religions

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Robert Boyle, the Bible, and Natural Philosophy

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Abstract: The great chemist Robert Boyle was also a serious student of the Bible and Christian theology, both of which profoundly influenced his natural philosophy. Christian beliefs and moral attitudes motivated him to extend human dominion over the creation by advancing scientific knowledge and giving medicines from his laboratory to the poor. His outspoken advocacy of empiricism, over and against those who believed that unaided reason was sufficient to probe the depths of nature, was rooted in the conviction that the free, wise, and powerful Creator knows the creation far better than we creatures ever will. He vigorously promoted what he called "the mechanical philosophy", partly because he found it far more theologically attractive than the pagan Greek conception taught in the universities, which conceived of "Nature" as a semi-divine being with a mind and powers of its own. It also underscored the great complexity of the world machine, requiring an intelligent Creator to have assembled it—thereby (he hoped) moving people not only to acknowledge God but to live piously and humbly.

Keywords: Robert Boyle; voluntarism; mechanical philosophy; intelligent design; piety; philosophy of science; accommodation

Citation: Davis, Edward B.. 2023. Robert Boyle, the Bible, and Natural Philosophy. *Religions* 14: 795. https://doi.org/10.3390/rel14060795

Academic Editor: John A. Bloom

Received: 12 May 2023
Revised: 12 June 2023
Accepted: 13 June 2023
Published: 15 June 2023

1. Introduction

Few natural philosophers influenced the rise of modern science more than Robert Boyle. Usually associated today with a universal law about gases bearing his name, he neither discovered it nor claimed ownership, and he did not express it algebraically or even view it as valid under all conditions. Rather, he published in tabular form his carefully obtained data showing that pressure and volume of atmospheric air (not some theoretical ideal gas) are inversely related within the limits of his ability to test it, confirming (and crediting) Richard Townley's unpublished conjecture (*Works*, 3: 57–65; cf. MacIntosh 2020, pp. 99, 122–24). That major experiment earned Boyle more than a footnote in the history of science, but his most important contributions lay elsewhere. A superb experimentalist and diligent collector of information about many aspects of nature, Boyle did as much as anyone else to create the modern laboratory, the methods it employs, and the scientific papers it produces. His publications were read throughout Europe and in parts of North America because the subtlety and precision of his work were matched only by the range of his knowledge and the honesty and clarity of his reports. In short, Boyle showed the world how science ought to be done: we might even say that his most important discovery was the activity of science itself.

At the same time, Boyle also wrote extensively and thoughtfully about philosophy of science, piety, morality, theology, the Bible, and the relationship between science and religion. Attitudes and ideas inspired by Scripture and Christian beliefs shaped his understanding of how scientific knowledge should be obtained, the limits of that knowledge, and how it ought to be used. Claims about Christian beliefs playing a constructive role in the history of science were viewed with much suspicion more than forty years ago when my doctoral work began. The situation was not without irony. My advisor's first book was called *Science and Religion in Seventeenth-Century England*, another member of my doctoral committee later wrote a book arguing that medieval theologians nourished natural philosophy in the universities, and a third member was a leading authority on the

Reformation (Westfall 1958; Grant 2004; Strauss 1978). Nevertheless, when I proposed a dissertation about the influence of theological beliefs on conceptions of scientific knowledge in the Scientific Revolution, I was told it might make a good thesis in religion, but not in the history of science. After I cited similar ideas from Alexandre Koyré, Edwin Arthur Burtt, and other canonical authors in the discipline, they reconsidered.

What made that conversation necessary? The History of Science Society and its two journals, *Isis* and *Osiris*, had been started before the Great War by Harvard scholar George Sarton, who regarded the positivistic philosopher August Comte as the real founder of his new academic discipline. In the inaugural issue of *Isis*, Sarton named Andrew Dickson White—the most influential proponent of the "Conflict" view of the history of Christianity and science, though he had many predecessors in Europe and America—as the source of a central idea in Sarton's vision for the history of science. "The interactions between science and religion have often had an aggressive character", Sarton wrote. "There has been most of the time a real warfare. But as a matter of fact it is not a warfare between science and religion—there can be no warfare between them—but between science and theology" (Sarton 1913, pp. 330, 339; see Ungureanu 2019, pp. 250–54). Sarton's attitude, inspired by Comte and White, ruled the history of science largely unchallenged for much of the last century.

