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Science and the Reformation: Historiographical Soundings

This article surveys some of the ways in which historians have conceived of the relations between science and the Reformation. Intended as an introduction for those unfamiliar with this literature, it focuses on a selection of studies that together illustrate something of the range of associations, interactions, and influences that historians have identified.

Keywords: history; reception history; science; religion; Christianity; Reformation; early modern

During the more than one hundred years in which they have been the subject of scholarly scrutiny, the relations between science and religion have been understood in a wide variety of ways. From the late nineteenth-century warfare metaphor of John Draper and Andrew Dickson White to the fourfold typology of Ian Barbour to the twenty-first-century multidimensional models of Mikael Stenmark and others, the overall trend – with some notable, vocal, exceptions, of course – has been a growing recognition of the complexities in the relations between the two.[1] Historians have been particularly helpful in encouraging this recognition, with an increasing number of studies since the 1980s uncovering a richly textured past in which science and religion are seen to have interacted in a variety of ways.[2]

Of all the possible sites of interest for understanding the historical relations between science and religion, the Reformation has captured a sig-

1 Draper, J.W. *History of the Conflict between Religion and Science*, Cambridge: Cambridge University Press (2009) [1875]; White, A.D. *A History of the Warfare of Science with Theology in Christendom*, Cambridge: Cambridge University Press (2009) [1896]; Barbour, I.G. *Religion in an Age of Science*, London: SCM Press (1990); Stenmark, M. *How to Relate Science and Religion: A Multidimensional Model*, Grand Rapids: Eerdmans (2009). The most obvious exceptions to this trend are the so-called New Atheists: Harris, S. *The End of Faith: Religion, Terror, and the Future of Reason*, New York: W.W. Norton (2004); Dawkins, R. *The God Delusion*, Boston: Houghton Mifflin (2006); Dennett, D. *Breaking the Spell: Religion as a Natural Phenomenon*, New York: Viking (2006); Hitchens, C. *God Is Not Great: How Religion Poisons Everything*, New York: Twelve (2007).

2 Lindberg, D. & Numbers, R. (eds.) *God and Nature: Historical Essays on the Encounter between Christianity and Science*, Berkeley: University of California Press (1986); Brooke, J.H. *Science and Religion: Some Historical Perspectives*, Cambridge: Cambridge University Press (1991); Lindberg, D. & Numbers, R. (eds.) *When Science and Christianity Meet*, Chicago: University of Chicago Press (2003); Numbers, R. (ed.) *Galileo Goes to Jail and Other Myths about Science and Religion*, Cambridge: Harvard University Press (2009); Dixon, T., Cantor, G. & Pumfrey, S. (eds.) *Science and Religion: New Historical Perspectives*, Cambridge: Cambridge University Press (2010).

nificant portion of historians' attention.[3] It is often observed that recognisably modern science came into existence during the early modern period (roughly the sixteenth and seventeenth centuries),[4] so it should come as no surprise that historians have expended substantial effort pondering the bearing that so prominent an event as the Reformation had on the emergence and subsequent development of science.[5] Those relations have been studied from many different angles. Some scholars have been interested in developing ambitious narratives of profound historical change occurring over long periods of time, and emphasise the ways in which Reformation-induced changes made it possible for science to emerge. Others have developed detailed case studies that focus on a small number of figures from a limited chronological period or geographical area to draw attention to specific phenomena, such as the reception of particular scientific theories among important (and not-so-important) reformers. Taken together, these studies suggest that there is no one right way of relating the Reformation to science, because the relations between the two are too complex and multi-faceted to reduce to a single type. How scholars conceptualise connections between the two is a product of how they understand historical change to occur, of the particular kinds of primary sources that they look at and of the assumptions or expectations that they bring to their study of the sources (among others).

3 Some of the foundational works in this area are now decades old; see Dillenberger, J. *Protestant Thought and Natural Science: A Historical Interpretation*, New York: Doubleday (1960); Hooykaas, R. *Religion and the Rise of Modern Science*, Edinburgh: Scottish Academic Press (1972); Klaaren, E.M. *Religious Origins of Modern Science: Belief in Creation in Seventeenth-Century Thought*, Grand Rapids: Eerdmans (1977). In addition to the more recent studies cited later, see Harrison, P. 'Protestantism and the Making of Modern Science,' in Howard, T.A.L. & Noll, M.A. (eds.) *Protestantism after 500 years*, Oxford: Oxford University Press (2016), pp.98-120; Reeves, J.A. 'How not to link the Reformation and science: reflections on Brad Gregory's The Unintended Reformation', *Religions* (2017) 8, 83.

4 Helpful introductions to the (so-called) Scientific Revolution include Dear, P. *Revolutionizing the Sciences: European Knowledge and Its Ambitions 1500-1700*, Princeton: Princeton University Press (2001); Henry, J. *A Short History of Scientific Thought*, Basingstoke: Palgrave Macmillan (2012); Osler, M.J. *Reconfiguring the World: Nature, God, and Human Understanding from the Middle Ages to Early Modern Europe*, Baltimore: Johns Hopkins University Press (2010); Principe, L.M. *The Scientific Revolution: A Very Short Introduction*, Oxford: Oxford University Press (2011).

5 Using the term 'science' in the context of discussion of the early modern era is anachronistic, both because the term only began to be used in the modern sense in the nineteenth century, and because early modern natural philosophy, while genealogically related, is by no means identical to modern science. Helpful studies for understanding the issues involved include Cunningham, A. 'Getting the game right: some plain words on the identity and invention of natural philosophy', *Studies in History and Philosophy of Science* (1988) 19, 365-389; Cunningham, A. 'How the Principia got its name; or, taking natural philosophy seriously', *History of Science* (1991) 29, 377-392; Osler, M. J. 'Mixing metaphors: science and religion or natural philosophy and theology in Early Modern Europe', *History of Science* (1997) 35, 91-113; Harrison, P. '"Science" and "religion": constructing the boundaries', *Journal of Religion* (2006) 86, 81-106; Harrison, P. *The Territories of Science and Religion*, Chicago: University of Chicago Press (2015).

