "this feels right") when System 2 processes (i.e., "let's evaluate the data systematically") would have resulted in an answer that is a better, or more probable, reflection of reality. For example, although the fat content of yogurt labeled 95% fat free is the same as yogurt labeled 5% fat, people overwhelmingly prefer the former; the same information packaged differently influences subsequent evaluation and choice.[9]

Yet, another piece in the puzzle of human reasoning is that accuracy is only one of several possible goals. Although explicitly stated goals of reasoning may focus on the production of accurate conclusions, a large body of research on motivated reasoning indicates that another potent goal is to arrive at a desired conclusion.[10] This goal is not explicit—that is, people do not indicate at the outset that they will examine, engage with, and remember information in such a way that they can retain their beliefs, regardless of what the information may reveal. Rather, we unconsciously adopt different strategies for the process of information evaluation—strategies that allow us to maintain, or even strengthen, our preexisting beliefs regardless of the evidence.[11] We are largely unaware of these unconscious influences on our current reasoning.[12]

Motivated reasoning produces outcomes in a desired direction and can influence any stage of the reasoning process. For example, it can be seen in the evidence search process that we are more likely to seek out and remember information that is consistent with our preexisting beliefs.[13] It can be seen in our asymmetrical use of analytical reasoning, such that we are more sensitive to deficiencies in evidence that contradict our beliefs than evidence that supports them.[14] Motivated reasoning can also be seen in how beliefs shift relative to how the evidence is framed; when under threat from conflicting evidence, individuals are more likely to stress aspects of their beliefs that are unfalsifiable with empirical evidence.[15] Moreover, even if we accurately identify and articulate data that conflict with our current beliefs, when these data imply a solution at odds with our values, we engage in other means to reduce the need to change beliefs.[16] These aspects of human reasoning are not new, but they are exacerbated in a cultural climate of echo chambers.[17] Increasingly, evidence suggests that we are likely to affiliate—and read, comment, and share online—with people and information that we already agree with, even if that information is inaccurate.[18]

At first blush, this seems like an entirely irrational goal: maintaining beliefs in the face of evidence to the contrary. However, as Dan Kahan points out, the purpose of some beliefs—especially those that are relevant to our identity—is not *just* to form accurate perceptions about the world.[19] In fact, some beliefs that we hold are central to the maintenance of our sense of self and our deeply held connections to important social groups, connections that often start in early childhood.[20] From this vantage, interpreting information through a lens of what is already believed and shared as true, even when it results in the often unconscious misinterpretation of the information at hand, is rational, in that it maintains

stability of self and self-in-social group (more discussion later).

An important point from this discussion is that data—new information, especially information that may challenge a currently held belief or attitude—are not self-evident.[21] All data processed through a human reasoning system are subject to filters, filters such as current beliefs, previous experiences, and cultural worldviews. These filters pre-date the new information to be processed and act on the new information in an automatic, unconscious fashion, serving as the unconscious motivational factors that bias how we engage with information.[22] Although these filters reduce the cognitive burden associated with information assimilation, they are also the fuel of motivated reasoning. The research on these filters tends to focus on the rejection of science in the United States, yet the general principles elucidated by this research on motivated reasoning apply across domains, including science acceptance, religious faith, and the relationship between science and Christian faith.

Importantly, there is considerable evidence to suggest that these filters—and the information distortion they predict as a function of motivation to maintain beliefs—are not explained by intellectual capacity. For example, Kahan has demonstrated that individuals scoring the highest on measures of analytical thinking (versus heuristic, System 1-driven processing) were the *most* likely to display motivated reasoning, misrepresenting key factual information in order to maintain consistency of the implications of the data with current beliefs.[23] In other research, Kahan and colleagues found that participants who scored highest in measures of numeracy, the ability to reason with empirical data, were better able than less-numerate individuals to reason about the outcome of a medication in the treatment of a skin rash by evaluating numerical outcomes.[24] However, when the exact same numerical evaluation test was nested in a politically polarizing context (i.e., gun control), high numeracy individuals were the *most* likely to misinterpret the data when they were presented as inconsistent with participants' own beliefs. In other words, when the data were at odds with individual beliefs about an important topic—when there was more to lose with a numerically accurate interpretation of the data—the data were much more likely to be misinterpreted by those who were best able to interpret the data. Prior beliefs about gun control (for or against), just as other prior beliefs, are powerful filters shaping human reasoning, even in clear-cut circumstances involving direct numerical evaluation.[25] Note the similarity here to the claim that some researchers make—that religious individuals are religious or antiscience because of their cognitive deficiencies—and the considerable research that debunks or nuances that claim.[26] Surely, the range of intellectual abilities among the religious and nonreligious are variable; yet they are not systematically varied according to religious belief.

Taken together, the two-system model of human reasoning and the role of unconscious motivational influences on the outcome of reasoning suggest that the formation, maintenance, and revision of beliefs are not typically the result of rationality. New information funnels through System 1 filters unconsciously, making the effects of these filters on our thinking difficult to spot, yet powerful nonetheless. Better understanding of these filters opens the possibility of intentionally promoting more-accurate reasoning about data. As mentioned, much of the work on motivated reasoning has been focused on the general public's acceptance of science (e.g., climate change, vaccine safety) in the context of polarizing *political* ideologies, yet the role of religion in scientific engagement is not lost in this discussion.[27] In discussions on the intersection of science and religious belief, these are particularly important questions to understand as public presentations often serve to polarize rather than to bridge.

As there is considerable variation on views of the Bible and science, even within denominations, we would expect these disagreements among Christians to be subject to these same cognitive biases and filters.[28] However, for Christians who claim to hold ultimate truth about reality, the importance of integrity of belief to evidence (i.e., accuracy in reasoning) is paramount for the sake of trustworthiness to others. Accuracy in reasoning should be a top priority for Christians, even when that requires belief revision. Thus, better understanding and limiting the negative impact of filters that may bias our reasoning are especially important for the Christian. With this in mind, I offer a brief discussion below of some of the specific filters beyond a System 1 / System 2 divide that affect human reasoning. Following, I turn to a discussion of the implications of these filters for enhancing more accurate and better-tempered engagement with potentially contentious topics in science and religion.

Filters in Human Reasoning

Research in motivated reasoning indicates that there are a number of filters affecting the outcome of human reasoning. Researchers employ different terms and theories to define and explore these filters, although the finer points of differentiation are beyond the scope of this review. Instead, the goal in the following paragraphs is to highlight three filters that may promote the interpretation of information that conflicts with current

beliefs in a biased (i.e., inaccurate) fashion: (1) cultural worldview, (2) implicit bias, and (3) shared reality.

Cultural Worldview. Research in psychology has demonstrated that culture permeates all aspects of human functioning, even the most seemingly biological functions.[29] That culture—a set of ideals, beliefs, and practices passed down from one generation to another—would also mediate how we perceive and interpret information is unsurprising.[30] Human thinking and behavior are not independent of cultural context; therefore, understanding any aspect of human functioning and activity requires understanding the culture in which that human is embedded.[31]

Consistent with understanding the role of culture in human psychology, the scholars involved in the Cultural Cognition Project seek to better understand how cultural worldview and values shape the way in which individuals perceive and interact with information around potential public risk, especially those that are polarized in the American context.[32] This project has indicated that differences in cultural values more powerfully predict beliefs about these topics than any other individual characteristic.[33] Although views on these topics appear divided along political affiliation, this research suggests that cultural worldviews concerning values related to hierarchy and individualism are more predictive than political affiliation alone.

Specifically, these core cultural values can be understood as existing along two orthogonal dimensions: hierarchy-egalitarian and individualist-communitarian.[34] Someone who endorses a hierarchical worldview endorses the belief that society functions best when social characteristics such as gender, wealth, or background are used to define proper roles and activities. On the other hand, an egalitarian worldview is consistent with the view that these characteristics should not be considered in the distribution of roles and activities within a society. An individualist, who could be either more hierarchy or more egalitarian leaning, gives priority to individual freedoms, action, and responsibility. Conversely, a communitarian believes that societal concerns take precedence over individual concerns and that a society is responsible for the overall well being of its members. When scientific information (i.e., data and evidence) is presented in a way that is consistent with worldview beliefs, it is readily accepted (e.g., endorsing freedom for an individualist); when the information is presented as inconsistent with these beliefs (e.g., endorsing limits of freedom for an individualist), it is more likely to be rejected or misrepresented. Although these worldviews are not all-or-nothing, patterns of worldview endorsement are powerfully predictive in understanding the formation of beliefs about scientific evidence. Cultural worldview, then, motivates reasoning.

One important implication for this work in thinking about issues of science and the Christian faith is that although Christians are unified as one body in Christ, we are also divided along many differences in theology and praxis.[35] Even within denominations, in which theology and praxis is more or less shared, there is variation in specific beliefs about how to read the Bible in light of science and what science means, if anything, for Christian faith.[36] These differences, even just within a Western context, may relate to meaningful differences in cultural worldviews—those described by Kahan and those yet unmeasured. Differences in the global body of Christ are likely even more marked.

Implicit Bias. Implicit bias refers to an unconscious affinity toward or disliking of something or someone as a function of its category membership. Organizing individuals into groups, the process of social categorization, is a foundational principle in human cognition and behavior as humans are fundamentally social beings.[37] Although for many years psychological research has focused on explicit attitudes, especially attitudes regarding social groups, these reports often fall short of predicting behavior toward members of shared/unshared social categories.[38]

To add explanatory power to the prediction of behavior, researchers have turned to implicit cognition in which "past experience influences judgment in a fashion not introspectively known by the actor."[39] These past experiences influence attitudes and stereotypes, both of which guide thinking and future behavior. In the past twenty years, research measuring these unconscious influences, using indirect or implicit measures, has exploded, answering many questions and igniting just as many.[40] For example, experimental research found that individuals who expressed negative attitudes toward African Americans on a measure of implicit bias were rated by independent observers as engaging in more negative social interactions with individual African Americans than those who did not express these negative implicit attitudes.[41]

By definition, individuals are unaware of the influence of these biases on their behavior, making them notoriously difficult to isolate outside of large sample sizes and group-level interpretation. As such, many researchers think about implicit bias as assisting in understanding the cultural context from which that bias is evident; that is, implicit bias is a form of "unsought cultural expertise."[42] From this perspective, it may be

easier—and more appropriate—to look at the results of implicit bias measures as indicative of the *context* in which those results emerge, rather than as a measure of individual bias or prejudice. For example, there is evidence suggesting that the implicit bias of White community members toward African Americans is strongly predictive of deviations within that community from base rates of police use of lethal force against African Americans.[43] This does not suggest that the individual police officers are racist, but rather that their behavior is informed in important—even if unobservable—ways by the community context in which they work. Thus, implicit bias, though existing and measured at the level of the individual, is primarily a measure of the effect of culture on an individual.

Although the bulk of research on implicit bias deals with categorization according to externally observable characteristics (e.g., race, gender, age, weight), this work is relevant to discussions about science and religion. There is a growing body of research indicating the presence of three related cultural views: (1) that atheism is associated with increased intelligence, (2) that science decreases belief in God by increasing analytic thinking, and (3) that Christians are antiscience or unintelligent.[44] Even if these are not the views of most religious believers or scientists, the prevalence of these conflict narratives in popular media has the psychological effect of making them appear more supported than they are.[45] These stereotypes about Christian (un)intelligence and nonbelievers' scientific acumen negatively influence Christian engagement in science.[46] Furthermore, there is some evidence suggesting that science is perceived as a discipline for atheists.[47] This evidence persists amid a host of research documenting pervasive and negative stereotypes toward atheists.[48] For Christians embedded in this cultural context, the perception of Christians as antiscience and unintelligent or the perceived association between science and atheism undoubtedly informs implicit, culturally driven attitudes via the same mechanisms as those documented in other implicit bias research. Even for an individual who rejects these negative perceptions about Christians and science (explicit beliefs), the impact of these culturally endorsed attitudes on implicit bias and behavior may still be powerful.

Figure 1 displays a theoretical cycle that can emerge as a function of cultural narratives and their influence on implicit cognition. I do not intend to make claims about the origin of this cycle (boxes are numbered for clarity only), but there is evidence suggesting the

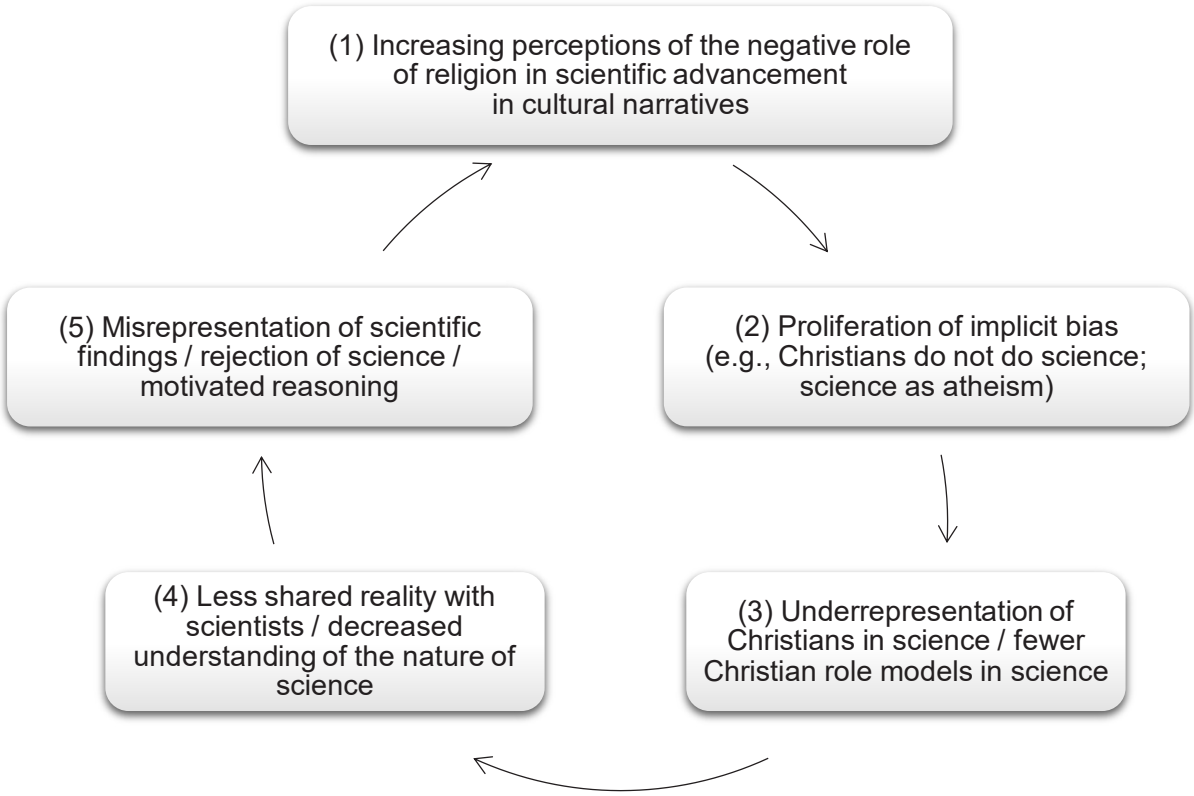


Figure 1. Theoretical cycle of cultural narratives and implicit bias around Christianity and science.

interrelationship of these various components. When, for example, there is cultural endorsement of negative stereotypes about Christians as antiscience and/or religion as detrimental to scientific progress (1), these cultural beliefs negatively affect science performance via implicit, unconscious cognition among Christians (2), which subsequently may explain the lower-than-expected representation of Christians in science.[49] Having fewer Christians in science means there are, overall, fewer role models for Christians who may otherwise pursue science. Although there are notable exceptions to this (e.g., Francis Collins, Jennifer Wiseman), research suggests that having role models with whom we can identify is central to overcoming potential stereotypes about who scientists are (3).[50] Having less access to trusted members of a religious community who can address potentially contentious scientific findings—and with whom shared reality can operate—can negatively influence learning about and engaging with science (content and foundations; see next section) (4). This makes science-religion issues not just "potentially contentious" but threatening; this result promotes misrepresenting or rejecting specific scientific findings via motivated cognition (5).[51]

This theoretical model does not suggest that implicit bias alone is sufficient to explain how members of a religious community engage with science. For example, the influences of cultural worldview on reasoning, as discussed in the previous section, are involved in the process of motivated reasoning (5). Although cultural worldview is not the same as political affiliation, political affiliation is often perceived as a shorthand for these cultural worldviews; especially in tumultuous, ideologically threatening political environments, religious beliefs are more strongly tied to political ideology.[52] Regardless of whether these views are objectively correct, the research discussed here indicates that these *perceptions* about the relationship between religious belief, political affiliation, and cultural worldview matter. One consequence of these perceptions is that they may reinforce the negative perception of religion relative to science (1), suggesting one possible role for cultural worldview in this cycle.

What this model does make clear is that implicit attitudes toward science generally, as well as the relationship between religious believers and science specifically, are an important filter provided by the broader culture that individuals use in their evaluation of information. In the context of scientific information that may conflict or challenge religious beliefs or vice versa, this filter may increase the presence of motivated reasoning.

Shared reality. Where implicit bias may serve as a measure of cultural imprinting on an individual, the broader cultural milieu exerts its influence in specific relational contexts. That is, the potential threat to religious beliefs implicitly posed by cultural perceptions about the relationship between Christians and science may be exacerbated or assuaged by important relationships. For example, Michael Magee and Curtis Hardin found that the unconscious threat posed to religious beliefs by evolution was negated when individuals believed that key individuals with whom they had a supportive, loving relationship—such as their parents—shared their religious beliefs.[53] This is in line with shared reality theory, which suggests that our subjective experiences become real, or objective, when they are shared with others.[54] Importantly, shared reality is more than just a mutual understanding; it is not enough to simply know what others know or believe. Shared reality is the joint experience and acceptance of that information for the purposes of regulating future social interaction. There is considerable evidence suggesting that when reality is shared, it regulates not only social interactions but also the self, especially concerning fundamental questions about individual meaning and purpose.[55] Our sense of who we are is deeply connected to the important and trusted social interactions that verify this sense of self.[56]

The role of looking to important social relationships as a verification of self, starts early in development. Children's sense of self is deeply connected to their sense of attachment with caregivers; children internalize the pattern of interactions with caregivers into implicit templates for understanding themselves, others, and the relationship between the two.[57] The role of shared reality—making the subjective real—continues to be important as children rely on the testimony of others for important information about the world that they cannot easily verify firsthand.[58] Across key relationships in a child's life, there is unity in these messages: for example, a unity that turns an otherwise singular statement about unobservable "germs" into a shared reality of fact. Although preschool-aged children have likely never seen a germ with their own eyes, they ubiquitously endorse their existence. Because the existence of germs is a belief shared with others, germs become real in children's minds.[59]

Notably, we do not receive the same messages about all things. Although there may be considerable consistency concerning the existence of germs, people receive different patterns of communication about the existence of Santa Claus, angels, and God, for example. These differences can divide social relationships and cultural contexts along important lines. Both psychology and scriptures recognize the fundamental importance

of social relationships to human functioning,[60] and for many families and communities, belief in God is a factor regulating the closeness of interpersonal relationships. What, then, is a rational response when an individual encounters information that conflicts, or appears to conflict, with beliefs that form the core of their identity and are shared in these important social relationships? Although the distortion of evidence via motivated reasoning may not be rational in one sense, to the extent that it promotes the maintenance of identity-in-relationship, this form of identity-protective cognition is highly rational in an important psychological sense.[61] If sharing beliefs is core to the perception of reality, including our sense of who we are, then the role of identity-protective cognition as a form of motivated cognition becomes clear. That is, shared reality serves as a filter for what kinds of information can be easily integrated as-is and what needs to undergo a protective, directionally motivated reasoning process so as not to threaten our sense of self and our self-in-relationship.

Summary. Human reasoning is constrained by the need to process large amounts of inconsistently complete information. Despite the computational complexity of the reasoning tasks humans engage in daily, we typically process and respond to this information without much difficulty, aided by the use of efficient System 1 heuristics and unconscious filters. Heuristics simplify mental tasks by employing strategies to shortcut the burden of exhaustive search and evaluation of information. Although these strategies are often good enough, their use may also systematically bias our engagement with information with important implications. By filtering information according to prior beliefs, the complexity of mental tasks is reduced. Three of these interrelated filters have been discussed: cultural worldviews, implicit bias, and shared reality. Cultural worldviews serve as a frame around important values about how the world should work, values that predict patterns of engagement with scientific information. Implicit bias is a feature of an individual that is an imprint of broader cultural views about how the world is categorized (e.g., what is good/bad) and includes narratives about the relationship between Christianity and science. Shared reality is an explanation for how beliefs are tied to identity in the context of relationships within which these beliefs are shared and subsequently experienced as real. Together, these filters work to shape how we encounter and process information that conflicts with our beliefs so as to, in most circumstances, protect important beliefs from the challenges posed by that information.

It is clear that human cognition is not neutral; we do not objectively process information and update internal models of reality according to the best data. Yet, these same data, describing how and why these heuristics and filters influence reasoning, also offer suggestions for improving the reception of challenging information. It is to these suggestions I now turn.

Improving Reasoning around Difficult Topics

Although the list of potential "difficult topics" appears to be quite large—weather is a common topic at social gatherings for a reason—the goal of this discussion is to offer suggestions that can be particularly useful for Christians aiming to engage difficult topics that emerge at the intersection of scientific research and religious beliefs. For Christians, accuracy in reasoning is important as a means of maintaining integrity; religious beliefs are less likely to be evaluated as accurate if they are expressed alongside beliefs that are the result of motivated processes. It is important to make clear that good reasoning may not always result in identical beliefs across people; in science and religion we are dealing with incomplete data, data that several competing theories may equally explain. We do not have unhindered access to reality.[62] It is not this kind of disagreement I am suggesting is problematic; it is the disagreements that come out of the perversion of evidence *so that beliefs do not need to be revised* that I take issue with. Disagreements, stemming from integrity to the evidence, advance understanding; disagreements, stemming from a motivated distortion of evidence, stymie (at best) and erode (at worst) understanding. As such, all of these suggestions are offered in the context of the encouragement of the Apostle Paul to the Ephesians: "Be completely humble and gentle; be patient, bearing with one another in love" (Eph. 4:2).

Psychological Threat

Psychological threat is the experience of anxiety, discomfort, or insecurity and can be experienced in a number of domains.[63] These threats may not be explicit, but, when perceived as real, they have important implications for thinking and behavior. One consistent means used to buffer against the adverse experience of threat is to bolster other psychologically protective features of self or environment. For example, a large body of research in terror management theory suggests that threat and the psychological terror it creates—thus, the origin of the theory's name—is "managed through the development of cultural worldviews: humanly created belief systems that are shared by individuals in groups."[64] The shared reality of these cultural values mitigates potential threats; there is psychological strength in the bolstering of these worldviews partly as a function of social consensus.

At the core of research on motivated reasoning is the concept of psychological threat. When exposed to information that is contrary to beliefs, individuals' engagement of motivated reasoning processes allows the maintenance of their beliefs, serving to assuage the potential threat of that evidence. As we have seen, when cultural worldviews are inconsistent with data—that is, threatened by data—these data are more likely to be misinterpreted.[65] When negative implicit bias about Christian engagement in science is activated, Christians demonstrate a decreased ability to reason correctly about science.[66] When evidence suggests that beliefs may need revision, the foundation of reality—the sharing of these beliefs with critical social relationships—is under siege.[67] If the goal is to reduce motivated reasoning, then the means of achieving that goal need to account for these psychological threats. The threat of the information, then, is not *just* the information, but a much broader threat to how an individual understands the way the world does and ought to work. Any success in increasing engagement under these circumstances requires disentangling the evidence from the threat to self and relationship.

Reducing threat makes psychological space for rational evidence evaluation. Below are three strategies to promote threat reduction: (1) affirming self-concept, (2) focusing on value congruity, and (3) expanding group identity. Particularly in discussions between Christians[68] on controversial or potentially threatening matters of science and religious beliefs, employing these strategies is likely to improve the outcome of the discussion. On their own, these strategies will not change minds, but the evidence suggests that they will promote the psychological safety for minds to be open to hear and engage with otherwise threatening ideas and data. As suggested by the title of this article, one particularly meaningful role for psychology is to improve the quality of science-religion dialogue by better understanding the humans involved in the dialogue rather than simply focusing on the dialogue content.

Affirm Self-Concept. According to self-affirmation theory, the threat in psychological threat comes from a potential reduction in our sense of self-worth.[69] The implication, then, is that, if an individual's sense of self-worth is bolstered prior to the experience of psychological threat, then the threat will not be as potent. This is what the data demonstrate. For example, Geoffrey Cohen, Joshua Aronson, and Claude Steele found across three experiments that participants who engaged in self-affirmation were more willing that those who did not, to revise their beliefs when given evidence disconfirming their original beliefs.[70] Unlike the patterns noted during motivated reasoning, self-affirmed participants were more critical of arguments from those who agreed with them, and, importantly, they were more open to the possibility that their beliefs may be wrong. The affirmation of self-worth prior to the introduction of threatening information effectively diffused the threat of that information, reducing potential defensive reactions that lead to motivated reasoning.

In these studies, the affirmation of self-worth is not simply an affirmation that "you are a good person." Instead, these affirmations ask participants to identify traits/aspects of themselves that are important to them, and to reflect on specific experiences in which they were able to positively exhibit those traits.[71] These affirmations focus on aspects of the self that promote feelings of industry and success, drawing from memories of these traits in specific social contexts.[72] Essentially, these affirmations are not just shallow esteem bolsters, but reminders of personal and relational resources.[73] This highlights two important notes about self-affirmation. First, participants affirmed themselves in a multifaceted manner. It was not just the affirmation of one aspect of identity, but three or four. In this way, if the information was threatening to one aspect of identity, there were several others already in mind that an individual could think on to retain a sense of self-worth. Second, memories are not isolated from the original context in which they occurred; thus, the memory retrieval of these self-affirming experiences also activates the memory of the social context and relationships surrounding these self-affirming experiences.[74] The activation of social relationships brings to mind another resource that affirms the self: social and relational resources.[75] Similar to the research on shared reality suggesting that the identification of shared beliefs reduces threat, the self-affirmation highlights one's importance and belonging while lowering resistance to potentially threatening information.[76]

The suggestion for constructive science-religion dialogue, then, is that constructive dialogue is more likely to occur when (a) participants' identities are affirmed in a multifaceted way and (b) participants' affirmations serve to remind them of their contributions to social relationships. Although this suggestion has not been tested specifically in science-religion dialogues, it is consistent with previous research on facilitating more rational engagement with threatening information. By affirming multiple aspects of personally important traits, if the information threatens part of one's identity, there are several other recently affirmed aspects to lean into. Moreover, the threat to identity that may arise from the challenging information is assuaged by a recent reflection on memories of social experiences that affirm one's value. The role of self-affirmation may be

the easiest to induce in a classroom context; an educator can take advantage of this by leading their students through a series of reflective, self-affirming activities prior to the introduction of theoretically unrelated information that is potentially threatening. Another way to facilitate self-affirmation, albeit indirectly, may come in the focus on value congruity.

Focus on Value Congruity. Value congruity refers to the extent to which information is understood as being consistent with personally meaningful ideas. Like self-affirmation, there is evidence suggesting that when information is framed in a value congruent manner, individuals respond to challenging information in a less threatened manner. For example, research suggests that Republicans' skepticism toward climate science abates when the problem is presented in a way that fosters a free-market solution. This same research shows an identical result for Democrats and gun rights.[77] In other words, when the information is framed in a way that is congruent with an individuals' political values, it is more likely to be accepted than when it is framed in a way that is value incongruent. Although the information did not change, its presentation did—presentation that matters for subsequent engagement. Likewise, despite the plethora of research suggesting that taking another person's perspective increases empathy and attitude change (i.e., may shift their beliefs, given conflicting evidence), when asked to take the perspective of someone with whom there is little perceived overlap in core values, research suggests that individuals experience a reduction in openness to belief change.[78]

Thus, a key implication from this research is that potentially threatening information is less likely to be engaged when it appears to be coming from a position or person who holds different values. For the Christian engaging with other Christians in a dialogue about science and religious belief, this presents a really promising avenue for improving the dialogue. Despite differences in beliefs about science, Christians can—at the outset—agree on many essentials about their core Christian values.[79] From these shared values, motivated reasoning to protect these core values is less necessary. This is the essence of shared reality theory; it is not sufficient to know or understand another's viewpoint, but shared beliefs about that viewpoint are the start of constructive and meaningful conversation.[80] To increase openness to ideas that are inconsistent with current beliefs, start with common ground—shared core values—and *then* explore the difference in beliefs/evaluation of evidence.

This suggestion can be extended further. In the context of individual uniqueness, Christians share core values about important aspects of self.[81] For the Christian, it may be possible to highlight shared values not only in terms of beliefs, but also in terms of character and the behavior that extends from character. Highlighting aspects of a Christian identity—such as humility, charity, compassion, and loving those who are unlike ourselves—may also serve as powerful cues of self-affirmation *in the context* of shared values. The suggestion, then, is to engage in a Christian identity self-affirmation and affirmation of shared values prior to discussing specific content that may spur disagreements and motivated reasoning.

Although it is an empirical question whether the affirmation of these traits—which are undoubtedly in development for the Christian—will serve to reduce the experience of threat in the face of belief-challenging information, there are some empirical clues to suggest that this would be the case. For example, motivated reasoning is less likely when individuals are in a positive mood, likely sharing some core features with the role of self-affirmation.[82] In addition, reflecting on one's ideal self, such as the development of Christlikeness, increases positive emotions.[83] Moreover, thinking about how a Christian ought to act may change subsequent behavior as a form of reputation management. For example, a child who believes that they were selected for a game because they are a "good kid" is less likely to cheat when given the choice; their behavior conforms to the belief that they are a good kid and that good kids do not cheat.[84] Similarly, a Christian reminded of the character traits of a Christian, according to Jesus and scripture, may be more likely to act accordingly. Awareness of identity can shape even implicit evaluation, at least in the short term, and practicing these aspects of identity is how they develop in the long term.[85]

Expand Group Identity. Psychological threat is experienced as a lack of security over beliefs about identity, self-worth, and belonging. As fundamentally social creatures, when changing beliefs requires changing social groups, there is an inherent and powerful resistance to belief revision.[86] This powerful draw to maintain beliefs for connection to important social networks is seen even among those who have revised beliefs. For example, research suggests that nonreligious believers may seek out a religious community specifically for the social connections, especially those offered to families.[87] Moreover, there is a strong societal influence, particularly in the United States, to present as religious—in part to prevent a disruption to the social context and relationships associated with the stigma of nonbelief.[88] Thus, a challenge in the presentation of

data that is inconsistent with beliefs is to communicate clearly what these data do and do not imply about the stability and confidence of one's group membership.

