PETER HARRISON

PHYSICO-THEOLOGY AND THE MIXED SCIENCES

The Role of Theology in Early Modern Natural Philosophy

The last decade has witnessed an energetic discussion amongst historians of the early modern period concerning the identity of natural philosophy. Two concerns have dominated the agenda: first, the manner in which mathematical explanations were imported into what was traditionally a qualitative enterprise;[1] second, the extent to which natural philosophy admitted theology and theological modes of explanation.[2] This chapter is primarily concerned with the second of these—to do with the relation of 'science' and 'religion' during this period—but will also suggest that the two issues are related in important ways. Three specific claims will be made: (1) that the emergence of the disciplinary category 'physico-theology' was an explicit attempt to address the issue of the place of theology in early modern natural philosophy; (2) that this category is analogous in certain respects to the 'physico-mathematics' inasmuch as both represent attempts to renegotiate traditional disciplinary boundaries; (3) that physico-theology resolved vocational tensions specific to this period concerning the extent to which it was legitimate for naturalists to be engaged in theology, and conversely, for clerics to be engaged in the study of nature.

1.GOD AND EARLY MODERN NATURAL PHILOSOPHY: GALILEO, BACON, AND DESCARTES

In an influential paper that appeared in 1988 Andrew Cunningham suggested that natural philosophy was fundamentally about 'God's achievements, God's intentions, God's purposes, God's messages to man'.[3] This claim has much to commend it, not least because it poses in an acute way the question of the nature of natural philosophy and of how it differs from modern science. The thesis also has wide-ranging implications. Thus, if Cunningham is correct in asserting that natural philosophy is essentially about God and his creation, then it would seem to follow that much of the discussion about 'science and religion' during this period is misplaced, since in natural philosophy we have a discipline that comprehended both

[1] Cunningham 1991; Dear 1995, chap. 6 and 1998; Gaukroger and Schuster 2002.
[2] Cunningham 1988; Osler 1997; Grant 2000; Dear 2001; Cunningham 2001.
[3] Cunningham 1988, p. 384.

P. R. Anstey and J. A. Schuster (eds.), The Science of Nature in the Seventeenth Century, 165-183.

topics within its scope.[4] One might also wonder why the discrete new disciplinary category of physico-theology arose, if natural philosophy already included a significant theological dimension. Some analysis of the relationship between physico-theology and natural philosophy is clearly called for. At the outset, then, we need to consider the 'Cunningham thesis' in order to determine whether, and in what sense, natural philosophy can be regarded as being uniformly about God's achievements, intentions, and so on. In this section I shall suggest that in fact the role of God and of theological explanations in early modern natural philosophy are not taken for granted by the major protagonists, and that there was considerable scope for a range of positions on this question. The positions I shall briefly consider here are those of Galileo, Descartes, and Bacon.

Early modern discussions of the place of God and of theological explanation in natural philosophy take place against the background of two aspects of Aristotle's influential conception of *scientia*. First, Aristotle had proclaimed that each of the sciences has its own class of objects, and that the methods appropriate for one science should not be transposed to another.[5] Aristotle had identified three speculative sciences: mathematics, which dealt with unchanging, immaterial objects that were dependent on the human mind; natural philosophy which was concerned with changeable material objects that were independent of the human mind, and the 'divine science' or metaphysics, which dealt with unchangeable, immaterial objects that were independent of the human mind.[6] The relation of the divine science to the other sciences, as we might expect, exercised the imaginations of Aristotle's medieval heirs to a considerable degree.[7] Thomas Aquinas, for example, considered the question of whether the divine science dealt with all objects. He concluded: 'Sacred doctrine does not treat of God and creatures equally, but of God primarily, and of creatures only so far as they are referable to God as their beginning or end. Hence the unity of this science is not impaired'. Aquinas thus argued that inasmuch as the creatures have God as their final cause, their study is part of the divine science. Aquinas also made reference to the notion of 'subordinate sciences': 'Nothing prevents inferior faculties or habits from being differentiated by something which falls under a higher faculty or habit as well … Similarly, objects which are the subject-matter of different philosophical sciences can yet be treated of by this one single sacred science.'.[8] For Aquinas, then, it was final causes that provided the key to understanding how the sciences of created objects were subordinate to theology.

[4] See, e.g., Dear 2001, p. 378.

[5] Aristotle, *Posterior Analytics*, 75a–b; *Metaphysics*, 989b–990a; *On the Heavens*, 299a–b. See also Funkenstein 1986, pp. 35–37, 303–307.

[6] Aristotle, *Metaphysics*, 1025b–1026a.

[7] Of course, medieval thinkers also operated with a modified conception of 'divine science', which for them was informed by revelation as well as reason.

[8] *Summa theologiae*, 1a. 1, 3. *Scientiae mediae* (middle sciences) is the expression that Aquinas used for other mixed sciences such as optics, mechanics, and music. Aquinas spoke of 'habits' in this context because for him, as indeed for Aristotle, *scientia* was in its primary sense not a body of knowledge but a mental habit. See, e.g., *Summa theologiae*, 1a2ae. 49, 1; 1a2ae. 50, 3; 1a2ae. 52, 2; 1a2ae. 53, 1.

The other significant element of the Aristotelian legacy concerned the ideal of scientific knowledge as demonstrative and certain.[9] Clearly the truths of revelation, some of which were contingent historical facts, did not admit of the demonstrative certainty of logically deduced propositions. How, then, could theology be a true science, far less the queen of the sciences? Aquinas addressed this problem by suggesting that truths of revelation derive their certainty from their source—God or the Church—thus providing alternative grounds for holding propositions to be certain.[10] In due course, Protestant theologians were to add that scriptural propositions also counted as 'scientific' knowledge. Mathematician and astronomer Georg Joachim Rheticus (1514–1576), for example, insisted that all passages of scripture, without distinction, bore the force of demonstration.[11] The allocation of equal weight to the words of scripture and the findings of properly constituted science raised the prospect of irreducible conflict between two demonstrative truths. Such a possibility had been anticipated by Augustine, who established the hermeneutical principle that scriptural assertions about physical reality could not be in conflict with demonstrated truths of natural philosophy.[12] The multi-layered system of biblical interpretation favoured by Augustine and his medieval successors allowed for non-literal readings of scriptural passages in such instances.[13] An alternative solution was that of the 'double truth', a notion commonly attributed to Averroës and some of the schoolmen, according to which what is true in philosophy may be false in theology, and vice versa.[14] These considerations, admittedly presented here in a somewhat simplified form, represent part of the medieval background to early modern discussions of the relation between theology and natural philosophy. They relate in particular to the legitimacy of explanation in terms of final causes, to how the Aristotelian model of 'subordinate sciences' might work in the case of sciences being subordinated to theology; and to how 'demonstrative knowledge' remained a significant scientific ideal.

When we consider the stated positions of Galileo, Bacon, and Descartes, the relevance of these concerns becomes immediately apparent. In his celebrated 'Letter to the Grand Duchess Christina' (1615), Galileo responded to those of his critics who had exploited theological or exegetical arguments against heliocentrism. While Galileo was mostly concerned to elaborate his view of how scripture was to be interpreted on matters relating to natural philosophy, he also sought to clarify the

[9] Aristotle, *Posterior Analytics*, 71b–72b.

