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The Three-Tier problem for Science and Religion at the popular and research levels

It has been long understood that without strong, current engagement, science and religion research and discussion can fall into a niche interest of the church or confined to the interests of academics. The church, Christian apologetics, and academic science and religion research face a three-tiered challenge for staying accurate and engaged with modern science. Here I discuss three distinct levels of engagement where an intersection of scientists, theologians and philosophers can process how science and religion interact. Unfortunately, the scale and speed of scientific research and discovery outpaces the conversation of its implications and interaction with religion at such a rate that much theological derivation is rendered useless without the knowledge of the research at academic or popular congregational level. Within the life sciences alone, the problem is particularly acute. Here I outline some serious challenges for Christian engagement at each level attempting to reflect meaningfully in theological and philosophical discussion on the present scientific research.

Keywords: Science and Religion, Science Communication, Design, Research Culture, Christians Apologetics, Biology and Christianity, Philosophy of Science.

In this paper I shall discuss three tiers of engagement for science in consideration of theological and philosophical reflection. These tiers of engagement are:

Tier 1: Academic and popular discussion of the relationship between science and religion.

Tier 2: Popular science communication to the wider public.

Tier 3: Current scientific research including innovations and technology at present.

Philosophical and theological reflection on the relationship and interaction between science and religion is a rich academic discipline that exploded during the twentieth century thanks to philosophers such as Alfred North Whitehead and Charles Hartshorne, as well as scientist theologians such as Ian Ramsey, Arthur Peacocke, Sir John Polkinghorne and Charles Coulson. Golden ages have been seen previously, such as the interwar period in the UK with world class scientists that had a large popular following such as Sir Arthur Eddington and Sir James Jeans. Whilst these names are not well known at the popular level of

church attendees, their general ideas were able to filter down to a large enough number. These religious scientists sold their books in enormous numbers in many countries that would rival or exceed the most popular science writers of today. Eddington's *The Nature of the Physical World* and Jeans' *The Mysterious Universe* were best sellers that were debated at the end of the 1920s and early 1930s. This explosion of interest also led to the first ever BBC Symposium on science and religion in 1931.[1] We can point to moments such as these as golden eras where acclaimed scientists used large platforms for theological and philosophical reflection at the academic and popular level to a large audience that engaged the church. At present, one may point to public thinkers such as John Lennox who is succeeding at bringing questions around artificial intelligence to church-level dialogue with the help of books, the internet and social media. However, in the 1920s and 1930s the aforementioned scientists and philosophers were at the peak of their careers, engaging with massive audiences in a manner that drew the skeptical response at the highest levels of media. There is no modern comparison. I maintain that part of the reason for this are problems located at the level of all three tiers.

The gap between academic discussions on science and religion and the popular level has always been large. Unfortunately, non-scientific organisations with missional aims (see any example from Creationism and Intelligent Design) that do not actively produce scientific research have aggressively marketed themselves to the religious popular level with great success. This has further widened the gap between academic science and religion and this popular level, as well as compounding the gap between current scientific research and academic science and religion through those ministries competing for space.

Futurists such as Lord Martin Rees have been speaking with tremendous authority and to large audiences on the current technological threshold we stand upon:[2] in an era of spacefaring, gene editing, and artificial intelligence, what will it mean to be human in the near future, and what place will be left for religion? Along with Rees, popular academics such as Yuval Noah Harari and Stephen Pinker have released multiple best-selling books that dominate the landscape of these discussions (One can make a strong case that there are no Christian Futurists competing in this space). In order to meaningfully engage with such questions, Christian academics must be aware of these changes, writing and reflecting on them with equal frequency and with an earned authority of our own.

Biology is at present going through a revolution that rivals the developments of the 1950s: gene sequencing, gene editing, structural biology and cancer immunotherapy have all seen technological revolutions that have dramatically

1 *Science and Religion: A Symposium*, London: Gerald Howe Ltd (1931).

2 See for example, Rees, M. *If science is to save us*, Cambridge: Polity Press (2022).

upscaled the data we have to understand nature. As a result, fields such as medicine and evolutionary biology are seeing revolutions of their own in both a technological and Kuhnian sense. When one considers discussions around ethics, healing, philosophy of religion (such as creation or the argument from design), science and religion at the first two tiers' (tier 1 academic/popular discussion of science and religion, tier 2 – science communication) risk becoming out of date and becoming irrelevant, whilst the church is at great risk of falling behind when it comes to engaging meaningfully with the life sciences.