From childhood, we create categories of in-group and out-group members on a number of characteristics.[89] However, many groups are not inherently defined by physical or observable characteristics. In this circumstance, our implicit biases, drawn from examples available in culture and memory, fill in the boundaries of group membership. For example, female STEM faculty, who, from their pictures, were rated high on femininity, were subsequently less likely to be viewed as scientists than those who rated lower in femininity because they did not conform to implicit expectations about what a scientist "looks like."[90] However, when individuals are exposed to women scientists, such as through the #ILookLikeAnEngineer campaign, their boundaries around category membership of "scientists" are expanded.[91] Exposure to exemplars pushed the boundaries around category membership, increasing the heterogeneity of subsequent ideas about membership. Other research suggests that beliefs about category membership are more rigid when exposure to members of that group is relatively homogeneous; yet exposure to diverse examples makes beliefs about the rigidity of category membership more flexible.[92]

In the context of science-religion dialogues, there are two different categories that need to be considered: boundaries around the categories of scientists, and boundaries around those of fellow Christian believers. As reviewed above, research suggests that many individuals draw boundaries around the category of scientists along lines of religious belief (i.e., scientists are not religious believers). There is evidence of implicit and explicit beliefs that to be a scientist is to be an atheist and to be a Christian is to be incapable of science.[93] Despite the error of these boundaries, they appear relatively entrenched in an American context. Taking a cue from the research on expanding representation of women in science, Christians would do well to increase exposure to Christians in science, especially mainstream and elite science. There are some notable examples here, such as Francis Collins and Jennifer Wiseman. There is evidence that exposure to these exemplars does shift conceptions about the nature of science and religion as collaborative, rather than combative.[94] Yet, for these exemplars to really shift these boundaries beyond the individual person, the number of exemplars needs to be increased. In the absence of modern exemplars, increasing religious believers' understanding of the historical relationship between Christianity and science may be equally important.[95]

In addition to expanding ideas about membership in the "scientist" category, Christians hoping to improve the status of dialogue in issues within science and religion also have to consider the "Christian" category. Augustine of Hippo famously claimed: *In essentials, unity. In non-essentials, liberty. In all things, love.* But what is essential? As many Christians know, there is considerable diversity within the Christian tradition. However, without intentional exposure to this diversity, human cognitive processes, such as those outlined above, increase the likelihood that *my* specific beliefs and the specific beliefs of *my* local faith community will be extended as the *only* beliefs that are acceptable or true. Yet, there is considerable, honest disagreement within the Christian faith on a number of issues, including a number of topics in science. It would be an error to believe that most of these contentions have only one acceptable belief in order to be included within the Christian category. Although only one belief may ultimately be correct, the diversity of beliefs exist because it is not yet clear which belief is correct.[96] The mistake of believing that our view on a particular implication in science is *the* view essential to salvation is the root of many of the hostilities between science and Christianity,[97] and within Christianity itself. The role of organizations like the ASA is vital to expanding the foundation of what being a Christian requires in terms of beliefs about religion and science. The intentional exposure to diversity reduces the threat of belief-challenging data, because to change some beliefs does not require abandoning our most important identity and community-giving beliefs.

Summary of suggestions. Drawing on research on self-affirmation, value congruence, and the expansion of group identity, three basic suggestions have been offered and are summarized here. These suggestions focus on how to approach, frame, and engage in discussions in science and religion that risk the distortion or denial of information, to the detriment of approaching a truthful understanding of reality.

1. Affirm self-worth to reduce the threat to identity associated with the possibility that belief change necessarily causes a change in identity and social relationships. Emphasize the multifaceted nature of identity and the stability of self-in-social context.
2. Agree first about core values (beliefs) and character traits (Christlikeness). Focus on framing information in a way that emphasizes value congruity, especially the shared values with those providing the information.
3. Highlight the diversity within Christian belief and point to exemplars of this diversity. Understanding that some religious and scientific viewpoints

> are heterogeneous, opens the possibility of diversity and tolerance to that diversity. Changing beliefs where there is diversity and tolerance is less threatening as it does not (and will not) require leaving important social relationships (e.g., the church).

Examples of Dialogue in Science and Christian Faith

The foundation of my argument is that filters in human cognition are ubiquitous, affecting reasoning about a host of topics, including those at the intersection of science and the Christian faith. I have suggested that understanding these filters and employing strategies to assuage the potential threat of challenging conversations will allow for the advancement of content-specific science and faith dialogue. Although true across topics and domains (i.e., not limited to science and religion discussions), in this section I want to provide a brief example of the application of this content in two areas of science that have overwhelming scientific consensus and yet have been met with varying degrees of controversy among Christians: the age of the earth, and evidence for climate change. My perspective is that most of the individuals opposing the dominant scientific perspective in these domains are engaging some degree of motivated reasoning, given the extent of scientific evidence for these claims. This is not to say that criticisms leveraged by those rejecting the scientific consensus are without value; important conversations, including conversations about how science works and biblical interpretation, have resulted from thoughtful critiques in these areas. At the same time, there is evidence that these critiques, even when thoughtful and earnest, are not immune to motivated reasoning.[98]

Age of the Earth

The scientific consensus is that the earth, and the universe that contains it, is billions of years old.[99] This is a view shared by many Christians (scientist or not), but it has also been subject to intense debate within some Christian communities.[100] The most notable voice challenging the scientific consensus in this debate comes from the Answers in Genesis (AiG) organization, which promotes apologetics related to a young-earth creationist viewpoint.[101] According to the AiG website, questions of creation and the age of the earth are vital because

> if Christians doubt what at first appears to be insignificant details of Scripture, then others may begin to look at the whole Bible differently, eventually doubting the central tenets of the Christian faith, namely the life, death, and resurrection of Jesus Christ.[102]

Thus, although AiG agrees that "our unity should be centered in Christ," AiG advances the view that being centered in Christ requires belief in a young earth (e.g., 10,000 years) and life as the result of special creation within that time period.[103] John Mark Reynolds says that "*Answers in Genesis* would concede that YEC [Young Earth Creation] is not 'necessary for salvation,' but insists that the YEC position is the only acceptable one for believers."[104] Given this conflict, how can two Christians engage with one another in a productive manner, in a way that reduces the likelihood of motivated reasoning about data—both empirical data from science and evidence from other sources such as biblical interpretation and scholarship, Christian tradition, and reason?[105]

In light of the preceding discussion, any productive dialogue should not start with the data. Thus, the first point to consider is the goal of the dialogue: by engaging a fellow Christian with a different view on the age of the earth, clarify the hoped-for outcome—at least within one's own mind. Even if persuasion is the ultimate goal, the proximate goal of the conversation at hand should not be about "winning." Instead, genuinely affirm the worth of the other (*affirm self-concept*) in the conversation. Make the conversation space psychologically safe by identifying and highlighting shared values, especially core values of the Christian faith (*value congruity,* creating space for *shared reality*). Starting with a recognition of the inherent value of the other, regardless of their views on the age of the earth—views which do not negate or mar the *imago dei* of either participant—refocuses the tone of the conversation. Rather than a battle, it can truly be a dialogue between individuals who believe they have been created with equal worth in Christ's eyes. Moreover, these shared core values make salient the kinds of behaviors that are appropriate and pleasing to Christ (e.g., humility, being quick to listen, and slow to speak). In the context of disagreement, it is easy to lose sight of these values. This can result in degrading both the quality and the impact of any heated discussion.

Moreover, looking for common ground (scientifically, theologically) in light of shared values may ultimately create a path for the dismantling of the core processes involved in motivated reasoning, even if this does not happen in one conversation (*engage System 2*). Consider also the possibility that belief change never happens as a result of this conversation and that the belief that the earth is thousands, not billions, of years old is maintained. If the goal was persuasion, this would be a failure; however, if the goal is about pursuing Christlikeness then such a conversation is a worthwhile one. Even without belief revision, when

individuals leave a conversation feeling edified, valued, and heard—perhaps especially in light of legitimate disagreement—this will produce better outcomes in terms of respect for and future willingness to engage in an open and honest way with future scientific and theological knowledge.[106]

Finally, by starting with shared values and viewpoints about science and theology, it is possible to identify otherwise implicit presuppositions that necessarily influence thinking. Presuppositions can operate like *implicit bias*, guiding thinking in ways that may be unarticulated. For example, when engaging with AiG, it is important to understand the "presuppositional approach to the debate" that starts with one particular interpretation of scripture.[107] All scientific statements must be filtered through that particular viewpoint; inconsistencies are rejected (e.g., the evidence is viewed as inherently flawed since it produces an outcome inconsistent with preexisting beliefs about scripture). At the core, the AiG stance is problematic from the perspective of motivated reasoning because, as John Mark Reynolds states, "a Christian in science has adequate reasons in theology and history to look for an alternative set of scientific explanations that would *preserve her or his preferred reading* of scripture."[108] In this viewpoint, one's personal interpretation of scripture is independent and superior to all other knowledge, including knowledge informed by scientific data and biblical scholarship, both of which continue to develop our understanding of the world as they change with new and better methods, understanding, and evidence.[109] When a belief is untouchable by any form of external evidence, this lays the foundation for the processes of motivated reasoning.[110] By taking the time to identify these presuppositions, the implicit can be made explicit and thus its bias reduced.[111] This can offer an important starting point for dialogue; data that are implicitly rejected because of unspoken presuppositions or biases are bound to fail to persuade.

Climate Change

Similar to questions about the age of the earth, research shows an overwhelming scientific consensus—at least 97% of climate scientists—concerning the change in global climate and the role of human activity in that change.[112] However, there is considerable discrepancy between the scientific consensus and the perspective of the American (and, in many cases, international) public on issues of climate change. Some of this discrepancy is attributable to the public's underestimation of the scientific consensus concerning climate change,[113] but other challenges to the alignment of public and scientific perspectives are more ideological. For example, views on climate change between 2002 and 2012 were more strongly influenced by cues from political leaders than from scientific communication and content.[114] Consistent with this finding, there is evidence that the rejection of climate change science is more strongly associated with political conservatism than religious ideology.[115] However, the close association between political conservatism and evangelical Christianity may explain why evangelicals are less likely than other Christians to accept climate change science.[116]

Just as with discussions around the age of the earth, to more effectively dismantle motivated reasoning processes, it is important to clarify the goals of the conversation while affirming the worth of the participants and highlighting the shared reality and connection afforded by shared core values and virtues. Keep in mind that the goal is not for Christians to simply accept some scientific finding uncritically. Christians may have legitimate reasons to be skeptical of science, which has been used to justify agendas that are entirely inconsistent with Christian values (e.g., slavery, eugenics). Rather, the goal is to promote better reasoning with all available data, even if disagreement remains. Uncritical rejection or acceptance of scientific information reflects motivated reasoning and is unhelpful in moving toward the goal of a clearer understanding of reality. The pursuit of this goal in the context of climate science may especially benefit from highlighting the diversity of viewpoints about climate change within the Christian faith (*expanding group identity*).

When scientific content produces psychological threat, it is, in part, due to the potential threat to loss of relationships and identity. The view that belonging to a particular "in group" (e.g., faith community[117]) requires a specific belief, even if a non-essential belief, can promote the rejection of evidence that points to a contrary conclusion (e.g., to be a Christian is to be a Republican is to reject climate change; deviation in one disrupts the whole). As argued above, one effective way to combat this identity chain is to highlight the diversity of beliefs around a particular issue; within the same in-group, there are many viewpoints. Doing this requires more effective listening and additional preparation.

When engaging in a dialogue with a climate science skeptic, more effective listening is required to better develop understanding around the reasons for the skepticism. Is it a form of solution aversion,[118] connections to a political party,[119] or a mistrust in scientists' agendas, scientists who may be perceived to be atheists?[120] Better identifying the root of the resistance can help move the conversation from System 1 to System 2 dialogue. Moreover, with an understanding of the source of the skepticism, additional preparation makes it possible

to more effectively provide *relevant* exemplars with whom the skeptic can identify as sharing core values, an important component of when perspective-taking is persuasive.[121] Motivated reasoning, at its core, suggests that it is not just enough to know the scientific content. In this case, it is also important to know who are the scientists themselves, especially when the scientists share important identity features (e.g., Katharine Hayhoe as a Christian, pastor's wife, and climate scientist[122]). Moreover, by understanding the biggest concerns first, the most relevant exemplars can be selected: would highlighting Christians in science be the most meaningful approach to combat a science-as-atheism bias or would it be more meaningful to highlight conservative politicians who acknowledge the reality of climate change and promote politically conservative solutions to combat climate change? In addition to these distant exemplars, it would be relevant to initiate conversations within one's own faith community where it is likely that diversity of viewpoints already exists and where these kinds of conversations may be especially important for motivating action to combat climate change.[123]

The important point is not that there is a disagreement—that is inherent in a world with incomplete access to knowledge. Instead, the important point is that the disagreement happens in a way that de-escalates the potential psychological threat of evidence. Recognizing and highlighting disagreement *within the Christian community* helps to normalize disagreement; a divergence of opinion on many issues is not the dividing line between membership and exclusion from Christian fellowship.

Challenging Conversations

Challenging conversations can happen in a variety of contexts. As an educator, I actively work to include these conversations in my classroom. I care that my students know and understand the relevant science in my classroom; however, because the science will likely change with new technology and data, I work to make space for students to participate in difficult conversations so that they might develop the skills necessary to engage science and Christianity with openness and integrity once they leave my classroom. I cannot leverage all of the tools I have described above in a classroom of thirty students, so I am careful to start difficult conversations at the intersection of science and Christian faith by first working to establish my relationship with students. When I am known to students first as a Christian and as a person who cares for them and shares many of their core values, it is much easier to ask challenging questions from science because my motives are not suspect and I know my conversation partners.

In the context of these specific conversations that might trigger psychological threat at the intersection of science and Christianity, I start as I have suggested above. I identify the goals of the conversation and what it looks like to have this conversation as Christians. Next I identify core values of excellence in Christian work and highlight Christian virtues.[124] In reminding my Christian students that we share these beliefs and are all equally prone before the cross, I clarify that my goal in the discussion is not to have students agree with me. Rather, my goal is to promote their clear, thoughtful, and evidence-based thinking.

As previously discussed, good thinking does not always produce a single answer, as we do not have access to all the necessary information for full and complete access to reality. In addition to promoting a psychologically safe space for respectful disagreement, this method of communication also models a humility of knowledge, for example, about science. Science can (and has) answered a lot of questions—many questions being asked and answered by Christians in science—but there are inherent limits to what science can say about reality.[125] These limits are not a reason to dismiss science, but they need to be thoughtfully considered as we engage with scientific content. Acknowledging the limits of science does not render science meaningless; it renders it appropriately leveraged alongside other sources of knowledge from theology, tradition, and reason in our work to better understand reality.

Conclusion

One thing that should be clear from these discussions is the insufficiency of data and rationality alone to persuade. Seemingly intractable problems in the landscape of science and religion will not be solved by amassing more or better data. A rational, System 2 solution alone will likely be insufficient. Instead, forward movement requires a thoughtful consideration of the *individuals* who are engaging with the problem. Even scientists, who practice data-driven thinking for a living, are prone to the influences described in this article and are often unconvinced by System 2 arguments.[126] For example, when scientists receive data inconsistent with their hypotheses, they are likely to generate alternative explanations for that data.[127] In other words, they, in the same manner as nonscientists reasoning about things they believe, are motivated to retain their well-thought-out, though unsupported, hypotheses.

Despite these cognitive shortcomings, science works in part because it supersedes the potential bias of any one individual, and is instead social and democratic. Faults that scientists are unable to see in their own work may be flagged by a reviewer or other scientists operating

from a different theoretical framework.[128] This is a strength of science: disagreement is standard in the scientific conversation; it does not imply or require separation from the scientific community. Instead, scientific disagreements are a defining feature of belonging in the scientific community and of the advancement of knowledge toward truth. Engaging the suggestions above may likewise provide space among religious believers to disagree in community. By affirming a multifaceted sense of self-worth, affirming core values, and expanding group identity to include diversity within the group, individuals can engage belief-challenging information without diluting or misrepresenting that evidence. In that, it may be possible to see these strengths of science duplicated into broader discussions of science and religion, advancing conversations as a result of accounting for the psychology of the participants in these conversations, and changing the culture around how these conversations occur. ●

Acknowledgment

The author is grateful to Emily A. Stewart for her work in formatting this article.

Notes

[1]Malcolm A. Jeeves and Thomas E. Ludwig, *Psychological Science and Christian Faith: Insights and Enrichments from Constructive Dialogue* (West Conshohocken, PA: Templeton Press, 2018).

[2]James C. Peterson, "Working Together across Disciplines," *Perspectives on Science and Christian Faith* 71, no. 3 (2019): 137.

[3]Ziva Kunda, "The Case for Motivated Reasoning," *Psychological Bulletin* 108, no. 3 (1990): 480–98, https://doi.org/10.1037/0033-2909.108.3.480.

[4]For example, what counts as evidence? Emilio J. C. Lobato et al., "Religiosity Predicts Evidentiary Standards," *Social Psychological and Personality Science* 11, no. 4 (2020): 1–6, https://doi.org/10.1177/1948550619869613; Gerald Rau, *Mapping the Origin's Debate: Six Models of the Beginning of Everything* (Downers Grove, IL: InterVarsity Press, 2012).

[5]Keith E. Stanovich and Richard F. West, "Individual Differences in Reasoning: Implications for the Rationality Debate?," *Behavioral and Brain Sciences* 23, no. 5 (2000): 645–65, https://doi.org/10.1017/S0140525X00003435; Amos Tversky and Daniel Kahneman, "Judgment under Uncertainty: Heuristics and Biases," *Science* 185, no. 4157 (1974): 1124–31; Daniel Kahneman, "Maps of Bounded Rationality: Psychology for Behavioral Economics," *The American Economic Review* 93, no. 5 (2003): 1449–75; and Daniel Kahneman, *Thinking, Fast and Slow* (New York: Farrar, Straus and Giroux, 2011).

[6]David Eagleman, *Incognito: The Secret Lives of the Brain* (New York: Pantheon Books, 2011).

[7]Gerd Gigerenzer and Daniel G. Goldstein, "Reasoning the Fast and Frugal Way: Models of Bounded Rationality," *Psychological Review* 103, no. 4 (1996): 650–69.

[8]Kahneman, *Thinking, Fast and Slow*; and Tversky and Kahneman, "Judgment under Uncertainty," 1124–31.

[9]Namely, the framing effect. Irwin P. Levin, Gary J. Gaeth, and Sandra L. Schneider, "All Frames Are Not Created Equal: A Typology and Critical Analysis of Framing Effects," *Organizational Behavior and Human Decision Processes* 76, no. 2 (1998): 149–88, https://doi.org/10.1006/obhd.1998.2804.

[10]Kunda, "The Case for Motivated Reasoning," 480–98.

[11]Troy H. Campbell and Aaron C. Kay, "Solution Aversion: On the Relation between Ideology and Motivated Disbelief," *Journal of Personality and Social Psychology* 107, no. 5 (2014): 809–24, https://doi.org/10.1037/a0037963; Peter H. Ditto and David F. Lopez, "Motivated Skepticism: Use of Differential Decision Criteria for Preferred and Nonpreferred Conclusions," *Journal of Personality and Social Psychology* 63, no. 4 (1992): 568–84; Kunda, "The Case for Motivated Reasoning," 480–98; Stephan Lewandowsky and Klaus Oberauer, "Motivated Rejection of Science," *Current Directions in Psychological Science* 25, no. 4 (2016): 217–22, https://doi.org/10.1177/0963721416654436; and Charles S. Taber and Milton Lodge, "Motivated Skepticism in the Evaluation of Political Beliefs," *American Journal of Political Science* 50, no. 3 (2006): 755–69, https://doi.org/10.1111/j.1540-5907.2006.00214.x.

[12]Taber and Lodge, "Motivated Skepticism in the Evaluation of Political Beliefs," 755–69.

[13]The confirmation bias. Raymond S. Nickerson, "Confirmation Bias: A Ubiquitous Phenomenon in Many Guises," *Review of General Psychology* 2, no. 2 (1998): 175–220.

[14]Ditto and Lopez, "Motivated Skepticism," 568–84.

[15]Justin P. Friesen, Troy H. Campbell, and Aaron C. Kay, "The Psychological Advantage of Unfalsifiability: The Appeal of Untestable Religious and Political Ideologies," *Journal of Personality and Social Psychology* 108, no. 3 (2015): 515–29, https://doi.org/10.1037/pspp0000018.

[16]For example, downplay scientific consensus concerning the data or the severity of the problem. Campbell and Kay, "Solution Aversion," 809–24.

[17]Shanto Iyengar and Douglas S. Massey, "Scientific Communication in a Post-Truth Society," *Proceedings of the National Academy of Sciences* 116, no. 16 (2019): 7656–61, https://doi.org/10.1073/pnas.1805868115.

[18]M. Anne Britt et al., "A Reasoned Approach to Dealing with Fake News," *Policy Insights from the Behavioral and Brain Sciences* 6, no. 1 (2019): 94–101, https://doi.org/10.1177/2372732218814855; and Fabiana Zollo, "Dealing with Digital Misinformation: A Polarised Context of Narratives and Tribes," *EFSA Journal* 17, no. S1 (2019): 1–15.

[19]Dan M. Kahan, "The Expressive Rationality of Inaccurate Perceptions," *Behavioral and Brain Sciences* 40 (2016): 26–28.

[20]Curtis D. Hardin and Edward Tory Higgins, "Shared Reality: How Social Verification Makes the Subjective Objective," in *Handbook of Motivation and Cognition Vol. 3: The Interpersonal Context*, ed. Richard M. Sorrentino and E. Tory Higgins (New York: The Guilford Press, 1996): 28–84; and Larisa Heiphetz, "The Development and Importance of Shared Reality in the Domains of Opinion, Morality, and Religion," *Current Opinion in Psychology* 23 (2018): 1–5, https://doi.org/10.1016/j.copsyc.2017.11.002.

[21]Martin Baekgaard and Søren Serritzlew, "Interpreting Performance Information: Motivated Reasoning or Unbiased Comprehension," *Public Administration Review* 76, no. 1 (2016): 73–82, https://doi.org/10.1111/puar.12406.

[22]Taber and Lodge, "Motivated Skepticism in the Evaluation of Political Beliefs," 755–69.

[23]Kahan, "The Expressive Rationality," 26–28.

[24]Dan M. Kahan et al., "Motivated Numeracy and Enlightened Self-Government," *Behavioural Public Policy* 1, no. 1 (2017): 54–86, https://doi.org/10.1017/bpp.2016.2.

[25]Baekgaard and Serritzlew, "Interpreting Performance Information," 73–82.

[26]Miguel Farias et al., "Scientific Faith: Belief in Science Increases in the Face of Stress and Existential Anxiety," *Journal of Experimental Social Psychology* 49, no. 6 (2013): 1210–13, https://doi.org/10.1016/j.jesp.2013.05.008; David Maij et al., "Mentalizing Skills Do Not Differentiate Believers from Non-believers, But Credibility Enhancing Displays Do," *PLOS ONE* 12, no. 8 (2017): 1–31, https://doi.org/10.1371/journal.pone.0182764; Kimberly Rios et al., "Negative Stereotypes Cause Christians to Underperform in and Disidentify with Science," *Social Psychological and Personality Science* 6, no. 8 (2015): 959–67, https://doi.org/10.1177/1948550615598378; Miron Zuckerman, Jordan Silberman, and Judith A. Hall, "The Relation between Intelligence and Religiosity: A Meta-Analysis and Some Proposed Explanations," *Personality and Social Psychology Review* 17, no. 4 (2013): 325–54, https://doi.org/10.1177/1088868313497266; and Miron Zuckerman et al., "The Negative Intelligence–Religiosity Relation: New and Confirming Evidence," *Personality and Social Psychology Bulletin* 46, no. 6 (2019): 1–13, https://doi.org/10.1177/0146167219879122.

[27]Bastiaan T. Rutjens, Robbie M. Sutton, and Romy van der Lee, "Not All Skepticism Is Equal: Exploring the Ideological Antecedents of Science Acceptance and Rejection," *Personality and Social Psychology Bulletin* 44, no. 3 (2018): 384–405, https://doi.org/10.1177/0146167217741314.

[28]Esther Chan and Elaine Howard Ecklund, "Narrating and Navigating Authorities: Evangelical and Mainline Protestant Interpretations of the Bible and Science," *Journal for the Scientific Study of Religion* 55, no. 1 (2016): 54–69, https://doi.org/10.1111/jssr.12245.

[29]For example, perception. Richard E. Nisbett and Takahiko Masuda, "Culture and Point of View," *Proceedings of the National Academy of Sciences* 100, no. 19 (2003): 11163–70, https://doi.org/10.1073/pnas.1934527100.

[30]Mary Gauvain, *The Social Context of Cognitive Development* (New York: The Guilford Press, 2001).

[31]Lev S. Vygotsky, *Mind in Society: The Development of Higher Psychological Processes* (Cambridge, MA: Harvard University Press, 1978).

[32]For example, climate change, gun control, vaccines. "The Cultural Cognition Project," Yale Law School, http://www.culturalcognition.net.

[33]Dan M. Kahan et al., "The Second National Risk and Culture Study: Making Sense of—and Making Progress In—the American Culture War of Fact," *SSRN Electronic Journal* (October 3, 2007), last revised April 16, 2013; GWU Legal Studies Research Paper No. 370; Yale Law School, Public Law Working Paper No. 154; GWU Law School Public Law Research Paper No. 370; Harvard Law School Program on Risk Regulation Research Paper No. 08-26, https://doi.org/10.2139/ssrn.1017189.

[34]Dan M. Kahan et al., "Culture and Identity-Protective Cognition: Explaining the White-Male Effect in Risk Perception," *Journal of Empirical Legal Studies* 4, no. 3 (2007): 465–505, https://doi.org/10.1111/j.1740-1461.2007.00097.x.

[35]Joel R. Beeke, Michael A. G. Haykin, and Sinclair B. Ferguson, *Church History 101: The Highlights of Twenty Centuries* (Grand Rapids, MI: Reformation Heritage Books, 2016); and "Christian Traditions," Pew Research Center: Religion & Public Life Project (December 19, 2011), https://www.pewforum.org/2011/12/19/global-christianity-traditions/.

[36]Chan and Ecklund, "Narrating and Navigating Authorities," 54–69.

[37]Henri Tajfel et al., "Social Categorization and Intergroup Behavior," *European Journal of Social Psychology* 1, no. 2 (1971): 149–78, https://doi.org/10.1002/ejsp.2420010202.

[38]For example, having a positive attitude toward pizza may not predict pizza-eating behavior, just as explicitly liking a people group may not predict meaningful social interaction with a person from that group. Richard T. LaPiere, "Attitudes vs. Actions," *Social Forces* 13, no. 2 (1934): 230–37, https://doi.org/10.2307/2570339.

[39]Anthony G. Greenwald and Mahzarin R. Banaji, "Implicit Social Cognition: Attitudes, Self-Esteem, and Stereotypes," *Psychological Review* 102, no. 1 (1995): 4–27.

[40]____, "The Implicit Revolution: Reconceiving the Relation between Conscious and Unconscious," *American Psychologist* 72, no. 9 (2017): 861–71, https://doi.org/10.1037/amp0000238.

[41]Allen R. McConnell and Jill M. Leibold, "Relations among the Implicit Association Test, Discriminatory Behavior, and Explicit Measures of Racial Attitudes," *Journal of Experimental Social Psychology* 37, no. 5 (2001): 435–42, https://doi.org/10.1006/jesp.2000.1470. See also the following for ongoing discussion about the interpretation of these results: Hart Blanton et al., "Strong Claims and Weak Evidence: Reassessing the Predictive Validity of the IAT," *Journal of Applied Psychology* 94, no. 3 (2009): 567–82, https://doi.org/10.1037/a0014665; Allen R. McConnell and Jill M. Leibold, "Weak Criticisms and Selective Evidence: Reply to Blanton et al. (2009)," *Journal of Applied Psychology* 94, no. 3 (2009): 583–89, https://doi.org/10.1037/a0014649; Anthony G. Greenwald et al., "Understanding and Using the Implicit Association Test: III Meta-Analysis of Predictive Validity," *Journal of Personality and Social Psychology* 97, no. 1 (2009): 17–41, https://doi.org/10.1037/a0015575; Anthony G. Greenwald et al., "Statistically Small Effects of the Implicit Association Test Can Have Societally Large Effects," *Journal of Personality and Social Psychology* 108, no. 4 (2015): 553–61, https://doi.org/10.1037/pspa0000016; Frederick L. Oswald et al., "Predicting Ethnic and Racial Discrimination: A Meta-Analysis of IAT Criterion Studies," *Journal of Personality and Social Psychology* 105, no. 2 (2013): 171–92, https://doi.org/10.1037/a0032734; and Frederick L. Oswald et al., "Using the IAT to Predict Ethnic and Racial Discrimination: Small Effect Sizes of Unknown Societal Significance," *Journal of Personality and Social Psychology* 108, no. 4 (2015): 562–71, https://doi.org/10.1037/pspa0000023.

[42]Greenwald and Banaji, "The Implicit Revolution," 867.

[43]Eric Hehman, Jessica K. Flake, and Jimmy Calanchini, "Disproportionate Use of Lethal Force in Policing Is Associated with Regional Racial Biases of Residents," *Social Psychological and Personality Science* 9, no. 4 (2018): 393–401, https://doi.org/10.1177/1948550617711229.

[44]Will M. Gervais et al., "Analytic Atheism: A Cross-Culturally Weak and Fickle Phenomenon?," *Judgment and Decision Making* 13, no. 3 (2018): 268–74; Will M. Gervais and Ara Norenzayan, "Analytic Atheism Revisited," *Nature Human Behaviour* 2, no. 9 (2018): 609, https://doi.org/10.1038/s41562-018-0426-0; Kathryn A. Johnson et al., "Science, God, and the Cosmos: Science Both Erodes (via Logic) and Promotes (via Awe) Belief in God," *Journal of Experimental Social Psychology* 84, no. 103826 (2019): 1–13, https://doi.org/10.1016/j.jesp.2019.103826; and James E.