Although there had been dissenting voices all along, systematic deconstruction of White's false narrative of inevitable conflict between Christian theology and science did not really get underway until the 1970s and did not gather much steam until the 1980s. More recently, a parallel phenomenon to reverse a similar unhistorical secularization of the past has emerged in religious history and the history of ideas more generally (Coffey and Chapman 2009; Gregory 2009; Muller 2009; Firestone and Jacobs 2012). Today almost all historians of science reject the "Conflict" thesis as woefully unreliable, ideologically motivated garbage that tells us far more about White and Sarton as historical actors themselves than about the history they purported to relate. David C. Lindberg and Ronald L. Numbers, early advocates of the need to jettison the "Conflict" thesis, put it no less bluntly. "For more than a century historians of Christianity and science like White have wasted their time and dissipated their energies attempting to identify villains and victims, often with polemical or apologetic intent and always within a framework heavily laden with values" (Lindberg and Numbers 1987, p. 148). So far, no single, simple alternative has yet emerged to replace the conflict thesis. What Numbers and many others are now calling the "complexity thesis" is probably the best candidate. According to John Hedley Brooke, "Serious scholarship in the history of science has revealed so extraordinarily rich and complex a relationship between science and religion in the past that general theses are difficult to sustain. The real lesson turns out to be the complexity" (Brooke 1991, p. 5).

Showing much historical insight, Brooke identified a few "levels on which statements about nature and statements about God have coexisted". Religious beliefs have presupposed the uniformity and intelligibility of nature, sanctioned or justified scientific activity, motivated individual scientists, and influenced theory selection and views of scientific methodology—and sometimes offered theological explanations for otherwise inexplicable events that proved superfluous when science advanced (Brooke 1991, pp. 18–33, quoting 18–19). Table 1 summarizes most of these relations.

Table 1. How Religious Beliefs Can Influence Science (adapted from Davis 1999).

Why can science be done? (Why is a science of nature possible?)	The possibility question
Why should science be done?	The morality/motivation/justification question
How should science be done?	The methodology/epistemology question
What **sorts** of theories are acceptable?	The regulative question

Although these are not necessarily religious questions, scientists' answers often reflect religious or metaphysical beliefs, as well as philosophical beliefs about the nature of scientific knowledge. For example, Michael Faraday's Christian faith drove his search for the unity of forces in the universe, answering both the motivation and regulative questions. According to biographer L. Pearce Williams, his faith "gave him both a sense of the necessary unity of the universe derived from the unity and benevolence of its Creator and a profound sense of the fallibility of man". Furthermore, "the speculations and imaginings which led him to the experiments and the courage which permitted him to publish physical heresies owe something to his unquestioning belief in the unity and interconnections of all phenomena. This belief, in turn, derived from his faith in God as both creator and sustainer of the universe" (Williams 1970, p. 527). Robert Merton's famous thesis about the formative influence of the "Puritan ethos" on science in early modern England—ironically written and published under Sarton's sceptical supervision—answers the justification question: why was science worth doing? (Merton 1938). Interactions such as these are hardly surprising, especially during the Scientific Revolution. At that time, as Margaret Osler said, "the roots of European intellectual life grew from the seeds planted by both the biblical religions and the ancient Greeks". The former "emphasized the unrestrained will of an all-powerful God, while the Greek approach emphasized a world ruled by impersonal principles of unity and harmony" (Osler 2010, p. 1; cf. Hooykaas 1972; Davis 1984). In such a milieu, it seems almost inevitable that religious beliefs would shape science in important ways. For Boyle, as we shall see, biblically grounded attitudes and beliefs interacted with his scientific work mainly on the lower three levels in the diagram.

2. Boyle and the Bible

Following an intense encounter with God as an adolescent, Boyle vowed to live piously. According to some of his closest friends, he took that vow very seriously. His bearing, actions, and speech reflected a deep sense of God's immediate presence. He revered the Bible, which he studied not only alone but also sometimes in the company of his sisters, Katherine Jones and Mary Rich, both of whom were stuck in bad marriages (Davis 2007). From his own experience, he commended "daily and orderly" reading of "some set Portion or Chapters of the Bible", even passages that at first "we Understand not", committing them to memory "till our Understandings be grown up" (*Works*, 2: 442). Apart from his intense spiritual interest, he sought deep academic knowledge of the texts, perhaps ultimately owing to conversations with Jewish rabbis and scholars on the continent and in England, including the great Amsterdam rabbi Menasseh ben Israel who worked for the readmission of Jews to England; their interpretations of certain verses he found troublingly difficult to refute. Challenged by his father's close friend James Ussher to learn the biblical languages, he did, partly by studying with a rabbi, to such an extent that he could quote the Greek from memory and wrote his own Hebrew grammar (Hunter 2009, pp. 80–85). Out of a desire to evangelize the world, he underwrote or otherwise aided the preparation or publication of translations of the gospels, the New Testament, or the whole Bible into Gaelic, Irish, Lithuanian, Malay, Turkish, and Algonquian—this last project the famous work of John Eliot.