In this 500th anniversary year of Luther's fateful posting of his 95 theses for disputation, the present article surveys some of the ways in which historians have conceived of the relations between science and the Reformation. Intended as an introduction for those unfamiliar with this literature, it focuses on seven studies that together illustrate something of the range of associations, interactions and influences that historians have identified. Each of the seven studies looks at one of three different types of relations that historians have repeatedly examined: the emergence of science, the connection between theological ideas and science, and the reception of scientific ideas among religious persons. The first and second sections of the article look at studies that investigate the first type, those in the third and fourth sections tackle the second type, while those in the fifth and sixth sections scrutinise the third type. Given this focus, primary textual sources from the period are not dealt with directly in what follows. Rather, attention is given to how scholars have read those sources and wrested from them some sense of how science and the Reformation are related.[6] The emphasis is primarily on journal articles rather than books, so that those who wish to study the historiography for themselves can begin by exploring shorter works like those discussed here before delving into more detailed, book-length treatments of the issues.

Emergence I: imagining new connections

In all areas of historical study one can find scholars who range over large chronological periods to tell stories of profound changes in the ways that human beings have lived, thought and acted. In the study of science and religion Peter Harrison has been one of the primary proponents of such an expansive approach.[7] Harrison sees the early modern period as a time of significant intellectual change, and he has spent much of his career characterising that change in order to shed light on the world that emerged from it.

The Reformation often features prominently in Harrison's work, and it is granted a central role in the first of his major studies of the emergence of modern science. A helpful way to understand what Harrison is up to in that study is to see it as an attempt to answer the following question: what needed to happen in order for modern ways of relating natural objects to each other, such as through mathematics and taxonomy, to emerge? Harrison argues that historically these have not been the only way that the relations between natural objects have been conceived, and that coming to see objects through such relations constitutes a significant shift away from completely different conceptual and perceptual frameworks in which they

6 Attention in this article is given exclusively to English language historiography.

7 Harrison, P. *The Bible, Protestantism, and the Rise of Natural Science*, Cambridge: Cambridge University Press (1998); Harrison, P. *The Fall of Man and the Foundations of Science*, Cambridge: Cambridge University Press (2007); Harrison *op. cit*., (5), *The Territories…*

had previously been situated. What Harrison offers is a description of this shift, as well as an explanation of its causes.

Harrison describes the shift in terms of interconnected changes in how one reads two books: the book of Scripture and the book of nature. In pre-modern times, the interpretation of objects in nature was intimately bound up with particular ways of reading the Bible, because natural objects were seen not so much in terms of their relations to other natural objects, but rather as pointing beyond themselves to theological truths. For the early theologian Origen, for example, the Bible contains hidden spiritual meanings beyond the surface meaning (the literal sense), and the fullness of the Bible's meaning is plumbed only when one discerns these other levels. Origen also thought that something similar was going on in the created order: as Harrison observes, for Origen, 'the visible world … was … invested with symbols which, if correctly interpreted, would teach the diligent observer about God.'[8] These symbolic meanings can only be uncovered by penetrating beyond the material appearance of created objects, thereby reaching those deeper and more edifying meanings.

The conviction that the natural world consists of entities that – like many of the words of the Bible – point beyond themselves to spiritual and theological truths persisted for centuries. According to Harrison, what regulated the meanings of natural objects during this period, and thereby prevented semantic anarchy, was the comparison of the characteristics of natural objects to the biblical references in which those objects are explicitly named. A natural object could in this way become a symbol of a central theological topic or teaching, as in the case of the pelican, for example, which became a symbol of Christ's atonement. Harrison summarises this pre-modern view as follows: 'For the Middle Ages the question "Where does the pelican fit into the scheme of things?", was not primarily a taxonomic question, far less an ecological, or a phylogenetic enquiry. What is being asked is what the pelican signifies, and how it fits into a complex, but nonetheless coherent web of theological and moral meaning.'[9] Symbolic readings of nature accompanied allegorical interpretations of Scripture, and the interpretation of the two books comprised a 'single hermeneutical enterprise'.[10]

Harrison argues that a monumental change took place with the Reformation, when allegorical interpretation of Scripture was essentially thrown out and the literal sense given precedence. He points to numerous places in which individual reformers like Luther and Calvin made programmatic statements rejecting allegorical readings and emphasising

8 Harrison, P. 'The Bible and the emergence of modern science', *Science and Christian Belief* (2006) 18, 115-132, (117).

9 *ibid*., 121-122.

10 *ibid*., 122.

instead the literal sense.[11] Because of the interrelations of the two books, Harrison argues that this rejection of allegorical readings of Scripture had profound implications for the interpretation of the natural world, for the simple reason that '[t]o deny the legitimacy of allegory is to deny the capacity of natural objects to act as transcendental signs'.[12] Rather than seeing natural objects as pointing beyond themselves to some theological truth or doctrinal claim – and therefore arguably not really seeing them for what they are in themselves at all – the shift in interpretative approach opened up the possibility of relating natural objects to each other in new and interesting ways. Harrison claims that the constituent elements of the book of nature were subsequently viewed as related to each other mathematically, taxonomically, or otherwise. Their capacity to convey rich theological teachings was correspondingly 'reduced to a single theological principle of design'.[13]

The following quotation encapsulates Harrison's argument:

> Protestant Reformers, with some help from Renaissance humanists, sponsored a new approach to the biblical text, and in doing so wrought a hermeneutical revolution that brought in its wake a new approach to natural objects. In rejecting allegory and insisting instead that the Bible, the book of God's words, was to be read for its literal or historical sense, they inadvertently made possible a new approach to that other 'book', the book of nature. That new approach was essentially a scientific one.[14]

A strong interpretation of this claim might suggest that modern science would never have arisen had these pre-modern habits of thought prevailed. A weak interpretation might instead suggest that the pre-modern views may have delayed the emergence of the new ways of looking at natural objects, but that the older views would not have prevented the new ways from emerging even if allegorical interpretation of texts persisted. Whatever the case may be, Harrison offers an intriguing characterisation of changes in how texts and, correlatively, objects were read, changes that swept away long-established ways of thinking.[15]

11 According to Harrison, the literal sense retained a degree of flexibility through the accompanying use of typological interpretation and the doctrine of accommodation. Typology 'assumes God's self-disclosure in historical events', while accommodation recognises the fact that Scripture speaks not in philosophically refined ways but instead is adapted to the 'limited capacities of those who were to receive it'; *ibid.*,124.