Therefore, risks abound at three distinct levels for science and religion: the first tier of academic science and religion could face a situation of 'talking past' science whilst the world has moved on exponentially. The second tier of popular science constantly faces the risk of failing to keep the public informed of where the research and technology actually are, ever reliant on producing more skilled communicators who are able to understand and interpret the findings whilst effectively informing the rest of the world through multiple effective mediums. There are implications here for the other tiers in how successful science communication is. Finally, the third tier of current scientific research is continually remaking the world, often with little time or patience to come to the table of wider ethical or philosophical discussion. Unfortunately, each of these issues compounds the other. This creates a snowball effect for science and religion engagement that will require ever greater levels of specialization and expertise as the problem grows. Reflecting on how differently these circumstances were a century ago is humbling as, at present, we are a long way from the situation at the time of Eddington and Jeans.

I shall examine each tier in turn, breaking down aspects of the problem and evaluating the implications for the other two. These tiers could easily be inverted and then compared in reverse order, but I have listed them this way for personal preference and ease from public talks of mine on the issue.

Tier 1 – Science and Religion in Academic Writing

Capable organisations of religious scientists have existed since the birth of the Royal Society in the early seventeenth century. Whilst there exist those that are professional, often with their own academic journals, there are also informed laypeople who work to equip the church or religious institutions with the tools to understand and engage with the sciences.

There is plenty of sophisticated individual research in recent years, for example around artificial intelligence and viruses. However, given the extent to which biology has outpaced science communication and the humanities in the past decade, we still find much of the discussion in science and religion is centered around older topics that have interested previous generations. In academic science and religion, one can find plenty of nuanced perspectives

around the levels of interaction between disciplines, as well as plenty of ethical considerations and historical biographic engagement. It is sophisticated and generally of a high level. Outstanding written works have been produced in recent years on artificial intelligence and its associated transhumanism,[3] advances in genomics and what they mean,[4] and the challenge of cheap, accurate and effective genetic engineering.[5] These are detailed, current, and accessible for both academics and the public. Journals in science and religion will contain reflections on modern science from a theological or ethical perspective, but these are not often read by church members or lay people. One could here posit a further tier between the academic journals and organisations around science and Christianity.

Sir John Polkinghorne has argued that rather than general epistemic argumentations, answering questions around the interplay of science and religion must come from 'investigation of specific truth-seeking projects.'[6] Given our current epistemological environment where truth claims are treated with even greater levels of suspicion in society,[7] grounding for claims around knowledge must be sturdier than in the past. Authority, evidence and consensus must be as strong as possible as a bulwark against this challenge.

Problems within tier 1 start with a lack of *active* scientists interested in engaging with theology and philosophy. Without a higher number of active scientists contributing to the field, the risk is ever present that the field itself relies on the skill and speed of popular science communication (tier 2). There is also a time lag where those in academic science and religion scholarship must discover the latest science communication, reflect on it and publish on the newest breakthroughs, discoveries and technologies. As such, much is left to chance.

Furthermore, this problem is compounded when considering the gap between actual scientific research (tier 3) and the popular science communication (tier 2). The other significant gap is within tier 1 itself: between academic science and religion scholarship and the popular church level awareness and discourse, a gap exacerbated by popular narratives that become assumed as Polkinghorne notes.[8] The success of ministries that orientate around criticism of evolution (those from creationism and Intelligent Design movements)

3 See for example Godde, S. J. *Reaching for Immortality: Can Science Cheat Death?* Eugene, Oregon: Wipf & Stock (2022).

4 Alexander, D. *Genes, Determinism and God*, Cambridge: Cambridge University Press (2017).

5 Massman, A, and Fox, K.R. *Modifying Our Genes*, London: SCM Press (2021).

6 Polkinghorne, J.C. *One World: The Interaction of Science and Theology*, West Conshohocken, PA: Templeton Press (2007) ix.