[10] Aquinas, *Summa contra gentiles*, 1.6. On Aquinas' view of *scientia* see MacDonald 1993. Cf. Descartes, who suggested that 'what has been revealed by God is more certain than any knowledge, since faith in these matters, as in anything obscure, is an act of the will rather than an act of the understanding'; *Rules for the Direction of the Mind*, §370; Descartes 1985, I, 15.

[11] 'For it is written that one shall not diverge from the words of the Lord, either to the right or to the left, and that the Word itself has the force of demonstration, since it has been given to us by God'; Rheticus 1984, pp. 65f. See also Lohr 1988, p. 633. The circularity of this piece of reasoning seems to have escaped Rheticus, but his view was not uncommon, particularly amongst Protestant thinkers for whom the authority of scripture was paramount.

[12] Augustine 1844–1905, vol. 34, p. 270.

[13] For Augustine's hermeneutics see Harrison 1998, pp. 25–33.

[14] It is doubtful, however, that any medieval theologian advocated such a position. See, e.g., Dales 1984 and MacClintock 1972.

relation of theology, as the queen of the sciences, to the 'subordinate' or 'inferior' sciences. The relation of superior to subordinate sciences can be understood in one of two ways, he suggests. First, the 'pure' science is superior to the 'applied', as in the case of arithmetic and geometry in relation to accounting and surveying, for the rules 'are more excellently contained' in the former than in the latter. The theoretical sciences are thus more comprehensive than their applied versions. Second, a science may be superior on account of the special dignity of its object and the manner in which its truths are communicated. Theology, Galileo insisted, is a superior science in this second sense. This account of the relation means that geometry, astronomy, music and medicine, though inferior to theology on account of their objects, are not more excellently contained in the pages of scripture than they are in the writings of the philosophers.[15] To crown his argument Galileo invoked Augustine's assertion that there can be no conflict between the truths of scripture and the demonstrated truths of the sciences. Galileo thus contended that 'truly demonstrated physical conclusions need not be subordinated to biblical passages, but the latter must rather be shown not to interfere with the former'.[16] Galileo seems here to adopt the position that philosophy should be independent of theology, and indeed if there is a dependent relationship, it is biblical interpretation that should rely on the demonstrated conclusions of philosophy, rather than the reverse.[17]

Francis Bacon also appears to insist on a number of occasions that natural philosophy remain pure from admixture with heteronymous disciplines, including theology. In *Novum Organum* he complained that: 'We have as yet no natural philosophy that is pure; all is tainted and corrupted; in Aristotle's school by logic; in Plato's by natural theology; in the second school of Platonists, such as Proclus and others, by mathematics, which ought only to give definiteness to natural philosophy, not to generate or give it birth'.[18] Natural theology, then, corrupts natural philosophy, or at least it did in the case of Plato. *The Advancement of Learning* contains Bacon's best-known admonition against 'unwisely mingling' divinity and philosophy:

> … let no man upon a weak conceit of sobriety or an ill-applied moderation think or maintain, that a man can search too far, or be too well studied in the book of God's word, or in the book of God's works, divinity or philosophy, but rather let men endeavour an endless progress or proficience in both; only let them beware that they

[15] Galileo, 'Letter to the Grand Duchess Christina', in Drake 1957, pp. 191–193. It might be thought that Galileo is mostly concerned with the relation of astronomy to theology, but in claiming that astronomy dealt with physical truths (rather than with mathematical hypotheses) Galileo was seeking to bring astronomy within the ambit of natural philosophy. He thus distinguishes 'mathematical astronomers' who seek to save the appearances, and 'philosophical astronomers who, going beyond the demand that they somehow save the appearances, seek to investigate the true constitution of the universe…', *Letters on Sunspots* in *ibid*., p. 97.

[16] *Ibid*., pp. 194f.

[17] '… having arrived at certainties in physics, we ought to utilize these as the most appropriate aids in the true exposition of the Bible and in the investigation of those meanings which are necessarily contained within'; *ibid*., p. 183. The issue of which philosophical truths might have demonstrative weight is skirted by Galileo.

[18] *Novum Organum*, I, xcvi; Bacon 1859, IV, p. 93.

> apply both to charity, and not to swelling; to use, and not to ostentation; and again, that they do not unwisely mingle, or confound these learnings together.[19]

Knowledge, Bacon goes on to say, 'is first of all divided into divinity and philosophy', implying that this is a boundary that ought to be respected.[20]

In the same work Bacon revisited these issues in his treatment of final causes, arguing that these causes should not be admitted into physics (i.e. natural philosophy): 'For the handling of final causes, mixed with the rest in physical enquiries, hath intercepted the severe and diligent inquiry of all real and physical causes, and given men the occasion to stay upon these unsatisfactory and specious causes, to the great prejudice of further discovery'. The appropriate venue for a discussion of final causes, he insisted, is metaphysics and not physics.[21] Finally, if philosophical theology is to be excluded from physics, so too, is biblical exegesis. Bacon thus censured 'the school of Paracelsus, and some others, that have pretended to find the truth of all natural philosophy in the scriptures'.[22] One cannot, he insisted in *Novum Organum*, found a system of natural philosophy on the first chapter of Genesis.[23] On the face of it, all of this is suggestive of a position that would largely exclude theological considerations from the scope of natural philosophy.

Descartes was another who sought to set out the explicit boundaries of natural philosophy and theology in such a way as to avoid confusion. In his *Comments on a Certain Broadsheet* (1648) he distinguished three kinds of knowledge with a view to clarifying the proper relation of philosophy to religion:

> First, some things are believed through faith alone—such as the mystery of the Incarnation, the Trinity, and the like. Secondly, other questions, while having to do with faith, can also be investigated by natural reason: among the latter, orthodox theologians usually count the questions of the existence of God, and the distinction between the human soul and the body. Thirdly, there are questions which have nothing whatever to do with faith, and which are the concern solely of human reasoning, such as the problem of squaring the circle, or of making gold by the techniques of alchemy, and the like.

Problems arise, Descartes observed, when the methods of philosophy are erroneously applied to revealed truths, and when putatively revealed truths are applied to things properly the subject matter of philosophy alone: 'Just as it is an abuse of Scripture to presume to solve problems of the third sort on the basis of some mistaken interpretation of the Bible, so it diminishes the authority of Scripture to undertake to demonstrate questions of the first kind by means of arguments derived solely from philosophy'.[24] The existence of problems of the third sort suggests a realm of knowledge that ought to be quarantined from theological interests. The second category of knowledge, however, concerning what can be

[19] *Of the Advancement of Learning*, I. i. 3; Bacon 1974, pp. 9f.
[20] *Ibid*., II. v. 1, p. 83.
[21] *Ibid*., II. vii. 7, p. 94. Bacon explains the difference in *Novum Organum*. The investigation of forms belongs to metaphysics and of efficient causes to physics. Each has a subordinate science, respectively magic and mechanics: *Novum Organum*, II, ix; Bacon 1859, IV, p. 126.
[22] *Of the Advancement of Learning*, II, xxv. 16; Bacon 1974, p. 207.
[23] *Novum Organum*, I, lxv; Bacon 1859, IV, p. 66.
[24] *Comments on a Certain Broadsheet*; Descartes 1985, I, p. 300.

known of God and the soul through reason alone, Descartes allowed to be the proper province of philosophers.[25]

As Galileo before him, Descartes did nonetheless subscribe to a particular understanding of the subordination of natural philosophy to theology. In the *Replies to Objections* he notes that in philosophy 'we must begin with knowledge of God, and our knowledge of all other things must then be subordinated to this single initial piece of knowledge'. This, he maintains, he had explained in the *Meditations*.[26] By this Descartes meant simply that knowledge of God provides the epistemological foundation upon which natural philosophy is constructed. This, of course, is a notion of subordination quite different from the traditional understanding.