12 *ibid.*

13 *ibid.*

14 *ibid.*, 116.

15 Two critiques of Harrison's thesis have appeared in the pages of this journal; see van der Meer, J.M., & Oosterhoff, R. 'The Bible, Protestantism and the rise of natural science: a response to Harrison's thesis', *Science and Christian Belief* (2009) 21, 133- 153, and Mandelbrote, S. 'Early modern biblical interpretation and the emergence of science', *Science and Christian Belief* (2011) 23, 99-113. Harrison responded to the first of these in Harrison, P.

Emergence II: recapitulating the prevailing ethos

While Harrison provides an account of how the way became clear for new conceptions of the natural world to emerge, he pays less attention in that study to the question of why the investigation of nature came to be pursued with such vigour in the early modern period.[16] One way in which historians have attempted to account for this vitality – especially in England – is by suggesting that there was a deep resonance between the values of the new science and those of a key product of the Reformation: Puritanism.

Unlike other aspects of the relations between the Reformation and science, the connections between Puritanism and science have been the subject of historiographical discussion for a very long time.[17] Throughout this period scholars have generally argued that the reason Puritanism mattered to the development of science is that it placed certain expectations on its adherents. One commentator has identified the impulse driving these expectations as follows: 'All men of practical affairs, including scientists, needed to demonstrate that their actions were in accord with the principles of godliness.'[18] What facilitated the vigorous pursuit of the new science in this context, it is claimed, was its proponents' ability to argue that science aligned with these pre-existing principles.

Two early studies illustrate the details of this claim. Dorothy Stimson identifies two contrasting historical moments – 1600 and 1687 – as indicative of a dramatic shift in the extent to which the new science was practised in England. At the beginning of the seventeenth century, says Stimson, there was very little indication that science was being embraced in England at all. By the end of the century a multitude of people, including numerous path-breaking figures – Wren, Boyle, Newton and many others – were devoting themselves to the pursuit. Stimson refers to these path-breaking figures as geniuses, but she does not offer a simplistic story of the explosion of science simply as a result of the birth of a large number

'The Bible, Protestantism and the rise of natural science: a rejoinder', *Science and Christian Belief* (2009) 21, 155-162.

16 He has addressed this topic in more recent studies; see Harrison, P. 'Religion, the Royal Society, and the rise of science', *Theology and Science* (2008) 6, 255-271; Harrison, P. 'Religion and the early Royal Society', *Science and Christian Belief* (2010) 22, 3-22.

17 Early studies include Stimson, D. 'Puritanism and the new philosophy in 17th century England', *Bulletin of the Institute of the History of Medicine* (1935) 3, 321-334; Merton, R. 'Puritanism, pietism, and science', *The Sociological Review* (1936) 28, 1-30; Jones, R.F. *Ancients and Moderns*, St. Louis (1936); Merton, R. 'Science, technology, and society in seventeenth-century England', *Osiris* (1938) 4, 360-632. More recent discussions of the topic include Mulligan, L. 'Puritans and English science: a critique of Webster', *Isis* (1980) 3, 456-469, and Webster, C. 'Puritanism, separatism, and science', in Lindberg & Numbers *op. cit.*,(2) *God and Nature*, pp. 192-217. A very comprehensive and insightful overview of the historiography surrounding the relations between Puritanism and early modern science is Morgan, J. D. 'The Puritan thesis revisited', in Livingstone, D. N., Hart, D.G & Noll, M.A. *Evangelicals and Science in Modern Perspective*, Oxford: Oxford University Press (1999), pp. 43-74.

18 Webster *op. cit.,* (17), p. 198.

of geniuses in the seventeenth century; after all, she writes, 'genius is always present hidden among the multitudes in every age'.[19] Rather, what she thinks is needed is an explanation of the emergence of the favourable cultural environment in which those geniuses flourished, because such an environment is a necessary, if not sufficient, condition for genius to be unleashed ('A favourable soil produces a full harvest').[20]

More than anything else, for Stimson it is the intellectual and religious characteristics of the time that explain why England embraced the new science and scientific genius was able to thrive. The cultural environment was indelibly shaped by moderate Puritanism, the 'low or broad church position' which sought to free the Church of England of all popery, and eventually to eliminate the episcopacy.[21] Protestantism more broadly challenged the authority of the pope, and aroused a 'spirit of challenge' in areas beyond ecclesiastical matters.[22] Combining a new emphasis upon private judgement in deciding the meaning of the Bible with an insistence upon an educated clergy, Protestantism unleashed profoundly transformative energies in Europe generally and England in particular. Within this wider setting, Puritanism was especially conducive to science both because of what it shared with Protestantism and because of how it went beyond it. Stimson points chiefly to Puritanism's emphasis upon 'the right of private judgement, its critical spirit, its insistence upon knowledge and reason, its independence and uprightness of character and its demand that men spend their time profitably' as vital ingredients in the mix.[23] The high moral standards to which Puritans kept themselves, for example, could lead them to science by discouraging them from pursuing less savory pastimes, such as going to the theatre. Furthermore, the potential usefulness of the discoveries that scientists made would have more than adequately justified the time they spent on scientific activities rather than on other things: 'What more suitable recreation', she asks, 'could be found for earnest upright men?'[24] Similarly, the right kind of person could find in scientific pursuits 'the interest and refreshment and the companionship' that could not be found elsewhere.[25]