7 Alexander, D. *Can we be sure about anything? Science, Faith and Postmodernism*, New York: Apollos (2005).

8 Polkinghorne, J. *Science and Theology: An Introduction*, London: SPCK (1998) 4.

at marketing to the general Christian population has compounded this gap challenge significantly by focusing the discussion around pseudoscience, discredited ideas and outdated writing. Furthermore, whilst the discussions stay stuck on disputing evolution, actual scientific research (tier 3) has accelerated at an almost unprecedented pace. Both the Human Genome Project and the COVID-19 pandemic served to rapidly progress technology, the level of data, and the speed of the research process higher than at any point in human history. Unfortunately, this leaves much of the general religious public incredibly deficient in understanding both where the science actually is (tier 3) and how to communicate with or understand it (tier 2).

When one considers the aforementioned examples from biology, the Nobel Prize alone serves as a strong example of the gap between tiers 1,2 and 3 and how large this problem currently is. The 2018 Nobel Prize in physiology and medicine was awarded to James P. Allison and Tasuku Honjo for cancer immunotherapy[9], the 2020 Nobel Prize in chemistry was awarded to Jennifer Doudna and Emmanuel Charpentier for CRISPR-Cas9 gene editing technology[10], and the 2024 Nobel Prize in chemistry was recently awarded for AlphaFold in its transformation of structural biology.[11] Regarding the revolutions in gene sequencing, Fred Sanger[12] is one of only 4 people to win 2 Nobel Prizes, both for his innovation of sequencing technology, and Francis Collins was awarded the Templeton Prize[13] for his work on the Human Genome Project. These have all passed with little to no reflection from academic science and religion, with the exception of ethical discussions around gene editing. At the popular level, few in churches will have heard anything at all about CRISPR-Cas9 whilst it is actively transforming medicine and reshaping the future of genetic technology. Since its advent, base editing[14] and prime editing[15] have offered alternatives able to make single base pair edits without breaking the DNA strand to harness repair mechanisms, whilst dramatically reducing the risks associated with off-target effects. These compound the need for engagement with gene editing and genomic medicine as we face the next great revolution in personalized medicine as a result. Here I will note that ethical discussions alone will not suffice. A

9 https://www.nobelprize.org/prizes/medicine/2018/summary/

10 https://www.nobelprize.org/prizes/chemistry/2020/summary/

11 https://www.nobelprize.org/prizes/chemistry/2024/summary/

12 https://www.nobelprize.org/prizes/chemistry/1980/sanger/facts/

13 https://www.templetonprize.org/francis-collins-awarded-2020-templeton-prize/

14 Rees H.A. and Liu D.R. 'Base editing: precision chemistry on the genome and transcriptome of living cells,. *Nat Rev Genet*. (2018) 19, 770-788. doi: 10.1038/s41576-018-0059-1. Erratum in: *Nat Rev Genet*. (2018) 19(12), 801. doi: 10.1038/s41576-018-0068-0. PMID: 30323312; PMCID: PMC6535181.

15 Anzalone, A.V., Randolph, P.B., Davis, J.R. *et al.* 'Search-and-replace genome editing without double-strand breaks or donor DNA'. *Nature* (2019) 576, 149–157. https://doi.org/10.1038/s41586-019-1711-4

more comprehensive engagement with the philosophical and theological questions raised by such powerful technology are needed.

In summary, tier 1 is suffering from an ever-widening gap between itself and tiers 2 and 3, as well as a widening gap within where academic discussion of science and religion is hindered from filtering down to the general Christian population by outdated and irrelevant discussions around the credibility of evolution by popular ministries.

Tier 2 – Popular Science Communication

Popular science communication is now a skill in high demand. My former institutions of Cambridge University and Birkbeck University of London both offer postgraduate courses in science communication as a career path that needs specific skills beyond standard journalism training. As the recent pandemic has demonstrated, quality communication of complicated science to the wider public is critical and nuanced.

Unfortunately, two problems in tier 2 present challenges for tiers 1 and 3. The ability to quickly and clearly communicate the latest findings of actual scientific research to the general public enables critical reflection at the academic level of science and religion and then its filtering down to the average religious devotee, but when this process slows down or is less effectively performed, large gaps emerge between each of the tiers. Science communication therefore acts as both a bridge between the two tiers without which traffic is slowed or halted, and as glue holding the entire science and religion enterprise together.