Descartes also shared Bacon's view that the consideration of final causes was not appropriate for natural philosophers. The weakness of human reason compared with the immensity of the divine mind meant that the purposes of the Deity were 'impenetrable'. 'And for this reason alone', Descartes concluded, 'I consider the customary search for final causes to be totally useless in physics'.[27] When Gassendi raised objections to this uncompromising position, Descartes pointed out that while it might be appropriate to praise God on account of the functioning of various creatures, we admire him as their efficient cause (i.e., as their creator), not their final cause.[28] Guessing at the purposes of the Deity was relegated to the realm of 'ethics' where, Descartes seems to imply, less restrained conjectures were permissible.[29]

This brief discussion of passages from Galileo, Bacon and Descartes, is not intended to provide a comprehensive account of their final position regarding the relation of theology and physics. Nonetheless it is revealing when we reconsider Cunningham's claim that natural philosophy at this time was about 'God's achievements, God's intentions, God's purposes, God's messages to man'. That natural philosophy should legitimately be about God's intentions and purposes was strongly denied by Descartes and to a lesser extent Bacon. Moreover, in none of these instances does there seem to be a single straightforward understanding of the role that God or theological claims might play in the sphere of natural philosophy. This suggests that the relation between the two disciplines was not a settled one and was under negotiation, as was also the case, for example, with the relation of mathematics to natural philosophy. Each of these individuals found it necessary to grapple with the place of theological argument in the sphere of natural philosophy, and each took a negative view of particular kinds of theological incursions into the realm of physics.

[25] 'As to questions of the second sort, not only do they [theologians] not regard them as being resistant to the natural light, but they even encourage philosophers to demonstrate them to the best of their ability by arguments which are grounded in human reason', *ibid*.

[26] *Objections and Replies*; Descartes 1985, II, p. 290.

[27] *Meditations* §55; Descartes 1985, II, p. 38.

[28] *Objections and Replies*; Descartes 1985, II, p. 258; cf. *Principles of Philosophy*, Pt I, §15; Descartes 1985, I, p. 202.

[29] 'In ethics, then, where we may often legitimately employ conjectures, it may admittedly be pious on occasion to try to guess what purpose God may have had in mind in his direction of the universe; but in physics, where everything must be backed up by the strongest arguments, such conjectures are futile', *ibid*.

By the same token, each also found some place for theological claims. Galileo thus invoked the commonplace metaphor of 'the book of nature' to assert that 'the glory and greatness of Almighty God are marvellously discerned in all his works and divinely read in the open book of heaven'. The glory of God becomes more apparent through 'the ingenuity of learned men', and thus astronomy and natural philosophy have a religious role.[30] Moreover, his assertion that the subject matter of the bible is salvation and not natural philosophy did not prevent him from interpreting passages of scripture in such a way that they would support his claims about the movement of the earth.[31] As for Bacon, the whole point of engaging in natural philosophical investigations was to participate in a redemptive process aimed at restoring the mastery of nature which the human race had lost at the Fall.[32] So that while Bacon strived for a natural philosophy that was free from the corrupting influences of 'religious zeal', nonetheless the whole goal of natural philosophy was presented as a religious one, and part of God's providential plan.[33] If the content of natural philosophy was to be innocent of theological considerations, for all that, its whole justification as a useful enterprise was intimately connected with divine intentions. We need also to treat with some caution Bacon's contention that philosophy is corrupted and tainted by admixture with 'natural theology', for Bacon is most probably using the term 'natural theology' in a quite restricted sense. There is a pejorative use of 'natural theology' in both Augustine and Aquinas—probably derived from Varro—and it is likely that Bacon is using the expression in this traditional sense to mean something like 'pagan theology'.[34] For his part, Descartes made theology the beginning rather than the end of natural philosophy, grounding the reliability of clear and distinct ideas, the existence of the material world, and the constancy of the laws of nature in the existence of a perfect and immutable being. Neither did Descartes take issue with the notion of God as an efficient cause, a view that was subsequently adopted with considerable enthusiasm by Malebranche, who famously claimed that God was in fact the only genuine efficient cause. As for the role of scripture, while Descartes clearly did not derive his cosmogony from the book of Genesis, he seems on occasion to have accepted that the biblical narratives of creation could delimit what could be true in the sphere of physics.[35]

[30] Galileo, 'Letter to the Grand Duchess Christina'; Drake 1957, pp. 196f.

[31] *Ibid*., pp. 214f.

[32] *Novum Organum*, II, lii; Bacon 1859, IV, p. 247; Harrison 1998, pp. 211–249. The power over nature which man derives from philosophy, moreover, is to be governed by religion: 'Only let the human race recover that right over nature which belongs to it by divine bequest, and let power be given it; the exercise thereof will be governed by sound reason and true religion', *Novum Organum*, I, cxxix; Bacon 1859, IV, p. 115.

[33] *Novum Organum*, I, xciii; Bacon 1859, IV, p. 287. On Bacon's attempts to establish natural philosophy as an independent enterprise see Gaukroger 2001, pp. 91–95 and Gaukroger's chapter in this volume.

[34] See e.g., Augustine, *City of God*, VI. 5, VI. 8. In Aquinas, *physicam theologiam* (usually rendered 'natural theology') refers to the erroneous theology of the philosophers. 'Natural theology', 'mythical theology' (essentially euhemerism, the worship of dead heroes) and 'civil theology' (state-sponsored worship of images) were all forms of 'superstitious idolatry'; Aquinas, *Summa theologiae*, 2a2ae, 94, 1.

[35] Harrison 2000, esp. pp. 181f.

All of this is suggestive of the fact that various solutions were offered to the question of how theology was to relate to natural philosophy or 'physics'. While God undoubtedly had a place in early modern natural philosophy, the fact that no single role was uncontroversially allotted him suggests that natural philosophy is perhaps best understood not as a monolithic entity in which God has a central and specific place. It is also apparent that the framing of this discussion still bore the imprint of the Peripatetic understanding of how the discrete sciences are to be related to each other—hence the notions of subordination that determine the appropriate conditions under which distinct sciences might be 'mixed'. And, of course, Aristotle's four-fold division of causes remained at the forefront of these discussions. The virtue of the Cunningham thesis is that it encourages consideration of the ways in which the natural philosophy of the period is distinctive, but does not quite tell the whole story. Part of this untold story concerns the emergence of the category 'physico-theology'. In what follows I shall propose that the appearance of the terms 'physico-theological' and 'physico-theology' in the second half of the seventeenth century represent one attempt to stabilise the relationship between theology and natural philosophy by establishing a particular mode of explanation and a specific field of enquiry that represented, to its advocates at least, a legitimate admixture of two distinct enterprises. In this respect, the category 'physico-theology' is akin to 'physico-mathematics', in that both were attempts to define new hybrid disciplines that redefined the boundaries of the traditional Aristotelian sciences.[36] That this is the case is most evident in the writings of Robert Boyle.