In these and other ways, Puritanism provided a generative context that encouraged the new science and contributed to its success. In their 'intellectual temper' and their 'definite personal participation' Puritans 'helped to produce the scientific ferment that made ready the soil in which gen-

19 Stimson *op. cit.*,(17), 321.
20 *ibid.*
21 *ibid.*, 333.
22 *ibid.*, 323.
23 *ibid.*, 325.
24 *ibid.*, 326.
25 *ibid.*, 327.

ius flourished'.[26] To be clear, Stimson is not claiming that all Puritans were scientific geniuses. Rather, Puritanism created an environment in which particular qualities or characteristics were valued. Into this fertile environment stepped that handful of true geniuses whose work we still remember today as constitutive of the scientific revolution.[27]

In a paper published a year after Stimson's, the historically minded sociologist Robert Merton makes a related argument about the importance of Puritanism.[28] Merton there presents a thesis that should by now sound familiar: 'the Puritan ethic, as an ideal-typical expression of the value-attitudes basic to ascetic Protestantism generally, so canalized the interests of seventeenth-century Englishmen as to constitute one important element in the enhanced cultivation of science'.[29] This was the case, Merton argues, because Puritans were unable to compartmentalise or delimit religion and its associated practices and values. As they spilled over into other areas of life, those values directly impacted other areas of life. In the realm of science, for example, Puritanism's ethic 'left [its] indelible stamp upon the attitudes of scientists toward their work'.[30] One way in which this influence may be seen, Merton contends, is when Puritans decided whether or not an activity was desirable to undertake based on how useful the activity would be for reaching a desired end. Within this utilitarian framework, Puritans defended the pursuit of science by appealing to its religious utility, such as when scientists of the time 'maintained that the study of Nature is to the greater glory of God and the Good of Man'.[31] Similarly, the Puritan focus on social welfare and the good of the whole is clearly visible in the Baconian assertion that science could advance human welfare and ameliorate the human condition.[32]

Other features of the new science could also be used to justify it according to pre-existing expectations within the Puritan community. Merton sees the rationalism and empiricism inherent in Puritanism as being 'canonized' or 'beatified' in science.[33] He also claims that the very possibility of scientific knowledge rests on the assumption of the orderliness of

26 *ibid.*

27 Puritanism was necessary for 'making conditions in England favorable to the new philosophy heralded by Bacon and in promoting the type of thinking that helped to arouse interest in science and to create a ready reception for the work of the geniuses produced in that century'. *ibid.* 321-322.

28 Merton went on to present a much more detailed argument in *op. cit.,* (17) 'Science, technology …'.

29 Merton *op. cit.,*(17) 'Puritanism …', 1.

30 *ibid.*, 3.

31 *ibid.*

32 *ibid.*, 6. Bacon's relationship to Puritanism more broadly is discussed in Gascoigne, J. 'The religious thought of Francis Bacon', in Cusack, C.M., & Hartney, C.(eds.) *Religion and Retributive Logic: Essays in Honour of Professor Garry W. Trompf*, Leiden: Brill (2010), pp. 209-228.

33 *ibid.,* 7-8.

nature, an orderliness that paralleled Protestant theories of predestination.[34] In sum, Merton sees Puritan religious interests as 'demand[ing] in their forceful implications the systematic, rational, and empirical study of Nature for the glorification of God in His works and the control of the corrupt world'.[35] Seen from the other side, science was as successful as it was because Puritan principles correlated directly with the attributes and goals of science.

Stimson and Merton's arguments have not gone unchallenged. The numerical evidence that each one assembled has been a particular point of contention,[36] with Charles Webster insisting that their head counting method 'is confronted by such profound methodological and conceptual difficulties that it is likely to generate conclusions that are either trivial or irresolvably contentious'.[37] Because of these and other concerns, Peter Harrison has suggested that arguments about the relations between Puritanism and science have in some sense been superseded by more general theses (such as the one proposed by Harrison himself) about the relations between Protestantism and the emergence of science.[38] Nevertheless, for our purposes Stimson and Merton are important to consider because of the kind of connection that they propose between the Reformation and science – one that tries to account for why the latter took flight where and when it did – rather than because of the specific forms of evidence upon which they drew.

Theology I: rethinking God's relationship to the world

As important as the religious sensibility that Stimson and Merton have identified may be, there are other features of religious traditions that a focus on sensibility alone ignores. It is therefore worth asking whether other aspects of the relations between the Reformation and science can be discerned by looking at any of these other features. The next two studies explore how the Reformation has been thought to influence one such feature – theological ideas – and examines how theological developments impacted science.

34 *ibid.,* 12.

35 *ibid.,* 1-2.

36 Stimson's evidence of the extent of the Puritan ethos, for example, is the Puritan influence purportedly detectable in seven of the ten men who formed the nucleus of what would become the Royal Society. Furthermore, of the 119 originally associated with the pre-1663 Society, Stimson sees forty-two as Puritan to some extent, from which she concludes that there is 'a strong Puritan tinge in the Society which led the scientific work of the age' (Stimson *op. cit.*,(17), 330). She also sees strong Puritan participation in and interest in science beyond the Royal Society, notably in the work of physicians like Thomas Sydenham.

37 Webster also states that the intricacies of English Puritanism 'constitute an insuperable barrier to the application of such simplistic numerical analysis' (Webster *op. cit.,* (17), p. 199).

38 Harrison *op. cit.,* (7) *The Bible …*, p. 7. This may well explain the relative paucity of studies of Puritanism and science since the late 1990s compared to the preceding six decades.