Taylor, "New Atheists," *Internet Encyclopedia of Philosophy*, https://www.iep.utm.edu/n-atheis/.

[45]Elaine Howard Ecklund, *Science vs. Religion: What Scientists Really Think* (New York: Oxford University Press, 2010); Elaine Howard Ecklund and Christopher P. Scheitle, *Religion vs. Science: What Religious People Really Think* (New York: Oxford University Press, 2018); Matthew Fisher and Frank C. Keil, "The Binary Bias: A Systematic Distortion in the Integration of Information," *Psychological Science* 29, no. 11 (2018): 1846–58, https://doi.org/10.1177/0956797618792256; and Derek J. Koehler, "Can Journalistic 'False Balance' Distort Public Perception of Consensus in Expert Opinion?," *Journal of Experimental Psychology: Applied* 22, no. 1 (2016): 24–38, https://doi.org/10.1037/xap0000073.

[46]Rios et al., "Negative Stereotypes," 959–67.

[47]Ain Simpson and Kimberly Rios, "Is Science for Atheists? Perceived Threat to Religious Cultural Authority Explains U.S. Christians' Distrust in Secularized Science," *Public Understanding of Science* 28, no. 7 (2019): 740–58, https://doi.org/10.1177/0963662519871881; and Bastiaan T. Rutjens and Steven J. Heine, "The Immoral Landscape? Scientists Are Associated with Violations of Morality," *PLOS ONE* 11, no. 4 (2016): 1–16, https://doi.org/10.1371/journal.pone.0152798.

[48]Will M. Gervais, "In Godlessness We Distrust: Using Social Psychology to Solve the Puzzle of Anti-atheist Prejudice," *Social and Personality Psychology Compass* 7, no. 6 (2013): 366–77, https://doi.org/10.1111/spc3.12035; and Will M. Gervais et al., "Global Evidence of Extreme Intuitive Moral Prejudice against Atheists," *Nature Human Behaviour* 1, no. 8 (2017): 1–6, https://doi.org/10.1038/s41562-017-0151.

[49]Rios et al., "Negative Stereotypes," 959–67; and Elaine Howard Ecklund et al., "Religion among Scientists in International Context: A New Study of Scientists in Eight Regions," *Socius: Sociological Research for a Dynamic World* 2 (2016): 1–9, https://doi.org/10.1177%2F2378023116664353.

[50]Sapna Cheryan et al., "Do Female and Male Role Models Who Embody STEM Stereotypes Hinder Women's Anticipated Success in STEM?," *Social Psychological and Personality Science* 2, no. 6 (2011): 656–64, https://doi.org/10.1177/1948550611405218; and Christopher P. Scheitle and Elaine Howard Ecklund, "The Influence of Science Popularizers on the Public's View of Religion and Science: An Experimental Assessment," *Public Understanding of Science* 26, no. 1 (2017): 25–39, https://doi.org/10.1177/0963662515588432.

[51]Kunda, "The Case for Motivated Reasoning," 480–98; Lewandowsky and Oberauer, "Motivated Rejection of Science," 217–22; and Rutjens, Sutton, and van der Lee, "Not All Skepticism Is Equal," 384–405.

[52]For example, Republicans as anti-science. Campbell and Kay, "Solution Aversion," 809–24; Farias et al., "Scientific Faith," 1210–13; Friesen et al., "The Psychological Advantage of Unfalsifiability," 515–29; and Sheldon Solomon, Jeff Greenberg, and Tom Pyszczynski, "A Terror Management Theory of Social Behavior: The Psychological Functions of Self-Esteem and Cultural Worldviews," in *Advances in Experimental Social Psychology*, Vol. 24, ed. Mark V. Zanna (San Diego, CA: Academic Press, 1991), 93–159.

[53]This research only addresses participants' perceptions of shared religious beliefs with their parents; it did not also measure whether participants perceived their parents to be more comfortable or threatened by evolution. Importantly, when participants perceived that their parents shared their religious beliefs, this reduced the threat of evolution. It seems unlikely that there would be a systematic relationship that those who shared beliefs with their parents would also have parents more comfortable with evolution such that it is actually the perception of the parents' comfort with evolution driving the reduction of evolution threat. This, however, is an empirical question. Michael W. Magee and Curtis D. Hardin, "In Defense of Religion: Shared Reality Moderates the Unconscious Threat of Evolution," *Social Cognition* 28, no. 3 (2010): 379–400, https://doi.org/10.1521/soco.2010.28.3.379.

[54]Hardin and Higgins, *Handbook of Motivation and Cognition*, 28–84.

[55]Ibid., 28–34.

[56]James F. M. Cornwell, Becca Franks, and E. Tory Higgins, "Shared Reality Makes Life Meaningful: Are We *Really* Going in the Right Direction?," *Motivation Science* 3, no. 3 (2017): 260–74, https://doi.org/10.1037/mot0000071.

[57]Inge Bretherton, "Communication Patterns, Internal Working Models, and the Intergenerational Transmission of Attachment Relationships," *Infant Mental Health Journal* 11, no. 3 (1990): 237–52, https://doi.org/10.1002/1097-0355(199023)11:3<237::AID-IMHJ2280110306>3.0.CO;2-X.

[58]For example, "Wash your hands to get rid of germs [that you cannot see] that will make you sick." Paul L. Harris and Melissa A. Koenig, "Trust in Testimony: How Children Learn about Science and Religion," *Child Development* 77, no. 3 (2006): 505–24; and Heiphetz, "The Development and Importance," 1–5.

[59]Paul L Harris et al., "Germs and Angels: The Role of Testimony in Young Children's Ontology," *Developmental Science* 9, no. 1 (2006): 76–96.

[60]Roy F. Baumeister and Mark R. Leary, "The Need to Belong: Desire for Interpersonal Attachments as a Fundamental Human Motivation," *Psychological Bulletin* 117, no. 3 (1995): 497–529, https://doi.org/10.1037/0033-2909.117.3.497; John Calvin, "Genesis 2:18," in *Commentaries on the First Book of Moses Called Genesis*, Vol. 1 (Grand Rapids, MI: Christian Classics Ethereal Library, 1554); and John Calvin, "Matthew 22:37–40," in *Commentary On a Harmony of the Evangelists, Matthew, Mark, and Luke,* Vol. 2 (Grand Rapids, MI: Christian Classics Ethereal Library, 1563).

[61]Kahan, "The Expressive Rationality," 26–28.

[62]1 Corinthians 13:12.

[63]For example, threat to sense of self, relationships, control. Kennon M. Sheldon and Tim Kasser, "Psychological Threat and Extrinsic Goal Striving," *Motivation and Emotion* 32, no. 1 (2008): 37–45, https://doi.org/10.1007/s11031-008-9081-5.

[64]Sheldon Solomon, Jeff Greenberg, and Tom Pyszczynski, "Pride and Prejudice: Fear of Death and Social Behavior," *Current Directions in Psychological Science* 9, no. 6 (2000): 200–201, https://doi.org/10.1111/1467-8721.00094.

[65]Dan M. Kahan, "Ideology, Motivated Reasoning, and Cognitive Reflection," *Judgment and Decision Making* 8, no. 4 (2012): 407–24; and Kahan et al., "Motivated Numeracy," 54–86.

[66]Rios et al., "Negative Stereotypes," 959–67.

[67]Gerald Echterhoff and E. Tory Higgins, "Shared Reality: Construct and Mechanisms," *Current Opinion in Psychology* 23 (2018): iv–vii, https://doi.org/10.1016/j.copsyc.2018.09.003; Hardin and Higgins, *Handbook of Motivation and Cognition*, 28–84; and John T. Jost et al., "Ideological Asymmetries in Conformity, Desire for Shared Reality, and the Spread of Misinformation," *Current Opinion in Psy-*

chology 23 (2018): 77–83, https://doi.org/10.1016/j.copsyc.2018.01.003.

[68]Although these unconscious factors are not limited to the Christian, the focus of this discussion is on leveraging psychology for improving intra-Christian dialogue. Within the Christian community, we can start from a shared understanding about the need to see clearly ourselves before we correct others (e.g., Matt. 7:3–5). Moreover, when the Christian community can engage in civil dialogue on contentious issues and demonstrate disagreement with integrity (i.e., correcting beliefs when the data overwhelmingly support that correction) and in love, this is a powerful witness to non-Christians. At least philosophically (even if not always in reality, for many of the psychological reasons discussed in this article), the scientific community respects disagreements in weight of evidence and theoretical arguments; seeing this same kind of discussion done with humility and Christian charity may be an especially important waypoint for a non-Christian scientist.

[69]Claude M. Steele, "The Psychology of Self-Affirmation: Sustaining the Integrity of the Self," in *Advances in Experimental Social Psychology,* Vol. 21, ed. Leonard Berkowitz (San Diego, CA: Academic Press, 1988), 261–302, https://doi.org/10.1016/S0065-2601(08)60229-4.

[70]Geoffrey L. Cohen, Joshua Aronson, and Claude M. Steele, "When Beliefs Yield to Evidence: Reducing Biased Evaluation by Affirming the Self," *Personality and Social Psychology Bulletin* 26, no. 9 (2000): 1151–64, https://doi.org/10.1177/01461672002611011.

[71]For example, if humor was important, participants would reflect on a time when they felt good about themselves in direct relationship to their humor. Cohen, Aronson, and Steele, "When Beliefs Yield to Evidence," 1151–64.

[72]Constantina Badea and David K. Sherman, "Self-Affirmation and Prejudice Reduction: When and Why?," *Current Directions in Psychological Science* 28, no. 1 (2019): 40–46, https://doi.org/10.1177/0963721418807705.

[73]Roy F. Baumeister and Kathleen D. Vohs, "Revisiting Our Reappraisal of the (Surprisingly Few) Benefits of High Self-Esteem," *Perspectives on Psychological Science* 13, no. 2 (2018): 137–40, https://doi.org/10.1177/1745691617701185; and Geoffrey L. Cohen and David K. Sherman, "The Psychology of Change: Self-Affirmation and Social Psychological Intervention," *Annual Review of Psychology* 65, no. 1 (2014): 333–71, https://doi.org/10.1146/annurev-psych-010213-115137.

[74]Steven M. Smith and Edward Vela, "Environmental Context-Dependent Memory: A Review and Meta-Analysis," *Psychonomic Bulletin & Review* 8, no. 2 (2001): 203–20, https://doi.org/10.3758/BF03196157.

[75]Cohen and Sherman, "The Psychology of Change," 333–71.

[76]Magee and Hardin, "In Defense of Religion," 379–400.

[77]Campbell and Kay, "Solution Aversion," 809–24.

[78]Rhia Catapano, Zakary L. Tormala, and Derek D. Rucker, "Perspective Taking and Self-Persuasion: Why 'Putting Yourself in Their Shoes' Reduces Openness to Attitude Change," *Psychological Science* 30, no. 3 (2019): 424–35, https://doi.org/10.1177/0956797618822697.

[79]"ASA Statement of Faith," The American Scientific Affiliation, https://network.asa3.org/general/custom.asp?page=ASAbeliefs.

[80]Hardin and Higgins, *Handbook of Motivation and Cognition*, 28–84; Sara D. Hodges, Kathryn R. Denning, and Sara Lieber, "Perspective Taking: Motivation and Impediment to Shared Reality," *Current Opinion in Psychology* 23 (2018): 104–8, https://doi.org/10.1016/j.copsyc.2018.02.007; and Namkje Koudenburg, "Regulating Shared Reality with Micro-Dynamics in the Form of Conversation," *Current Opinion in Psychology* 23 (2018): 47–51, https://doi.org/10.1016/j.copsyc.2017.12.002.

[81]For example, the fruit of the Spirit (Gal. 5:22–23).

[82]Cohen, Aronson, and Steele, "When Beliefs Yield to Evidence," 1151–64.

[83]Kennon M. Sheldon and Sonja Lyubomirsky, "How to Increase and Sustain Positive Emotion: The Effects of Expressing Gratitude and Visualizing Best Possible Selves," *The Journal of Positive Psychology* 1, no. 2 (2006): 73–82, https://doi.org/10.1080/17439760500510676.

[84]Genyue Fu et al., "Young Children with a Positive Reputation to Maintain Are Less Likely to Cheat," *Developmental Science* 19, no. 2 (2016): 275–83, https://psycnet.apa.org/doi/10.1111/desc.12304.

[85]Yi Jenny Xiao and Jay J. Van Bavel, "Sudden Shifts in Social Identity Swiftly Shape Implicit Evaluation," *Journal of Experimental Social Psychology* 83 (2019): 55–69, https://doi.org/10.1016/j.jesp.2019.03.005.

[86]Baumeister and Leary, "The Need to Belong," 497–529.

[87]Elaine Howard Ecklund and Kristen Schultz Lee, "Atheists and Agnostics Negotiate Religion and Family," *Journal for the Scientific Study of Religion* 50, no. 4 (2011): 728–43, https://doi.org/10.1111/j.1468-5906.2011.01604.x.

[88]Will M. Gervais and Maxine B. Najle, "How Many Atheists Are There?," *Social Psychological and Personality Science* 9, no. 1 (2018): 3–10, https://doi.org/10.1177/1948550617707015.

[89]For example, race, gender. Marilynn B. Brewer, "The Social Psychology of Intergroup Relations: Social Categorization, Ingroup Bias, and Outgroup Prejudice," in *Social Psychology: Handbook of Basic Principles*, ed. Arie W. Kruglanski and E. Tory Higgins (New York: The Guilford Press, 2007), 695–715; and Marjorie Rhodes and Tara M. Mandalaywala, "The Development and Developmental Consequences of Social Essentialism," *WIREs: Cognitive Science* 8, no. 4 (2017): e1437, https://doi.org/10.1002/wcs.1437.

[90]Sarah Banchefsky et al., "But You Don't Look Like a Scientist!: Women Scientists with Feminine Appearance Are Deemed Less Likely to Be Scientists," *Sex Roles* 75, no. 3–4 (2016): 95–109, https://doi.org/10.1007/s11199-016-0586-1.

[91]Rebecca Zamon, "#ILookLikeAnEngineer Reminds Us That Anyone Can (and Should) Be an Engineer," *The Huffington Post Canada*, August 4, 2015, https://www.huffingtonpost.ca/2015/08/04/ilooklikeanengineer_n_7934098.html; and Cheryan et al., "Do Female and Male Role Models," 656–64.

[92]Tara M. Mandalaywala et al., "The Nature and Consequences of Essentialist Beliefs about Race in Early Childhood," *Child Development* 90, no. 4 (2019): e437–e453, https://doi.org/10.1111/cdev.13008.

[93]Rios et al., "Negative Stereotypes," 959–67; and Simpson and Rios, "Is Science for Atheists?," 740–58.

[94]Scheitle and Ecklund, "The Influence of Science Popularizers," 25–39.

[95]Peter Harrison, *The Territories of Science and Religion* (Chicago, IL: The University of Chicago Press, 2015).

[96]For example, 1 Corinthians 13:12.

[97]James K. A. Smith, "Introduction: Taking Theology and Science to Church," in *All Things Hold Together in Christ: A Conversation on Faith, Science, and Virtue,* ed. James K. A. Smith and Michael L. Gulker (Grand Rapids, MI: Baker Academic, 2018), xi–xxi.

[98]As stated previously, motivated reasoning can occur on both sides of the same issue. Although I focus this section on dismantling the protective processes that promote motivated reasoning away from the scientific consensus, this posture does not assume clear, rational, and totally unmotivated reasoning on the side of mainstream science. As with all of these conversations, nuance is key; knowledge is not held exclusively and perfectly in the minds of scientists or theologians.

[99]Michael G. Strauss, "Age of the Universe and Earth (Billions-of-Years View)," in *Dictionary of Christianity and Science,* ed. Paul Copan, Tremper Longman III, Christopher L. Reese, and Michael G. Strauss (Grand Rapids, MI: Zondervan, 2017), 28–32.

[100]Todd S. Beall, "Age of the Universe and Earth (Thousands-of-Years View)," in *Dictionary of Christianity and Science,* ed. Copan, Longman, Reese, and Strauss, 32–36.

[101]Marcus R. Ross, "Answers in Genesis," in *Dictionary of Christianity and Science,* ed. Copan, Longman, Reese, and Strauss, 42–43.

[102]"Does Young-Earth Creation Matter?," Answers in Genesis, https://answersingenesis.org/why-does-creation-matter/.

[103]"Biblical Creation Divisive?," Answers in Genesis, https://answersingenesis.org/why-does-creation-matter/.

[104]John Mark Reynolds, "Creationism, Young-Earth (Supportive View)," in *Dictionary of Christianity and Science,* ed. Copan, Longman, Reese, and Strauss, 146.

[105]J. W. Rogerson and Judith M. Lieu, eds., *The Oxford Handbook of Biblical Studies* (New York: Oxford University Press, 2006); Kevin Vanhoozer, "From the Literal Interpretation of Genesis to the Doctrine of Literal Six-Day Creation," lecture for Creation Project, Scripture and Ministry from Carl F.H. Henry Center for Theological Understanding, Deerfield, IL, September 14, 2016, video and audio, 57:56, https://henrycenter.tiu.edu/resource/from-the-literal-interpretation-of-genesis-to-the-doctrine-of-literal-six-day-creation/; Gavin Ortlund, "Did Augustine Read Genesis 1 Literally?," September 4, 2017, https://henrycenter.tiu.edu/2017/09/did-augustine-read-genesis-1-literally/; and Victor Reppert, "Argument from Reason," in *Dictionary of Christianity and Science,* ed. Copan, Longman, Reese, and Strauss, 563–65.

[106]I have heard a pastor state that we cannot shout someone into salvation. In the same way, I do not believe that we can shame someone into science. Research on belief polarization and motivated reasoning would affirm this conclusion.

[107]Reynolds, "Creationism, Young-Earth (Supportive View)," 145.

[108]Ibid., 146 (emphasis added).

[109]Rogerson and Lieu, eds., *Oxford Handbook of Biblical Studies.*

[110]Friesen et al., "The Psychological Advantage of Unfalsifiability," 515–29. It is also worth noting the philosophical consistency here between this kind of thinking in Christian communities and the kinds of statements made by ardent atheists such as Richard Dawkins endorsing the belief that it is not possible to pursue good science and be a Christian. In both these extremes, there is not a lot of room for diversity of viewpoint. These viewpoints may be particularly recalcitrant to change.

[111]Mason D. Burns, Margo J. Monteith, and Laura R. Parker, "Training Away Bias: The Differential Effects of Counterstereotype Training and Self-Regulation on Stereotype Activation and Application," *Journal of Experimental Social Psychology* 73 (2017): 97–110, https://doi.org/10.1016/j.jesp.2017.06.003.

[112]Edward Maibach, Teresa Myers, and Anthony Leiserowitz, "Climate Scientists Need to Set the Record Straight: There Is a Scientific Consensus That Human-Caused Climate Change Is Happening," *Earth's Future* 2 (2014): 295–98, https://doi.org/10.1002/2013EF000226.

[113]Sander L. van der Linden et al., "The Scientific Consensus on Climate Change as a Gateway Belief: Experimental Evidence," *PLOS ONE* 10, no. 2 (2015): e0118489, https://doi.org/10.1371/journal.pone.0118489.

[114]Robert J. Brulle, Jason Carmichael, and J. Craig Jenkins, "Shifting Public Opinion on Climate Change: An Empirical Assessment of Factors Influencing Concern over Climate Change in the U.S., 2002–2010," *Climate Change* 114 (2012): 169–88, https://doi.org/10.1007/s10584-012-0403-y.

[115]Rutjens, Sutton, and van der Lee, "Not All Skepticism Is Equal," 384–405.

[116]Pew Research Center, "Religion and Views on Climate and Energy Issues," October 22, 2015, https://www.pewresearch.org/science/2015/10/22/religion-and-views-on-climate-and-energy-issues/.

[117]Or scientific community.

[118]Campbell and Kay, "Solution Aversion," 809–24.

[119]Rutjens, Sutton, and van der Lee, "Not All Skepticism Is Equal," 384–405.

[120]Simpson and Rios, "Is Science for Atheists?," 740–58; and Rutjens and Heine, "The Immoral Landscape?," 1–16.

[121]Catapano, Tormala, and Rucker, "Perspective Taking and Self-Persuasion," 424–35.

[122]Katharine Hayhoe, "Biography," http://www.katharinehayhoe.com/wp2016/biography/.

[123]____, "The Most Important Thing You Can Do to Fight Climate Change: Talk about It," lecture for TEDWomen, November 2018, video, 17:04, https://www.ted.com/talks/katharine_hayhoe_the_most_important_thing_you_can_do_to_fight_climate_change_talk_about_it?language=en.

[124]For example, Colossians 3:23; Galatians 5:22–23.

[125]Samir Okasha, *Philosophy of Science: A Very Short Introduction* (New York: Oxford University Press, 2016).

[126]Jeffrey Winking, "Exploring the Great Schism in the Social Sciences: Confirmation Bias and the Interpretation of Results Relating to Biological Influences on Human Behavior and Psychology," *Evolutionary Psychology* 16, no. 1 (2018): 1–10, https://doi.org/10.1177/1474704917752691.

[127]William F. Brewer and Bruce L. Lambert, "The Theory-Ladenness of Observation and the Theory-Ladenness of the Rest of the Scientific Process," *Philosophy of Science* 68, no. 3 (2001): S176–S186; and John P. A. Ioannidis, "Why Science Is Not Necessarily Self-Correcting," *Perspectives on Psychological Science* 7, no. 6 (2012): 645–54, https://doi.org/10.1177/1745691612464056.

[128]Christopher Allen and David M. A. Mehler, "Open Science Challenges, Benefits and Tips in Early Career and Beyond," *PLOS Biology* 17, no. 5 (2019): e3000246, https://doi.org/10.1371/journal.pbio.3000246.

James C. Ungureanu

Newton Deified and Defied: The Many "Newtons" of the Enlightenment

James C. Ungureanu

More than any other scientist in history, Isaac Newton has been both deified and defied. In this article, I wish to summarize several aspects of the revised historiography on Newton. I will note in particular Newton's debt to the prisca sapientia *and* prisca theologia *for his natural philosophy. I argue that Newton's natural philosophy cannot be separated from his theology. In the process, however, Newton had radically altered traditional Christian beliefs. And, in so doing, Newton ironically perpetuated the conflict he wished to avoid.*

According to the eighteenth-century French *philosophes*, Isaac Newton's life and work ushered in the modern age. In early spring of 1727, for instance, Voltaire (1694–1778) had witnessed the funeral preparations for Newton, who was buried in the Jerusalem Chamber at Westminster Abbey. Voltaire described Newton's ceremony as full of grandeur, his pall carried by English noblemen, including the Lord Chancellor himself. "He was buried," Voltaire notes, "like a king who had done well by his subjects."[1] True to that description, his heirs erected in 1731 a monument at his tomb in Westminster Abbey, "a baroque monstrosity with cherubs holding emblems of Newton's discoveries."[2] An inscription below it reads:

> Here is buried Isaac Newton, Knight, who by a strength of mind almost divine, and mathematical principles peculiarly his own, explored the course and figures of the planets, the paths of comets, the tides of the sea, the dissimilarities in rays of light, and, what no other scholar has previously imagined, the properties of the colors thus produced. Diligent, sagacious and faithful, in his expositions of nature, antiquity and the holy Scriptures, he vindicated by his philosophy the majesty of God mighty and good, and expressed the simplicity of the Gospel in his manners. Mortals rejoice that there has existed such and so great an ornament of the human race![3]

Similarly, Voltaire exclaimed that Newton had been the "greatest man who ever lived, the very greatest, the giants of antiquity are beside him children playing with marbles,"[4] and in one of his notebooks wrote, "Before Kepler, all men were blind, Kepler had one eye, and Newton had two eyes."[5]

These hagiographic celebrations of Newton following his death would endure, as when popular writer Benjamin Martin (1705–1782), in his *Panegyrick on the Newtonian Philosophy* (1749), declared that the "mystery that has been hid from Ages, and from Generation … is now made manifest to all Nations, by the divine Writings of the immortal Sir Isaac Newton." As such, he concluded, "it is more Honour to be King of the learned British Nation, then Emperor of all the World besides."[6] Scottish philosopher and historian David Hume (1711–1776) concurred when he writes, in his *History of England* (1756), that "in Newton this island [i.e., England] may boast in having produced the greatest and rarest genius that ever rose for the ornament and instruction of the species."[7] In 1802, French

James C. Ungureanu, *PhD (Institute for Advanced Studies in the Humanities-University of Queensland), is Historian in Residence at the George L. Mosse Program in History at the University of Wisconsin-Madison. His most recent book is* Science, Religion, and the Protestant Tradition: Retracing the Origins of Conflict *(University of Pittsburgh Press, 2019).*

philosophe Henri de Saint-Simon (1760–1825) went so far as to found a new church under the hegemony of scientist-priests, calling it the "Religion of Newton."[8] But perhaps the best known, and oft-cited, hagiographic panegyric for Newton came from Alexander Pope's (1688–1744) famous couplet:

> Nature, and Nature's Law lay hid in Night.
> GOD said, *Let Newton Be!* and all was Light.[9]

This *deification* of Newton, with adjectives of "divine" and "immortal," had become, as historian Peter Gay put it, "practically compulsory."[10] According to most of the *philosophes*, Newton was the paragon of the Enlightenment, the first great emancipator of human thought from the despotic rule of tradition, prejudice, and authority, ushering in a new epoch of enlightened rationality. Even in our own time, writers continue to enlist Newton in their personal cult of the "greats" of modern civilization.[11]

However, more than any other scientist in history, Newton himself has been *defied*, in the sense that his disciples and biographers have produced not only an inaccurate but sometimes entirely false account of his life and work. This "Newtonian mythomania,"[12] as one scholar called it, was inaugurated not by the *philosophes* but by Newton's first biographers. Voltaire had already recognized that they attributed all knowledge and discovery to an idealized Newton:

> There are people who think that if we are no longer content with the abhorrence of the vacuum, if we know that the air has weight, if we use a telescope, it is all due to Newton. Here is the Heracles of the fable, to whom the ignorant attributed the deeds of other heroes.[13]

Indeed, it was a contemporary of Newton's, namely, William Stukeley (1687–1765), who began the fables. Stukeley was Newton's first biographer, and his *Memoirs of Sir Isaac Newton's Life* (1752) was clearly a devotional, if not a propagandizing, account of his hero's life, often extolling Newton and his work as "immortal" and able to "wipe out all faults."[14] During the Victorian period, Thomas Chalmers (1780–1847), David Brewster (1781–1868), Adam Sedgwick (1785–1873), John F. W. Herschel (1792–1871), and William Whewell (1794–1866), among many others, exalted Newton for his social, intellectual, and moral ideals.[15] Brewster, for instance, published a similar hagiographic account in his *The Life of Sir Isaac Newton* in 1831. Unlike Stukeley, however, Brewster had access to most of Newton's voluminous, unpublished manuscripts. Yet he decided to reinforce the hagiographic image, calling Newton the "high-priest of science," rationalizing those aspects that contradicted his mythical Newton.[16]

Two other biographers deserve special mention: Member of Parliament and Master of Mint John Conduitt (1688–1737) and English theologian William Whiston (1667–1752). Newton scholar Stephen D. Snobelen points out that, in the notes for a projected biography of Newton, Conduitt believed that Newton was engaged in the reform of both natural philosophy and theology—that is, a "dual-reformation." Conduitt, who incidentally succeeded Newton as Master of Mint after his death, had access to Newton's unpublished manuscripts, and was troubled to discover that his friend had been deeply involved in theological questions that veered into religious heterodoxy. But for the ordained clergyman Whiston, who also succeeded Newton as Lucasian Professor of Mathematics at Cambridge, he had no reservations about his mentor's heresy. He openly converted not only to Newton's natural philosophy but also to his heterodoxy, which ultimately cost him the Lucasian chair and led to his expulsion from the university. Like his idol, Whiston argued for something like a dual-reformation in natural philosophy and theology.[17]

There is no doubt that Newton's scientific achievements were unprecedented. His pioneering work on the calculus, his theory of universal gravitation, his experiments in optics, and his construction of the first reflecting telescope marked the culmination of movements and ideas that had begun in the Middle Ages. However, Newton is not the man that his most slavish disciples claim him to be. The problem is, of course, that most of the popular accounts are fictions, Voltaire's "pack of tricks we play on the dead." For, in addition to his scientific achievements, Newton was also an anti-Trinitarian, a natural magician and alchemist, and, perhaps most important, an adherent of the "*prisca sapientia*" and "*prisca theologia*" of the ancients, which was actually a collection of Renaissance concepts that contended that there was an "original" unity to all religious and philosophical schemes. As we shall see, Newton's idea of reform was closely associated with the recovery of what he believed was a lost "ancient wisdom" or "theology." Indeed, Newton's studies in astronomy, optics, and mathematics occupied only a small portion of his time, whereas most of his efforts were devoted to church history, theology, prophecy, and alchemy.[18]

The real Newton first began to emerge in 1936, when economist John Maynard Keynes (1883–1946) purchased a set of Newton's manuscripts considered to be of "no scientific value" from the Portsmouth Collection.[19] Keynes had examined its contents and prepared a brief essay based on his observations to be delivered at the Royal Society in London. He died, however, three months before the address was to take

place. His brother Geoffrey in turn read the address to the Society, and what was said would forever change Newtonian scholarship:

> In the eighteenth century and since, Newton came to be thought of as the first and greatest of the modern age of scientists, a rationalist, one who taught us to think on the lines of cold and untinctured reason. I do not see him in this light. I do not think that anyone who has pored over the contents of that box which he packed up when he finally left Cambridge in 1696 and which, though partly dispersed, have come down to us, can see him like that. Newton was not the first of the age of reason. He was the last of the magicians, the last of the Babylonians and Sumerians, the last great mind which looked out on the visible and intellectual world with the same eyes as those who began to build our intellectual inheritance rather less than 10,000 years ago.[20]

By "magician," Keynes meant that Newton could no longer be seen simply as the "prince of scientific rationalism," but someone who was also a mystic and alchemist, who "looked on the whole universe and all that is in it *as a riddle*, as a secret which could be read by applying pure thought to certain evidence, certain mystic clues which God had laid about the world to allow a sort of philosopher's treasure hunt to the esoteric brotherhood." For Newton, according to Keynes, the universe was a "cryptogram set by the Almighty."[21]

The last several decades have seen an avalanche of books, articles, and conference papers revising popular conceptions of Newton as chiefly a scientist.[22] The rest of this article has two central aims. First, I wish to summarize several aspects of this revised historiography, noting particularly Newton's debt to the *prisca theologia* tradition for his natural philosophy. Secondly, and concomitantly, I argue that Newton's natural philosophy cannot be separated from his theology. Newton's life and work, as Keynes so vividly put it, demonstrates one grand project: deciphering the "cryptogram" of God's creation. Thus "science and religion" for Newton were not distinct spheres, but integral and homogenous. For Newton, God's truth is revealed in his two books: the book of scripture and the book of nature.