2.BOYLE ON PHYSICO-THEOLOGICAL EXPLANATION

The earliest use in English of the term 'physico-theological' occurs in Walter Charleton's *The Darknes of Atheism Dispelled by the Light of Nature. A Physico-Theologicall Treatise* (1652).[37] But if the philosopher-physician Charleton coined the compound term, he took no credit for inventing a new disciplinary category in the pages of his book. The *Physico-Theologicall Treatise* was one of the first in the genre of English natural theology, and indeed, Charleton seems to use the adjective to describe natural theology as we would understand it—and not in the Baconian sense—his self-described task being 'the *Demonstration of the Existence of God*, by beams universally deradiated from that Catholick *Criterion*, the *Light of Nature*'.[38] The arguments of the book include logical and metaphysical cases for existence of God—that is, the 'ontological' and 'cosmological' arguments—as well as the

[36] Admittedly, there were different uses of 'physico-mathematics', and the term did not necessarily imply a single understanding of the relationship between physics and mathematics. Some who used the expression intended it to connote the subordination of one science to another. Descartes and Beeckman, however, seem to use to term to describe a mixed discipline with no connotations of the subordination. See Gaukroger and Schuster 2002, p. 536.

[37] The *Oxford English Dictionary* postpones the appearance of the term until Boyle's *Physico-Theological Considerations* in 1675.

[38] Charleton 1652, To the Reader. The prefix 'physico' for Charleton thus refers not to the discipline 'physics' but to nature (Gk. *φύσις*).

argument from design, which would later become known as the 'physico-theological' argument.

Robert Boyle subsequently used the expression in his *Physico-Theological Considerations about the Possibility of the Resurrection* (1675), and in the *Disquisition about the Final Causes of Natural Things* (1688). However, the general question of the relation between theology and natural philosophy was broached in *The Excellency of Theology, Compar'd with Natural Philosophy*, a work first published in 1674, but written in 1665.[39] The thesis of the book is clear enough from the title. For Boyle, the superiority of theology lay in 'the Excellence and Sublimity of the Object we are invited to contemplate'—the argument of Galileo—and in the unrivalled utility of divine knowledge.[40] More important for our present purpose, however, Boyle also considers some of the ways in which theology and natural philosophy might be combined to their mutual advantage. Thus, we learn in divinity many things relevant to natural philosophy—that the world had a beginning, the approximate age of the earth, that the earth will come to an end, and other 'discoveries' about angels, the universe, and our souls.[41] The first three chapters of Genesis alone, Boyle suggests, relate 'divers particulars, in reference to the Origine of things, which though not *unwarily* or *alone* to be urg'd in Physics, may yet afford very considerable *Hints* to an attentive and inquisitive Peruser'.[42] Conversely, Boyle also cherished the belief that there were many more mysteries of divinity to be disclosed to one possessed of 'a philosophical eye'. Philosophy, in other words, could help unlock hitherto unknown secrets of theology. A combination of both disciplines could provide the foundations of a new pansophia:

> The Gospel comprises indeed, and unfolds the whole Mystery of Man's Redemption, as far forth as 'tis necessary to be known for our Salvation: And the *Corpuscularian* or Mechanical Philosophy, strives to deduce all the *Phœnomena* of Nature from Adiaphorous Matter, and Local Motion. But neither the Fundamental Doctrine of Christianity, nor that of the Powers and Effects of Matter and Motion, seems to be more than an Epicycle (if I may so call it) of the Great and Universal System of God's Contrivances, and makes but a part of the more general Theory of things, knowable by the Light of Nature, improv'd by the Information of the Scriptures: So that both these Doctrines, though very general, in respect of the subordinate parts of Theology and Philosophy, seem to be but members of the Universal Hypothesis, whose Objects, I conceive, to be *the Nature, Counsels, and Works of God, as far as they are discoverable by us* (for I say not *to us*) *in this Life*.[43]

In a sense, the *Physico-Theological Considerations*, which appeared in the following year, represent Boyle's first essay in this ambitious task.

The title term 'physico-theological', is here used quite unreflectively, but seems to refer to an application of the methods of physics to a single theological doctrine. Thus Boyle was concerned to investigate possible natural mechanisms—in particular that of a 'plastick power'—that might account for the post-mortem reconstitution of

[39] I am grateful to Peter Anstey for pointing out the relevance of this work.

[40] Boyle 1674, p. 2. Boyle admits another argument, that theology is duty in a way that natural philosophy is not; see *ibid*., p. 66.

[41] *Ibid*., pp. 13–25.

[42] *Ibid*., p. 22.

[43] *Ibid*., pp. 51f. 'Adiaphorous' in this context means 'neutral or theologically indifferent'.

bodies. By the same token, he puzzlingly insists that resurrection 'shall be effected, not by or according to the ordinary course of Nature, but by his [God's] own Power'.[44] This would imply that resurrection was miraculous—that is, above or against the powers of nature—in which case deliberations at the level of natural philosophy would seem to be largely irrelevant. Elsewhere he was to state that, considered from the perspective of reason alone, 'the Resurrection of the Dead' seemed an 'Absolute Impossibility'. Thus he also placed the doctrine beyond the bounds of natural theology.[45] Boyle's apparent equivocation on this point is probably owing to a genuine uncertainty as to what kinds of events, if any, were in principle beyond the explanatory framework of natural philosophy. Boyle's approach implies that this is not something that can be known in advance. To put it another way, there can be no *a priori* division of subject matter between the natural philosopher and the theologian. Some events may successfully resist naturalistic explanation, and thus eventually be delivered over to the theologian. Equally, other events previously regarded as inherently miraculous might well succumb to naturalistic explanation, provided that one prosecutes the investigation with sufficient diligence. Any robust approach to explanation, on this analysis, must in principle allow for both physical and theological accounts, and thus the conscientious investigator must adopt a physico-theological frame of mind.

Boyle's ruminations on this topic were not unrelated to a controversy in the late seventeenth and early eighteenth centuries over the appropriateness of naturalistic accounts of biblical miracles and eschatological events—the creation of the world, the Deluge, the miracles of Moses, and the final destruction and restoration of the earth. The debate was sparked by the appearance in 1681 of Thomas Burnet's *Telluris Theoria Sacra*, a work that attempted to provide a naturalistic account of Noah's flood and of the final conflagration of the world in terms of Descartes' cosmogony. Burnet's work inspired a number of imitators, most notably William Whiston who, in his *New Theory of the Earth* (1696), substituted the more potent natural philosophy of Newton for that of Descartes. John Ray's *Three Physico-Theological Discourses* (1693) covered similar territory. Common to these works was the attempt to use the resources of natural philosophy to provide explanations for apparently miraculous events in biblical narratives and prophecies. At issue was whether such events lent themselves to explanation in terms of laws discovered in natural philosophy, or whether they were to be thought of as wholly miraculous, and hence beyond the bounds of natural philosophical speculation.[46] This was the issue that Boyle had broached with his essay on resurrection.[47]

These discussions are relevant for an understanding of the subject matter not only of natural philosophy, but of natural theology. The latter has typically been regarded as being concerned with theological doctrines that can be known through

[44] Boyle 1675, p. 3. Cf. '... the Christian doctrine doth not ascribe the *Resurrection* to *Nature*, or any created Agent, but to the peculiar and immediate operation of *God*.…'; *ibid*., p. 29; see Boyle 1674, pp. 23f.