The implications of large gaps emerging are that the general population and science and religion scholarship fall further out of step with where science currently lies. This necessitates active scientific researchers with communication skills at high levels of engagement at both tiers 1 and 3 to safeguard against this failure. I claim here also that interdisciplinary research is also in greater need, but the appetite for this niche has not always been celebrated or rewarded enough. In some spheres, interdisciplinary is very much in vogue, but between the sciences and humanities it can be occasionally seen as something of a gimmick. A good example of this is the lack of attention given to the philosophy of science in undergraduate philosophy as opposed to philosophy of religion or philosophy of mind, and perhaps philosophy of art.

The church at large, and science and religion as a field, is now increasingly dependent on active scientific researchers with the talent and qualification to bring quality science communication to both the wider public and the religious communities that hopefully will be receptive. This also requires churches and church leaders to give greater priority to exploring science for its own sake, rather than *a priori* requiring certain dogmatic attitudes to areas such as evolutionary biology. It also means religious science organisations need to add

science communication to their strategies, by which I mean the public (non-academic, specialized) communication of the latest scientific advances and ideas with philosophical and religious engagement in a manner easily accessible to churches and Christians in general. Not only do these bodies need to succeed purely in engaging religious adherents, but they require science communication as a skill for themselves.

A deficit can grow here also when a lack, or a predominance, of generalists emerge. When generalists dominate, then important niche or fringe scientific developments can fall through the cracks with delayed engagement from theologians. When generalists are scarce, then theological reflection can become obsessed with a particular topic (for example, as is currently being seen with artificial intelligence) at the expense of other important developments across different fields.

In summary, as science advances ever more quickly, particularly during periods of revolutionary breakthrough in technology, the need for skilled science communication increases. This allows for quick, clear and accurate dissemination of knowledge to the general public including academic researchers in science and religion who are not themselves involved in those specific fields. A deficit here is seriously detrimental to the church and Christian apologetics for staying relevant and reflecting on the implications of new science for the day. Therefore, science communication is a skill required for the benefit of the church, theological reflection, and the individual believer.

Tier 3 – Where Scientific Research actually is

To better understand the challenge from the progression of science we need to take a detour through the early development of philosophy of science. The question of what revolutionary science is and how it moves can help elucidate the challenge to science communication and theological reflection.

In the early and mid-twentieth century as philosophy of science became established as its own technical, academic discipline, two schools of thought emerged to dominate the landscape of demarcation on what science itself actually is and how it progresses. Karl Popper's most famous thinking on the matter centers around *falsification*. Popper wrote extensively about this in two books, *The Logic of Scientific Discovery*[16] and in *The Open Society and its Enemies*.[17] In trying to solve the problem of induction outlined best by David Hume, as well as addressing the challenge of demarcation presented by the likes of Freud and Adler as well as the communists all claiming that their ideas were as scientific as Einstein, Popper suggested that true science is based on falsification, not

16 Popper, K. *The Logic of Scientific Discovery*, Oxford: Routledge (2005).

17 Popper, K. *The Open Society and its Enemies*, London: Routledge (1945).

verification. Many challenges were made to this, most importantly by Imre Lakatos and the Duhem-Quine thesis. However, the most well-known and crucial counter claim on the progress of science comes from Thomas Kuhn later in *The Structure of Scientific Revolutions*[18] which was immensely influential. Kuhn claims that science is not a steady upward march towards greater truth, but rather lurches forward on the back of scientific revolutions of thinking and discovery that overthrow former paradigms. There is certainly merit to both cases; that science lurches forwards by revolutions in thinking (such as in the cases of Newton, Darwin and Einstein) and that true science moves forwards in experimental falsification of bad ideas. However, at present we are dealing with a new revolution: a data revolution. Computational biology, artificial intelligence and revolutions in technology (especially miniaturization and processing power) are disrupting multiple branches of science in unprecedented ways. This serves as both a revolutionary leap in application and understanding in the manner of Kuhn, whilst also opening new experimental avenues that have corrected previous ideas in the manner of Popper. The immense speed of multiple tandem advances alongside the technological leap presents a problem for tier 1 and 2 to functionally adapt and catch up.

One must recognize that at present scientific research is approaching, or already in, revolutionary status. As well as the aforementioned transformations in biology across medicine, computational life sciences, and technological methods (further examples could include revolutions in both crystallography and cryo-EM, or the impact of artificial intelligence on the life sciences now allowing for more accurate visualization of molecules in solution or more difficult structures such as membrane proteins), spacefaring and robotics are undergoing some of the most transformative revolutions in their history. As this continues to raise investment and bring costs down, disruption will increase.