In the process, however, Newton had radically altered his Christian beliefs. And in so doing, Newton ironically perpetuated the conflict he wished to avoid. This, indeed, will further clarify where the "conflict" really lies: that is, not between some abstract notion of "science and religion" but between contending theological beliefs.[23] After decades of scholarship denouncing the "conflict thesis," the idea that science and religion are irrevocably and fundamentally at odds, historians of science and other scholars continue to talk about it with little sign of changing public opinion. Acknowledging that conflict emerges within a theological context rather than between science and religion will not only move the discussion forward, but it will also hopefully alert Christian scholars and scientists to the nuances of the debate, and thus help them prepare to redirect (or perhaps correct) their own commitments and convictions.

Religion, Prophecy, and Heresy

Newton "saw himself as the last of the interpreters of God's will in actions, living on the eve of the fulfillment of the times."[24] How he came to view himself and his work as an instrument of God's will began before his interests in natural philosophy. Growing up in a Protestant home in the seventeenth century, its ethos was doubtless a historical and scriptural religion. The Bible was also central to his education at grammar school in the 1650s. Richard Westfall points to the possibility that a young and docile Newton read through hundreds of theological books his stepfather, the Reverend Barnabas Smith, left behind at his death in 1653.[25] Moreover, several books he is known to have bought in 1661, the year of his matriculation at Trinity College, were on Protestant theology—including John Calvin's *Institutio christianæ religionis* (1561) and his disciple, Theodore Beza's *Annotationes maiores in novum testamentum* (1594).[26] Furthermore, in one of his notebooks, dated 1662, Newton listed some 50 sins of his youth, exemplifying his teenage turpitude, and, more importantly, demonstrating his austere Protestant piety. The list included, for example, "using the word 'God' upenly," "eating an apple at Thy house," "making a mousetrap on Thy day," "making pies on Sunday night," "threatening my father and mother Smith to burne them and the house over them," "wishing death and hoping it to some," "striking many," "having uncleane thoughts words and actions and dreamese," "setting my heart on money," "not turning nearer to Thee for my affections," "not loving Thee for Thy self," among many others.[27]

Shortly after arriving at Cambridge, Newton appears to have abandoned—or, at least, very quickly moved beyond—the traditional scholastic curriculum. Westfall notes that Newton manifested very quickly an interest toward the new mechanical philosophy in vogue, devouring works of Descartes, Charleton, Galileo, Boyle, Hobbes, More, and others.[28] At about the same time, Newton purchased another notebook and began recording the progress of his studies, entitling it with "*Quæstiones quædam Philosophicæ*," or "Certain Philosophical Questions."[29] In it, theological topics parallel sections on natural philosophy, including discussions on God, creation, the soul, and biblical

exegesis. In other words, Newton's *Questiones* reveals that his stream of thought regarding natural philosophy coincided with his developing theological speculations.

Other notebooks dating from 1664 to 1670 show that Newton was also venturing to ever more complex systems of mathematics. It was during these years, for example, the so-called *annus mirabilis* of 1666, that Newton developed his method of *fluxions*—i.e., the calculus. Newton never did anything halfheartedly, fastidiously incorporating his calculus into his mathematical physics and his study of optics.[30] To this, Newton also added the study of alchemy. This was an inconvenient truth for many of his early admirers. In his *Memoirs* of Newton's life, for instance, Brewster had grudgingly acknowledged that between 1666 and 1669, his studies "were of a very miscellaneous kind," and involved a "new branch of science which seems at this time to have occupied his attention, and which he continued to prosecute with much zeal during the most active period of his life." He notes that, among other things, Newton had purchased a variety of chemicals, along with "lenses" and "furnaces," including a copy of German publisher Lazarus Zetzner's (1551–1616) alchemical text, *Theatrum chemicum*, which was a massive six-volume compendium or textbook on alchemy published from 1602–1661.[31] Brewster also went on to cite a letter by Humphrey Newton (no relation), Isaac's assistant and amanuensis for nearly five years, from 1683 to 1689, wherein he recalled that his master

> very rarely went to bed till *two* or *three* of the clock, sometimes not until *five* or *six*, lying about four or five hours, especially at spring and fall of the leaf … he used to employ about *six* weeks in his elaboratory, the fire scarcely going out either night or day … What his aim might be I was not able to penetrate into, but his pains, his diligence at these set times made me think he aimed at something beyond the reach of human art and industry.[32]

Brewster felt he needed to apologize that Newton, a "mind of such power," could "stoop to be even the copyist of the most contemptible alchemical poetry, and the annotator of a work, the obvious production of a fool and a knave."[33] I will return to Newton's alchemy below; for now, it is enough to say that, by the end of the decade, Newton had begun not only serious reading in alchemy, but had also obtained furnaces, initiated his own experimental program, and immersed himself in alchemical networks, all the while he was working out his calculus.

Signs of Newton's religious heresy began to emerge during the same period, in the early 1670s. Sometime after his appointment to the Lucasian Professorship in 1669, around his early thirties, Newton became obsessed with certain theological issues. As Westfall observes,

> There can be no reasonable question that at least part of the time, when Newton expressed impatience at the interruptions caused by optical and mathematical correspondence during the 1670s, it was theology that preoccupied him.[34]

During this time, Newton began an exacting, painstakingly intense study of the Bible, which apparently led him to conclude that the doctrine of the Trinity was a post-biblical corruption. Further, having seemingly read all the important patristic writers, Newton came to view Athanasius, the fourth-century bishop of Alexandria, as a charlatan and beguiler of scripture, who introduced metaphysical subtleties into the church, and therefore corrupted the original meaning of the Bible. Newton argued that

> as a father and his son cannot be called one King upon account of their being consubstantial but may be called one King by unity of dominion if the Son be Viceroy under the father: so God and his son cannot be called one God upon account of their being consubstantial.[35]

Though Newton did not want to limit the power of the Son, he determined that Christ's power was derived solely from the Father and that of himself could do nothing. In all things, the Son submitted his will to the Father, which would be altogether unreasonable if he were his equal. The union of Father and Son was like that of the saints, an agreement of wills.[36] By emphasizing those passages that speak of Christ's subordination to the Father, while dismissing other putative scriptural passages used to support the doctrine of the Trinity as later corruptions, Newton concluded that Christ should be worshipped for his obedience unto death—for what he had done, not for who he is. Though a divine mediator, Christ was subordinate to the Father, whose will he carried out.

Thus by the mid-1670s, Newton was committed to some type of anti-Trinitarianism theology. In 1553, Michael Servetus (1509–1553), who was a brilliant physician and often credited for discovering the pulmonary circulation of blood, was executed in Calvin's Geneva for publishing his *De Trinitatis Erroribus* (1531) and *Dialogorum de Trinitate* (1532), in which he argued that the Council of Nicaea was a great apostasy, and that the promulgation of the doctrine of the Trinity had offended God.[37] At around the same time, a group of Italian humanists who similarly rejected a number of orthodox doctrines, including the doctrine of the Trinity, fled Switzerland for Poland in hopes of finding religious tolerance. Included in this refugee group was Laelius Sozzini (Latinized as "Socinus") (1525–1562), the man from whom Socinianism derives its name.

Laelius doubted the doctrine of the Trinity and questioned the Atonement. His more well-known nephew, Faustus Socinus (1539–1604), systemized his uncle's theology, and became the leader of the so-called "Minor Reformed Church," or what would later be called "Unitarians," who, of course, deny the doctrine of the Trinity.[38]

During Newton's lifetime, numerous English anti-Trinitarian treatises appeared. In fact, many of the Latitudinarian divines, who were a group of liberal Anglican clergymen who aligned themselves with progressive and liberal movements, often expressed anti-Trinitarian sympathies. Moreover, the Latitudinarians, in many ways a product of the earlier Cambridge Platonists, hailed the sciences as signs of a new age of light.[39] English philosopher and Anglican Samuel Clarke (1675–1729), for example, who was a personal friend of Newton, published in 1712 his *The Scripture Doctrine of the Trinity*, in which he promoted a "moderate Arianism," according to Maurice Wiles.[40] If Clarke's views were "moderate," Newton's anti-Trinitarianism was still yet more radical. In one of his "drafts on the history of the Church," for example, Newton fumed that "the heathens made all their Gods of one substance and sometimes called them one God, and yet were polytheists."[41] Most of Newton's theological writings are singularly devoted to exposing the so-called "falsifiers" of New Testament texts, vilifying the Church Councils as the corruptors of the pristine and original religion.

Indeed, integral to Newton's anti-Trinitarianism was his deep interest in biblical prophecy, and, ultimately, his high view of scripture. While working out his notes on the *Principia* and formulating his "*Regulæ Philosophandi*," or "Rules for the Study of Natural Philosophy," Newton was also engaged in developing a hermeneutic of the prophetic books of the Bible. He wrote,

> So many and clear Prophecies, concerning the things to be done at Christ's second coming, are not only for predicting but also for effecting a recovery and re-establishment of the long-oft truth, and setting up a kingdom wherein dwells righteousness.[42]

He goes on to say that the coming events will "prove" the Apocalypse, and "all together will make known the true religion, and establish it."[43] Like many others during his time, Newton argued that miracles associated with biblical claims were the best evidence to guarantee both the authority of the Bible and the authority of Christ as portrayed in the Bible. And according to Newton, of all the kinds of miracles, fulfilled prophecies were the most convincing.

But what needs to be emphasized here is that, just as Newton formulated rules for the study of nature, he also formulated rules for interpreting the Bible.[44] As he proceeded with both endeavors, it seems clear that his methodology in the two domains reinforced one another and that they depended strongly on his conceptions of God and of the relationship between God and creation. Parallels between the two abound. One of the most remarkable parallels is between Newton's first rule for the study of nature and the ninth of his "Rules for methodising the Apocalyps," which, incidentally, were both formulated at approximately the same time. The first rule in the *Principia* states that we are to admit "no more causes of natural things than such as are both true and sufficient to explain their phenomena," because "nature is simple and does not indulge in the luxury of superfluous causes."[45] The ninth rule for prophecy reinforced a similar interpretation of scriptural passages based on the principle of simplicity:

> … choose those constructions which, without straining, reduce things to the greatest simplicity … Truth is ever to be found in simplicity, and not in the multiplicity and confusion of things. As the world, which to the naked eye exhibits the greatest variety of objects, appears very simple in its internal constitution when surveyed by the philosophic understanding, so it is in these visions. It is the perfection of all God's works that they are done with the greatest simplicity. He is the God of order and not confusion. And therefore as they that would understand the frame of the world must endeavor to reduce their knowledge to all possible simplicity, so must it be in seeking to understand these visions.[46]

What is most important for our purposes is that, in these early statements, Newton believed that he had recovered some of the original purity of pristine Christianity. Indeed, Newton saw himself in a "special bond to God … destined to unveil the ultimate truth about God's creation."[47] In a series of letters to philosopher John Locke (1632–1704), beginning in November of 1690, Newton outlines a "historical account of two notable corruptions of Scripture," which reveals Newton's theological agenda as both reformist and heretical.[48] The two corruptions were ostensibly the prime trinitarian passages in the Bible: 1 John 5:7, and 1 Timothy 3:16. Newton also composed another letter about some twenty-six additional passages, all lending support to trinitarianism, which he believed were also corruptions:

> By these instances it's manifest that y^{e} scriptures have been very much corrupted in y^{e} first ages & chiefly in the fourth Century in the times of the Arian Controversy. And to y^{e} shame of Christians be it spoken y^{e} Catholicks are here found much more guilty of these corruptions (so far as I can yet

> find) & then to justify & propagate them exclaimed against the Hereticks & old Interprets, as if the ancient genuine readings & translations had been corrupted.[49]

It is notable that Newton's prophetic interests and heretical leanings continued even after the publication of his *Principia*, and are therefore evidenced both in his personal correspondence and unpublished manuscripts.

Several conclusions can be drawn here. The most obvious is that Newton used his scientific discoveries in support of the belief in an intelligent and all-powerful God. Newton's famous "General Scholium" in his 1713 edition of the *Principia* is devoted entirely to his ideas about God. In it, Newton powerfully declared that "this most elegant system of sun, planets, and comets could not have arisen without the design and dominion of an intelligent and powerful being." For Newton, the "true God is a living, intelligent, powerful" God who "rules all things, and he knows all things that happen or can happen." The true God, in short, "endures always and is present everywhere."[50] Moreover, his 1692–1693 letters to classical scholar and theologian Richard Bentley (1662–1742), the first of the Boyle lecturers in natural theology, show that he would assist a project which turned the *Principia* into an argument for divine providence.[51]

Newton's piety and his search for the "true religion" were part and parcel of a developing pattern in his intellectual thoughts. But herein lie perhaps the most disturbing elements of Newton's religious convictions. As Snobelen has shown, there is an anti-Trinitarian subtext to his theology in the General Scholium.[52] Here Newton referred to God as "*Pantokrator*"—that is, the "Almighty" or "universal ruler." In his private papers, he used the same expression to declare that the *Pantokrator*, the Father alone, is truly God, and that the metaphysical speculations of the "Gentiles" (i.e., the homoousians) corrupted the original meaning of the term "God." The parallels show that Newton had used the Scholium, in part, as a subversive anti-Trinitarian polemic, something only his most trusted friends would have recognized.

Moreover, there is a direct connection between Newton's search for the "true religion" and his alchemical writings and experiments. We now know that Newton transcribed and composed about a million words on the subject of alchemy. During the early modern period, "alchemy" and "chymistry," as it was called then, were not distinct disciplines. Alchemy was never simply about the transmutation of metals into gold.[53] As historian William Newman has recently shown, Newton's engagement with alchemy was rational, serious, sustained, and largely experimental.[54]

But to what end? If we turn to other Newton scholars, we find hints of an answer. P. M. Rattansi, for instance, insisted that Newton's alchemical papers demonstrated his growing allegiance to the hermetic doctrine of "universal spirit" animating all life—a doctrine which he shared with the Cambridge Platonists.[55] More explicitly, according to Betty Dobbs and Richard Westfall, Newton posited "occult" forces of attraction and repulsion in his system of physics. In his early years at Cambridge, Newton compiled a massive "Index Chemicus," a compendium of over one hundred pages that contained thousands of references to more than 150 alchemical works.[56] Between the years 1668 and 1696, Newton spent approximately one third of his time working out some of these alchemy formulas. This work occupied the spring and autumn of each year, during which time his "furnace never went out." The only other work to get in the way of his alchemy was the writing of the *Principia*, which took only about eighteen months.

But, again, what was Newton after in his alchemical research and experiments? According to Dobbs, during the seventeenth century "alchemy served a real though largely unconscious religious function for the adepts and that spiritual aspect of alchemy received emphasis during a time of religious unrest and dissatisfaction after the Reformation."[57] Dobbs argues that Newton used alchemy as a critical counterweight against the inadequacies of ancient and contemporary atomism, which was seeing something of a revival at the time. Mechanical philosophies before Newton were not unified by any means, but these variegated theories generally agreed that bodies interacted only by contact. Thus, when Newton devised his own mechanical theory, he tacitly promoted nature's ability to act on bodies from a distance with what he called "active principles," which earned him the opprobrium of German philosopher Gottfried Leibniz (1646–1716) and Dutch physicist Christiaan Huygens (1629–1695), among others. But for Newton, these "active principles" were responsible for gravity, magnetism, fermentation, and other forces. As Dobbs writes, "the alchemical active principle—the vital spirit of which he [Newton] was in hot pursuit—was no more and no less than the agent by which God exercised his providential care among the atoms."[58] For Newton, alchemy was important because it could demonstrate God's action in the world, and thus forever lay atheistic mechanistic philosophy to rest.

For Newton, the "active principles" are God's means of ordering and bringing activity to the world, and thus exercising his divine providence over it. Activity in nature was the province of divinity, and where Newton used the term "active" in his discussions of forces, we really should understand, wrote Dobbs, "that a divine

spirit is there at work either directly or indirectly, and that divine spirits … are unequivocally incorporeal."[59] What is more, Newton identified this "divine spirit" with Christ, who acted as God's viceroy:

> He [Christ] is said to have been *in the beginning with God* & that *all things were made by him* to signify that as he is now gone to prepare a place for the blessed so in the beginning he prepared & formed this place in which we live & thenceforward governed it. For the supreme God doth nothing by himself which he can do by others.[60]

With this, we can see a fascinating connection between Newton's alchemy and his anti-Trinitarianism. For, in the same manuscript, Newton goes on to say that "God & his son cannot be called one God upon account of their being consubstantial," but only through a "unity of Dominion … the Son receiving all things from the Father, being subject to him, executing his will … & so is but one God with the Father as a king & his viceroy are but one king."[61] In other words, Christ, as God's executive, directs the "active principles." Thus, universal gravity, for Newton, demonstrates the omnipresence of God the Father; the alchemical agent in micromatter indicates continuing supervision of the world by God's viceroy, the Christ. Newton's alchemy, then, was his attempt to locate God's hand in nature, and thus push back against what he saw as an increasingly mechanized universe. Newton, it seems, found a way to link God to gravity through alchemy.

Newton preferred not to publicize his involvement in alchemy. A handful of his contemporaries did know about it though. A fascinating correspondence between Newton and Locke, for example, following the death of Boyle, reveals that the three men exchanged alchemical secrets and pledged each other to silence.[62] As Newman observes, if Newton was a "magician," then so were Boyle, Locke, and many other figures of the so-called "scientific revolution." This should not surprise us for, to borrow a concept from Alfred North Whitehead, this was the "climate of opinion." As Dobbs pointed out, alchemy—and the study of the natural world in general—held a special religious function for these thinkers, especially ones who were dissatisfied with the general state of the religious world. Indeed, Newton's most concentrated work on alchemy and the scriptures occurred concurrently. In both alchemy and theology, Newton believed that a pure ancient doctrine had been corrupted in the course of its transmission through history. But he also believed that it could be recovered by intensive interpretative efforts devoted to a wide range of texts. His method for interpreting scriptural prophecies, as we took note of earlier, could equally have described his approach to the alchemical writings.

Newton was certain that all of the prophets had written in "one & the same mystical language," which was "as certain & definite in its signification as is the vulgar language of any nation whatsoever." He went on:

> The Rule I have followed has been to compare the several mystical places of scripture where the same prophetical phrase or type is used & to fix such a signification to that phrase as agrees best with all the places.[63]

This process of understanding both alchemical and biblical text engendered an allegorical hermeneutic. Newton came to believe that the account of Creation presented in Genesis was an allegorical description of an alchemical process. In the mid-1670s, Newton copied a manuscript note which begins:

> It may seem an admirable & new paradox y^{t} Alchemy should have concurrence wth Antiquity and Theology; y^{e} one seeming merely humane & y^{e} other divine; & yet Moses, y^{t} ancient Theologue describing and expressing y^{e} most wonderful Architecture of this great world tells us y^{t} y^{e} spirit of God moved up y^{e} waters wth was an indigested chaos, or mass created before by God.[64]

Out of this chaos, "God's great Alchemy" created the order of the world, manipulating matter by means of the *spiritus* as the alchemist tried to do in the laboratory. The alchemist's work was thus analogous to the divine activity at the Creation: both achieved their effects through the manipulation of the subtle vegetative spirit. As Newton explained in a notebook from the 1680s:

> [J]ust as the world was created from dark Chaos through the bringing forth of the light and through the separation of the aery firmament and of the waters from the earth, so our work begins forth the beginning out of black chaos and its first matter through the separation of the elements and the illumination of matter.[65]

Newton's research in alchemy and theology were thus simultaneous and interconnected. In both cases, Newton was engaged in a process of textual interpretation, devoted to uncovering the secret truth that had been distorted and concealed by intentional obfuscation.

The Recovery of the Ancients

What is most important here for our purposes is that, as Dobbs observed, "Newton's intellectual development is best understood as a product of the late Renaissance, a time when the revival of antiquity had conditioned the thinkers of Western Europe to look backward for Truth."[66] While he was working out his alchemy and composing his rules for the interpretation of biblical prophecy and for the understanding of nature, Newton had also immersed himself in the study of comparative

mythology and the origins of religious idolatry, which had become an increasingly popular genre of seventeenth-century historiography.

We know, for instance, that Newton owned, read, and annotated the universal histories of Walter Raleigh (1552–1618), Samuel Bochart (1559–1667), Gerardus Joannes Vossius (1577–1649), John Marsham (1602–1685), Robert Morden (1650–1703), Anton van Dale (1638–1708), and others, all of whom dealt with the "history" of religious idolatry through an examination of Jewish, Christian, and pagan sources. Such histories were attempts to justify the ways of God to humankind by disclosing the providential order in an otherwise postlapsarian world. Perhaps most important for Newton was Vossius's *De theologia gentili, et physiologia Christiana, sive, De origine ac progressu idololatriæ: ad veterum gesta, ac rerum naturam, reductæ: de que naturæ mirandis, quibus homo adducitur ad Deum* (1641), which was one of the first books to examine the theology of non-Christian religions from a historical perspective. As one of Holland's leading humanists, who was also the son of a Reformed minister and himself a minister, Vossius believed that "true religion" required both true knowledge and true worship of the true God. Although pagan religion and idolatry are false, their object were ultimately correct. For Vossius, even false religion may have a divine origin since God reveals himself not only in scripture but also in nature and history.[67]

Newton took the material found in Vossius and others and composed, sometime in the mid-1680s, perhaps one of his most puzzling manuscripts, *Theologiæ Gentilis Origines Philosophicæ*, or "The Philosophical Origins of Gentile Theology."[68] But as Westfall rightly points out, the *Origines* was the "most important theological work" Newton ever produced. Here Newton offered a history of the gradual corruption of an original, pristine, and true religion. He traced true religion back to the biblical Noah and his family. According to Newton, this Noachide religion survived in the Temple at Jerusalem and, to some extent, in pagan temples, especially those of the Roman cult of Vesta, the goddess of the hearth.

Newton also believed that these adherents of true, primitive religion had acknowledged the heliocentric cosmos in the architecture of their temples or prytanæa, which were constructed around central fires that represented the sun. As Newton wrote,

> … one design of y^{e} first institution of y^{e} true religion to propose to mankind by y^{e} frame of y^{e} ancient Temples, the study of the frame world as the true Temple of y^{e} great God they worshipped. And thence it was y^{t} y^{e} Priests anciently were above other men well skilled in y^{e} knowledge of y^{e} true frame of Nature & accounted it a great part of their Theology.[69]

Thus the original, pristine monotheistic religion included the study of nature. The ancient priests, such as the Persian magi and the Chaldeans of Babylon, were at once astronomers and theologians. This expression of belief in a *prisca theologia* pervaded Newton's theological writings.

But this primitive religion and its knowledge of the natural world was lost over time with the rise of idolatry, for just as Judaism had been corrupted after the time of the prophets, so Christianity had been led astray by proponents of the doctrine of the Trinity. Yet Newton also believed that God periodically brought about reformations that restored primitive religion, and the two most notable figures he cites are Moses and Christ. Thus, like other Protestant universal histories, Newton argued that men had discarded an absolute faith in God for a "veneration" of secondary effects, thereby confusing form and content, the kernel and the husk.

Perhaps most importantly, Newton also proposed a way to recover the pristine religion of Noah. Newton, in short, called on a divinely sanctioned natural philosophy to return humanity to a prelapsarian Paradise. Indeed, Newton considered the notion that he himself might be part of "a remnant, a few scattered persons which God hath chosen," who "can set themselves sincerely & earnestly to search after truth."[70] It was this "remnant" who preserved or were able to recover ancient natural philosophy and true religion with the kind of dedication and commitment that Newton himself had given to science, theology, and history. The discoveries made by Newton in natural philosophy, then, were merely the rediscovery of the ancient revelations.

The *Origines*, therefore, is an apocalyptic narrative of decline that emphasized the crucial role science could play in overcoming corruption in religion *and* natural philosophy. In this sense, Newton had decentered the Bible, despite his dedication to biblical chronology and prophecy. There is no way, he wrote in *Origines*, "to come to y^{e} knowledge of a Deity but by the frame of nature." For as far back as Noah, the true system of the world was known through the study of nature, "so that anyone of keen mind, from any people, might gather the truth from it, and thus come to know God from his works." After all, the trinitarians had corrupted the biblical text, and thus undermined the earlier metaphor of "Two Books," the book of nature and the book of God's word. The true "frame of nature," then, is made manifest only through a painstaking program of inductive investigation of nature.

All of this also shows strong echoes of the Renaissance commonplace of the lost *prisca sapientia*, particularly the

Hermetic tradition. Indeed, according to Frank Manuel, Newton felt closer to the hermetic philosophical tradition than he did to the English mechanical philosophers of his own time.[71] In the fifteenth century, Marsilio Ficino (1433–1499), a central figure in Renaissance humanism, worked for the Medicis, the powerful royal and banking family of Florence, translating new works of Plato that had recently been discovered. Around 1463, a new set of documents was recovered from a Macedonian monastery. These came to be known as the *Corpus Hermeticum*, purported to be the ancient writings of Hermes Trismegistus, an Egyptian sage who was admired by some of the early Church Fathers, including Athenagoras, Clement of Alexandria, Tertullian, Lactantius, and Eusebius.[72] However, it was later demonstrated by Isaac Casubon (1559–1614) that these texts were actually from the fourth century CE, written by several authors, and from a number of different theological perspectives.[73]

Immensely rich in content, there are only a handful of features of the Hermetic tradition that we can note. Ficino's foreward to his translation of the *Corpus* became commonplace. Combing aspects of Neoplatonic and late antique Christian thought, Ficino argued that Hermes was "the father of all theology." "There arose," he wrote, "a single, internally consistent, primal theology (*prisca theologia*)."[74] A similar interpretation was made by Giovanni Pico della Mirandola (1463–1494), another central figure of Renaissance humanism. To be sure, Pico's ideas were not solely derived from Hermeticism, but his debt to it is revealed in that in his "nine hundred theses" on philosophical, Cabalistic, and theological conclusions, ten are directly drawn from several works of the *Corpus*.[75] Central to both Ficino and Pico's interpretation of the *Corpus* is that they believed that there was

> a fundamental agreement among the various traditions of intellectual history, which included the Greek philosophy of Plato and Aristotle, the Judeo-Christian tradition of the Bible and its theological interpretation in the works of Thomas Aquinas, and the esoteric traditions of the Cabala, Hermeticism, and Arab philosophy.[76]

The popularity of the *Corpus* continued into the next century. While none of these traditions, however, were uniquely or even primarily "Hermetic," they gained authority by virtue of their connection with the primary values expressed in the vestiges of the Hermetic tradition. Both Jacques Lefèvre d'Étaples (1455–1536) and Philip Melanchthon (1497–1560), one a professor of the Genevan reformer John Calvin (1509–1564), the other a close colleague of Martin Luther (1483–1546), offered distinct interpretations of the *Corpus*. The physician, natural philosopher, and alchemist Paracelsus (1493–1541) was also part of this broader background. His work illustrates the importance of the Pythagorean or Neoplatonic worldview that had revitalized the Hermetic tradition. This Neoplatonic approach to the world continued to endure as an important element within "modern" science throughout the seventeenth century. Newton, for example, was deeply involved with the study of Paracelsan alchemy.[77]

Newton, of course, was not alone among his contemporaries who appealed to the *prisca* tradition.[78] But it is only with his theological and chronological writings that we can now see how Newton regarded his natural philosophy as an integral part of a radical and comprehensive recovery of the true ancient religion. This apparently eccentric idea, and its significance for Newton's approach to mechanics, can be shown in his drafts for the additional corollaries that he wrote around 1694 for a projected second edition of the *Principia*. This material was intended to support the philosophical assertions on which the *Principia's* demonstrations rest. Ultimately, however, most of it remained unpublished. Nevertheless, it is clear that Newton regarded such ideas as an essential justification for his system of mechanics, together with its theories of matter, space, and gravitation.