One theological idea to which historians have repeatedly returned is the God/world relation.[39] In a notable study of the topic, Keith Hutchison has suggested that late-medieval theological ideas about God's relationship to the world were significantly modified by Martin Luther and John Calvin, and that these new ideas were co-opted by those seeking to promote the mechanical philosophy because they dovetailed so well with the view of matter promoted within that philosophy.[40] Before the Reformation, that relationship was strongly influenced by Aristotle's philosophy following the rediscovery of Aristotle's texts, starting in the twelfth century.[41] In an Aristotelian understanding of things, the world consists of a hierarchy of entities each possessing their own intrinsic causal powers, and any given entity can exercise its powers to causally affect other entities. When situated in a Christian view of creation by theologians like Thomas Aquinas, those entities are seen as having contingent existence – that is, they do not exist eternally, but rather they are held in being at every moment by God – but they still possess their own intrinsic causal agency, even if that agency is a perpetual gift from God.[42] With the exception of those times when God goes above and beyond what created causes are capable of doing on their own (i.e., miracles), changes in the created order can be fully explained by the operation of these intrinsic causal powers. In other words, natural causes are both necessary and sufficient to answer the question of what causes a given effect. God's role in such situations is vicarious; as Hutchison puts it, 'God was seen as normally acting in his universe mediately, through a hierarchy of implanted powers.'[43]

Magisterial reformers like Luther and Calvin vehemently opposed this view of God and the world because it seemed to put God at too great a

39 This is especially true of those historians who have explored the significance of voluntarism and intellectualism in the context of early modern science; see e.g. Osler, M.J. 'Descartes and Charleton on nature and God', *Journal of the History of Ideas* (1979) 40, 445-456; Osler, M.J., 'Eternal truths and the laws of nature: the theological foundations of Descartes' Philosophy of Nature', *Journal of the History of Ideas* (1985) 46, 349-362; Osler, M.J. *Divine Will and the Mechanical Philosophy: Gassendi and Descartes on Contingency and Necessity in the Created World*, Cambridge: Cambridge University Press (1994); Henry, J. 'Religion and the Scientific Revolution', in Harrison, P. (ed.) *The Cambridge Companion to Science and Religion*, Cambridge: Cambridge University Press (2010), pp. 39-58. Many of the issues are explored in an exchange between Peter Harrison and John Henry: see Harrison, P. 'Voluntarism and early modern science', *History of Science* (2002) 60, 1-27; Henry, J. 'Voluntarist theology at the origins of modernity: a response to Peter Harrison', *History of Science* (2009) 67, 79-113; Harrison, P. 'Voluntarism and the origins of modern science: a Reply to John Henry', *History of Science* (2009) 67, 223- 231.

40 Hutchison, K. 'Supernaturalism and the mechanical philosophy', *History of Science* (1983) 21, 297-333.

41 Grafton, A. 'The availability of ancient works', in Schmitt, C.B., Skinner, Q., Kessler, E. & Kraye, J. *The Cambridge History of Renaissance Philosophy*, Cambridge: Cambridge University Press (1988), 767-791.

42 The forms which are integral to Aristotle's understanding of the world represent those internal powers that God establishes as the causes of natural processes.

43 Hutchison *op. cit.*,(40), 302.

distance from the world that he created. As Hutchison sees it, Protestants instead 'placed great emphasis on the immediacy and universality of divine providence, and saw it as a great fault that the Roman Church officially characterized God as acting through intermediaries rather than directly'.[44] This emphasis on immediate divine sovereignty led reformers to reject the Aristotelian view in favour of much more direct divine manipulation of what goes on.

In Hutchison's opinion, this rejection of Aristotle conveniently served the purposes of a number of post-Reformation natural philosophers who espoused a new, non-Aristotelian, mechanical philosophy. Robert Boyle, Isaac Newton, Samuel Clarke and others promoted this philosophy and its associated view of matter as absolutely passive because of its supposed superiority for understanding phenomena in nature.[45] If created entities are denied intrinsic causal powers, however, one must invoke something like a radically sovereign God to organise matter into an orderly system in the first place, and to govern its subsequent motion, because on this view 'God does everything, Nature does nothing.'[46] Fortunately, proponents of the mechanical philosophy had a ready-made theological perspective – the Protestant understanding of God as intimately related to, and working within, the created order – within which to situate their preferred view of matter.

In his three-fold typology relating the Reformation to the rise of science, Gary Deason suggests that this is a clear case of an indirect effect of the former on the latter.[47] Both reformers and natural philosophers wanted to overturn Aristotelianism, and the latter's insistence upon the complete

44 *ibid.*, p. 313

45 While Hutchison focuses primarily on Protestant scholars in relation to the mechanical philosophy, Catholics were also important in the development of this new understanding of nature. For a helpful overview see Ashworth, W.B. Jr., 'Catholicism and early modern science', in Lindberg & Numbers *op. cit.,* (2) *God and Nature* …, pp. 136-166.

46 Deason, G.B. 'The Protestant Reformation and the rise of modern science', *Scottish Journal of Theology* (1985) 38, 221-240 , 234. This corresponds to an elision of the clearer distinction in the late medieval period between what is natural and what is supernatural or miraculous; the magisterial reformers either obliterate the distinction altogether so as to supernaturalise everything, or they so de-emphasise natural powers so much as to effectively render all things supernatural. According to the new view, what seems natural is merely that which happens so regularly that we no longer remember that it is in fact supernatural (as everything is); as Hutchison puts it, 'we simply term behaviour "natural" which is most familiar to us.' From God's perspective there is no longer a genuine natural/supernatural distinction, as though God were less active in the former and more active in the latter; again, according to Hutchison, 'in reality, ['natural' behaviour] is no more natural than that which we call miraculous. The distinction is one of human consciousness, nominal rather than ontological.' Hutchison *op. cit.,* (40), 316.

47 The strong interpretation 'holds that specific doctrines or attitudes affirmed by the Reformers and their followers contributed directly to the growth of science'. The weak interpretation 'acknowledges that modern science developed as a movement independent of the Reformation and it claims only that Protestantism offered relatively few obstacles to scientific expansion'. Deason *op. cit.,*(46), 221.

passivity of matter led them to invoke the former's insistence upon divine sovereignty.[48] The Reformation's influence on natural philosophy here is only indirect because the theological ideas propounded by reform-minded theologians were opportunistically co-opted by scientists. The pre-existence of this theological framework may also have made the mechanical philosophy seem even more compelling to its advocates, even though that framework had been developed in response to other considerations.