[45] Royal Society Boyle Papers, vol. VII, fol. 23.

[46] For an outline of the controversy see Harrison 2000.

[47] Subsequent writers were also to attempt naturalistic explanations of resurrection; see, e.g., Bonnet 1769.

reason alone: God's existence, immortality of the soul, moral values, and so on. Generally, resurrection is not regarded as a topic of natural theology, neither are such doctrines as the Trinity and the Incarnation, for these are said to be known only through revelation typically in scripture, and cannot be ascertained through the exercise of reason alone.[48] Boyle's treatment of resurrection as amenable in certain respects to a physical treatment, however, suggests that it might well be dealt with within the scope of natural theology. Around the time of the publication of the *Physico-theological Considerations* some of the Cambridge Platonists were also suggesting that such doctrines as the Trinity could be known through reason. This was because versions of Trinitarian theology had supposedly been espoused by Platonic philosophers ignorant of the Christian revelation.[49]

One implication of the contentions of the Cambridge Platonists was that the traditional division of subject matter between natural and revealed theology was really a matter of historical contingency. The mark of whether a particular doctrine belonged to natural or revealed theology was whether it had been embraced by any culture beyond the pale of Christendom. Thus, neither the Greeks nor anyone else had subscribed to a doctrine of resurrection, and it was inferred on this basis that such notions could not be arrived at through the exercise of reason alone. However, with the early modern challenge to ancient systems of natural philosophy, it became possible to suggest that the Pagan philosophers' ignorance of, say, resurrection—traditionally ascribed to a lack of access to the revealed truths of scripture—might as easily be attributed to the deficiencies of their natural philosophy. This, in turn, meant that no subject matter could in principle be ruled outside the boundaries of natural philosophy. In short, the most robust methodological approach to phenomena allowed for philosophical explanation *and*, in the event of its failure, theological explanation. The kinds of subject matters that particularly lent themselves to such an approach included the beginning and end of the world, animal and human generation (that is, reproduction and embryology), along with death, immortality, and resurrection.[50] All of this meant that revealed doctrines could be considered as legitimate topics for a physico-theological treatment in a way that the traditional topics of natural theology could not. As late as 1749 the Comte de Buffon could still describe the cosmological and eschatological speculations of Burnet, Whiston, and others, as 'physical theology'.[51] For this period, then, physico-theology was not a sub-set of natural theology.

Boyle's more mature reflections on physico-theology came to fruition in his *Disquisition about the Final Causes of Natural Things* (1688). Here, for the first time, we find a formal account of what physico-theological explanation might entail. Boyle's point of departure was the issue that had occupied both Bacon and

[48] But cf. Sibiuda [i.e. Raymond Sebonde] 1966, who in his fifteenth-century work *Theologia naturalis seu liber creaturarum* [*Natural Theology, or the Book of the Creatures*], asserted that all of the central tenets of Christian doctrine were evident in the natural world, and could be known from a reading of the book of nature.

[49] See especially Cudworth 1845, II, pp. 312f.

[50] For examples of early modern treatments of some of these topics, see Harrison 2001, pp. 199–224.

[51] Georges Louis Leclerc, Comte de Buffon 1812, I, p. 131.

Descartes—that of the place of final causes in natural philosophy.[52] The crux of Boyle's case, which follows a number of helpful distinctions between different senses of the term 'final cause', is that 'arguments in Physicks should be grounded in solid reasons, but those reasons need not themselves be physical'. As an example Boyle cites the Cartesian principle that the quantity of motion in the universe remains constant. This axiom of physics, he points out, was grounded by Descartes in the immutability of God. Descartes thus admitted a metaphysical principle as a component of physical explanation.[53] Peripatetic strictures on the exportation of specific methods across disciplinary boundaries Boyle addresses in this fashion: 'And to me 'tis not very material, whether or no, in Physicks or any other Discipline, a thing be prov'd by the peculiar Principles of that Science or Discipline; provided it be firmly proved by the common grounds of Reason'.[54] Boyle thus suggests that physics (along with other disciplines) is distinguished by its subject matter, but not by specific methods. This bears a direct analogy to the Renaissance understanding of the division of labour within a 'middle science' (*scientia media*) such as mixed mathematics, which was understood as a subject in which the *res considerata* belongs to natural philosophy, but whose *modus considerandi* belongs to mathematics.[55]

Boyle subsequently introduced terminology that reflects this distinction. There are, he noted, two kinds of arguments from ends—'*Physical* Ones' and '*Physico-Theological* Ones'. Purely physical explanations from final ends refer to the means by which 'the End design'd by Nature may be best and most conveniently attain'd'. Physico-theological arguments, by way of contrast, 'relate to the Author of Nature, and the General Ends he is suppos'd to have intended in things Corporeal: As, when from the manifest usefulness of the Eyes, and all its parts, to the Function of Seeing, Men infer, that at the Beginning of Things the Eye was fram'd by a very Intelligent Being…'.[56] This, then, was not simply the familiar 'argument from design', but rather reflected Boyle's ambitious vision, originally articulated in *The Excellency of Theology*, for a study of 'the Great and Universal System of God's Contrivances' that would constitute a component of 'the more general Theory of things, knowable by the Light of Nature, improv'd by the Information of the Scriptures'.[57]

For all this, Boyle did not go on to propose a distinct discipline 'physico-theology'. As far as I know, he never used the noun. On the face of it, then, he seems to equivocate on the extent to which physico-theological arguments are allowable in

[52] Boyle refers to the issue as 'the grand Difficulty that has, ever since *Aristotles* time, and even before that, Perplex'd those that allow in Natural Philosophy, the Considerations of *Final Causes*'; Boyle 1688, p. 87.

[53] Boyle 1688, pp. 24f. Cf. Descartes, *Principles of Philosophy*; Descartes 1985, I, p. 240.

[54] Boyle 1688, pp. 23–24.

[55] Jardine 1991, p. 102. Thus physico-mathematics 'The Mixed [Mathematics] consist of physical subjects investigated and explained by mathematical reasoning'. *Oxford English Dictionary*, *sv* 'physico-mathematics'.

[56] Boyle 1688, pp. 104f. Boyle, following Bacon, also suggests that we can call such arguments 'metaphysical'. But unlike Bacon, he does not draw the implication that they should be excluded from physics.

[57] Boyle 1674, p. 51.

physics. He notes for example, that physico-theological arguments amount to what Bacon had called 'metaphysical arguments', but makes no reference to Bacon's objection to the deployment of such arguments in the sphere of natural philosophy.[58] Did he mean to imply here that physico-theological arguments, despite being essentially metaphysical, do in fact have a legitimate place in physics? And if so, why did he not directly address Bacon's concerns?