Theology was another keen interest. He spent his early teenage years with his older brother Francis in Geneva, under the tutelage of Isaac Marcombes, a Huguenot refugee related by marriage to the eloquent preacher and Bible translator Jean Diodati, a Calvinist theologian who helped write the Canons of Dordt, whom Boyle met. Marcombes guided the boys through both biblical testaments and Calvin's catechism, while saying prayers twice a day and attending church twice a week (Hunter 2009, pp. 44–47). As an adult, Boyle was very well-read in theology, especially Socinianism (which he opposed) and controversies over free will and predestination where he was ultimately content to leave the matter unresolved with an eye on God's sovereignty and superior knowledge. Indeed, he often functioned as a lay theologian, writing roughly one million words on biblical and theological topics, including natural theology, large parts of which were published in his

lifetime and much of the rest subsequently. However, he was typically careful to avoid committing himself to specific theological views that were contested among Christians. Contrary to what is sometimes said, there is no clear evidence that Boyle saw himself as a Calvinist, or even that Reformed theology *per se* influenced his natural philosophy (Anstey 2000).

A sophisticated reader of Scripture, Boyle did not regard the Bible as a scientific text and never used it that way. For example, his two large books containing experiments on light, colours, and cold—around a quarter million words altogether—include a grand total of just two biblical references. One mentions God's curse on Ham in Genesis 9: 25, a passage pertinent to his discussion of the dark complexion of sub-Saharan Africans. There Boyle rejected the traditional interpretation, "that the Curse meant by *Noah* to *Cham*, was the Blackness of his Posterity" (*Works*, 4: 89; in all quotations the original spelling, punctuation, and italics are retained). The word "God" appears just eight times in those two books, only once (in the place just mentioned) in a scientific context. This was business as usual in natural philosophy. For example, the first edition of Newton's *Philosophiae Naturalis Principia Mathematica* (1687) has just two references to "God", one of which disappeared in the second edition (1713) when the passage was reworded. Only in the "General Scholium" added to the second edition, an explicitly theological essay containing no mathematics, did Newton frequently mention God and cite Scripture (Snobelen 2017). The implication that Boyle placed his scientific work in a different conceptual category from his biblical and theological work is borne out by several catalogues of his writings prepared for his own use either by his servants, or Henry Oldenburg, "as were mentioned to me by the Honourable Robert Boyle" (BP 36, fols. 88–89; *Works*, 14: 337–39). Titles are listed under different headings, "papers of Divinity", "theological", or "philosophical [scientific]" (MS 185, fols. 1v and 3; *Works*, 14: 345–46; BP 36, fol. 72; *Works*, 14: 351–52), or else assigned by category to different storage boxes without headings (BP 36, fols. 59–60, *Works*, 14: 341–42; BP 36, fols. 119–20, *Works*, 14: 343–44; BP 36, fol. 121; *Works*, 14: 349–50; and BP 36, fols. 122–23; *Works*, 14: 353–55).

Overall, Boyle endorsed the classic notion, at least as old as Basil and Augustine, that nature and Scripture are both harmonious divine revelations. According to a manuscript snippet, "Right Reason and Divine Revelation being both of them Emanations from the Father of Lights: there is no likelihood that they should contradict one another" (BP 1, fol. 86, transcribed long after Boyle's death by Henry Miles on BP 7, fol. 252). He also believed that biblical language was accommodated to popular speech and human ignorance, so it should not be placed in opposition to scientific facts (Clericuzio 2008). Although he did not identify specific sources for these ideas, he was well acquainted with Augustine and Calvin. The latter especially had used accommodation frequently, especially in his biblical commentaries, where he was quick to seek an alternate interpretation if the literal sense of a text conflicted with the science of his day. For example, Calvin thought it was "opposed to common sense, and quite incredible, that there should be waters above the heaven" on the second day of creation (Gen. 1: 6–7), as Basil, Luther, and many others had thought. In his view, those waters must be "such as the rude and unlearned" perceived; he thought they were clouds. "He who would learn astronomy, and other recondite arts, let him go elsewhere", for "the history of the creation . . . is the book of the unlearned". On the fourth day of creation, when God made "the greater light, to rule the day, and the lesser light to rule the night" (Gen. 1: 16), we must keep in mind "that Moses does not speak with philosophical acuteness on occult mysteries, but relates those things which are everywhere observed, even by the uncultivated, and which are in common use". The text is not about "how great the sun is in the heaven, and how great, or how little, is the moon; but how much light comes to us from them". Calvin knew that "astronomers prove, by conclusive reasons that the star of Saturn, which on account of its great distance, appears the least of all, is greater than the moon", but "Moses wrote in a popular style things which without instruction, all ordinary persons, endued with common sense, are able to understand". Perhaps the most interesting comments accompany David's reference to