Theology II: overcoming the Fall

In the previous case, theology is seen as having indirectly given scientific ideas a credibility that they may otherwise have lacked. A more direct link between theological ideas and the promotion of scientific pursuits is postulated by Peter Harrison in his work on the rise of experimental natural philosophy as a response to the epistemological effects of the Fall.

The starting point for Harrison's second study interrogating the effects of Protestantism on science is his observation that early modern authors almost universally believed that the first human being, Adam, possessed an encyclopedic knowledge of nature, and that Adam 'enjoyed a greater facility in natural philosophy than any of his descendants'.[49] Harrison identifies numerous reasons that early moderns gave for why Adam was so capable in this regard – some thought divine revelation perfected Adam's knowledge; others believed that Adam was in possession of senses of extraordinary power and precision; yet others thought that Adam preserved the proper hierarchy of relations among the faculties of the mind (will, reason and imagination) – but they all agree that Adam was a scientist par excellence.

According to Harrison, the ways in which the Fall was understood to have affected Adam and all subsequent human beings reflect the ways in which Adam's pre-Fall superiority was conceptualised. Psychological accounts of the fall, for example, concentrated on the 'breakdown of the proper harmonious relations which had once existed' among the faculties of the mind.[50] The reformers revived a particularly severe Augustinian form of the doctrine of original sin and, as a result, the epistemological consequences of the Fall were brought to the forefront. Whatever the Fall's effects were thought to be, Adam's originally perfect knowledge of nature led to the belief that all human minds originally had the capacity to know

48 As Deason writes, 'the Protestant Reformation influenced the rise of science indirectly, by providing new ideas and arguments opposed to Aristotelian philosophy, which were adopted by proponents of the new science to strengthen their own position against Aristotle'; *ibid.,* 227.

49 Harrison, P. 'Original sin and the problem of knowledge in early modern Europe', *Journal of the History of Ideas* (2002) 63, 239-259, 241.

50 *ibid.,* 242.

the truth in its fullness.

Even though the Fall seemed to render this intended telos unreachable, early modern authors nevertheless focused their efforts on undoing its effects: 'once those impediments which followed upon the Fall had been identified and neutralized, the mind would once again, of its own nature, arrive at truth, or at least be better equipped to do so'.[51] This led to what Harrison refers to as the 'standard pattern' for proposals to advance knowledge at this time: start with an account of what caused the error in the first place (i.e., the Fall's effects), and then propose some set of procedures or methods through which the ailments plaguing the human mind might be overcome.

The specific proposals put forward for the restoration of the human mind depend on the extent to which Adam's abilities were thought to have been impaired in the Fall. Harrison observes that the reformers tend to assume that Adam's capacities after the Fall were greatly diminished compared to his pre-Fall state, while late-medieval thinkers tend to minimise the cognitive effects of the Fall.[52] Aquinas, for example, remained optimistic about the natural abilities of the human mind after the Fall, and it was partly on this basis that Aristotle's natural philosophy was thought to be perfectly acceptable in the medieval period: if the Fall's effects are relatively minor, there is 'no reason to be suspicious of learning which had sprung from the exercise of natural and universal principles of reason'.[53] In the early modern period Rene Descartes' confident proposal for overcoming the effects of the Fall reveals strong sympathies with these scholastic views.

What has all of this got to do with science? Although Cartesian-inspired rationalism was an important part of the early modern scene, the Reformers' rather more pessimistic view – emphasising a harsher view of the effects of the Fall – was repeated throughout the seventeenth century, and many accepted its terms. This in turn led to what Harrison judges to be 'somewhat more modest' restorative projects. It is in this context that the empiricist approaches advocated by proponents of experimental natural philosophy are to be understood: the experimental methods promoted by Francis Bacon, Joseph Glanvill, and others were an attempt by fallen human reason to gain reliable knowledge. Harrison speaks of the time-consuming empiricist methods put forward by Bacon, for example, as follows: 'The Baconian method of a slow and laborious accumulation of knowledge of nature by means of the collection and arrangement of natural histories is in keeping with this less ambitious view of the possibility of a general science.'[54] Harrison observes that the assumption that the

51 *ibid.*, 244.
52 *ibid.*, 245.
53 *ibid.*, 245.
54 *ibid.*, 250.

Fall's effects were devastating 'served as [a] warning against naïve and uncritical epistemologies' such as those offered by Aristotle.[55] In this scenario, then, a Reformation-era theological claim is seen as providing direct motivation for the pursuit of knowledge about nature through a method – experimental study and observation – that is still recognised today as a central part of science.

Reception I: astronomy among Protestant theologians

The studies described thus far have conceived of a range of links between the Reformation and science. Another place in which historians have looked to understand the relations between science and the Reformation is the reception of new scientific ideas among theologians, ecclesiastical figures, teachers and others who were intimately involved with the reforming movement. The following two studies represent examples of this approach.

The first is Robert Westman's account of an episode in the reception of Copernicus' heliocentric view of the cosmos.[56] Westman's study is an attempt to understand the temporal dynamics of the reception of new scientific ideas – that is, the ways in which a scientific theory may, for example, be accepted in part at an early stage of its life and in its entirety only at a later date, or vice versa. To grasp what is going on in situations like these, Westman thinks that historians must try to understand how interpretations of a scientific theory are shaped by factors external to the theory itself – for example, by such considerations as 'prior emotional expectations and procedural habits', the 'reactions of close colleagues and friends' and the 'context in which the new ideas are first encountered'.[57]

The particular historical moment in which Westman explores these dynamics is the response to Copernicus' new astronomical ideas by the German reformer Philip Melanchthon and the coterie of scholars under Melanchthon's tutelage. Copernicus' reception by Melanchthon and those who studied with him is important because Melanchthon and his followers had a considerable impact on the subsequent study of astronomy in Germany and elsewhere: German universities were staffed with people who had trained with the group, and Melanchthon's circle wrote astronomy texts that were used at those universities. As a result, this 'informal scientific group' influenced the early reception of the Copernican theory in ways that 'cannot be underestimated'.[58]

55 *ibid.,* 254.