Two aspects of Boyle's approach clarify this position. First, he argued that previous abuses of teleological explanation do not provide sufficient grounds for their exclusion from natural philosophy. If the admission of final causes in philosophy had occasioned lazy thinking and absurdities in the past, the appropriate solution lay in the establishment of adequate safeguards against these abuses rather than in a wholesale abandonment of final causes as a mode of explanation. Boyle thus cautioned against allowing the quest for final causes to displace the more immediate task of the philosopher—the discovery of efficient causes.[59] By the same token, he provided clear illustrations of cases in which the quest for final causes has resulted in important advances in knowledge, as for example in Harvey's discovery of the circulation of the blood.[60] Equally importantly, however, Boyle's concern was not simply with the legitimacy of particular modes of explanation and their relative importance, but also with who it is that is providing the explanation. At issue was not only the identity of the discipline, but also the identity of the investigator.

3.PHYSICO-THEOLOGY AND THE CHRISTIAN NATURAL PHILOSOPHER

At least part of Boyle's concern in the *Disquisition* is with what he refers to as the duties and responsibilities of 'the *Christian* philosopher'. The work is explicitly addressed to 'Christian philosophers', and to benefits that relate 'as well to Philosophy as Piety'.[61] Boyle suggests that Christian philosophers, having access to revealed truths concerning God's ends, ought not to ignore this information. ''tis plain', he writes, 'that I suppose the Naturalist to discourse meerly upon Physical Grounds. But if the Revelations contain'd in the *Holy Scriptures*, be admitted, we may rationally believe More, and speak less Hæsitantly, of the Ends of God, than bare Philosophy will warrant us to do'. There is a clear admission, then, of what is permissible in 'bare philosophy', but Boyle suggests that Christian naturalists need not confine their conclusions to what is sanctioned by the methodological requirements of 'bare philosophy'. This amounts to an argument against the Cartesian position, or at least against those Cartesians who identify themselves as Christian. Boyle writes: 'those *Cartesians,* that being Divines, Admit the Authority of Holy Scripture; should not reject the Consideration of such Final

[58] *Ibid*., pp. 104f.
[59] *Ibid*., pp. 229–237.
[60] *Ibid*., p. 157.
[61] *Ibid.*, Preface, p. 29.

Causes, as *Revelation* discovers to us'.[62] He went on to express the hope that his arguments 'may justly serve to Recommend the Doctrine about Final Causes that we embrace, to Philosophers *that are truly pious*…'. These pious Christian philosophers are thus in a different position to 'the Ancient Aristotelians, who look'd upon the World as Eternal and Self-existent in a Condition like its present System; [and who] did not use to Thank *God* for the Benefits they receiv'd from things Corporeal'.[63] The absence of robust doctrines of creation and providence in the Aristotelian scheme accounted for both the absence of the theistic teleology and for the strict division of labour that kept natural philosophy and the sacred science distinct. On Boyle's analysis, the traditional division of labour, in which theistic explanations were banished from the study of nature, was an unwelcome vestige of Aristotle's ignorance of the true origin and destiny of the world.

Boyle thus held that the *Christian* philosopher has a 'duty' to progress beyond mere physics to the more sublime reaches of the physico-theological. To adopt any other procedure would be needlessly to mimic the approach of the ancients who, bereft of a Christian view of the world, were blind to the fact that the operations of nature were in fact the operations of the providential Deity. On this analysis, Cartesian philosophers were unconsciously re-enacting a groundless Peripatetic prejudice when they proposed to eschew explanations that invoked divine purposes. Theistic teleology was legitimate, Boyle argued, for anyone who acknowledged 'a most wise author of things'.[64] At any rate, for Boyle the status of physico-theological arguments was as much to do with the religious commitments of the natural philosopher as with the relevant disciplinary boundaries. In these religious commitments, moreover, lay one of the chief justifications for the pursuit of natural philosophy in the first place—namely, the extension of its utility beyond the sphere of mere material gain to the more exalted realm of spiritual benefits.[65]

Boyle's emphasis on the duties of the Christian natural philosopher relates to the larger issue of the vocation of the early modern naturalist. The lack of a specific profession 'scientist' during this period generated considerable difficulties for those who considered themselves called to the study of nature.[66] There were few socially-sanctioned roles for the profession of natural philosophy, and neither was it obvious that scientific proclivities could be comfortably incorporated into one of the three official professions of medicine, law, or theology.[67] In this context Boyle's argument amounts to an assertion that the study of nature, on account of its theological implications, was closest to the clerical vocation. There is, of course, something distinctively Protestant about Boyle's conception of the role of the Christian natural philosopher, for it is related to the Reformation principle of 'the priesthood of all

[62] *Ibid*., p. 80.
[63] *Ibid*., pp. 100f.
[64] *Ibid*., p. 16. The Cartesians, for their part, might reasonably argue that they differed from the Aristotelians in that they identified the efficient cause as God.
[65] This argument parallels to some degree Stephen Gaukroger's contentions about Bacon's concern with 'the office of the natural philosopher' as one whose knowledge contributes to the public good. See Gaukroger 2001, pp. 44–57.
[66] Ross 1962.
[67] Feingold 2002.

believers'. According to this doctrine, which replaced the medieval division of society into vertical 'estates', any individual, in principle, is capable of fulfilling the priestly role.[68]

It is in this context that we are to understand Boyle's identification of natural philosophers as 'priests of nature'—a designation that the Protestant astronomer Kepler had also adopted.[69] For figures such as Kepler and Boyle, the realm of theological speculation was one that was no longer restricted to the priestly classes. Their explorations into theological territory represent not only the breakdown of traditional disciplinary boundaries—as evidenced by the new category of physico-theological explanation—but also signal the disintegration of the traditional vocational demarcations of the middle ages, a process which, in respect of the ontological status of the clergy, took place far more quickly in Protestant than in Catholic countries. It is significant, then, that neither Galileo nor Descartes ventured much into what we might call physico-theological territory, subscribing to a strong view of the integrity of theology and of the unique status of clerical theologians. At the same time, they clearly did not wish to invite reciprocal incursions by theologians into the realm of natural philosophy, and this policy could thus serve to maintain the independence of philosophy. Taking a high view of the unique status of clergy was a means of demarcating theology and philosophy, and for keeping the respective roles of theologian and philosopher distinct.

If linking theology with the pursuit of natural philosophy served to elevate the status of the latter, equally importantly, it sanctioned the pursuit of natural philosophy for those committed to the clerical vocation. Boyle argued, against those who wished to restrict divines to the study of theology, that 'nothing hinders, but that a man who values and inquires into the Mysteries of Religion, may attain to an Eminent degree in the knowledge of those of Nature'.[70] Copernicus, he pointed out, was a 'Churchman', Gassendi a Doctor of Divinity, a number of Jesuits, 'have as prosperously addicted themselves to Mathematicks as Divinity'. Moreover, a number of English clergymen who were 'not onely solid Divines, but Excellent Preachers, have yet been so happily conversant with Nature'.[71] The resolution of these apparently conflicting vocational commitments was to be resolved through a realisation that the ends of natural philosophy served the more noble ends of theology. Thus:

> Those Religious Naturalists, who are invited to Attention and Industry, not onely by the pleasantness of the Knowledge it self, but by a higher and more ingaging Consideration; namely, that by the Discoveries they make in the Book of Nature, both themselves and others may be excited and qualifi'd the better to admire and praise the Authour, whose Goodness does so well match the Wisdom they celebrate.[72]

[68] For the reformers' rejection of hierarchical estates see Luther, *To the Christian Nobility of the German Nation* (1520); Luther 1970, p. 12; Calvin 1960, I, p. 502, II, p. 1473.