The general output of modern science is enormous. During the pandemic, thousands of articles were published per day on COVID-19 alone, with recent examination of PubMed showing that over five hundred articles were published on CRISPR-Cas9 per week on average. The challenge of keeping abreast of the developments of science is staggering, but a gulf between science, communication and reflection for theology and philosophy cannot be allowed to become too large. Ethical considerations have deepened the concern that the research is outpacing the understanding and reflective processes too much. The gap between the popular communication and present science is deeply pronounced in areas such as AI and genetics. A shortage in skilled science communicators could compound this problem further for tier 1, but also emphasizes the needs for Christians to be at the forefront of the fields as well as those in tier 1 to be readily receptive.

18 Kuhn, T. *The Structure of Scientific Revolutions*, Chicago: University of Chicago Press (1962).

Perhaps another example to illustrate this challenge comes with the Anthropic Principle in physics, popularized in Christian apologetics as so-called "Fine Tuning." Popular articulation of this by apologists comes verbatim from Christian writers such as John Polkinghorne or William Lane Craig. However, Polkinghorne's *One World* is over 30 years old, and Craig (who is not a scientist) quotes word for word from the epochal episode of BBC Horizon titled "The Anthropic Principle." However, this aired on 18th May 1987.[19] Whilst these arguments have been popular and remain extremely effective in Christian apologetics, the science has now progressed immensely with more questions raised as well as interesting speculations to add to the very complex picture. As technology such as NASA's James Webb Telescope adds quality new data to our knowledge of cosmology, the Christian is irresponsible to rely on data that is three decades old.

Much as Christians were a significant presence in the birth of the Royal Society, organisations of Christian scientists and researchers will need to be more highly engaged in recruitment, communication with the wider church and religious bodies, and interdisciplinary work.

A brief example: Intelligent Design

Although this is not a paper critiquing Intelligent Design, it stands as a fine example of this problem at all three tiers. Because Intelligent Design proponents make no contributions to modern science and feature few active researchers, their attention is not directed at the latest developments in biology, chemistry and physics. The focus of ID organisations is on arguments predominantly from the 19th and 20th centuries. The result is that at tier 1 discussion is tremendously outdated and confined to discussions of evolution and creation that have an appearance of being modern, yet have not moved far.

Intelligent Design also fails at tiers 2 and 3 because of its adversarial relationship with the scientific establishments, categorizing them as holding a materialist agenda. This conspiratorial narrative is pushed very strongly by the Discovery Institute and others who create an "us versus them" dichotomy with academic research.[20] As I have pointed out elsewhere, ID proponents seem to be mostly unaware of recent advances in biology.[21] On the popular communication side, this is demonstrated in their in-house publication *Evolution News*, which features precious little on CRISPR-Cas9 (as well as base editing or

19 https://www.imdb.com/title/tt2113325/

20 See for example Chapter 20 'Why it matters' in Meyer, S. *Signature in the Cell*, New York: Harper Collins (2009).

21 See my review of Williams, P.S. 'A Universe from Someone', *Science and Christian Belief* (2024) 36, 253 https://www.cis.org.uk/serve.php?filename=scb36-2-review.pdf

prime editing), cancer immunotherapy or DNA repair treatments for cancer, cryo electron microscopy, AlphaFold, despite them all being awarded Nobel prizes since 2015 and being at the forefront of current research. Results when searched for tend to bring ethical considerations, arguments from them for Intelligent Design, yet no applications for research that a scientific institution would produce. Likewise, the journal *Biocomplexity* produces nothing on any of these topics when searched for. A science-religion body engaged in research would be discussing these revolutionary topics in great deal, depth and urgency, instead of rare, cursory dialogue within a narrowly confined framework centered on Intelligent Design alone.

Unfortunately, this serves as a strong case for what can go wrong when all three tiers interplay around theological engagement with the sciences. However, it is hardly alone in this.