56 Westman, R.S. 'The Melanchthon Circle, Rheticus, and the Wittenberg interpretation of the Copernican Theory', *Isis* (1975) 66, 164-193; see also Westman, R.S. 'The Copernicans and the Churches', in Lindberg & Numbers *op. cit.,* (2) *God and Nature …*, 76-113.

57 Westman *op. cit.,* (56), 166.

58 *ibid.,* 168.

Westman situates Melanchthon's interest in the new astronomical ideas emerging at the time in the context of the educational reforms that occurred as Luther and his followers upended the church.[59] Some zealous early followers of Luther hoped to do away with education completely, but Melanchthon and others resisted this tendency and instead reformulated and revitalised the university educational curriculum. At age twenty-one Melanchthon was appointed professor of Greek at the University of Wittenberg, and from there he launched a 'vigorous and far-reaching campaign of educational reform', one which was to have a profound impact on what students learned at German universities.[60] The many changes that he instituted included an increased emphasis on mathematics and astronomy within the university curriculum, a modification that reflected Melanchthon's conviction that the study of nature is one means through which one can recognise the creator. Combined with Melanchthon's dedication to his students, Melanchthon's new curriculum inspired many of those who studied with him to focus their energies on mathematics and other natural sciences.

Westman's analysis concentrates on the influential reading of Copernicus' *De Revolutionibus* (1543) established by Melanchthon and his followers. Viewed superficially, this 'Wittenberg interpretation' (Westman's appellation) appears to be fully consistent with Copernicanism, but a closer look shows that Melanchthon and his followers did not accept every aspect of Copernicus' views in equal measure. Rather, they effectively split the work into multiple parts, with certain elements accepted wholesale and others rejected outright. For example, members of the group generally agreed that Copernicus' predictions about the angular position of a given planet were useful, and some of them preferred the Copernican models because they replaced Ptolemy's equants with epicycles. However, these models were translated into a geostatic frame of reference, because among members of the group the belief that the earth moved was the 'least satisfactory Copernican claim'.[61] They also tended to ignore Copernicus' teaching about the linear distances between planets. Among many of those associated with the Wittenberg circle, then, those parts of Copernicus' work that were adopted and deemed to be consistent with the foundations of astronomy were viewed favourably only if they were interpreted against the backdrop of a stationary earth. Other aspects of his work were rejected, ignored, or seen as 'possessing low truth content'.[62]

Westman believes that theological convictions were responsible for this partial or conditional reception of Copernicanism. Melanchthon rec-

59 See Kusukawa, S. *The Transformation of Natural Philosophy: The Case of Philip Melanchthon*, Cambridge: Cambridge University Press (1995).

60 Westman *op. cit.,* (56), 169.

61 *ibid.,* 167.

62 *ibid.*

ognised that Copernicus' views could be interpreted as suggesting that the earth was indeed genuinely in motion around an unmoving sun, but that Melanchthon rejected this interpretation because it contradicted the 'divine testimony of Scripture'.[63] Westman sees Caspar Peucer as similarly rejecting the motion of the earth in his introductory astronomy textbook because it challenged the teaching contained in the Bible, a fact that Peucer saw as a significant impediment.[64] However much the astronomer's views may have found favour among those who followed Melanchthon, Westman finds that the 'realist and cosmological claims of Copernicus' great discovery failed to be given full consideration'.[65] Despite being among the early advocates of Copernicus, this particular coterie's theological commitments made them unwilling to countenance the possibility that Copernicus' speculations about the movement of the earth around the sun might be physically true.

Reception II: promoting certainty

Westman judges Melanchthon to have given mathematics and astronomy higher standing in the educational curriculum than they had previously been given. Delving into Melanchthon's reasons for doing so reveals another aspect of the reception of scientific ideas and practices in the Reformation era: encouraging the pursuit of scientific knowledge because of its perceived religious and political utility.

A good example of this kind of argument can be seen in a recent article by Charlotte Methuen. Beginning with Melanchthon, Methuen argues that the German reformer liked mathematics in part because he saw it as a path to sure and certain knowledge.[66] It has this capacity because it can show how 'confused things may be unravelled and understood'.[67] This power that mathematics possesses is particularly clear in the case of the motion of the heavens, where it gives one the remarkable ability to predict where the planets will be in the future.[68] As worthwhile as such knowledge is, even more significant is the fact that the ability mathematics gives one

63 *ibid.,* 174.

64 Peucer rejected the moving earth on philosophical grounds because such motion went against Aristotle's understanding of motion; *ibid.,* 179.

65 *ibid.,* 168.

66 Methuen, C. 'The German Reformation and the mathematization of the created world', *Theology and Science* (2011) 9, 35-44. Methuen has compiled a number of her earlier studies of the relations between science and the Reformation in Methuen, C. *Science and Theology in the Reformation*, London: T&T Clark (2008). For more on certainty in the early modern world see Schreiner, S.E. *Are You Alone Wise? The Search for Certainty in the Early Modern Era*, Oxford: Oxford University Press (2010).

67 Methuen *op. cit.,* (66) 'The German…', 37.

68 As Methuen points out, Melanchthon's focus on the use of mathematics to understand planetary motion is based on a strong reading of Aristotle's distinction between the celestial and the sublunary realms, with mathematics applicable only to the former.

to calculate the paths of the planets and to predict their future locations is a consequence of the heavenly realm's being supremely ordered and exquisitely arranged. In Melanchthon's view this orderliness can have only one source: God. By understanding how the heavens move, the frail human mind not only gains reliable knowledge, one also peeks into God's mind and catches a glimpse of the orderliness that resides there.