[69] Boyle 1688, p. 34; Kepler 1938–, VII, p. 25; Letter to Herwath von Hohenburg, 26 March 1598, *ibid*., XIII, p. 193; see also Fisch 1953.

[70] Boyle 1674, p. 217.

[71] *Ibid*., p. 217.

[72] *Ibid*., p. 220.

Considerations such as these were to inform the vocational choices of a number of prominent clergymen-naturalists. John Ray, for example, had lamented in 1658 that he 'must of necessity enter into orders or else live at great uncertainties'. He thus resolved 'to make it my business to execute the priest's office'. That office, as he then understood it, required the relinquishing of his natural philosophical pursuits: 'I shall bid farewell to my beloved pleasant studies and employments, and give myself up to the priesthood'.[73] As his publishing history testifies, however, Ray subsequently managed to reconcile his priestly calling with the pursuit of natural philosophy, producing in the last decades of the seventeenth century pioneering works of natural history and plant taxonomy. Significantly, though, his most celebrated work was the physico-theological classic, *The Wisdom of God Manifested in the Works of Creation* (1691). This was followed two years later by his *Three Physico-Theological Discourses* (1693). It was the new notion of a legitimate physico-theological approach that enabled Ray to combine his scientific interests with a priestly vocation in a way that those with a more traditional understanding of the relation of theology to natural philosophy would have found difficult.

Thus it was that the overlapping offices of 'the Christian natural philosopher' as epitomised by Boyle, and 'the clergyman-naturalist' as exemplified by Ray, produced the relevant enterprise, 'physico-theology'. The title of the mixed discipline first appears, appropriately enough, in the title of the Boyle Lectures given by the clergyman William Derham in 1711/12: *Physico-Theology: Or A Demonstration of the Being and Attributes of God from the Works of his Creation* (1713). This work assured a place for the term in the English lexicon, and paved the way for hybrid disciplines that represented the increasing specializations of natural philosophy—Derham's own *Astro-theology* (1715), Friedrich Lesser's *Insecto-Theologia* (1738), Peter Ahlwart's *Bronto-Theologie* (1745), and John Balfour's *Phyto-Theology* (1851).[74]

These physico-theological works should not be regarded simply as examples of 'natural theology' or as mere rehearsals of the 'argument from design'. From the outset, physico-theology was intended to represent a combination of natural philosophy and theology—a form of theologising, yes, but one that could only be conducted by those with expertise in natural philosophy and, increasingly, natural history. The familiar form that it took over the course of the eighteenth century consisted in endless rehearsals of instances of organic 'contrivances', listed seriatum, all of which were designed to lead to a final conclusion—the existence of a divine designer. These compilations aimed at providing a watertight cumulative argument and, crucially, one based on induction. Increasingly, then, physico-theology was represented by its exponents as an inductive science, indeed perhaps the one form of theological argument that could lay claim to be such a science. As one of its nineteenth-century exponents was later to express it, natural theology in this form was 'open to no objection', 'in strict conformity with the rules of the inductive philosophy', and 'consistently denied by those only who reject the "Principia" of Newton'. This writer went on to claim that:

[73] Ray 1928, p. 16; quoted in Feingold 2002, p. 95.
[74] Lesser 1738; Ahlwardt 1745; Balfour 1851.

> Our knowledge of the existence of God, as far as that knowledge is traceable by the light of nature, is acquired by an intellectual process strictly analogous, and exactly similar, to the intellectual process by which we acquire our knowledge of the laws of the physical world…. Newton discovered the true system of the heavens; and it is only by this reasoning that the theist can ascertain, from the light of Nature, the existence and attributes of Him who made the heavens. The proof of a divine intelligence ruling over the universe is as full and, as perfect as the proof that gravitation extends throughout the planetary system.

The great physico-theological works eighteenth and nineteenth century represented, for this author, nothing less than 'inductive philosophy … applied to theology'. [75]

In sum, physico-theology became a unique enterprise, bearing the dignity of its ultimate object God, and bolstered by the 'scientific' authority of induction. Thus understood, the discipline was true to Boyle's original conception of a theological enterprise that relied on the methods of natural philosophy.

4.CONCLUSION

The emergence of the mixed science 'physico-theology' is symptomatic of the disciplinary flux that was characteristic of the early modern period, and the existence of this term signals an attempt to arrive at a solution to the question of how the new forms of natural philosophy related to theology. If in the seventeenth-century term 'physico-theological' had referred largely to a mode of investigation, the eighteenth century was to deploy this method within a discrete discipline—physico-theology. More specifically, however, the existence of this new hybrid discipline suggests that for at least some early modern figures natural philosophy per se was not considered to be essentially theological in orientation (*pace* Cunningham), for if this were the case there would be no requirement for the introduction of a distinct kind of explanation that went beyond the methodological limits of 'bare philosophy', to use Boyle's expression.

The subsequent history of the term 'physico-theology' has conspired against a proper understanding of its historical significance. Since Kant, it has been customary to associate physico-theology with the argument from design, for in the *Critique of Pure Reason* (1781) Kant appropriated the term 'physicotheological' to label that specific proof for God's existence.[76] In modern analytical philosophy of religion, 'the physico-theological argument' is simply an inelegant synonym for 'the teleological argument' and is treated as one of the three classical arguments for God's existence. Typically, this argument is traced back to the ancient Greeks.[77] Clearly this standard usage overlooks the historical origins of the expression and masks its significance as a marker for an important phase in the evolving and overlapping boundaries of natural philosophy and theology.

[75] Anon. 1834, pp. 216, 217.

[76] *Critique of Pure Reason*, Transcendental Logic, Second Division: Transcendental Dialectic, II. iii. 6; Kant 1965, p. 518.

[77] Thus, e.g., 'Physicotheology is the aspect of natural theology that seeks to prove the existence and attributes of God from the evidence of purpose and design in the physical universe. The argument is very ancient…'; Carré 1967, p. 300.

REFERENCES

Ahlwardt, P. (1745) *Bronto-Theologie, oder vernünftige und theologische Betrachtungen über den Blitz und Donner*, Greifswalde and Leipzig.

Anon., (1834) 'Crombie's Natural Theology', *Quarterly Review*, 51, March and June, pp. 216–218.

Aristotle (1984) *The Complete Works of Aristotle: The Revised Oxford Translation*, ed. J. Barnes, 2 vols, Princeton: Princeton University Press.

Augustine (1844–1905) in *Patrologia Latina*, vols 32–47, ed. J.-P. Migne, Paris.

Bacon, F. (1859) *The Works of Francis Bacon*, 14 vols, eds J. Spedding, R. Ellis and D. Heath, London.

— (1974) *Of the Advancement of Learning and New Atlantis*, ed. A. Johnston, Oxford: Clarendon Press.

Balfour, J. (1851) *Phyto-Theology; or, Botanical Sketches intended to illustrate the works of God in the structure, functions, and general distribution of plants*, London and Edinburgh.