These drafts have become known by Newtonian scholars as the "classical" Scholia, for they drew heavily upon the thoughts of Greco-Roman philosophers. A letter from Swiss mathematician Nicolas Fatio de Duillier (1664–1753) to Dutch physicist Christiaan Huygens (1629–1695) in 1691 provides a clear public statement of Newton's interests in the *prisca sapientia* of the ancients. Fatio, who had been chosen by Newton to prepare a second edition of the *Principia*, informed Huygens that Newton believed he had discovered quite clearly that the ancients, like Pythagoras, Plato, and others, had already discovered the true "system of the world," including his own inverse-square law.[79] Likewise, after visiting Newton at Cambridge in 1694, the Scottish mathematician David Gregory (1659–1708) reported that Newton

> spread himself in exhibiting the agreement of this philosophy with that of the ancients, and principally with that of Thales. The philosophy of Epicurus and Lucretius is true and old, but was wrongly interpreted by the ancients as atheism …[80]

Gregory went on to note that

> He [Newton] has written a tract on the origin of the Gentiles. Religion is the same at all times, but that which was received pure by Noah and the first men, the Nations corrupted by their own inventions; Moses initiated a reformation but retained the different

> things of the Egyptians (it was the Egyptians who most of all corrupted religion with superstition) and from them it spread to other Gentiles. Christ reformed the religion of Moses.[81]

We should also note that when Gregory published his own *The Elements of Astronomy, Physical and Geometrical* in 1702, he included Newton's ideas on the antiquity of the theory of gravitation in its Preface.[82]

Many of Newton's own revised manuscripts survive. In the draft Scholium of Proposition VI, Newton includes an extensive discussion of Lucretius and his contribution to gravitation theory:

> Even the ancients were aware that all bodies which are round about the Earth, air and fire as well as the rest, have gravity towards the Earth, and that their gravity is proportional to the quantity of the matter of which they consists. Lucretius this argues in proof of the void …[83]

Further, in the draft Scholium of Proposition VIII, Newton asserted that Pythagoras had known the inverse-square law theory. He argued that Pythagoras had discovered by experiment the inverse-square relationship in the vibrations of strings. From this discovery, he said, Pythagoras went on to apply the same principle to the heavens:

> … and consequently by comparing those weights with the weights of the planets, and the lengths of the strings with the distances of the planets, he [Pythagoras] understood by means of the harmony of the heavens that the weights of the planets towards the Sun were reciprocally as the squares of their distances from the Sun …[84]

In his reading of the ancients, Newton sees them as ascribing the cause of gravity to God, the "Deity." In the draft for the Scholium of Proposition IX, Newton empathically draws from Marcobius, Cicero, Virgil, Porphyry, and Orpheus. "So far I have expounded the properties of gravity," he wrote,

> … Its cause I by no means recount. Yet I shall say what the ancients thought about this subject. Thales regarded all bodies as animate … He held the sun and Planets for Gods. And in the same sense Pythagoras … said that the sun was the prison of Zeus … And to the mystical philosophers Pan was the supreme divinity inspiring this world with harmonic ratio like a musical instrument and handling it with modulation, according to the saying of Orpheus "striking the harmony of the world in playful song." Thence they named harmony God and soul the world composed of harmonic numbers … From this, it seems, arose the opinion of the Peripatetics concerning Intelligences moving solid globes. But the souls of the sun and of all the Planets the more ancient philosophers held for one and the same divinity exercising its powers in all bodies whatsoever …[85]

The above citations reveal a remarkable proposition: the more ancient the philosophy, the closer it was to the true natural philosophy. Although these were drafted and unpublished portions of Newton's thoughts, the same basic thesis of the *prisca sapientia* and *prisca theologia* can be found in both the General Scholium of the 1703 *Principia* and the concluding pages of his 1704 *Opticks*. So published or not, Newton argued that his mathematics represents a recovery of the true natural philosophy of the ancient *prisca* tradition.

This belief in restoring both religion and natural philosophy to its original, pristine nature was Newton's attempt at a "dual-reformation." Newton's goal, his entire scientific project, was therefore an attempt to "revive" or perhaps restore the Ur-religion of the Noachides. This connection between natural philosophy and an original, pristine theology, moreover, is found in the "handmaiden" philosophy of the Church Fathers, in which the Greek classical past was put to the service of theology—the queen of the sciences. Thus there is definite continuity between the supposed "modern" Newton and an ancient Christian tradition.

Conclusion

Newton's religion, alchemy, hermeticism, and natural philosophy were tributaries that flowed and coalesced into a remarkable project: deciphering God's will and actions in the universe. He attempted to achieve this by calling for a reformation not only in current discussions of natural philosophy, but in theology as well. Thus it seems clear that if Newton had not had the theological conceptions that he did, his scientific achievements would have turned out to be strikingly different. This observation raises serious questions about our understanding of so-called "conflicts" between religion and science. The new mechanical philosophy that emerged in the eighteenth century was not atheistic. For Newton, a mechanistic world was imbued with the presence of God.

But among Newton's disciples, the immediate presence and activity of God in nature gradually eroded. The concept of force was ultimately secularized, and came to be regarded as inherent in matter. Eventually, natural philosophers came to apply this modified mechanistic explanation to principles of light, magnetism, electricity—even biology. Matter was "brute," autonomous, and self-sufficient. Newton's notion of "active principles" was absorbed into a materialistic philosophy: the very kind that he intended to refute in his published and unpublished writings. Ironically, it was this materialistic philosophy that came to be known as the "Newtonian" worldview.[86]

Interestingly, the popularization of the "Newtonian" worldview was not primarily the work of scientists. Hubert Butterfield recognized this new "habit of mind," and in his *The Origins of Modern Science* (1958) argued that the transmission of the scientific movement of the eighteenth century into a comprehensive materialistic philosophy was largely achieved by literary men, who "invented and exploited a whole technique of popularisation."[87] This observation, moreover, leads Butterfield to conclude that "the great movement of the eighteenth century was a literary one—it was not the new discoveries of science in that epoch but, rather, the French *philosophe* movement that decided the next turn in the story and determined the course Western civilization was to take."[88] Gay also recognized Voltaire's desire to have "Newton's physics without Newton's God,"[89] and thus it was not science per se that was absorbed so much as a "new thinking cap," a new view of life and the universe. As we have seen, this continues to be the case with modern popularizers of Newton.

Therefore, how odd it is that what came to be called the "Newtonian" worldview was so antithetical to everything Newton himself believed in. Newton's natural philosophy grew out of his desire to explain how God acts in his creation. In the end, however, the real Newton was *defied* and was replaced with the *deified* Newton. Thus a very different, and far more complex, view of the relationship between science and religion can be obtained simply by looking more closely at the kind of scientific work done in the eighteenth century. And yet the story is still more complicated, for while he sought to show the harmony between science and religion, Newton had sacrificed core Christian beliefs. His gift to Christians lies chiefly in his determined, all-encompassing effort to ascertain God's will and action in creation; but his rejection of Christian tradition and his embrace of what amounts to an incipient—and, doubtless, crude—form of biblical higher criticism, also serves as a cautionary tale. ●

Notes

[1]See Voltaire's *Letters Concerning the English Nation* (London, 1733), XIV and XXII.

[2]Richard S. Westfall, *Never at Rest: A Biography of Isaac Newton* (Cambridge, UK: Cambridge University Press, 1980), 874.

[3]"Sir Isaac Newton: Scientist, Mathematician and Astronomer," Westminster Abbey, https://www.westminster-abbey.org/abbey-commemorations/commemorations/sir-isaac-newton.

[4]Cited in Theodore Besterman, *Voltaire* (Oxford, UK: Blackwell, 1976), 246.

[5]Cited in Peter Gay, *The Enlightenment: An Interpretation*, vol. 2, *The Science of Freedom* (New York: W.W. Norton, 1969), 2:131.

[6]Ibid., 131.

[7]Ibid., 130.

[8]Frank E. Manuel, *The Religion of Isaac Newton* (New York: Oxford University Press, 1974), 53.

[9]Alexander Pope, "Epitaph, Intended for Sir Isaac Newton," in *The Major Works* (Oxford, UK: Oxford University Press, 2006), 242.

[10]Gay, *The Enlightenment*, 2:131.

[11]See, e.g., Daniel J. Boorstin, *The Discoverers: A History of Man's Search to Know His World and Himself* (New York: Vintage Books, 1983), 401–2; Allan Bloom, *The Closing of the American Mind* (New York: Simon and Schuster, 1987), 264; and finally the great science popularizers Carl Sagan, *The Demon-Haunted World: Science as a Candle in the Dark* (New York: Ballantine Books, 1996), 271; and Neil deGrasse Tyson and Donald Goldsmith, *Origins: Fourteen Billion Years of Cosmic Evolution* (New York: W. W. Norton, 2005), 64.

[12]Manuel, *The Religion of Isaac Newton*, 53.

[13]Voltaire, *Letters*, XIV.

[14]William Stukeley, *Memoirs of Sir Isaac Newton's Life* (London, 1752).

[15]See, e.g., Patricia Fara, *Newton: The Making of Genius* (New York: Columbia University Press, 2002); Rebekah Higgitt, *Recreating Newton: Newtonian Biography and the Making of Nineteenth Century History of Science* (London, UK: Pickering & Chatto, 2007). See also Richard Yeo, "Genius, Method, and Morality: Images of Newton in Britain, 1760–1860," *Science in Context* 2, no. 2 (1988): 257–84, https://doi.org/10.1017/S0269889700000594.

[16]David Brewster, *The Life of Sir Isaac Newton* (New York: Harper & Brothers, 1836), 18. Brewster repeated this praise verbatim in *Memoirs of the Life, Writings, and Discoveries of Sir Isaac Newton*, 2 vols. (Edinburgh, Scotland: Edmonston and Douglas, 1860 [1855]), 1:3.

[17]Stephen Snobelen, "'The True Frame of Nature': Isaac Newton, Heresy, and the Reformation of Natural Philosophy," in *Heterodoxy in Early Modern Science and Religion,* ed. John Brooke and Ian Maclean (Oxford, UK: Oxford University Press, 2005), 223–62. See also the many other articles by Snobelen on the topic: especially, "Isaac Newton, Heretic: The Strategies of a Nicodemite," *British Journal for the History of Science* 32, no. 4 (1999): 381–419, https://doi.org/10.1017/S0007087499003751; "'God of gods, and Lord of lords': The Theology of Isaac Newton's General Scholium to the *Principia*," *Osiris* 16, no. 1 (2001): 169–208, https://doi.org/10.1086/649344; and "To Discourse of God: Isaac Newton's Heterodox Theology and His Natural Philosophy," in *Science and Dissent in England, 1688–1945,* ed. Paul Wood (London, UK: Ashgate, 2004), 39–65.

[18]In addition to Westfall and Manuel, more substantial studies on these themes include, e.g., the pioneering work of B. J. T. Dobbs, *The Foundations of Newton's Alchemy or 'The Hunting of the Greene Lyon'* (Cambridge, UK: Cambridge University Press, 1975) and *The Janus Faces of Genius: The Role of Alchemy in Newton's Thought* (Cambridge, UK: Cambridge University Press, 1991). For more recent studies, see Andrew Janiak, *Newton as Philosopher* (Cambridge, UK: Cambridge University Press, 2008); Rob Iliffe, *Priest of Nature: The Religious Worlds of Isaac Newton* (Oxford, UK: Oxford University Press, 2017) and William R. Newman, *Newton the Alchemist: Science, Enigma, and the Quest for Nature's "Secret Fire"* (Princeton, NJ: Princeton University Press, 2019).

[19]See discussion in A. N. L. Munby, "The Keynes Collection of the Works of Sir Isaac Newton at King's College, Cam-

bridge," *Notes and Records of the Royal Society of London* 10, no. 1 (1952): 40–50, https://royalsocietypublishing.org/doi/10.1098/rsnr.1952.0006. More recently, see Daniel Kuehn, "Keynes, Newton and the Royal Society: The Events of 1942 and 1943," *Notes and Records of the Royal Society of London* 67, no. 1 (2013): 25–36, https://royalsocietypublishing.org/doi/10.1098/rsnr.2012.0053.

[20]Quoted in Munby, "The Keynes Collection of the Works of Sir Isaac Newton," 42.

[21]Ibid.

[22]Credit for this revised view largely goes to the ongoing efforts of the men and women behind the Newton Project, http://www.newtonproject.ox.ac.uk/. For a brief history of this remarkable digital harvest, see the review by Niccolò Guicciardini, "Digitizing Isaac Newton," *Isis* 105, no. 2 (2014): 403–9, https://doi.org/10.1086/676577.

[23]See James C. Ungureanu, *Science, Religion, and the Protestant Tradition: Retracing the Origins of Conflict* (Pittsburgh, PA: University of Pittsburgh Press, 2019).

[24]Manuel, *The Religion of Isaac Newton*, 23.

[25]Westfall, *Never at Rest*, 58.

[26]Ibid., 309–10.

[27]Cited in Richard S. Westfall, "Short-Writing and the State of Newton's Conscience, 1662," *Notes and Records of the Royal Society of London* 18, no. 1 (1963): 10–16, https://doi.org/10.1098/rsnr.1963.0002.

[28]Westfall, *Never at Rest*, 89.

[29]For a detailed discussion of Newton's Trinity notebook, see J. E. McGuire and Martin Tammy, eds., *Certain Philosophical Questions: Newton's Trinity Notebook* (Cambridge, UK: Cambridge University Press, 1983).

[30]For a detailed discussion of these years, see Westfall, *Never at Rest*, 140–175.

[31]Brewster, *Memoirs of the Life*, 1.27–29. See also the detailed discussion in Newman, *Newton the Alchemist*, 136–49.

[32]See Brewster, *Memoirs of the Life*, 2:50–54.

[33]Ibid., 2:300–302.

[34]Westfall, *Never at Rest*, 310.

[35]Yahuda MS. 15.7, fol. 154, cited in Manuel, *The Religion of Isaac Newton*, 58.

[36]Manuel, *The Religion of Isaac Newton*, 59.

[37]See Earl Morse Wilbur, ed. and trans., *The Two Treatises of Servetus on the Trinity* (Cambridge, MA: Harvard University Press, 1932).

[38]After Socinus's death, his followers continued to defend and develop the basic doctrinal position he espoused, eventually producing the "Racovian Catechism" of 1605. See, e.g., Thomas Rees, *The Racovian Catechism, with Notes and Illustrations* (London, UK: Longman, Hurst, Rees, Orme, and Brown, 1818). For a general history of Unitarianism, see E. M. Wilbur, *A History of Unitarianism: Socinianism and Its Antecedents* (Cambridge, MA: Harvard University Press, 1945). See also Andrea Greenwood and Mark W. Harris, *An Introduction to the Unitarian and Universalist Traditions* (Cambridge, UK: Cambridge University Press, 2012), especially 32–50.

[39]Newton was both a student and friend of Cambridge Platonists Henry More (1614–1687) and Ralph Cudworth (1617–1688) and Latitudinarian Isaac Barrow (1630–1677). See Dennis G. Wigmore-Beddoes, *Yesterday's Radicals: A Study of the Affinity between Unitarianism and Broad Church Anglicanism in the Nineteenth Century* (Cambridge, UK: James Clarke & Co., 1971), 15–27. See also Martin I. J. Griffin, Jr., *Latitudinarianism in the Seventeenth-Century Church of England* (Leiden, Netherlands: Brill, 1992).

[40]Maurice Wiles, *Archetypal Heresy: Arianism through the Centuries* (Oxford, UK: Clarendon Press, 1996), 110. A full-length study on Clarke can be found in Thomas C. Pfizenmair, *The Trinitarian Theology of Dr. Samuel Clarke (1675–1729): Context, Sources, and Controversy* (Leiden, Netherlands: Brill, 1997).

[41]Yahuda MS. 15.7, fol. 154, cited in Manuel, *The Religion of Isaac Newton*, 59–60.

[42]Isaac Newton, *Observations upon the Prophecies of Daniel and the Apocalypse of St. John* (London, 1733), 252.

[43]These "Rules" have been reproduced in Manuel, *The Religion of Isaac Newton*, Appendix A, 107–125.

[44]Ibid.

[45]Isaac Newton, *The Principia: Mathematical Principles of Natural Philosophy*, trans. I. Bernard Cohen and Anne Whitman (Berkeley, CA: University of California Press, 1999), 794.

[46]Cited in Manuel, *The Religion of Isaac Newton*, 120.

[47]Manuel, *The Religion of Isaac Newton*, 19.

[48]Isaac Newton, *Correspondence of Isaac Newton*, vol. 3: *1688–1694*, vols. 1–3, ed. H. W. Turnbull (Cambridge, UK: Cambridge University Press, 1961), 3:82–146.

[49]Newton, *Correspondence of Isaac Newton*, 3:138.

[50]See Newton, *Mathematical Principles of Natural Philosophy*, 939–43.

[51]Newton, *Correspondence of Isaac Newton*, 3:233–56. In his December 10, 1692 letter to Bentley, Newton explicitly states: "When I wrote my treatise about our Systeme I had an eye upon such Principles as might work wth considering men for the beleife of a Deity & nothing can rejoice me more than to find it useful for that purpose."

[52]Snobelen, "'God of gods, and Lord of lords,'" 169–208.

[53]See Lawrence M. Principe, "Alchemy Restored," *Isis* 102, no. 2 (2011): 305–12.

[54]Newman, *Newton the Alchemist*, especially 497–99.

[55]P. M. Rattansi, "Newton's Alchemical Studies," in *Science, Medicine and Society in the Renaissance*, 2 vols., ed. Allen G. Debus (Cambridge, UK: Cambridge University Press, 1972), 2:167–82; see also his "Some Evaluations of Reason in Sixteenth- and Seventeenth-Century Natural Philosophy," in *Changing Perspectives in the History of Science,* ed. Mikulas Teich and Robert Young (London, UK: Heinemann Educational Books, 1973), 148–66.

[56]See Richard Westfall, "Isaac Newton's Index Chemicus," *Ambix* 22, no. 3 (1975): 174–85, https://doi.org/10.1179/amb.1975.22.3.174.

[57]Dobbs, *The Foundations of Newton's Alchemy*, 80.

[58]See discussion in B. J. T. Dobbs, "Newton's Alchemy and his Theory of Matter," *Isis* 73, no. 4 (1982): 511–28. See also Dobbs, "Newton's Alchemy and His 'Active Principle' of Gravitation," in *Newton's Scientific and Philosophical Legacy,* ed. P. B. Scheurer and G. Debrock (Boston, MA: Kluwer Academic Publishers, 1988), 55–80.

[59]Dobbs, "Newton's Alchemy and his Theory of Matter," 526.

[60]Yahuda MS 15, cited in Dobbs, "Newton's Alchemy and his Theory of Matter," 527.

[61]Ibid.

[62]Newton, *Correspondence of Isaac Newton*, 3:193, 215, and 216.

[63]Cited Dobbs, *The Foundations of Newton's Alchemy*, 109.

[64]Cited in ibid., 111–13.

[65]Cited in ibid., 164.

[66]Dobbs, *The Janus Faces of Genius*, 10.

[67]On Vossius, see, e.g., C. S. M. Rademaker, *Life and Work of Gerardus Joannes Vossius (1577–1649)* (Assen, Netherlands:

Van Gorcum, 1981) and Nicholas Wickenden, *G. J. Vossius and the Humanist Concept of History* (Assen, Netherlands: Van Gorcum, 1993).

[68]On this text, see Richard S. Westfall, "Isaac Newton's *Theologiæ Gentilis Origines Philosophicæ*," in *The Secular Mind: Transformations of Faith in Modern Europe*, ed. W. Warren Wager (New York: Holmes & Meier, 1982), 15–34; J. Knoespel, "Interpretive Strategies in Newton's *Theologiæ gentilis origines philosophicæ*," in *Newton and Religion: Content, Nature, and Influence*, ed. James E. Force and Richard H. Popkin (Dordrecht, Netherlands: Springer, 1999), 179–202; and Snobelen, "Isaac Newton, Heretic," 381–419.

[69]Yahuda MS 41, fol. 7r, cited in Knoespel, "Interpretive Strategies in Newton's *Theologiæ gentilis origines philosophicæ*," 196.

[70]Yahuda MS 1.1, cited in Westfall, *Never at Rest*, 325.

[71]Manuel, *The Religion of Isaac Newton*, 45.

[72]Florian Ebeling, trans. David Lorton, *The Secret History of Hermes Trismegistus, Hermeticism from Ancient to Modern Times* (Ithaca, NY: Cornell University Press, 2007), 43.

[73]There are several important studies on the *Hermetic Corpus*. The one I found most useful for this article is Brian P. Copenhaver, ed., *Hermetica: The Greek Corpus Hermeticum and the Latin Asclepius in a New English Translation, with Notes and Introduction* (Cambridge, UK: Cambridge University Press, 1992).

[74]Quoted in Ebeling, *The Secret History of Hermes Trismegistus*, 62.

[75]Ibid., 66.

[76]Ibid., 65.

[77]See Charles Webster, *From Paracelsus to Newton: Magic and the Making of Modern Science* (Cambridge, UK: Cambridge University Press, 1982).

[78]See discussion in Iliffe, *Priest of Nature*, 189–218.

[79]Newton, *Correspondence of Isaac Newton*, 3:193, cited in J. E. McGuire and P. M. Rattansi, "Newton and the 'Pipes of Pan,'" *Notes and Records of the Royal Society of London* 21, no. 2 (1966): 109, https://doi.org/10.1098/rsnr.1966.0014.

[80]Newton, *Correspondence of Isaac Newton*, 3:338, cited in McGuire and Rattansi, "Newton and the 'Pipes of Pan,'" 110.

[81]Newton, *Correspondence of Isaac Newton*, 3:338.

[82]See David Gregory, *The Elements of Astronomy, Physical and Geometrical*, 2 vols. (London, 1715), 1:i–xii.

[83]Cited in McGuire and Rattansi, "Newton and the 'Pipes of Pan,'" 112.

[84]Cited in ibid., 116–17.

[85]Cited in ibid., 119.

[86]See, e.g., Margaret C. Jacob, "Newton and the French Prophets," *History of Science* 16, no. 2 (1978): 134–42, https://doi.org/10.1177%2F007327537801600204; Edward B. Davis, "Newton's Rejection of the 'Newtonian World View': The Role of Divine Will in Newton's Natural Philosophy," *Fides et Historia* 22, no. 2 (1990): 6–19; and J. B. Shank, "'There Was No Such Thing as the "Newtonian Revolution," and the French Initiated It.' Eighteenth-Century Mechanics in France before Maupertuis," *Early Science and Medicine* 9, no. 3 (2004): 257–92, https://doi.org/10.1163/1573382042176263.

[87]Herbert Butterfield, *The Origins of Modern Science: 1300–1800* (New York: The Macmillan Company, 1958), 160.

[88]Butterfield, *The Origins of Modern Science*, 166.

[89]Gay, *The Enlightenment*, 2:140–50.

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

Jitse M.
van der Meer

Essay Book Review

Reformed Theology and Evolutionary Theory: A Critical Review

Jitse M. van der Meer and Koert van Bekkum

Koert van Bekkum

Gijsbert van den Brink, *Reformed Theology and Evolutionary Theory* (Grand Rapids, MI: Eerdmans, 2020). 328 pages. Paperback; $39.99. ISBN: 9780802874429.

> *Whatever the natural sciences can really demonstrate to be true of physical nature, we must show to be capable of reconciliation with our Scriptures; and whatever they assert in their treatises which is contrary to these Scriptures of ours, that is to Catholic faith, we must either prove it as well as we can to be entirely false, or at all events we must, without the smallest hesitation, believe it to be so.*
> Augustine, *De Genesi ad litteram*, I.21.41

"This is a book for Christians who want to make up their mind on evolutionary theory, as well as for non-Christians who consider the faith but are convinced of evolution" (p. 1). Six major challenges to Christian theology are discussed with excursions into Reformed theology when appropriate. The verdict is that they can be met in ways true to the Gospel. There have been a few books dealing with this question from the perspective of a particular theological tradition. This is the first one that does so for Reformed theology. The book is very well organized; the arguments are clear and accessible to the general reader. A must read for theologians, biologists, and anyone interested. Strongly recommended.

The first three chapters set the stage. Chapter 1 introduces Reformed theology as a unity in diversity: with the help of Wittgenstein's metaphor of family resemblances, Reformed theology is understood as a range of confessions, denominations, and theological accents reflecting a particular stance characterized by a catholic Christian perspective. Some of its features are challenging and others helpful in coming to terms with evolutionary theory. As a stance, Reformed theology tends to intensify the following catholic affirmations in relation to evolution. It underlines the meaning of scripture as a whole in the interpretation of the Bible (*tota Scriptura*). It stresses the openness to correction (*semper reformanda*). It cherishes the world in which we find ourselves, for it is the work of the Creator as expressed in the "two book" metaphor of the Belgic Confession written by Guy de Brès. In this chapter, van den Brink opposes Karl Barth's interpretation of this metaphor and correctly underlines the open attitude the Reformed tradition has historically had toward science. Yet, he could have admitted that, although the Reformers granted the idea of a natural knowledge of God in their use of the images of spectacles (Calvin *Institutes* I.vi.1) and books (de Brès) of nature and scripture, they were critical of nature as an independent source for this knowledge.

Chapter 2 is devoted to avoiding misunderstandings by defining the relevant scientific concepts. Overall this is very successful with one exception. "Gradualism" (p. 36) is used to refer to the fact that fossils are found in a sequence of increasing complexity (pp. 54–55) apart from any interpretation (p. 36). But "gradualism" is also used to describe a central concept in the history of evolutionary thought (pp. 37–40). More confusion is created because "gradualism" is a current interpretation of biological evolution as a process, and the author uses gradualism with that meaning as well (p. 99). Finally,

Jitse M. van der Meer *is Emeritus Professor of Biology and Fellow of the Pascal Centre, Redeemer University, Ancaster, Ontario, Canada.*

Koert van Bekkum *is Professor of Old Testament at the Evangelische Theologische Faculteit, Leuven, Belgium, and Associate Professor of Old Testament, Theological University, Kampen, Netherlands.*

"complexity" is open to multiple interpretations. There is genomic complexity, functional complexity, and structural complexity, to mention a few. Why not use "sequentiality" to refer to the fossil record? Further, he introduces the three levels in evolutionary theory distinguished by Fowler and Kuebler[1]—deep time, common descent, and natural selection by random mutation—surveys their theological implications, using them to organize chapters 4–8 accordingly.

Chapter 3 addresses the relation of evolutionary theory and scripture interpretation. The view that biblical statements about the physical world correspond to scientific facts (concordism) is rejected. It distorts the interpretation of both nature and scripture. Moreover, concordists must invent new harmonizations with scripture whenever scientists discover new facts. This is self-defeating. The author's alternative is perspectivism, "the hermeneutical view that when the Bible is interpreted, its theological content should be distinguished from the world picture within which this content is embedded" (p. 81). He distinguishes biblical, theological, and scientific perspectives. Theological content is rooted in the history of events—an overarching theme in scripture clearly affirmed by the author. The distinction between theological content of the Bible and the world picture in which this content is embedded appears to be a reference to divine accommodation. But, the author explains, the principle of accommodation is not without problems. For instance, how does one decide that the story of creation, fall, and redemption is due to divine revelation rather than human imagination? How does one determine what in the story belongs to the theological content rather than to the world picture? The author argues that these two cannot be cleanly separated. But theological content can be identified by the fact that it belongs to the narrative focus of scripture. To explain how to handle apparent conflict between science and scripture, van der Brink appeals to G.C. Berkouwer: "Certain results of science, be it natural science or historical research, can provide the *occasion* for understanding various aspects of scripture in a different way than before" (p. 94). That is, as (alleged) data of science can be reconsidered in the light of scripture, so can established interpretations of scripture be reconsidered in the light of science for the theological meaning of the Bible cannot contradict what we know from the sciences.

The author does not go further into detail about Berkouwer's hermeneutical principle. This is unfortunate because it is commonly applied when extra-biblical sources are used in exegesis. It is thus important in describing the relation between science and the interpretation of scripture. Berkouwer's hermeneutical principle quoted above is not specifically Reformed. Yet, Berkouwer's quote finds its background in the theological discussions surrounding the (in)famous so-called snake trial of the Reformed Churches in the Netherlands in 1926, which also related to creation and evolution. In particular, the term "occasion" was meant to safeguard the *sola scriptura* of the Reformation. Later reflections on this principle underlined that the exegetical, historical, and theological debate regarding biblical texts ought to be open to weighing all the available data and the diverse methods from a specific perspective by asking to what extent they help in understanding scripture.[2]

Accordingly, two important theological remarks are to be made with respect to the use of the above-mentioned principle: (1) To respect the authority of scripture, any (new) interpretation of scripture has to be justified on scriptural grounds, and (2) Science must also provide its own justification, because God has created a world of material things, and therefore, this materiality needs to be respected and this respect consists in submitting our understanding of nature to the things God has created. These rules help avoid imposing science on scripture and vice versa, or accepting conflict between scripture and science. Van den Brink seems to be willing to follow these principles (p. 176). By not making them explicit, however, his analysis runs the risk of primarily being concerned with safeguarding the theological meaning of scripture.

The remainder of the book addresses the theological implications of animal suffering (chap. 4), common descent (chaps. 5, 6), and random variation and natural selection (chaps. 7–8), all in the context of the three levels of evolutionary theory.

Theological Responses to Animal Suffering

Chapter 4 reviews theological responses to animal suffering. Before addressing them, two preliminaries are covered: what scripture says about animals (God glories in creating predators and in providing prey for them) and whether animals can suffer (likely). Next the author turns to the main reasons why people think animals suffer: human sin, God's plan, and demonic agency. These responses predate Darwin and did not change after the emergence of the theory of evolution. Therefore, the theory of evolution did not introduce these problems. But the discovery of animal suffering before the existence of humans did provide an occasion to reconsider the notion that human sin caused a cosmic fall.

The author applies the principle of using the results of science as an occasion for a reinterpretation of scripture in the light of scripture as a whole in his rejection of the cosmic fall interpretation. That leaves two responses. The second one focuses on how a good God can create suffering. As for demonic involvement in animal suffering, representatives including C. S. Lewis, Michael Lloyd, Alvin Plantinga, Thomas Torrance, Neil Messer, and Nicola Hoggard Creegan are discussed in some detail as this view is not well known. The pros and cons of demonic agency are clearly explained. Van den Brink concludes that "as tiny and sinful human beings we are not in a position to evaluate what sorts of evils

God may or may not permit" (p. 134). In this, the author rightly emphasizes that we can only reflect on this issue as fallen human beings. As Job did not know why he was suffering, so we do not know why animals are suffering. Christians trust that God has good reasons to include animal suffering in his plan. It is to be noted that Jon Garvey recently also pointed to the fact that prior to the Reformation, most Christian writers understood the inherent wildness of the world (including predation) as part of God's glorious and good creation.[3]

Theological Implications of Common Descent

Chapter 5 discusses how to understand human dignity and the image of God if they were created through evolution. Historically, human dignity was emphasized by inflating the status of Adam and Eve. This strategy aimed at stressing the height of the Fall, the blameworthiness of the first couple, and the boundless grace of God. But it surpassed what the text warranted. Evolutionary creation affects this approach. Animal ancestry downgrades human dignity, thereby diminishing the Fall. But it does so only if human dignity and the image of God are defined in terms of characteristics unique to humans, as has been traditionally done. Human uniqueness was questioned when its defining characteristics were found in animals, and this diminished human dignity. The author avoids this outcome by grounding human uniqueness not in their evolved attributes, but in the calling of God to be his representatives. This view of the image of God concurs with other recent reflections on the *imago Dei*, for instance that by John Kilner.[4] This does not exclude the existence of uniquely human attributes. Only humans are religious as the author affirms and only humans are concerned for the good which is what defines moral behavior (chap. 8). We add recently discovered unique attributes, including genes required for human brain development and joint attention behavior.[5] Thus, animal ancestry does not need to downgrade human uniqueness. But unique characteristics no longer constitute the image of God. Further, animal ancestry raises the question discussed in the next chapter, whether humans can be blamed for behaviors inherited from animal ancestors.