For Melanchthon, then, mathematics offers a way 'for fallen human reason to transcend the restrictions of the fallen, corrupted sub-lunar sphere and be raised to heaven, not only in the cosmological sense, but in the sense of understanding the mind of God'.[69] As if this were not enough, Melanchthon is further convinced that by raising one's mind to divine heights, mathematics ultimately helps one to live a godly life. It can do this because the orderliness of the celestial realm should be reflected in the ordered lives of human beings. Methuen thus argues that for Melanchthon, mathematics has a 'strong ethical undertone', because 'the study of mathematics – and indeed of philosophy as a whole – was … a means by which divine order could be introduced into human life, and this was his primary interest in it'.[70] It is these connections between mathematics, order, divinity and piety – premised on the conviction that mathematical disciplines are marvellous tools for exploring the relationship between God and humanity because they offer 'deeper understanding of the place of humankind in God's creation and his providential plan' – that make mathematics such a worthwhile pursuit in Melanchthon's eyes.[71]

Methuen notes that others followed Melanchthon's lead in these matters. His contemporary fellow reformer, Simon Grynaeus, similarly argued that mathematics allows the human mind to comprehend the universe in its entirety, and thereby to appreciate God's works. Grynaeus also acknowledged the power that mathematics possessed to engender philosophical and theological agreement through its ability to bypass conflict. According to Methuen, Grynaeus wanted a 'certain philosophy' grounded in the 'knowledge and wisdom of God', but which was not 'susceptible to the "turbulences and tumults" of philosophers or to the "monstrous absurdities" of scholastic philosophy'. Grynaeus thought that geometry offered the most 'clear and certain means of learning the reasoning associated with such a philosophy'. In this way, mathematics 'offered a means of transcending the ambiguity of words and thus a solution to the confusion of different texts and methods with which he and his contemporaries found themselves confronted'.[72]

Methuen sees this rise in the esteem in which mathematics is held, and

69 *ibid.,* 37.
70 *ibid.,* 37-38.
71 *ibid.,* 38.
72 *ibid.,* 39.

the increasing emphasis on its ability to transcend division, as culminating in the writings of Johannes Kepler. Kepler's understanding of the celestial realm was simultaneously mathematical and theological, a fact reflected in Kepler's decision to style himself a 'priest of the book of nature'.[73] Like Melanchthon, Kepler thought that mathematics could help one to understand the order intrinsic to the heavens, and that through it one might glimpse the peaceful orderliness that God also intended for the human race. Strikingly, through its ability to reveal the 'deeper, divine structures of the universe'[74] – manifesting in the well-known relationship that he perceived between the ratios of the planetary spheres and the so-called Platonic solids – Kepler also thought that mathematics and astronomy might offer better and more accurate knowledge of God than one can obtain from the Scriptures. The remarkable fit between mathematical truths and reality, and the ability of mathematics to 'unlock the secrets of the universe', stem from the fact that God thinks in mathematical terms, and so mathematical knowledge constitutes a form of divine knowledge.[75] And like those who preceded him, Kepler hoped that the study of mathematics and the truths about God revealed through that study would lead to peace.

Conclusion

In order to tell a story about the past, historians must decide the kind of story that they want to tell with the historical evidence that they have at their disposal. The particular stories that historians tell about two such variegated phenomena as the Reformation and science depend upon judgements that historians make about a very wide range of issues: the nature of the Reformation (what it is, where it took place, when it took place, etc.), the nature of science in the early modern period (what it consisted of, who was doing it, where were they doing it, etc.), the nature of historical causation and historical change, and a host of other matters.[76]

Each of the studies discussed in this article provides a distinctive account of the relations between science and the Reformation, and in doing so each addresses these issues slightly differently from the others. For example, focusing as he does on the conditions of possibility of the emergence of modern science, Harrison looks primarily at a wide range of scholarly theological and philosophical texts from various key moments in western

73 *ibid.,* 40; see Fisch, H. 'The scientist as priest: a note on Robert Boyle's Natural Theology', *Isis* (1953) 44, 252–265; Harrison, P. "Priests of the Most High God, with respect to the Book of Nature': The Vocational Identity of the Early Modern Naturalist', in Menuge, A. *Reading God's World: The Scientific Vocation*, St Louis: Concordia Publishing (2004), pp. 55-80.

74 Methuen *op. cit.,* (66) 'The German…', 42.

75 *ibid.,* 42-43.

76 An enjoyable and accessible introduction to the kinds of issues that historians must grapple with is Arnold, J. *History: A Very Short Introduction*, Oxford: Oxford University Press (2000).

European history – the early church until Augustine, the high medieval period, the Renaissance and Reformation, and the seventeenth century – to narrate a story of disruption to traditional interpretive practices caused by a religious event of profound historical significance. Change is perceived in terms of conscious resistance to previous thoughts and habits, a move that provides sufficient space for the emergence of new ways of thinking and acting. Westman, on the other hand, focuses on a handful of persons connected through social and institutional ties in a relatively small geographical area from a limited chronological period, and tries to discern the group's general attitude toward a novel astronomical theory by looking at a variety of texts – especially educational textbooks from the time – in which they described and discussed that theory.

Harrison, Westman and the other authors have uncovered a diverse array of influences and interactions between science and the Reformation that together suggest that the relations between the two cannot, and should not, be reduced to a single, monolithic story. At the same time, they make it clear that when dealing with such complex phenomena, the choice to focus on certain influences and interactions at the expense of others inevitably involves trade-offs. Fast gallops through large swathes of history generally do not allow the time to stop and look at individual figures in detail, meaning that subtleties will be missed or profundities overlooked. Yet the urgency to study an individual figure usually only arises if that figure is of historical significance for some reason, and often that significance can be established only by looking at that figure against the backdrop provided by a longer stretch of history.

Given the inevitable shortcomings of any one approach, a variety of historical methods and styles – microscopic to telescopic, miniscule to cosmic – will in many situations be necessary to fully appreciate the meaning and the significance of the past. Gaining a deep understanding of the multifaceted relations between science and the Reformation clearly requires nothing less.

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