Bonnet, C. (1769) *Palingenesie philosophique*, Geneve.

Boyle, R. (1674) *The Excellency of Theology*, London.

— (1675) *Physico-Theological Considerations about the Possibility of the Resurrection*, London.

— (1688) *Disquisition about the Final Causes of Natural Things*, London.

Buffon, Comte de (1812) *Natural History, General and Particular*, trans. W. Smellie, 20 vols, London.

Burnet, T. (1681) *Telluris Theoria Sacra*, London.

Calvin, J. (1960) *Institutes of the Christian Religion*, 2 vols, ed. J. T. McNeill, trans. F. Battles, Philadelphia: Westminster Press.

Carré, M. (1967) 'Physicotheology' in *The Encyclopedia of Philosophy*, 8 vols, ed. P. Edwards, New York: Macmillan, 6, pp. 300–305.

Charleton, W. (1652) *The Darknes of Atheism Dispelled by the Light of Nature. A Physico-Theologicall Treatise*, London.

Cudworth, R. (1845) *The True Intellectual System of the Universe*, 3 vols, ed. J. Harrison, London: 1st edn 1678.

Cunningham, A. (1988) 'Getting the game right: some plain words on the identity and invention of science', *Studies in History and Philosophy of Science*, 19, pp. 365–389.

(1991) 'How the Principia got its name: or, taking natural philosophy seriously', *History of Science*, 28, pp. 377–392.

— (2001) 'A response to Peter Dear's "Religion, science, and philosophy"', *Studies in History and Philosophy of Science*, 32A pp. 387–391.

Dales, R. C. (1984) 'The origin of the doctrine of the double truth', *Viator*, 15, pp. 169–179.

Dear, P. (1995) *Discipline and Experience: The Mathematical Way in the Scientific Revolution*, Chicago: University of Chicago Press.

— (1998) 'The Mathematical Principles of Natural Philosophy: toward a heuristic narrative for the Scientific Revolution', *Configurations*, 6, pp. 173–193.

— (2001) 'Religion, science, and natural philosophy: thoughts on Cunningham's thesis', *Studies in History and Philosophy of Science*, 32, pp. 377–386.

Derham W. (1713) *Physico-Theology: Or A Demonstration of the Being and Attributes of God from the Works of his Creation*, London.

Descartes, R. (1985) *The Philosophical Writings of Descartes*, trans. J. Cottingham, R. Stoothoff, and D. Murdoch, 2 vols, Cambridge: Cambridge University Press.

Edwards, P. ed. (1967) *The Encyclopedia of Philosophy*, 8 vols, New York: Macmillan.

Feingold, M. (2002) 'Science as a calling: the early modern dilemma', *Science in Context*, 15, pp. 79–119.

Fisch, H. (1953) 'The scientist as priest: a note on Robert Boyle's natural theology', *Isis*, 44, pp. 252–265.

Funkenstein, A. (1986) *Theology and the Scientific Imagination*, Princeton: Princeton University Press.

Galileo, G. (1957) *Discoveries and Opinions of Galileo*, ed. and trans. S. Drake, New York: Doubleday.

Gaukroger, S. W. (2001) *Francis Bacon and the Transformation of Early-Modern Philosophy*, Cambridge: Cambridge University Press.

Gaukroger, S. W. and Schuster, J. A. (2002) 'The hydrostatic paradox and the origins of Cartesian dynamics', *Studies in History and Philosophy of Science*, 33, pp. 535–572.

Gaukroger, S. W., Schuster, J. A. and Sutton, J. eds (2000) *Descartes' Natural Philosophy*, London: Routledge.

Grant, E. (2000) 'God and natural philosophy: the late Middle Ages and Sir Isaac Newton', *Early Science and Medicine*, 6, pp. 279–298.
Harrison, P. (1988) *The Bible, Protestantism and the Rise of Natural Science*, Cambridge: Cambridge University Press.
— (2000) 'The influence of Cartesian cosmology in England', in *Descartes' Natural Philosophy*, eds S. W. Gaukroger, J. A. Schuster and J. Sutton, London: Routledge, pp. 168–92.
— (2001) 'Scaling the ladder of being: theology and early theories of evolution' in *Religion, Reason, and Nature in Early Modern Europe*, ed. R. Crocker, Dordrecht: Kluwer, pp. 199–224.
Jardine, N. (1991) 'Demonstration, dialectic, and rhetoric in Galileo's Dialogue' in *The Shapes of Knowledge from the Renaissance to the Enlightenment*, eds D. R. Kelley and R. H. Popkin, Dordrecht: Kluwer, pp. 101–122.
Kant, I. (1965) *Critique of Pure Reason*, trans. N. Kemp Smith, London: Macmillan: 1st edn 1781.
Kelley, D. R. and Popkin, R. H. eds (1991) *The Shapes of Knowledge from the Renaissance to the Enlightenment*, Dordrecht: Kluwer.
Kepler, J. (1938–) *Johannes Kepler Gesammelte Werke*, 20 vols, eds W. von Dyck and M. Caspar, Munich: C. H. Beck.
Kretzmann, N. and Stump, E. eds (1993) *The Cambridge Companion to Aquinas*, Cambridge: Cambridge University Press.
Lesser, F. C. (1738) *Insecto-Theologia*, Franckfurt and Leipzig.
Lohr, C. (1988) 'Metaphysics' in *The Cambridge History of Renaissance Philosophy*, eds C. Schmitt, Q. Skinner, E. Kessler, and J. Kraye, Cambridge: Cambridge University Press, pp. 537–638.
Luther, M. (1970) *Three Treatises*, Philadelphia: Fortress Press.
MacClintock, S. (1972) 'Averroës' and 'Averroism' in *The Encyclopedia of Philosophy*, 8 vols, ed. P. Edwards, New York: Macmillan, 1, pp. 220–226.
MacDonald, S. (1993) 'Theory of knowledge', in *The Cambridge Companion to Aquinas*, eds N. Kretzmann and E. Stump, Cambridge: Cambridge University Press, pp. 160–195.
Osler, M. J. (1997) 'Mixing metaphors: science and religion or natural philosophy and theology in early modern Europe', *History of Science*, 35, pp. 91–113.
Ray, J. (1693) *Three Physico-Theological Discourses*, London.
— (1928) *Further Correspondence of John Ray*, ed. R. Gunther, London.
Rheticus, G. J. (1984) *G. J. Rheticus' Treatise on the Holy Scripture and the Motion of the Earth*, ed. and trans. R. Hooykaas, Amsterdam: North-Holland Publishing.
Ross, S. (1962) '"Scientist": the story of a word', *Annals of Science*, 18, pp. 65–86.
Sibiuda, R. [Raymond Sebonde] (1966) *Theologia naturalis seu liber creaturarum [Natural Theology or, the Book of the Creatures]*, ed. F. Stegmüller, Stuttgart-Bad Canstatt.
Thomas Aquinas, St. (1924) *Summa contra gentiles*, trans. The English Dominican Fathers, New York: Benziger Brothers.
— (1964–1976) *Summa theologiae*, 60 vols, ed. Thomas Gilby, trans. by Fathers of the English Dominican Province, London: Eyre & Spottiswood.
Whiston, W. (1696) *New Theory of the Earth*, London.