Chapter 6 prepares this discussion by introducing the five exegetical approaches to Genesis 2–3 distinguished by Denis Alexander. The aim is to test whether common descent can be compatible with the historicity of Adam and the Fall as well as with death as punishment, original sin, and the need for salvation.[6] The "prehistorical" and the "protohistorical" readings of the biblical chapters are thought to "remain faithful to the historical and covenantal character of Reformed theology, while doing justice to the scientific data on human origins" (p. 166). These are incorporated into a hypothetical narrative that associates the events involving Adam and Eve and those represented by them with the Upper Paleolithic Revolution, roughly 45,000 years ago, when archaeological evidence of full personhood was thought to appear at the time of writing. But the story of Genesis 2–3 is set in the Neolithic farming culture of the Middle East of 10,000 years ago. The author speculates that the time gap may have been bridged by revelation, prophetic divination, or critical adoption of older ancient Near Eastern materials put to text much later. He observes further that since anatomically modern humans (AMHs) first appeared 200,000 years ago, Adam and Eve are not the first AMHs and may have been created from AMHs.

In van den Brink's own opinion, this reconstruction of early human history suits the Reformed principle of using the results of science as an occasion for a reinterpretation of scripture. Such usage is as uncontroversial as the use of ancient Near Eastern records in biblical exegesis. Therefore, it cannot be viewed as a concordistic way of imposing "any (purported) scientific discoveries on the text" (p. 179). At this point, however, the above-mentioned criteria added to van den Brink's principle turn out to be helpful in evaluating whether this is indeed the case.

First, it is to be noted that the reconstruction of early human history under discussion combines important theological dimensions with available scientific data. Therefore, as such, the reconstruction is not justified by science itself and has to be understood as a theological model. Accordingly, the question is: Does this use of scientific data in the interpretation of scripture suit the criteria for this use and can the result be justified on scriptural grounds? Here, two problems occur.

1. Biblical scholars generally agree that nonbiblical data can be used in the interpretation of a text only if there is some overlap in the chronological horizons of both the text and the historical data or the availability of its information. Yet, that is not the case here: neither general historical knowledge nor the Bible contains data that can be used to create a convincing channel of transmission from the supposed events in the Neolithic period to the composition of the biblical story in the Late Bronze or Iron Ages. Accordingly, from the perspective of scholarly exegesis, it is simply unjustified to create such a connection. The only way to escape this objection is to state that the biblical story is the product of immediate divine revelation or prophetic divination. But that would be highly speculative, for the text does not contain any indication in that direction and none of the interpretations used by van den Brink explains the text in this way.

2. Another problem is the portrait of Adam and Eve in the biblical story. Van den Brink rightly highlights their symbolic and representational nature. Thinking of them as a group is not against the text. Yet, it is an enormous step to identify the concrete people of the story—human beings with bodies, a character, and emotions; who act, talk, and make choices; who also function as the head of the ancient Near Eastern kinship group "humanity"—with the abstract hypothetical group of the species of

hominids as reconstructed by science. Even when one agrees with van den Brink that, although both categories, each in its own way, refer to the past and therefore might in some way or another be related, in the end, the types of information are too different in nature to be connected. As a result, the hypothesis offered by van den Brink is concordistic, contrary to what he claims. Some further reflections on the nature of scientific reconstructions and history would have been more helpful. In line with van den Brink's methodology in chapter 3, a perspectivist approach needs to highlight the limited nature of the evidence from scripture, nature, and history. Accordingly, it would be better to conclude that from a systematic-theological point of view, science, Christian doctrine, and biblical exegesis are not incompatible with one another, but that, in this case, we simply do not have enough information available to offer a unifying historical narrative.

More convincing are the author's more-conceptual reflections regarding the relation between common ancestry and the Fall. He maintains a historical fall as an account of why humans sin. The alternative—that we inherited sinful tendencies from animal ancestors—destroys human accountability and, with that, the need for redemption. The author proposes a re-contextualized Fall that is compatible with common ancestry. Humans and their ancestors arose as a group. God equipped AMHs with self-awareness and free will so that they could be held morally accountable after being called to be God's image. But since God had not yet given the law, the behaviors inherited from animal ancestors were not yet counted as sin. This allows the author to interpret original righteousness and holiness as innocence, because without law they could not know what sin was. The assumption is that God gave a law in some form—at the least, created in the heart (chap. 8)—and that free will included the ability to resist the behaviors inherited from animal ancestors. God's call to be God's image may have gone to a couple representing the group. They may have been the first to act in willful disobedience, which was then imputed to all those they represented. Or perhaps all of them committed the first disobedience, with the first couple functioning to describe this type of human being. Here again, however, problems would arise. The more concrete the hypothetical historical narrative becomes, the harder it will be to construct a straightforward connection with the biblical narrative. For instance, it is hard to see how the evolution of deception, theft, sexual promiscuity, and violence against fellow humans in the hypothetical historical narrative could connect with the spiritual evil symbolized by the snake. The author refrains from making his hypothetical narrative more concrete.

Common ancestry is often taken to threaten the need for redemption. The author promotes a prelapsarian view. That is, from eternity, God planned an evolutionary creation and the vicarious death of God the Son. This view implies among others that redemption is part of creation. Specifically, the salvation of humankind is part of its creation which is still unfolding. Common descent does not rule out that redemption is in God's plan of creation, that we are fallen, and that we are responsible for our fallen state. Thus the author sees no threat to the need for redemption.

Theological Implications of Random Variation and Natural Selection

Assuming that evolution is true, chapter 7 asks whether random processes fall under divine sovereignty and providence. Are there theological implications of random variation and natural selection for divine providence? It is especially important to distinguish fact and interpretation, the author warns, because the interpretation of randomness has been shaped by world views. For instance, some argue that since variation is random, it clashes with divine guidance. But this follows only if randomness is interpreted as a metaphysical or religious category. It does not follow if one acknowledges that God gave creatures relative autonomy to act. Random processes are created and, therefore, under God's power. Compatibility is gained by distinguishing between divine (primary) and creaturely (secondary) causation. Thus, properly distinguished, randomness and divine guidance are compatible because they belong in different categories.

Others argue that since the variation required for evolution is random, no divine guidance is needed in explanation. The author responds that this does not entail that divine guidance is false. One must distinguish between the technical meaning of randomness in evolutionary theory (not guided by environment) and its metaphysical interpretation (not guided by God). The former does not entail the latter. Thus random mutation and divine providence are logically compatible. This is an astute solution to the problem, in line with the distinction between first and secondary agencies in classical theology.

Finally, the author proposes that randomness can be considered consonant with divine providence. His example is evolutionary convergence, that is, the tendency of organisms with different evolutionary histories to have the same solution to particular problems. Take the problem of detecting prey. Squid, jellyfish, and humans have the so-called camera eye that allows perception in three dimensions. This has been explained in terms of a combination of law-like and random behavior. It makes the point that randomness is integral to the order of nature as created by God. God is certainly able to guide random processes, because he has created them. Van den Brink concludes that the theory of evolution is not only compatible with, but also consonant with the existence of a God who knows and controls random processes. We wish the author had made the providence of God more concrete by mentioning the Holy Spirit as an agent immanent in creation.

Chapter 8 assesses the possible implications of Darwinian evolution for views about social life, morality, and religion. Since there is no agreement on how to define religion, the author refers to religious experiences, practices, attitudes, et cetera, for the sake of argument. But for himself, he defines religion using the Christian doctrine of revelation. One of the implications is that humans have a natural capacity to know God and to discern good and evil because that is how they have been created. The introduction of this faith commitment is appropriate, because it operates on the same level as the faith commitment to naturalism. Thus the author affirms an objective and external source of religious knowledge expressed in God's will. This includes moral knowledge.

The author first reviews mistaken implications of evolutionary theory that have moved Christians to reject it. These include the naturalistic fallacy and attempts to reduce human social and religious behavior to its biological basis driven by anti-religious ideology. The remainder of this chapter focuses on the cognitive science of religion (CSR) because it is the current paradigm for natural explanations of religion. While current CSR is weak both theoretically and empirically, he proceeds on the assumption that those challenges will be overcome as follows. First, the classical Christian view of morality and religion is that Christians find their source in God's revelation. Second, this view is discredited according to many scientific critics of religion, because science explains morality and religion in terms of natural causes. Third, the author takes the critics' argument to be that natural causes exclude supernatural ones. He neutralizes this argument by countering that God could have used natural means to bring about the capacities for morality and religiosity. Just as the causes involved in producing this text explain nothing about its content, similarly the causes involved in the evolution of morality and religion do not explain or explain away their content. Further, he takes the scientific critics of religion as rejecting revelation as a source of moral and religious knowledge. This rejection, he concludes, is an implication of philosophical naturalism, not of science.

More specifically, the author counters that atheists cannot accept the reliability of scientific knowledge while rejecting that of moral and religious knowledge, if one accepts that both have evolved in natural ways. Logically, this is correct, but the premise is false. The reliability of science is achieved by trial and error. The history of science reveals many incorrect explanations, as the author points out in chapter 2. This is what one would expect if the cognitive processes underlying the production of knowledge are the product of evolution. An evolution of cognitive processes by random variation would lead one to expect correct as well as incorrect scientific theories. However, this also applies to moral and religious knowledge. If God uses random variation to create a diversity of moral and religious knowledge, does God not create the conditions for moral and religious relativism? One might counter that God may have used natural selection to create true moral and religious knowledge. But this would bind God to the way natural selection operates. What is selected depends on the selective forces and these vary randomly.

Chapter 9 concludes that

> although evolutionary theory does not leave unaffected our ways of thinking about the doctrine of scripture, the goodness of God, theological anthropology, the history of redemption, divine providence, and the doctrine of revelation, there is no reason to think that these classical loci fall apart as soon as one starts to take evolutionary theory seriously. (p. 266)

However, we must reject a hermeneutic of concordism as well as the cosmic fall and the notion that human history starts with Adam and Eve. As for other doctrines—eschatology, miracles, Christology, pneumatology and ecclesiology—he argues that there is no need for further adaptations. What about the doctrine of creation? It has not been mentioned, mainly because, from a theological perspective, it does not address how creatures evolved. It deals with more important issues, such as who the Creator is, why God created anything at all, that the Creator transcends the creation, and that the latter depends on the former.

To conclude, this is a very well-informed volume that will be of immense help for anyone asking what consequences evolutionary theory would have for one's faith and theology. It is clear, comprehensive, and nuanced in its discussion of systematic-theological issues that might be affected by evolutionary theory. ●

Notes

[1]Thomas B. Fowler and Daniel Kuebler, *The Evolution Controversy: A Survey of Competing Theories* (Grand Rapids, MI: Baker Academic, 2007).

[2]Koert van Bekkum, "'How the Mighty Have Fallen': *Sola Scriptura* and the Historical Debate on David as a Southern Levantine Warlord," in *Sola Scriptura: Biblical and Theological Perspectives on Scripture, Authority, and Hermeneutics*, ed. Hans Burger, Arnold Huijgen and Eric Peels (Leiden, Netherlands: Brill, 2017), 159–60. For similar reflections, see Kevin J. Vanhoozer, *The Drama of Doctrine: A Canonical-Linguistic Approach to Christian Theology* (Louisville, KY: Westminster John Knox Press, 2005), 231–37.

[3]Jon Garvey, *God's Good Earth: The Case for an Unfallen Creation* (Eugene, OR: Cascade, 2019), 71–102.

[4]John F. Kilner, *Dignity and Destiny: Humanity in the Image of God* (Grand Rapids, MI: Eerdmans, 2015).

[5]David Wilcox, "Our Genetic Prehistory: Did Genes Make Us Human?," *Perspectives on Science and Christian Faith* 66, no. 2 (2014): 83–94; ___, "A Proposed Model for the Evolutionary Creation of Human Beings: From the Image of God to the Origin of Sin," *Perspectives on Science and Christian Faith* 68, no. 1 (2016): 22–43; and Felix Warneken, Frances Chen, and Michael Tomasello, "Cooperative Activities in Young Children and Chimpanzees," *Child Development* 77, no. 3 (2006): 640–63.

[6]Denis Alexander, *Creation or Evolution: Do We Have to Choose?*, 2nd rev. ed. (Oxford, UK: Monarch Books, 2014).

History of Science

CONVERSATIONS WITH GALILEO: A Fictional Dialogue Based on Biographical Facts by William R. Shea. London, UK: Watkins Media, 2019. xi + 115 pages, including notes and further reading. Hardcover; $14.95. ISBN: 9781786782496.

Have you ever wanted to engage in an extended conversation with a famous person whose work and historical milieu you have studied carefully for many years? William R. Shea, one of the world's leading Galileo scholars, invites you to sit down, relax with a cup of coffee or a glass of wine, to engage in a conversation with Galileo. *Conversations with Galileo: A Fictional Dialogue* incorporates many of Galileo's own words taken from his works or letters. This slim book will allow you to experience how such a dialogue may have transpired.

Shea, a Canadian historian, was Galileo Professor of the History of Science at the University of Padua, Italy from 2003–2012, the very university where Galileo once taught. He has authored many books about Galileo and the Scientific Revolution. The latest, co-authored with Mariano Artigas, are *Galileo in Rome: The Rise and Fall of a Troublesome Genius* (2003) and *Galileo Observed: Science and the Politics of Belief* (2006). Conversations with Galileo is part of a series of books published by Watkins Media Ltd., offering conversations with luminaries such as JFK, Oscar Wilde, Casanova, Buddha, Charles Dickens and Isaac Newton.

First, a word about the format of *Conversations with Galileo*: A three-page introduction by Dava Sobel, author of *Longitude* (1995) and *Galileo's Daughter* (1999), is followed by a short (21-page) biography by Shea entitled "Galileo (1564–1642): His Life in Short." Then we are offered 13 chapters dealing with a vast range of topics. Each chapter then begins with Shea posing a leading personal question. These questions cover what, I suspect, most people would want to ask Galileo: questions about censorship, the earth as a planet, scientific failures, what do you take the Bible to say, relations with the Roman Catholic Church Congregation of the Holy Office, also known as the Roman Inquisition, and the Congregation of the Index, other church officials, and, perhaps a final question: what is your claim to fame? The Galileo I remember: the rebel, the seat-of-the-pants philosopher, the "heretic," the defender of the Copernican world-picture, and the creator of a "science of motion" (appearing in the last chapter, "His Claim to Fame") are all present.

So, what more would you want to ask? To me it was surprising to see what else Shea does in fact ask. There are conversations/chapters dealing with "Family Burdens," "Wine, Women and Song," "The Burdens of Teaching," "Moonlighting," "Mind your Horoscope," "The Plague," and "On Art and Literature." This is a Galileo with a human face, with human foibles, jealousies, amorous interests, financial pressures and responsibilities, work-load issues, social conventions, concerns about the plague and social distancing, and literary interests. These are subjects which are usually hidden or absent in many accounts of Galileo's exploits. For instance, we learn of Galileo the lutenist and of his musical family: his father Vincenzo, his brother Michelangelo (a court musician to the grand duke of Bavaria in Munich). We meet his children: his two daughters, Virginia and Livia, who both entered a convent, and his son Vincenzo who had no scientific interests. We also learn about Galileo's life as a student. At seventeen, Galileo attended the University of Pisa to study medicine and "natural philosophy" (science in our parlance). He attended lectures for four and one-half years without acquiring a degree (which was quite common at the time) but did develop his mathematical interests. These are only a few of the personal details in Galileo's life which Shea explores in this book.

All in all, this is a delightful and inviting book, carefully constructed, written in an engaging style, and easy to read. Don't let the poorly designed cover keep you from picking it up. This is a good read for anyone wanting to get a look behind the scenes and meet an illustrious natural philosopher as he lived his rich and complex life.

Reviewed by Arie Leegwater, Department of Chemistry and Biochemistry, Calvin University, Grand Rapids, MI 49456.

Origins

FINDING OURSELVES AFTER DARWIN: Conversations on the Image of God, Original Sin, and the Problem of Evil by Stanley P. Rosenberg (general editor) and Michael Burdett, Michael Lloyd, and Benno van den Toren (associate editors). Grand Rapids, MI: Baker Academic, 2018. vii + 375 pages. Paperback; $34.00. ISBN: 9780801098246. Kindle; $16.99. ISBN: 9781493406586.

Finding Ourselves after Darwin responds to questions of how humanity defines itself and understands its primeval origins in a post-Darwinian world. It does so by offering a representative selection of Christian responses to questions about the image of God, original sin, and the problem of evil raised at the interface of evolutionary science and Christian faith. This book grew out of the project "Evolution and Christian Faith" funded by BioLogos, and many contributors participated in several colloquia held at Oxford.

Finding Ourselves after Darwin is thematically and structurally coherent, unlike many similar edited volumes. Two introductory essays by general editor Stanley Rosenberg and associate editor Benno van den Toren introduce the truth-seeking and dialogue-modeling commitments of the book. Following these essays, the book is divided into three parts: (1) The Image of God and Evolution, (2) Original Sin and Evolution, and (3) Evil and Evolution. Each part features five or six

contributors' responses to issues raised in each topic. Associate editors Michel Burdett, Benno van den Toren, and Michael Lloyd each provide introductory and conclusory comments to one of the three parts, in which they identify the part's driving questions and then summarize and interact with the material.

Discussion in part 1, The Image of God and Evolution, centers on the ability of four conventional models of imaging (functional, structural, relational, dynamic) to withstand challenges posed by evolution. Defending the viability of these four models takes precedence over intermittent discussion of human uniqueness, origins, and telos. Wentzel van Huysteen's introductory chapter suggests that evolutionary insights help inform a robust understanding of the human capacity for imaging. According to his "bottom-up" approach, the image of God emerged from nature through evolution; he believes we should take this into account when trying to understand the human person.

Following van Huysteen, Mark Harris shares a version of the functional model of imaging, which locates the *imago Dei* in humanity's role to be God's representative rulers on the earth. Harris uses scripture well but only marginally engages evolutionary theory since, according to him, it poses few challenges to the functional model of imaging.

Next, Aku Visala offers a strong defense for the structural theory of imaging against challenges raised by evolutionary theory. Structural theories of imaging often locate the image of God in uniquely human cognitive, moral, relational, and religious capacities; therefore, challenges to human uniqueness—such as claims that no clear dividing line exists between humans and animals—appear to threaten the viability of structural models of imaging. However, Visala shows that an appropriately modified version of the structural theory withstands these challenges by requiring no such clear dividing line (instead, humans stand apart from animals in the unique degree to which they actualize certain capacities). Visala also suggests that animals can have nonhuman souls and that animals continue to evolve in their imaging capacity; consequently, the "image of God is as much about becoming as it is about being" (p. 77). Visala advocates for an emergent dualist approach to the soul, one which embraces evolutionary insights into the way our "perceptual, conceptual, and emotional systems work" while maintaining that the soul accounts for certain phenomena evolutionary that explanations cannot account for, such as the existence of the person, human dignity, and life after death (p. 71).

Then Jay Oord presents a relational-love model of imaging in which he suggests that "living a life of love" is the essence of imaging (p. 88) and that God invites nonhuman creatures to bear God's image by imitating God's love.

Finally, Ted Peters offers a dynamic model of imaging in which humans are still evolving into the *imago Dei*. According to this model, the *imago Dei* exists not in humanity's past or present, but in humanity's future and in the person of Christ. As such, it functions as a "divine call forward" to become increasingly Christlike (p. 96). Peters refrains from locating the *imago Dei* in humanity's past because he believes humanity's fallen state is "equiprimordial with our appearance in biological history" (p. 104) and that human nature was not fixed at some historical point but is retroactively determined by what humanity will be at the redemption. Unfortunately, Peters offers no clear definition of the *imago Dei* or explanation of its incompatibility with fallenness.

All contributors in part 1 affirm human uniqueness although some affirm it only by way of degree. In his concluding comments, editor Michael Burdett encourages readers to explore hybrid models, which allow them to affirm multifaceted understandings of imaging.

Part 2, Original Sin and Evolution, addresses the origins, transmission, and universality of sin. Contributors disagree whether the origins of human sinfulness should be identified with an intentional, human decision to turn away from God at a particular time in history (C. John Collins, Andrew Pinsent, and Gijsbert van den Brink) or with the inevitable realization of innate tendencies for aggression and self-assertion inherited from prehuman ancestors (Christopher Hays). Some contributors present science-compatible Fall narratives. For example, Collins proposes a "federal head" model in which two representative humans intentionally turned away from God at the headwaters of human history, bearing consequences for all humans. Hays, on the other hand, regards the historic placement of the first sin irrelevant since it was not responsible for subsequent sins. According to Hays, we can affirm the universality of sin and human culpability for sin without an originating sin.

McCoy's chapter cautions against misusing Irenaeus's theology to support theologies that dismiss a traditional Fall, which he argues is necessary to Irenaean thought. McCoy's chapter is insightful, but unless the reader is familiar with the external discussion McCoy is responding to, the chapter appears somewhat tangential to part 2's driving questions.

Contributors affirm the universality of sin, although they disagree on the mechanisms that unify humanity in sin and account for the transmission of sin: Collins suggests that unity in sin is rooted in covenant with God, Van den Toren argues that transmission of sin is inseparable from cultural evolution, and Pinsent suggests that original sin is propagated by the absence of supernatural grace (which he suggests was a pre-Fall addition to human nature).

Part 3, Evil and Evolution, addresses questions of why God is not culpable for animal suffering in prehuman history and why God employed violent means of creating; it highlights a variety of avenues available to affirm God's goodness in light of prehuman suffering. Only-way theodicies dominate: they include Rosenberg's view that death and decay are necessary marks of a finite world, Vince Vitale's "non-identity theodicy" (based on the idea that the existence of individuals alive today is contingent on past suffering), and Christopher Southgate's argument that the values of this world come at the expense of its disvalues. Michael Lloyd provides the only substantive free will defense, which attributes a cosmic Fall to free angelic beings, and Richard Swinburne offers an Irenaean soul-making theodicy which argues that the finite amount of suffering God allows us to endure is outweighed by the goodness of the soul-making opportunities it provides.

Part 3 benefits from the way contributors highlight lingering concerns in each other's models. Lloyd's chapter "Theodicy, Fall, and Adam" is exemplary: from only-way theodicies Lloyd calls for better defense of the unique creativity of violence, and from Augustinian nonbeing approaches he calls for a better defense of the inability of God to counteract creation's tendency toward nonbeing now if God will do so post-eschaton. However, since the format of the book does not facilitate intra-book responses, such challenges remain unaddressed. Moreover, editorial content and many contributors assume that prehuman suffering is "evil," and, although some contributors disagree, this assumption is unfortunately never explicitly contested. Nevertheless, part 3 concludes the book in a helpful way: it outlines potential solutions to concerns about evil and the goodness of creation that are discussed throughout the book.

In conclusion, part 1 provides defenses of four models of imaging—sometimes at the expense of discussion concerning human uniqueness, origins, and telos. Part 2 successfully provides a multifaceted discussion on the origins, transmission, and universality of sin. And part 3 offers theodicies that illuminate various directions forward; it also raises many unanswered questions. Ultimately, bringing a representative selection of views to the table—more so than novel ideas—is the function of this book. Editorial contributions unify *Finding Ourselves after Darwin* as an accessible, well-assembled exploration of truth. Editors, and sometimes contributors, offer epistemological guidance and identify fruitful avenues for future exploration, making the discussion one that uniquely moves the reader forward in their search for truth. Interaction between contributors, when present, adds richness to the discussion but is not consistent throughout the book. *Finding Ourselves after Darwin* is further unified by a commitment to the doctrinal core that is accompanied by various degrees of flexibility concerning the retention of theological theories that have grown up around certain doctrines. *Finding Ourselves after Darwin* will help undergraduate students, pastors, and other informed Christians pursue a coherent and scientifically informed faith.

Reviewed by Charlotte Combrink, Religious Studies at Westmont College, Santa Barbara, CA 93108.

READING GENESIS WELL: Navigating History, Poetry, Science, and Truth in Genesis 1–11 by C. John Collins. Grand Rapids, MI: Zondervan Academic, 2018. 336 pages. Paperback; $36.99. ISBN: 9780310598572.

C. John Collins makes judicious use of C.S. Lewis throughout his book and offers a reading of the early chapters of Genesis that seeks to avoid both an ahistorical fundamentalist interpretation and a dismissive scientism that views Genesis as bad science by ignorant people. Collins identifies himself as a "religious traditionalist," and he seeks to read Genesis in ways that take seriously the original context of the author and first readers of the text. In doing so, he makes more evident the real meaning of Genesis as a rival creation story to other creation stories circulating at that time in the ancient near East. Collins has a twofold goal.

> The first is to provide guidance to those who want to consider how these Bible passages relate to the findings of the sciences. The second is to establish patterns of good theological reading, patterns applicable to other texts. (p. 32)

Collins emphasizes quite rightly that to interpret a text correctly it is important to consider the context. It is context that determines whether the words, "I'm going to kill you" are a lethal threat to life or the joking retort of a friend. Genesis is not trying to do contemporary science, so to read Genesis as opposed to or in support of contemporary science is to rip Genesis from its ancient context in terms of both its literary form and its world view. The story of Genesis is not trying and failing to answer contemporary scientific questions; rather, the story of Genesis is emphasizing that, "all human beings have a common origin, a common predicament, and a common need to know God and have God's image restored in them" (p. 113).

We can understand what Genesis truly means by putting Genesis back into its ancient context. As Collins notes, "I take the purpose of Genesis to begin with opposing the origin stories of other ancient peoples by telling of one true God who made heaven and earth …" (p. 137). Once Genesis is put back into its context, we can better appreciate the genre of the work. The language of Genesis is not scientific but poetic. Collins notes that we can communicate truths using different kinds of language. In ordinary language, we say, "You are beautiful." In scientific language, we might say, "You exhibit visible signs of youth, health, fertility, and symmetry." In poetic language, we could say, "Shall I compare thee to a summer's day? Thou art more lovely and more temperate: Rough winds do shake the darling buds of May, And summer's lease hath all too

short a date." Imagine someone who got out a weather almanac, looked up the speed of winds last May, and replied, "Last May, the winds were unseasonably calm. No rough winds at all. Shakespeare was horrible at correctly noting the weather! What a dunce!" Of course, in writing Sonnet 18, Shakespeare was not trying and failing to compose an accurate weather report. The Bard's purposes, genre, and context are entirely different than meteorology. So, too, Genesis is not trying and failing to provide a scientific account of the origin of sun, moon, and stars—or man. To fault Genesis as a bad science is like faulting Shakespeare as a bad weather man. Collins correctly notes, "To call Genesis 'science,' whether ancient or modern is an enormous literary confusion" (p. 279).

So, if Genesis is not failing to be good science, since it is not even attempting to do science, what is Genesis about? The Genesis account is a correction to the rival stories of the ancient world. Genesis holds, in contrast to the pagan myths, that the sun, moon, and stars are not gods. The heavenly bodies exist to serve humans, to mark time. The idea that nature is not a god is an idea of signal importance, for if the created order is not divine, then the door is open for science to dissect and examine the secrets of nature. Genesis steers a middle course between a radical environmentalism (worshiping nature as divine) and a radical anti-environmentalism (domineering of nature as worthless material).

The role of humankind is also made more plain by contrasting Genesis with rival stories. Collins notes,

> In the Mesopotamian stories the gods made humankind to do the work they do not wish to do, but they regret their action and decide to eliminate humanity because people have multiplied and become so noisy that the gods cannot rest (which was their original goal in making man). (p. 190)

How unlike the God of Abraham who urges human beings to be fruitful and multiply. The Greek poet Hesiod wrote, "Zeus who thunders on high made women to be an evil to mortal men, with a nurture to do evil." By contrast, Genesis proclaims both man and woman to be made in the image and likeness of God. Both man and woman fall to the serpent's temptation. Both man and woman are cared for by God after the Fall.

Reading Genesis Well is a good book, and it could be made even better. At times, there is a great deal of windup before the pitch. At other times, there is needless repetition. For example, Collins writes, "The creation narrative portrays the sun, moon, and stars as makers for the (liturgical) seasons. They are servants to help humankind worship the Maker, not masters themselves worthy of human worship" (p. 293). This is a great point, but the point is made at least three times in the text.

The organization of the text could be improved in places. For example, when Collins quotes Rudolf Bultmann's famous assertion, "It is impossible to use the electric light and the wireless [radio] and to avail ourselves of modern medical and surgical discoveries, and at the same time to believe in the New Testament world of spirits and miracles," he does not respond to this assertion until pages later.

In places, not just form but substance can be improved. Collins quotes with approval James Packer saying, "The church no more created the canon [of scripture] than Newton created the law of gravity; recognition is not creation." But this is not quite right. The New Testament was written by early leaders of the church, such as Paul, Mark, Luke, Matthew, and John. It was the Council of Rome (p. 382) that fixed the biblical canon which was in some state of flux until then. The New Testament arose from the leaders of the early church and was cast into its current form by the leaders of the patristic church. That is much more than a mere recognition. Collins touches on the monogenism-polygenism question but does not address the dispute at sufficient length.

None of these quibbles should deter readers from profiting from Collins's research. *Reading Genesis Well* can indeed help us better understand one of the most ancient, most important, and most influential texts of all time.

Reviewed by Christopher Kaczor, Professor of Philosophy, Loyola Marymount University, 1 LMU Drive, Los Angeles, CA 90045.

OLD-EARTH OR EVOLUTIONARY CREATION? Discussing Origins with Reasons to Believe and BioLogos by Kenneth Keathley, J. B. Stump, and Joe Aguirre, eds. Downers Grove, IL: InterVarsity Press, 2017. 256 pages. Paperback; $28.00. ISBN: 9780830852925.

In *Old-Earth or Evolutionary Creation? Discussing Origins with Reasons to Believe and BioLogos*, the main question comes down to, "When science and faith appear to conflict, how is the apparent conflict navigated?" In other words, which gives in and changes first, scriptural interpretation or acceptance of scientific findings? We (the reviewers) hold different opinions about several of the debates and specific arguments outlined in this book. Dr. Vukov is a philosopher and practicing Roman Catholic while Dr. Burns is an agnostic atheist and a molecular biologist. Our take on issues at the intersection of science and religion is bound to be divergent.