Potential solutions

First and foremost, this challenge can only be resolved by a willingness to engage fully with what current science uncovers and a desire to remain so. Arthur Peacocke wrote that:

This understanding is one which, while being embedded in and informed by the Christian tradition, aspires to be open to new knowledge and perspectives on the grounds that any specifically 'religious' truth about the relationship of humanity, nature and God cannot but be enriched by a genuine widening of our human horizons.[22]

Quakers, mysticists, and those of more fringe Christians groups such as Sir Arthur Eddington and Michael Faraday (who was a Glasite) had great success in the nineteenth and early twentieth centuries in communicating their faith and science, perhaps because they were not part of the mainstream denominations. As such, their unconventional approach and perspective met with less skepticism and was more considered or unusual in reaching its audience. Their openness to new knowledge, more nuanced perspectives, and particular philosophy lent itself well to popular communication and public speaking. Perhaps we can learn from them in an era more dominated by evidentialist approaches and fitting the new science into doctrinal boxes.

More skilled interdisciplinary people are needed to address this challenge. This is difficult when polymaths are in short supply, but where they are they need to be skillfully deployed. Encouragement can and should be given to scientists to study theology either professionally or in their personal interest, as well as philosophy and ethics. This can help to balance those in theology and

22 Peacocke, A. *God and the New Biology*, London, J.M. Dent & Sons Ltd (1986) ix.

philosophy who have done no science themselves but engage in science and religion as an academic or popular discipline.

Philosophy of science, whilst requiring more scientists to take part, has been a necessary bulwark against overreaches in how science should be received and interpreted by those eager to enshrine every new proclamation by a scientist on what it means for the rest of us. How the sciences dialogue with each other, as well as with other disciplines, requires treading carefully. As F.R. Tennant said, 'it is only as a philosopher of the sciences that one can attempt to determine whether these several descriptions and estimations of the human being are compatible or incompatible with one another.'[23]

The church and Christian apologetics should give particular attention and opportunities to scientists with a Christian faith. Much authority on matters of science and faith within Christian apologetics is given to philosophers and theologians that dominate the space who themselves have no qualifications, expertise or experience within the sciences. This situation is the inverse from what it was in the early days of modern science and into the late nineteenth century, where much of the reflection was done by scientists themselves. Encouragement should be given to religious adherents within the sciences to both reflect and explain both the findings and implications of modern science for philosophy and theology.

Greater reach is needed by official bodies in science and religion to the popular level. This can be helped by recruitment and training of skilled science communicators by religious institutions with prior training, either in the sciences, or in science communication itself. Rather than outreach being focused solely on recruitment to their movements, emphasis must also be placed on communicating with churches on the sciences simply for its own sake.

Conclusions

The danger in making this case is that it can come across as an opinion piece calling for change. However the point I am making in this article is technical: as is best demonstrated in biology in the past decade, as science undergoes a technological leap or a revolution in discovery, theological reflection suffers if the communication gap widens without adequate expertise. The problem facing Christian reflection on science and religion has become a 3-tier problem today with widening issues at each level, significant gaps between the 3 tiers themselves and a shortage of skilled, interdisciplinary personnel.

Whilst Christian apologetics has remained chiefly engaged with questions that are now seriously outdated, science itself has moved on significantly, pre-

23 Tennant, F.R. *Philosophy of the Sciences*, Cambridge: Cambridge University Press (1932) 3.

senting a new communication challenge for tier 1 of talking *across* the science as opposed to *with* it. If science and religion at any level becomes fixated on certain topics that draw more interest (for example, artificial intelligence) then other disciplines can suffer from a lack of attention or applied expertise. It is certainly understandable that a large preoccupation with questions around ethics may come to dominate when technological changes such as those brought about by artificial intelligence or genetic engineering come to the fore. However, science continues to advance, and the humanities must not stand pat whilst it does so, especially when the advance is at record pace and continuing to accelerate. During the pandemic, a record pace of publication occurred in virology and epidemiology, but the other sciences did not stop progressing.

We need not be afraid, but we must not be left behind. Thomas F. Torrance encourages us that

constant dialogue with natural science enabling us to share in its remarkable discoveries of God's handiwork can only be helpful to us in developing our knowledge of God, even when we allow our minds, as we surely must, to be lifted above the world of nature that they may acquire patterns of belief and thought really appropriate to God under the transforming impact of his self-communication to us in Jesus Christ.[24]

Our most meaningful service to the world in theology and science requires *constant* dialogue with natural science.

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24 Torrance, T.F. (ed) *Belief in Science and in Christian Life*, Eugene, Oregon: Wipf & Stock (1980) xvii.