The book is structured as a dialogue between the two aforementioned groups, Reasons to Believe (RTB) and BioLogos, and is moderated by members of the Southern Baptist Convention (SBC). The chapters each focus on a particular aspect of the science surrounding evolution and how the debating groups respond to or critique the science and/or integrate it into their faiths.

Who are BioLogos and RTB? Both groups have similar mission statements. BioLogos "invites the church and the world to see the harmony between science and

biblical faith as [they] present an evolutionary understanding of God's creation."[1] RTB's mission is similar: the organization seeks "to spread the Christian gospel by demonstrating that sound reason and scientific research … consistently support, rather than erode, confidence in the truth of the Bible and faith in the personal, transcendent God revealed in both Scripture and nature."[2] In other words, both groups seek to promote science literacy among fellow Christians while also proselytizing nonbelievers. Generally speaking, however, RTB emphasizes the latter while BioLogos emphasizes the former.

RTB and BioLogos also share a common view of the "two books," that is, the book of nature and the book of scripture by which God reveals himself. This offers a starting point for their discussion. Since the "two books" are both aspects of God's revelation, they de facto cannot conflict with one another—while "they may be referring to different things … they are not saying contrary things."[3]

But of course, these two books do sometimes come into conflict, at least apparently. One virtue of old-earth or evolutionary creation is that several of the questions presented in it go beyond the kinds of conflicts covered in mainstream media dialogues. Rather than "did evolution take place?" you hear "what does it mean for a literal Adam and Eve if evolution is correct?" The former question, we (and RTB and BioLogos) believe, is settled, making the latter question the more interesting one. Many denominations, after all, put quite a bit of stock in there having been a historical first pair of humans in the form of Adam and Eve. The Fall of these humans, also a historical event by these interpretations, had consequences that were passed on to each member of the succeeding generations of humans, much as how genes are passed from one generation to the next. In these interpretations of the Fall, there is therefore a theological need for a single lineage of humans. Evolutionary theory, however, rejects the idea of a single human lineage having arisen from a single couple. It is clear then that something needs to give way: either a single pair of humans, Adam and Eve, did not exist literally as described (perhaps they were instead metaphorical placeholders for a small population of early humans) or there's something untrustworthy about the genetic models of how populations evolve. BioLogos opts for the former option, RTB for the latter. BioLogos's tendency to defer more to the book of nature than is RTB's is seen throughout the book.

Consider, for example, the evolution-specific lines of evidence debated in the book's pages. The debate between the two groups across the range of scientific evidence regarding humanity's place in an evolutionary framework is taken piecemeal across the chapters: each chapter is devoted to one topic, such as fossil evidence. One unfortunate effect of this organization is that the evidence for evolution is diluted. Indeed, when the scientific evidence regarding humanity's place in an evolutionary framework is taken as a set of convergent, predictive findings, there is a unified scientific theory into which human evolution fits quite well.

This organizational issue aside, however, we find the current field of genomics to be the most exciting body of evidence presented in the book. This body of evidence is also, perhaps, the most damning for RTB, who advocate for a "special creation" of humans, thus resisting the weight of evidence in favor of placing humans in the great causal chain of evolution by natural selection over the vast span of biological time. In this regard, RTB is simply not taking a scientific approach when arguing against the genomic evidence. At several points in the back and forth, it is highlighted that, for instance, there is approximately a zero percent chance that the human population was ever smaller than several thousand individuals. This is a known fact and all the evidence and models of population genetics agree on this. The only way around this would be to (1) invoke some form of miraculous intervention to allow for some other possibility (e.g., a single pair of humans) followed by another miracle to make the models based on evidence look otherwise or (2) suggest that the thousands of world-class evolutionary biologists, geneticists, statisticians, and bioinformaticians who build and use these models are seriously mistaken, without empirical evidence to suggest that they are.

It is fitting, then, that Francis Collins both founded BioLogos and was also the lead scientific administrator behind the Human Genome Project. Collins, we would presume, has found a way to do what RTB has not—to reconcile what the "book of nature" is telling him about creation and to use that knowledge to shape his interpretation of what is revealed by scripture. Again, what the two groups exemplify throughout their dialogue are differences in priority that are attributed to the "two books." BioLogos pushes for the incorporation of current scientific findings inside the framework of their evolving knowledge of the Christian faith, whereas RTB, by contrast, appears substantially more reluctant to accede to any alterations of their current interpretations of what they see revealed in the Bible. Both may formally recognize the two books. But RTB clearly sees the book of nature as written in a much smaller font than does BioLogos.

In their discussions, the topic of methodological naturalism (MN) also comes up with regularity. In the text, MN is defined (or rather, not defined) as "… a contingent value of most practicing scientists today" (p. 109). Colloquially, MN is simply the assumption that when you are applying a scientific test to interpret the results of an experiment, you rule out any supernatural explanations. For the methodological naturalist, you, as a scientist, should approach the cosmos as if it were composed exclusively of natural bits of matter and energy—no gods or spirits or divine interventions

at play. Why do things this way? Well, it appears to work, and functionality alone is relatively strong evidence for its practical application as the way of doing science. It isn't that MN disproves anything supernatural. It is simply that supernatural explanations appear to be irrelevant.

There is, of course, plenty of room for disagreement about MN, and BioLogos and RTB are no exceptions. Obviously, as both are Christian groups, neither is comfortable with pure MN as the only way of viewing the universe, but they do have differences of opinion regarding its utility. J. B. Stump, writing for BioLogos, suggests that "... understanding of natural theology needs MN. It is another question, though, whether theological conclusions can be derived from purely scientific premises" (p. 111). This claim, however, is at odds with a belief that "[methodological naturalism] is not a necessary part of science" (p. 109), a view that is directly at odds with the current understanding of science as a process. What does a scientific process that incorporates the ineffable, unpredictable actions of nonnatural entities look like? Jeff Zweerink (RTB) argues that "For practical purposes, scientists must operate largely from a standpoint of methodological naturalism … however, that does not completely exclude theological considerations" (p. 113). In RTB's view, the Bible is a source of testable scientific claims that can be assessed to reveal or support theological truths. Curiously, the two groups seem to agree on the utility of MN, but BioLogos sees it as a means of correcting their incomplete interpretations of faith while RTB sees it as a way to buttress their existing interpretations.

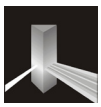
What is our take on the debates found in the book? It should be clear by now that we prefer BioLogos's approach to that of RTB's. But that's not to say that we agree completely with BioLogos, or indeed, with each other. One thing we do agree upon, however, is the value of intellectual humility in approaching these issues. And that also leads us to favor the approach of BioLogos. Indeed, with respect to the approaches to the integration of the science surrounding human origins and Christian faith as outlined by BioLogos and RTB, it is clear that the former is more readily able to accept their intellectual limits—or rather, accept that perhaps some of their prescientific beliefs and biblical interpretations might be mistaken or in need of revision. For some, this admission might be seen as a sign of weakness of faith and lacking in conviction. For others, this is a sign of a faith that is wholly human, an admission that no one has a perfect understanding of the revelations found in either of the "two books," and a presumption that one's position is destined to be readjusted as the two interplay.

Should you read this book? We commend the groups involved in the work (BioLogos, RTB, and the SBC) for their demonstration of vigorous intellectual engagement. It is a testament to their pursuit of knowledge that they are able to engage in good-faith argument on these contentious topics. Reading through this work will provide believers with a wide variety of positions regarding human origins and Christianity while also covering the scientific support underpinning our understanding of human evolution. For nonbelievers, this work might be of interest to provide perspective on how believers view the topics of debate. However, it contains much material about issues along the lines of "how many angels can fit on the head of a pin"-type Christian esoterica that are typically uninteresting and unconvincing to outsiders. In this regard, the debate presented here clearly targets the faithful. If you are a Christian who is interested in challenging your perspectives on what it might mean to think deeply about human origins and faith, this book is an excellent and rigorous starting point.

Notes

[1]BioLogos, "What We Believe," accessed February 18, 2019. https://biologos.org/about-us/what-we-believe/.
[2]Reasons to Believe, "Mission and Beliefs," accessed May 4, 2020, https://reasons.org/about.
[3]Kenneth Keathley, J. B. Stump, and Joe Aguirre, *Old-Earth or Evolutionary Creation? Discussing Origins with Reasons to Believe and BioLogos* (Downers Grove, IL: InterVarsity Press, 2017), 12.

Reviewed by Michael B. Burns, Assistant Professor of Biology at Loyola University Chicago, Chicago, IL 60660; and Joe Vukov, Assistant Professor of Philosophy at Loyola University Chicago, Chicago, IL 60660.



Physics

AMAZING GRACE OF QUANTUM PHYSICS by Dillard W. Faries. Eugene, OR: Pickwick Publications, 2017. 268 pages. Paperback; $33.55. ISBN: 9781532614217.

What if beneath the world of everyday experience things were not as they seem? If all things did not really have predictable locations or follow predictable trajectories but instead only appear to because they are large enough that their true behavior is undetectable to our senses? If the cosmos did not consist of discrete particles acting independently of all others; that everything was somehow connected with everything else? Strange as these possibilities may seem, these are not "what-ifs"; according to quantum physics, they are in all likelihood how the real world actually behaves. How physics arrived at this quantum mechanical understanding—if, indeed, it may legitimately be so called—forms a major theme of Dillard Faries's *Amazing Grace of Quantum Physics*, which also seeks to unpack some of the philosophical and theological implications of the quantum mechanics (QM) shockingly counterintuitive picture of reality.

Amazing Grace of Quantum Physics consists of an introduction, 18 chapters, an epilogue, and two appendices, but is perhaps better thought of as involving three main somewhat loosely overlapping parts. The first involves introductory material and consists of the introduction

and first chapter. The former introduces the main themes and offers a précis of the book. The latter surveys the main categories of classical physics that were radically challenged by QM, such as determinism and locality.

The second section roughly comprises chapters 2–10 and unpacks the main historical episodes that culminated in the development of QM, beginning with the discovery of radioactivity and culminating in competing equivalent mathematical formulations of quantum phenomena and the Copenhagen interpretation in the 1920s. Unlike other books on QM, this account focuses on how physicists, ranging from Benjamin Thompson, Michael Faraday, and James Maxwell to Max Planck, Albert Einstein, Louis de Broglie, Wolfgang Pauli, Erwin Schrödinger, Werner Heisenberg, Niels Bohr, and others, offered new understandings of reality that developed, problematized, and ultimately challenged classical Newtonian physics. This is central to Faries's narrative since the classical physics that was overthrown both arose from and misinformed Western theology before it descended into a sterile deism in the wake of Humean skepticism. Thus a theme of this section is that the overthrow of classical physics by QM is good news for Christian theism.

The final section comprises chapters 11–18 and the epilogue; it carries forward the story of QM to the present day. These chapters seek to explain QM's counterintuitive and somewhat paradoxical picture of reality, suggesting a number of implications for Christian thought along the way. This section focuses on a number of issues. These include the difficulty of relating the mathematical results of QM to physical reality so that they can be interpreted in the Copenhagen sense as probabilities or, less commonly, more deterministically in de Broglie-Bohm interpretation. Other issues include indeterminacy and the EPR paradox, Bell's inequality and the impossibility of agreement between QM and local reality, and the observer effect. Along with Fermat's principle of least time, which suggests that waves somehow know the shortest path to take, Faries argues that these open up possibilities to interpret reality as purposeful and consistent with Christian theism, which Faries demonstrates by offering his own tentative interpretation of QM. He ends by inviting the reader to do the same.

On one level *Amazing Grace of Quantum Physics* is a serious book in the sense of offering the quantum physics as consistent with a theology of mystery in which there is room for meaningful free will and divine action. However, as Faries himself explains, he is neither a theologian nor a philosopher. This shows, in that he does little to systematically develop a theology of mystery and does not interact with the extensive recent work in the history and philosophy of physics or with the science and religion literature on quantum indeterminacy and divine action (or issues such as the scope and limits of natural theology). Instead, he prefers to offer his own sweeping suggestions and, in the case of divine action, build directly from the insights of William Pollard that have formed the backdrop to such discussions since the 1950s. So, in the end, *Amazing Grace of Quantum Physics* is perhaps best taken as a physicist who is a Christian explaining that he sees room for consonance between Christianity and science in the world of quantum physics.

Amazing Grace of Quantum Physics suffers from a number of flaws. The most flagrant is Faries's tendency to skip key details and insert entertaining but distracting tangents in the midst of otherwise cogent explanations. This, coupled with his tendency to allow loose analogies or hints to stand in for arguments, tends to obscure rather than illuminate what Faries is trying to convey. I often found myself having to insert key details or connections from my own knowledge, make assumptions about what exactly he was referring to, and, in a few cases, supply a missing argument. Nevertheless, between my own understanding of QM and because Faries ultimately gets around to explaining everything by the end of the book, both the physics he was trying to explain and the shape of his argument had become clear.

The book will be of value mainly to professional physicists and teachers of physics. In contrast those who are unversed in the basics of quantum physics or have little prior knowledge about its history are likely to find some parts impossible to follow (or, worse, acquire a superficial and incorrect understanding). Instead, these readers should start by reading a more accessible introduction. Some readers might also be alienated by Faries's casual jabs at Calvinism or his unnecessary use of an offensive racial slur to vivify the personality of Werner Heisenberg (which may have been done in ignorance as the slur is not a common one).

Nevertheless, those who are able to overlook the limitations of *Amazing Grace of Quantum Physics* will find value in its pages. It is one of the few works that seeks to offer a fairly robust overview of quantum physics along with nuggets of encouragement and pregnant hints. Here I offer two of particular note. The first is Faries's invocation of mystery as a useful but largely unexplored category in science-faith discourse, at least in the evangelical circles of which Faries is a part. The second is akin to John Polkinghorne's earlier and more theologically and philosophically sophisticated exploration of the similarities between theology and physics in his *Quantum Physics and Theology: An Unexpected Kinship* (Yale University Press, 2007), in which Polkinghorne demonstrates consonance between the search for reality through physics and theology. Faries does something similar at one point in this section, offering that Christians should not feel overly anxious in the absence of a complete and unassailable understanding of how to relate science and Christian theology. In Christianity,

as in quantum physics, for the time being, we can be confident resting in what we know, even when there appear to be paradoxes or explanations that seem partial, tentative, and generative of new questions as well as answers.

Reviewed by Stephen M. Contakes, Department of Chemistry, Westmont College, Santa Barbara, CA 93108.

THE WORLD ACCORDING TO PHYSICS by Jim Al-Khalili. Princeton, NJ: Princeton University Press, 2020. 336 pages. Hardcover; $16.95. ISBN: 9780691182308.

The World According to Physics is Jim Al-Khalili's "ode to physics" (p. vii). While Al-Khalili has been publishing popular science for over twenty years, this is his first attempt to provide the layperson a cohesive overview of physics as a whole, linking together relativity, quantum mechanics, and thermodynamics into one unified (or rather, not yet unified) picture of the cosmos. "Ode" is appropriate, for the author's unrelenting adoration of his subject is apparent throughout; this is a child's dream fulfilled, and in many ways is a broader summa of the world according to the mature Al-Khalili, bringing together not only physics, but also his views on truth, society, and our future.

Khalili opens with a discussion of how the human mind craves narrative. Yet science has displaced much of the old myths and religions:

> Contrary to what some people might argue, the scientific method is not just another way of looking at the world, nor is it just another cultural ideology or belief system. It is the way we learn about nature through trial and error, through experimentation and observation, through being prepared to replace ideas that turn out to be wrong or incomplete with better ones, and through seeing patterns in nature and beauty in the mathematical equations that describe these patterns. All the while we deepen our understanding and get closer to that "truth"—the way the world really is. (p. 2)

While physics is not just another "story," it does have a cosmic scale that gives it a captivating wonder of its own, providing the basis for chapter 2 ("Scale"). Physics encompasses the infinitely small (e.g., subatomic particles) as well as the infinitely large (e.g., the expansion of spacetime at the farthest reaches of existence). Further, its scope is not merely all of space but all of time as well, getting within decimal points of the first instant after the big bang, while providing prophetic approximations of how the cosmos might end. While Al-Khalili does not play his cards this early, his later chapters (pp. 242–43 in particular) will reveal that this extensive scope establishes physics as the most fundamental discipline, the reigning queen of the sciences.

The deeper project begins in chapter 3 ("Space and Time"). Al-Khalili wishes to display the underlying skeleton that comprise the unification project of physics, charting each merger until the final matchup is made (similar to a playoff line-up, where 16 teams soon become 8, then 4, then 2, then 1). Just as Newton wedded heaven and Earth through gravity, Einstein wedded space and time, explaining a diversity of phenomena with ever-simpler equations. While Al-Khalili's popular explanations of special and general relativity are merely adequate, his grasp of the broader narrative of unification in which these theories stand is incredibly useful, helping the layman see the trajectory of the book and physics as a whole, even when they cannot understand each individual step.

While chapter 3 unified space and time, chapter 4 ("Energy and Matter") unifies the energy and mass which warp said spacetime. Yet the unifications of relativity hit a snag when they come to "The Quantum World" (chapter 5) and to "Thermodynamics and the Arrow of Time" (chapter 6). While Einstein seems to rule over the kingdom of all things great, quantum mechanics rules over all things small, and no one has managed to negotiate a treaty just yet. Things do not work "down there" as they do "up here"; the laws of the macro are not the laws of the micro. Further, thermodynamics suggests that there is a directionality to time—for things move toward greater entropy—yet it is unclear how this can be made consistent with relativistic time or the conceptual reversibility of time in the quantum world.

Al-Khalili then moves in chapter 7 ("Unification") to possible reconciliations of these issues. He does an admirable job of explaining how the electromagnetic and weak nuclear forces were unified into the electroweak force, as well as explaining the ongoing attempt to unify the strong force with the electroweak force in a grand unified theory. This would leave only the holy grail: the attempt to unify gravity with the other three forces. String theory attempted such a unification by appealing to ten dimensions, yet by the 1990s there were five different string theories, which themselves needed to be unified, spawning M Theory (which required an additional eleventh dimension). An opposing contender soon arrived in loop quantum gravity. While string theory posits a quantum particle (the graviton) that exists within spacetime, loop quantum gravity inverts the order, making space more fundamental than a quantized particle within space, and so quantizing spacetime itself. These quanta of space are then "looped" together, determining the shape of spacetime.

Having unveiled the best approximations at a unified theory in physics today, Al-Khalili then ventures in chapter 8 to evaluate the subsequent state of the subject. He expresses frustration that no definitive proof has adjudicated between possible theories of everything, and that such unification seems further away now than it did thirty years ago. Even major discoveries, such as the Higgs boson, have mostly confirmed what we already suspected for decades, rather than

genuinely pushing the envelope. Yet while he has given plenty of reason to be sceptical, Al-Khalili then lists recent developments that show that plausible models of quantum gravity continue to come forward, for example, Witten's M-Theory or Maldacena's gauge/gravity duality. Further, physics continues to make substantial technological contributions to daily life. This leads naturally into chapter 9 ("The Usefulness of Physics"). Particular attention is paid to the future possibilities of quantum computing for physics, medicine, AI, and a whole host of other multi-disciplinary simulations and processes that quantum superpositions would allow (for superpositions enable a greater degree of complexity in contrast to binary).

Al-Khalili concludes with a final chapter ("Thinking like a Physicist") about how physics and the scientific method can and should help govern public discourse. In this chapter, the true aim of his project comes to light, suggesting he is not providing a picture of the world according to physics, but the world as it simply is:

> One day we may find a new theory of quantum gravity, but it will never predict that my ball will take twice or half as long as Newton's equation of motion predicts. That is an absolute truth about the world. There is no philosophical argument, no amount of meditation, no spiritual awakening or religious experience, or gut instinct or political ideology that could ever have told me that a ball dropped from a height of five metres would take one second to hit the ground. But science can tell me. (p. 276)

While Al-Khalili claimed in the preface that he would try to avoid metaphysical questions (p. xiii), he inevitably (and at times, self-consciously) stumbles back upon them, making ontological claims about the world-in-itself. Indeed, even his quest for unification is arguably based on a philosophical presupposition that unity is more fundamental than diversity, a tradition which came to fruition in Neoplatonism and Christian monotheism. While Al-Khalili acknowledges the need for philosophy and science to communicate (p. xiv), in practice he seems to treat philosophy as a useful tool for science when it hits a roadblock (e.g., for unpacking the implications of quantum mechanics) rather than a discipline in its own right that has the ability to question the underlying epistemic and ontological assumptions of science itself. As such, while his manner is more open and humble than your average humanist/materialist (he was elected president of the British Humanist Association in 2012), his actual beliefs do not seem to have absorbed much at all of the philosophical or theological complexity required for the sorts of claims he is making:

> The human condition is bountiful beyond measure. We have invented art and poetry and music; we have created religions and political systems; we have built societies, cultures, and empires so rich and complex that no mere mathematical formula could ever encapsulate them. But, if we want to know where we come from, where the atoms in our bodies were formed—the "why" and "how" of the world and universe we inhabit—then physics is the path to a true understanding of reality. And with this understanding, we can shape our world and our destiny. (p. 281)

Ultimately, if one wants a helpful primer on physics, Al-Khalili provides a passionate and serviceable introduction. While his explanations of some topics were perhaps too much for newcomers, his weaving together of subjects often treated in isolation helps get things back on track, providing a grander narrative for lost readers to latch on to. Yet, if one is looking to see how this narrative fares as an all-encompassing account of the "why" and "how" of our world, then there are superior accounts available on the market. Indeed, thousands of years of writing and prayer have already sought out and encountered the One at the heart of creation.

Reviewed by Jonathan Lyonhart, University of Cambridge, Sidney Sussex College, Cambridge, UK CB2 3HU.

Scientific Vocation

THE PERFECT PREDATOR: A Scientist's Race to Save Her Husband from a Deadly Superbug by Steffanie Strathdee and Thomas Patterson. New York: Hachette Books, 2019. 311 pages, plus reference and index. Hardcover; $29.00. ISBN: 9780316418089.

I have never been a fan of nonfiction, and although I love biology, I do not have much experience reading about it outside of textbooks. If you had asked me a few months ago, I would have said a book at the intersection of these genres sounded likely to be lethargically paced, overly detailed, and boring. However, Steffanie Strathdee and Tom Patterson's memoir/medical thriller *The Perfect Predator* changed my mind. The married coauthors share the story of the nine months when Patterson was near death from a formidable antibiotic-resistant bacterial infection. When his situation appeared hopeless, Strathdee enlisted a team of scientists to resurrect a treatment long forgotten by modern medicine: phage therapy. Christians will find much to admire in the selflessness and community displayed by the country-wide team that put together this novel treatment, and any reader will be inspired by the story of compassion and risk-taking to beat the odds. The story is both emotionally engaging and readable, despite all the science, and it draws much-needed attention to the antibiotic resistance crisis and the life-saving potential of phage therapy.

Strathdee, the primary narrator, sets our scene in Egypt, where the couple was on vacation in November of 2015. After a long day of sight-seeing, Patterson came down with what they assumed was a stomach bug. But by the time he had been taken to an Egyptian clinic, medevacked to Germany, and finally transferred back home to a US San Diego hospital, it turned out to be an infection with one of the most dangerous antibiotic-resistant bacteria in the world. Luckily for Patterson, though,

Strathdee is a determined epidemiologist as well as a devoted wife. As the doctors' list of options dwindled, she started to do her own research.

She stumbled upon the mostly forgotten technique of phage therapy—using bacteriophages to kill the bacteria that were causing an infection. Viruses and their hosts are precisely matched, so the right virus could be the "perfect predator" to kill even the deadliest bacteria. With the rise of antibiotics in the mid-twentieth century, phage therapy disappeared into the background of medical research. However, antibiotics were proving useless against Patterson's infection. Desperate, Strathdee decided to take a chance on phage therapy, untested as it might be. She enlisted phage researchers from across the country in a race against time to save her husband's life.

Even though the main attraction of the book, phage therapy, does not come into play until halfway through, it never feels like a slog to get to "the interesting part." Strathdee makes those nine long months eventful, and the vulnerability in her writing ensures that we are with her through all the hope and heartache along the way. Readers who enjoy memoirs will feel at home with this book. The science might sound formidable, but the authors ensure that their audience does not need a background in medicine or microbiology. Their readable descriptions provide everything necessary to understand what is going on, whether it is a quick definition of sepsis or a crash course on the history of penicillin.

Strathdee writes with humility; her narrative intentionally and thoroughly highlights all the help she received. Doctors and phage researchers from across the world contributed to Patterson's care. She notes the remarkable collaboration as a picture of global medicine, but I think Christians will also recognize it as a picture of selfless community. So many people dropped what they were doing to save a total stranger, from the researchers who worked overtime to isolate phages, to the FDA officials who fast-tracked the approval paperwork through the system. They demonstrate a lot of the virtues that the body of Christ should exemplify, including compassion, unity, and selflessness.

It is no wonder there were so many people involved, because the path to the phage cocktail that saved Patterson's life was long and convoluted. It took almost half the book before the idea of phages even comes into the picture. Once the idea was introduced, I expected every chapter to be the chapter that they finally start treating Patterson. But Strathdee is too thorough a writer for everything to be over so simply. Her narrative walks the reader through the many, many steps of getting the phages from a culture plate to Patterson. Deciding which phages to use, transporting the phages, getting the necessary paperwork and approval, preparing them at the pharmacy, determining dosages, choosing a method and location of administration—the list goes on. I was getting impatient that the book was so slow, until it occurred to me how agonizing it would be to endure all this waiting in real life, like Patterson's family and care team did. After all, I know what they did not: Tom survives.

That occasional feeling of slowness is this book's only flaw. One thing that contributes to it is the lack of increasing stakes. If this were a novel, the stakes would have to get higher as the plot progressed, but Patterson's life had been on the line since they were in Frankfurt. It has been life-or-death since the beginning, so there is nowhere to go. Of course, this is not the authors' fault. Strathdee does her best to create a sense of urgency by the way she describes her emotional experience. We can feel her becoming more desperate the longer Patterson spends in the hospital.

Another authorial choice that helps the stakes was the inclusion of the "interludes." These short anecdotes are told from Patterson's perspective. While his wife and care team searched for a cure, he wandered in a surreal world of threatening, acid-trip imagery. Even unconsciousness did not protect him from suffering. These interludes remind us of the stakes from his perspective as well as from Strathdee's. Not only could Strathdee lose her husband, but Patterson could die alone and hopeless in the agonizing wilderness of his hallucinations.

However, the authors are aware that the stakes are high for more than the two of them. They do not stop the story after reporting that the phages were successful, and Patterson survived. In the last chapter, they present a larger perspective on the significance of his landmark case. First of all, it is an excellent example of global collaboration and medicine. But more than that, Patterson's case brings much-needed attention to phage therapy's potential. It is a promising and personalizable treatment that has been too long overlooked. Research is needed to explore its efficacy and, if the studies are favorable, to regulate it so that it can save lives on a large scale.

This will not happen, however, until there is more awareness of the antibiotic resistance crisis that demands solutions such as phage therapy. Strathdee is an epidemiologist, and even she did not realize the magnitude of the problem until it nearly killed her husband. Precedent suggests that crises are often what push medicine forward. As the authors point out, WWII and the AIDS epidemic both stimulated advances in medicine and access to treatments. Now is the time, with the resistance crisis causing antibiotics to become less and less effective, to pursue new approaches and to bring phage therapy back out of the shadows.

All in all, I found *The Perfect Predator* to be a fascinating combination of science and storytelling. Strathdee and

Patterson are considerate, compassionate writers, and they do an excellent job of avoiding the traps that could make this book dull. I would recommend it especially to those who work in health care, but it is also relevant and accessible to laypeople. Christians in particular might connect to the kind of selfless community displayed by the phage researchers. This book combines the best of the genres it spans. It is a lucid description of a remarkable achievement in medical science, but it is also the very human story of a woman fighting to save her husband. Whether phage therapy turns out to be the future or not, *The Perfect Predator* definitely made a medical memoir convert out of me.

Reviewed by Karsten Garwood with Sara Sybesma Tolsma, Department of Biology, Northwestern College, Orange City, IA 51041.

HOW TO BE A BETTER SCIENTIST by Andrew C. Johnson and John P. Sumpter. New York: Routledge, 2019. 247 pages, index. Paperback; $23.95. ISBN: 9781138731295.

It is hard to imagine the need for yet another offering in the crowded field of generalized science books. This is especially true in the case of Johnson and Sumpter's broad *How to Be a Better Scientist*, which lacks an obvious audience or niche. However, the authors largely achieve their stated aim of producing a book that is not only accessible but also relevant to aspiring and established scientists alike, including those at every career stage—from beginning students to seasoned principal investigators (PIs). The tone of the slim volume is light and leavened with great dollops of humor, yet the topics are so well mined that occasional nuggets of wisdom make the book even more interesting and appealing.

Breadth rules over depth, with chapters covering everything from how to choose a graduate school sponsor and research project, to how to secure grant funding and to design a conference poster. The individual chapters and the overall organization span the range from planning experiments and seeking jobs, to making the most of scientific meetings and social media, but the overall view is from the proverbial 30,000 feet rather than close up. The vocabulary is simple, the mood informal and breezy rather than stuffy or preachy, and the writing mostly crisp and to the point. Each chapter ends with a handy concluding checklist reiterating major "take-home" messages.

Late-career scientists might appreciate the practical advice on keeping a busy lab running effectively while supervising students and postdocs. Nonetheless, it is hard to imagine that most of the "hands-on," step-by-step advice provided here (such as how to create and present a conference talk, how to plan and submit a manuscript, and where to seek funding) would not already be well known to experienced scientists, even if it might be nice for them to skim the chapters and see the world of scientific investigation through the fresh eyes of newbies. Indeed, most of the practical advice dispensed here is aimed squarely at the beginning, or even aspiring, scientist. Still, the authors make clear that even a late-stage scientist's career is best considered a "work in progress," and there is practical advice for more-seasoned scientists, including how to deal with collaborators, funders, administrators, and media.

The authors offer appropriate examples to support their arguments, such as the discovery that gastric ulcers are caused not by stress but by pathogenic bacteria, demonstrating that while it is difficult to overturn conventional wisdom, scientific data typically achieve this effect in the end. Occasional references are provided, but readers are generally left on their own to hunt down sources for further reading. However, the focus is largely on practical advice. Readers are urged to join ResearchGate, to use many subheadings in their writing, and to use figures in place of words in explaining results.

Still, this is by no means a technical book. The authors make clear in their foreword that they never intended to write a technical book or to engage in philosophical exploration or description of any or all particular branches of scientific investigation. Instead, Johnson and Sumpter draw on their many years of combined experience as professional scientists, including publication of numerous articles and supervision of dozens of graduate students, in seeking to halt the spread of what they characterize as "poor science": boring or impenetrable writing, lackluster talks, unfocused projects, and (worst of all, in their view) unhappy scientists. The authors write of witnessing many aspiring scientists abandon their career goals due not only to an unfortunate inability to do good science but also to an exasperating inability to find fulfillment and joy in their work.

One of the major themes of the book—handled often and well—is that science is a brutal battleground that poses great psychological perils for its practitioners. The authors make clear that recurring setbacks and frustrations play a huge role in how scientific findings, and individual scientists themselves, advance. They also make clear that such frustration is not anomalous but instead routine. There are multiple detailed sections on how to handle criticism and rejection, and even an entire chapter on "When Things Are Not Going Well" (sample advice: "Do not try to work yourself out of trouble"). It is both refreshing and admirably constructive for Johnson and Sumpter to advocate, indeed urge, that scientists of all ages and experiences take solid steps to protect their time, sanity, lifestyle, and emotional health. Again and again, the authors recommend that scientists find a balanced life outside the lab. They argue that to become a better scientist, one must become a better person. The focus on scientific integrity and, in particular, on admitting mistakes and telling one's story with honesty and transparency, is commendable.

Indeed, apart from its "something for everyone" approach, the book's true strength lies in its recognition of communication as a central focus of science. Yes, too many scientists forget the scientific method's all-important final step: to share one's findings. "The need to communicate well in science is not appreciated as much as it should be" (p. 110). The authors urge that scientists should be able to explain their work—what they do and why it matters—to parents or other family members. They further advise dedication of large blocks of time to writing. "Easy reading is damn hard writing" (p. 144).

However, the authors' mostly thorough exploration of communication leaves one huge boulder unturned, which exposes the book's central weakness. Much is made of the importance of scientists explaining their findings to other scientists, but in today's world it is just as crucial for scientists to communicate the relevance of their findings to critics outside science. How should one explain research to skeptics and deniers who question the legitimacy of scientific findings, let alone the need for science in the first place? Is a better poster, or even more data, really the best way to handle vaccination doubters and climate change deniers? Regrettably, the authors barely touch on this topic.

My second criticism of the book involves a different focus. Although the authors pointedly wished to steer clear of anything smacking of philosophy (or even academic debate), I found myself at times wishing they would have at least acknowledged some of the numerous and important philosophical ideas concerning the proper undertaking of science. For example, one of the topics they mention throughout the book, both directly and indirectly, involves how one knows when one has collected sufficient data to test one's hypothesis and justify conclusions. Unfortunately, this is never dealt with in depth or head on, with the result that some of the advice becomes contradictory ("Be thorough and don't take shortcuts" versus "Don't be a perfectionist"). How much trust should we put in our findings and conclusions? How do we know if they are true? How do we know when to stop doing replicates of experiments—do we base the decision on statistical inference alone? or on something more? I appreciate that the authors sought to provide practical guidance rather than venturing into potentially pedantic territory, but even simple recognition of such issues, with references as to where to explore further, would be a big boon to scientists of all levels in search of self-improvement. There is also virtually no mention of faith.

How to Be a Better Scientist is fun to read. It will provoke smiles, raise eyebrows, and bring useful rewards. Overall, there is much to recommend here, but like the best of science, there remains a never-ending list of further questions to be addressed.

Reviewed by Alexander J. Werth, Professor of Biology, Hampden-Sydney College, Hampden Sydney, VA 23943.

Technology

THE AGE OF AI: Artificial Intelligence and the Future of Humanity by Jason Thacker. Grand Rapids, MI: Zondervan Thrive, 2020. 192 pages. Hardcover; $22.99. ISBN: 9780310357643.

There are not yet many books that engage with artificial intelligence theologically. Jason Thacker's *The Age of AI: Artificial Intelligence and the Future of Humanity*, written for a general audience, provides an important start to much-needed theological discussions about autonomous and intelligent technologies. As an early effort in this complex interdisciplinary dialogue, this book deserves credit for its initial exploratory efforts. Thacker's book also points to the larger and more complex territory requiring further exploration.

Thacker, creative director at the Ethics and Religious Liberty Commission of the Southern Baptist Convention and project lead for their "Artificial Intelligence: An Evangelical Statement of Principles," is eager to draw attention to the pervasive and disruptive presence of artificial intelligence in our lives. While some may be distracted by images of AI that are speculative—the utopian Commander Data or the dystopian Terminator—many have not given much thought to the actual forms of AI that are part of our lives already, such as recommendation systems and digital assistants. "AI is everywhere," Thacker says; "And we aren't prepared." To help the unprepared understand AI, Thacker provides an orientation to current AI developments and explores the wide-ranging impacts of these on self-understanding, medicine, family, work, war, privacy, and the future. Along the way, he recalls biblical wisdom about old moral problems and imperatives, such as what the Ten Commandments prohibit and what Micah 6:8 prescribes (doing justice, loving mercy, and journeying attentively with God). He also offers a number of familiar biblical assurances, such as not being afraid and trusting in God.

All of this is helpful, to an extent. Thacker's major conclusions about AI are that we should not let our creations—our artificial agents—supersede human agency, and that we should not place too much hope in technology, for it alone cannot save us. Both of these are important points, although neither is very controversial nor necessarily theological: transparency is called for in many AI ethical frameworks, and we are well into a period of technological disenchantment.

Thacker starts *The Age of AI* by asking two significant questions. First, what does it mean to be human? Thacker looks to Genesis 1, which states—three times—that God created humans in the image of God. Clearly, this is an important theological claim; it is also a very complex one. There are various interpretations of what it means to be created in the image of God, and this is only the first chapter of the biblical narrative. Thacker

emphasizes a functional interpretation of Genesis 1: We are called to work to glorify God. Elsewhere, however, Thacker shifts to a more essentialist interpretation that emphasizes human dignity. He asserts that our dignity does not come from what we do and that "nothing in this world defines us" (p. 117). But what about the work we are called to do in and for the world?

Another challenge of beginning in Genesis 1 is what happens in Genesis 3—humanity's rebellion against God. Thacker claims that "the image of God in us was not lost" (p. 19), though he does not address the extent to which this image was corrupted. For Christians, what is most important is Jesus's redemption and transformation of that fallen image. What does the image of God in Christ, the new Adam, reveal about the future of humanity?

Questions raised by Thacker's answer to his first question carry over into his answer to his second question, what is technology (including AI)? For Thacker, technology itself is morally neutral: "What's sinful isn't the sword but how people choose to use it" (p. 20). Given Isaiah's eschatological image of swords beaten into plowshares, many would argue that the sword is part of a system of weaponry and warfare that is immoral and must come to an end. Going beyond Isaiah, Jacques Ellul concluded that the biblical city, as an image of the technological society, must ultimately be destroyed: the city is an autonomous, multi-agent system with a diabolical power that exceeds the power of the human agents who created it. (Ellul almost seems to suggest that there is something like a rogue AI in the Bible!) Ellul goes too far with this, missing the good in the city and the transformative power of new creation over sinful systems, but he rightly points to the deformative power of technology. Thacker acknowledges that technology profoundly changes us and our world, positively and negatively, but he seems to suggest that humans can easily remain in control of and essentially unchanged by it.

Thacker's emphasis on Genesis, "where everything began," appears to close off any discussion about evolution and its insights into the role of technology in our emergence as a species. Indeed, the archeological record reveals that the use of simple stone tools shaped ancient human bodies and brains. Technology not only preceded the arrival of *Homo sapiens*, it shaped our understanding of what a human being is in form and function. Furthermore, throughout human history, technology has continued to change us fundamentally. Consider, for example, Walter Ong's insight that the technology of writing restructured consciousness. From the perspective of evolution and cultural development, technologies have been shaping and changing what we are from the beginning.

Thacker critiques Max Tegmark and Yuval Noah Harari for conflating evolution and cultural development, but that misses their interest in how humans might continue to outrun natural selection through innovation—a path our species has been on for many millennia, at least since the agricultural revolution and the creation of the complex artificial environments we call cities. As controversial as they may be, Tegmark and Harari point to how a deeper historical and philosophical understanding of technology enables us to explore questions about the holistic transformation of humans and human agency.

Thacker's view of technology encourages pursuing "technological innovation to help push back the effects of the fall" (p. 70). He worries that we might be tempted to "transcend our natural limitations," although it is not clear how far we are permitted to push back against the corrupted creation. He also fears "the people of God buying the lie that we are nothing more than machines and that somehow AI will usher in a utopian age" (p. 182). Educating people to resist being reduced to the status of machines (or data or algorithms) should be a learning outcome in any class or discussion about AI. As for ushering in a utopian age, this is one way of describing (in a kingdom-of-God sense) the Christian vocation: participating with God in the new creation. And perhaps AI has a role in this.

Thacker is absolutely right that we need a foundational understanding of who we are and of what technology is, and his answers provoke a number of questions for further exploration. The Bible reflects a rich interplay between human technological and spiritual development, from Edenic agriculture through Babelian urban agencies. And, as a technology itself, the Bible participates in these developments through its origin, nature, and function to mediate divine agency that transforms human agency. The biblical narrative makes it clear that we are not going back to the primordial garden in Genesis; we are moving toward the eschatological city, New Jerusalem, imaged in Revelation—"and what we will be has not yet been revealed" (1 John 3:2). How we understand the relationship between technological transformation and the transformation of all things through the new creation deserves much more attention within Christian theology.

With AI, it is clear that we are facing an even more profound restructuring of our lives and world—and of our selves. Rather than looking back to the *imago Dei* corrupted in the beginning, Christians might find it more generative to look to the *imago Christi*. As N.T. Wright powerfully argues in *History and Eschatology: Jesus and the Promise of Natural Theology* (SPCK, 2019), the new creation inaugurated through the resurrection of Jesus provides a radically new perspective on creation. This includes us and our artificial creations. While Thacker believes "nothing will ever change fundamental aspects of the universe" (p. 168), some of us may imagine AI participating in the new creation.

For someone just beginning to think about AI and Christianity, *The Age of AI* might be a good place to

start. But more needs to be read and written to explore the theological and technological questions this book raises.

Reviewed by Michael J. Paulus Jr., Dean of the Library, Assistant Provost for Educational Technology, and Director and Associate Professor of Information Studies, Seattle Pacific University, Seattle, WA 98119.

2084: Artificial Intelligence and the Future of Humanity by John C. Lennox. Grand Rapids, MI: Zondervan Reflective, 2020. 124 pages. Hardcover; $19.99. ISBN: 9780310109563.

Oxford mathematician and science philosopher John C. Lennox has been active in Christian apologetics for more than ten years. Best known, perhaps, for his debates with Richard Dawkins, Christopher Hitchens, Michael Shermer, and others (many of these debates are readily available online), Lennox has written numerous books defending the rationality of Christian faith. Many of his books address relationships between science and Christianity, such as his 2009 release: *God's Undertaker: Has Science Buried God?*

Lennox firmly believes that science and faith are compatible, as demonstrated by his easy way of integrating knowledge from science and theology. He often uses argument from design logic for God's existence. From his mathematical perspective, he points to the improbability of biogenesis to argue for the direct, non-evolutionary creation of life by God. As a result, he is often associated with advocates of intelligent design (ID). While the merits of ID with respect to creation matters are contested, it is indispensable when considering a future that will be (intelligently?) designed and built by human society. This is the central focus of *2084*, its title a leap forward from George Orwell's *1984*.

In chapters 1–3, Lennox cites many secular writers, utopian and dystopian, to highlight future possibilities. Their work accords with the assertion that artificial intelligence (AI) is of central importance; "AI will inevitably affect us all," so it is of interest not only to developers, but also to "philosophers, ethicists, theologians, cultural commentators, novelists, and artists" (p. 16).

But what is AI? Lennox offers his answer in two parts. Part one, chapters 4–5, examines "narrow" AI: computer systems designed to fulfill specific tasks, such as analyzing vast amounts of data or assisting in diagnosing illnesses. Narrow AI is operational now, providing great benefits to society, and its future potential is even greater. Unfortunately, like most technologies, it can also be corrupted by human sin. Lennox is not a Luddite, but he is realistic about AI's risks, and he lauds Christians involved in developing AI, such as Rosalind Picard at MIT.

Part two, chapters 6–7, describes the wider hopes some people have for AI, such as fundamental changes to human life. Indeed, transhumanists believe AI will eventually solve *all* the problems that beset human beings, including the "technical" problem (p. 85) of death itself. This hope is based on the development of Artificial General Intelligence (AGI): a conscious, self-improving, *superintelligent* computer system. Human creativity would, in effect, bestow life on a technological artifact, just as God breathed life into the dust of the earth in Adam. These aspirations reveal, according to Lennox, a hope to become gods, the realization of the false promise of the serpent in Genesis 3.

In chapter 8, Lennox interprets such utopian hopes as rejecting God and his promises. He notes the irony "that those who are seeking to create a superintelligence do not realize that there is good evidence that a superintelligence, *the* superintelligence, already exists: God the Creator and Sustainer of the heavens and the earth" (p. 117). By rejecting the creator, the creatures made in God's image are diminished and at risk of being made "useless" (p. 128).

From a traditional Christian perspective, chapters 1–8 (more than half the book) provide a good overview of AI as the cornerstone of transhumanism. Anyone unfamiliar with such matters will benefit from the account Lennox offers. Nevertheless, he skips over many of the details to get to his main interest: chapters 9–13, in which he develops his theological and eschatological perspectives on AI and its potential impacts.

Lennox is neither a preterist nor a post-millennial. Instead, he integrates the apocalyptic passages of Daniel, 2 Thessalonians, and Revelation to visualize what lawless progress in AI could produce. Ultimately, Lennox connects dystopian views of advanced technology, especially AGI, to the apocalyptic "beasts" in Daniel and Revelation. The mysteries of the apocalyptic genre do not concern Lennox; he is confident that the full meaning of such mysteries will become apparent as events unfold (p. 205). In the meantime, the prophecies encourage believers to be watchful and to guard against deception. With this call for watchfulness, Lennox moves to his conclusion: "There is no way to a glorious future that bypasses the problem of human sin, and the only one who has offered a viable solution to that problem is Jesus Christ, who faced it head-on on the cross" (p. 227).

For too long, many Christians have focused exclusively on matters of human origins, but the *future* of human life is ignored. Yes, all Christians look for the return of Christ, but what of the time between now and then? It seems that few believers are even aware of the challenges they will face later this century. By examining the future from a biblical perspective, Lennox offers an important corrective.

Christians will disagree over the future of human life, just as they do about human origins. In *2084*, Lennox offers his views of the future, in accordance with his

reading of scripture. His conclusions will satisfy some readers—and dissatisfy others—but *2084* will certainly inform them of AI and its importance. As believers ponder the future, by God's grace the church can remain true to its mission, finding answers to tough questions by searching the scriptures in light of the doctrines they reveal.

Reviewed by David Winyard, Associate Professor of Engineering, Grace College, Winona Lake, IN 46590.

HUMBLE PI: When Math Goes Wrong in the Real World by Matt Parker. New York: Riverhead Books, 2020. 336 pages. Hardcover; $27.00. ISBN: 9780593084687.

Humble Pi delivers a veritable potpourri of mathematical mistakes in the real world, as the title suggests. Consequently, the book may be of interest to a wide variety of readers. Mathematics educators who are looking for reasons why their students should pay attention in class will find plenty of examples to convince even the most skeptical student that mathematical mistakes can have real-world consequences. Meanwhile, readers who struggled in math class may be happy to see that even the supposed experts suffer the consequences of their own miscalculations. While the book is predominantly written in a light-hearted tone that makes it relatively easy to read for a broad audience, it occasionally is somber when real lives are put in danger due to the math going wrong.

The author, Matt Parker, is likely more well known as a YouTube mathematician. His channel "Stand-up Maths" has half a million subscribers and sixty million views. Parker's attempt to channel his high energy, "math is fun" persona into the written word is a challenging task, but he mostly delivers. For example, the page numbers count down until they reach 0, causing an error so the next page is numbered 4,294,967,295. This seemingly random large number happens to be $2^{32} - 1$; reading the rest of the book will explain why. The chapters count up from 0, except for a small chapter 9.49 which follows the chapter on rounding. Parker adds levity at the meta level as well as in the writing itself which builds on itself effectively. For this reason, readers who already are familiar with Parker's work on YouTube will likely catch some extra inside jokes. However, to be clear, the book is not simply fan fiction; it is a well-researched and thorough account of mathematical mistakes in various contexts and should appeal to a wide audience.

The content of the book is organized into chapters based on the types of mistakes: losing track of time, counting errors, geometry gone awry, unit conversions, and statistics, to name a few. If one chapter fails to capture interest, the next one delivers something fresh. While this feature is mostly true, it fails in one way. So many of the mistakes come down to computer programming errors. At the core, there is a mathematical idea at play, but the mistake comes from improperly coding that idea into a computer. The author did research a rich set of mathematical mistakes, but often it was not the mathematics that failed but the programming. As a mathematician, I was hoping for more mistakes that felt like mathematics itself going wrong. Yet I suspect that for most readers this is a distinction without a difference.

While the author is not writing explicitly from a Christian perspective, that does not mean that the book is therefore neutral or without perspective. Parker finds a deep joy in the doing of mathematics, a latent aspect of creation awaiting cultivation; he may not express it this way, but the joy is unmistakable. Many of the errors depicted in the book have led to the loss, or near loss, of human lives, sometimes in the hundreds. In a way, this book deeply values life, and one possible outcome would be that people could be more aware of mitigating such errors. In the final chapter, titled "So, What Have We Learned from Our Mistakes?," Parker writes:

> I've done a lot of research from accident-investigation reports that were publicly released, but that generally happens only when there is a very obvious disaster. Many more, quiet mathematical mistakes are probably swept under the rug. Because we all make mistakes. Relentlessly. And that is nothing to be feared. Many people I speak to say that, when they were at school, they were put off mathematics because they simply didn't get it. But half the challenge of learning math is accepting that you may not be naturally good at it, but if you put the effort in, you can learn it. As far as I'm aware, the only quote from me that has been made into a poster by teachers and put up in the classrooms is: "Mathematicians aren't people who find math easy; they're people who enjoy how hard it is." (p. 7)

This is a book which outlines mathematical mistakes in the hope that it could prevent some future mistakes; this hope is laudable, and it provides some levity along the way, which is sorely needed in 2020. However, the example of the UK government refusing to change the picture of an incorrect soccer ball on their signs suggests that many mathematical mistakes are likely to be commonplace.

Finally, it should be noted that the book is not only about mistakes, it also provides lots of "Wow, I didn't know that!" moments. Did you know that a year of "seasons" and a year of the earth's orbit are not the same thing? The book is peppered with vignettes such as this that keep the reader wanting more. In the end, the book is entertaining, includes a lot of fresh examples of math in the real world that STEM educators might find helpful, and is written for a broad audience. The fact that mathematics goes wrong in the modern world mostly in connection with computers is important to note; that there are so many ways for it to go wrong is fascinating.

Reviewed by Thomas J. Clark, Department of Mathematics and Statistics, Dordt University, Sioux Center, IA 51250. ●

Animals Are an Integral Part of Healthy Agriculture

Thank you to Dorothy Boorse for the review in the June issue of *Perspectives on Science and Christian Faith* (vol. 72, no. 2 [2020]: 112) of the book *Beyond Stewardship: New Approaches to Creation Care,* ed. David Paul Warners and Matthew Kuperus Heun. I have this book (currently on loan to a friend) and found it a very stimulating and thought-provoking collection that has me rethinking my use of terms such as stewardship and natural resources. It would be great for a small group study.

I do have a couple of concerns, including advocacy to remove animals from agriculture. I strongly believe that agriculture needs to transition from an industrial paradigm to an ecological paradigm. Healthy ecosystems, including agricultural ecosystems, have animals as an integral part (and I am not referring to livestock factory operations). For example, water quality is a major issue in my home state of Iowa. There are a range of remediation techniques available, but the more perennial vegetation that is on the landscape, the better. Although there is exciting and encouraging experimental work with perennial grains, notably Kernza, currently the kinds of perennial vegetation from which an agriculturist can earn money are largely forage crops, which means livestock. Also, my former officemate, who works with farmers, says that fertilizers that meet organic standards are essentially manures. At least one study found that integrating crops and livestock increased beneficial insectivorous birds without increasing granivorous birds, suggesting that such agricultural systems may benefit natural pest control without increasing the risk of bird damage to crops.[1] There is a need for theologians and theoretical ecologists to interact with those who make their living from Creation (i.e., farmers, ranchers, owners of working forests) and those who directly work with them (i.e., county agents, state agency personnel, scientists at land grant universities).

Note

[1]Olivia M. Smith et al., "Highly Diversified Crop-Livestock Farming Systems Reshape Wild Bird Communities," *Ecological Applications* 30, no. 2 (2019): e02031.

Lynn Braband
ASA member, NYS Integrated Pest Management Program of Cornell University, retired

A Call for Book Reviewers

The readers of *PSCF* have long appreciated the many insightful book reviews published within its covers. If you would be open to being asked to contribute to this interesting and important service of writing a book review, please send a brief email that describes your areas of expertise and preferred mailing address to Stephen Contakes at scontakes@westmont.edu.

UNITED STATES POSTAL SERVICE® Statement of Ownership, Management, and Circulation (All Periodicals Publications Except Requester Publications)

1. Publication Title	2. Publication Number	3. Filing Date
Perspectives on Science and Christian Faith	0028-3740	09/22/2020
4. Issue Frequency	**5. Number of Issues Published Annually**	**6. Annual Subscription Price**
Quarterly	4	$50.00

7. Complete Mailing Address of Known Office of Publication *(Not printer) (Street, city, county, state, and ZIP+4®)*: 218 Boston St, Ste 208, Topsfield MA 01983 — Contact Person: Lyn Berg; Telephone *(Include area code)*: (978) 887-8833

8. Complete Mailing Address of Headquarters or General Business Office of Publisher *(Not printer)*: Same as above.

9. Full Names and Complete Mailing Addresses of Publisher, Editor, and Managing Editor *(Do not leave blank)*

Publisher *(Name and complete mailing address)*: American Scientific Affiliation, 218 Boston St, Ste 208, Topsfield MA 01983

Editor *(Name and complete mailing address)*: James Peterson, Roanoke College, 221 College Ln, Salem VA 24153

Managing Editor *(Name and complete mailing address)*: Lyn Berg, 218 Boston St, Ste 208, Topsfield MA 01983

10. Owner *(Do not leave blank. If the publication is owned by a corporation, give the name and address of the corporation immediately followed by the names and addresses of all stockholders owning or holding 1 percent or more of the total amount of stock. If not owned by a corporation, give the names and addresses of the individual owners. If owned by a partnership or other unincorporated firm, give its name and address as well as those of each individual owner. If the publication is published by a nonprofit organization, give its name and address.)*

Full Name	Complete Mailing Address
The American Scientific Affiliation	218 Boston St, Ste 208, Topsfield MA 01983

11. Known Bondholders, Mortgagees, and Other Security Holders Owning or Holding 1 Percent or More of Total Amount of Bonds, Mortgages, or Other Securities. If none, check box → ☑ None

Full Name	Complete Mailing Address

12. Tax Status *(For completion by nonprofit organizations authorized to mail at nonprofit rates) (Check one)*
The purpose, function, and nonprofit status of this organization and the exempt status for federal income tax purposes:
☑ Has Not Changed During Preceding 12 Months
☐ Has Changed During Preceding 12 Months *(Publisher must submit explanation of change with this statement)*

13. Publication Title	14. Issue Date for Circulation Data Below
Perspectives on Science and Christian Faith	09/01/2020

15. Extent and Nature of Circulation			Average No. Copies Each Issue During Preceding 12 Months	No. Copies of Single Issue Published Nearest to Filing Date
a. Total Number of Copies *(Net press run)*				
b. Paid Circulation *(By Mail and Outside the Mail)*	(1)	Mailed Outside-County Paid Subscriptions Stated on PS Form 3541 (Include paid distribution above nominal rate, advertiser's proof copies, and exchange copies)	977	984
	(2)	Mailed In-County Paid Subscriptions Stated on PS Form 3541 *(Include paid distribution above nominal rate, advertiser's proof copies, and exchange copies)*	0	0
	(3)	Paid Distribution Outside the Mails Including Sales Through Dealers and Carriers, Street Vendors, Counter Sales, and Other Paid Distribution Outside USPS®	153	147
	(4)	Paid Distribution by Other Classes of Mail Through the USPS (e.g., First-Class Mail®)	6	0
c. Total Paid Distribution *[Sum of 15b (1), (2), (3), and (4)]* ▶			1136	1131
d. Free or Nominal Rate Distribution *(By Mail and Outside the Mail)*	(1)	Free or Nominal Rate Outside-County Copies included on PS Form 3541	28	20
	(2)	Free or Nominal Rate In-County Copies Included on PS Form 3541	0	0
	(3)	Free or Nominal Rate Copies Mailed at Other Classes Through the USPS (e.g., First-Class Mail)	0	0
	(4)	Free or Nominal Rate Distribution Outside the Mail *(Carriers or other means)*	17	15
e. Total Free or Nominal Rate Distribution *(Sum of 15d (1), (2), (3) and (4))*			45	35
f. Total Distribution *(Sum of 15c and 15e)* ▶			1181	1166
g. Copies not Distributed *(See Instructions to Publishers #4 (page #3))* ▶			87	121
h. Total *(Sum of 15f and g)*			1268	1287
i. Percent Paid *(15c divided by 15f times 100)* ▶			96.19	97.00

16. Electronic Copy Circulation	Average No. Copies Each Issue During Preceding 12 Months	No. Copies of Single Issue Published Nearest to Filing Date
a. Paid Electronic Copies ▶	225	210
b. Total Paid Print Copies (Line 15c) + Paid Electronic Copies (Line 16a) ▶	1361	1341
c. Total Print Distribution (Line 15f) + Paid Electronic Copies (Line 16a) ▶	1406	1376
d. Percent Paid (Both Print & Electronic Copies) (16b divided by 16c × 100) ▶	96.80	97.46

☑ **I certify that 50% of all my distributed copies (electronic and print) are paid above a nominal price.**

17. Publication of Statement of Ownership
☑ If the publication is a general publication, publication of this statement is required. Will be printed in the 12/1/20 issue of this publication. ☐ Publication not required.

18. Signature and Title of Editor, Publisher, Business Manager, or Owner	Date
Vicki Best, Director of Operations and Development	09/22/2020

I certify that all information furnished on this form is true and complete. I understand that anyone who furnishes false or misleading information on this form or who omits material or information requested on the form may be subject to criminal sanctions (including fines and imprisonment) and/or civil sanctions (including civil penalties).

American Scientific Affiliation

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

American Scientific Affiliation Forums

We encourage members to submit comments and questions on the articles published in this journal on the ASA **PSCF Discussion Forum** at www.asa3.org → RESOURCES → Forums → PSCF Discussion.

The ASA RESOURCES → Forums also contains links to other members-only discussion groups. The **General Discussion** is for thoughtful discussion of various issues in science and faith. **Books** hosts a series of discussions on seminal books on science and faith. The **Director Emeritus Musings** is a blog of occasional musings by Randy Isaac, ASA Executive Director, 2005–2016.

An **Open Forum** is open to the public for dialogue on topics of science and faith at www.asa3.org → RESOURCES → Forums → Open Forum.

Canadian Scientific & Christian Affiliation

A closely affiliated organization, the Canadian Scientific and Christian Affiliation, was formed in 1973 with a distinctively Canadian orientation. The CSCA and the ASA share publications (*Perspectives on Science and Christian Faith* and the *God and Nature* magazine). The CSCA subscribes to the same statement of faith as the ASA, and has the same general structure; however, it has its own governing body with a separate annual meeting in Canada.

Canadian Scientific and Christian Affiliation, PO Box 63082, University Plaza, Dundas, ON L9H 4H0. Website: www.csca.ca.

How Do I Join the ASA?

Anyone interested in the objectives of the Affiliation may have a part in the ASA. Membership and subscription applications are available at www.asa3.org → MEMBERSHIP → Join ASA or Subscribe to PSCF.

Full membership is open to all persons who give assent to the Doctrinal Statement and meet at least one of these criteria: (1) they have attained a bachelor's or higher degree in a scientific discipline, where science is interpreted broadly to include any disciplines of natural and social science, health sciences, technology, engineering, and mathematics or (2) they are philosophers, historians, Bible scholars, theologians, or other professionals whose vocational activity contributes to the intersection of faith and science. Full Members receive all member benefits and publications and take part in all the affairs of the ASA, including voting and holding office.

Associate membership is available to interested nonscientists who can give assent to our Doctrinal Statement. Associates receive all member benefits and publications and take part in all the affairs of the ASA except voting and holding office.

Student Membership is open to students working toward a degree or certificate program in a discipline leading to full or associate membership, who give assent to the Doctrinal Statement, and who are committed to making progress in their education. Student Members are eligible to participate in all the affairs of the ASA except voting and holding office.

Friends of the ASA are individuals who, for whatever reasons, do not wish to join the ASA, but who nevertheless wish to support the aims of the organization and to receive its publications. Friends are not considered members and do not enjoy the rights of members.

Subscriptions to *Perspectives on Science & Christian Faith (PSCF)* are available at $50/yr. (individuals), $90/yr. (institutions), and $20/yr. (student premier).

How Do I Find Published *PSCF* Articles?

Articles appearing in *Perspectives on Science and Christian Faith* are abstracted and indexed in the *ATLA Religion Database; Christian Periodical Index; EBSCO; ESCI; Gale: Cengage Learning; Religion Index One: Periodicals; Religious & Theological Abstracts*, and *Guide to Social Science and Religion in Periodical Literature*. Book Reviews are indexed in *Index to Book Reviews in Religion*.

Contents of past issues of *PSCF* are available at www.asa3.org → PUBLICATIONS → PSCF Academic Journal.

American Scientific Affiliation
218 Boston St, Ste 208
Topsfield, MA 01983-2210

Phone: (978) 887-8833
E-mail: asa@asa3.org
Website: www.asa3.org