"the deaf adder that stoppeth her ear; Which will not hearken to the voice of charmers" (Psalm 58: 4–5). Since Calvin did not accept the validity of snake charming, he concluded that "David here borrows his comparison from a popular and prevailing error" (Calvin 1578 at verses cited; cf. Hooykaas 1972, pp. 117–19). Since Calvin (and virtually all of his contemporaries) accepted the Ptolemaic astronomy taught in all the universities, he never applied accommodation to the biblical texts about the Sun, Earth and Moon that were later scrutinized in the introduction to Kepler's *Astronomia nova* (1609) or Galileo's *Letter to Christina* (circulated in 1615, but not published until 1636). Modern commentators typically point out that the language in those texts is no more unscientific than references today to the rising or setting sun, and that verses in poetic books should not be read literally anyway. At that time, however, the earth's motion lacked proof, while solid scientific arguments contradicted it (Graney 2015). Consequently, as Cardinal Roberto Bellarmino told the priest Paolo Foscarini, all ancient and modern commentators "agree in expounding literally that the sun is in the heavens and travels swiftly around the earth, while the earth is far from the heavens and remains motionless in the center of the world" (Drake 1957, p. 163). It took the acceptance of Copernican astronomy to alter the situation.

Since Boyle was a Copernican, he would surely have agreed with the need for figurative interpretations, whether or not he read those two particular works by Kepler and Galileo (which he did not cite). He was in Florence when Galileo died and already realized the importance of his encounter with Rome (Hunter 1994, pp. 19–20). Although he did not apply accommodation to Joshua's prayer for the sun to stand still (the most famous text related to Copernican theory) in the two brief references to that passage in his published works, elsewhere he explicitly endorsed crucial components of the principle (*Works*, 5: 109–10 and 10: 529). In an early, unpublished "Essay of the Holy Scriptures", he said, "that God so condiscends to our inevitable Ignorance" (BP 7, fol. 9; *Works*, 13: 179). Therefore, as he stated in *The Excellency of Theology* (1674), we should not "deduce particular Theorems of Natural Philosophy from this or that Expression of a Book, that seems rather design'd to instruct us about Spiritual than Corporeal things", indeed "nobler and better Truths, than those of [natural] Philosophy". However, in the same passage, he rejected the "Opinion, that would so turn the first Chapters of *Genesis* into an Allegory, as to overthrow the Literal and Historical sense" (*Works*, 8: 21). In typical fashion, Boyle did not identify a specific target for this objection. Perhaps he was thinking of Calvin's rejection of Augustine's view that creation was instantaneous, and the creation "days" were literary devices, not ordinary days, an accommodation to our ignorance of the deeply mysterious creation process (Augustine 1982). Calvin "manifestly refuted" those "who maintain that the world was made in a moment. For it is too violent a cavil to contend that Moses distributes the work which God perfected at once into six days, for the mere purpose of conveying instruction. Let us rather conclude that God himself took the space of six days, for the purpose of accommodating his works to the capacity of men" (Calvin 1578). Regardless, Boyle believed we could learn the time, order, and "divers other Circumstances of the Manner, wherein the Fabrick of the World was compleated", only from revelation, "bare Reason being evidently unable to inform us of *Particulars* that preceded the Origine of the first Man". Where "those fabulous *Chaldeans* gave the age of the world as "up to 40,000 or 50,000 years", Boyle thought "the World is very far from being so old by 30 or 40 thousand years as they", no more than about 10,000 years old (*Works*, 8: 21). If he was thinking specifically of Ussher's number (4004 BC), he did not say. Apart from the account of creation, however, "in most other places of the Scripture, where the Works of Nature are mentioned but incidently, or in order to other purposes, they are spoken of rather in a Popular then Accurate manner", so the Bible should not be invoked "in the doubtful contentions of Naturalists, about such matters as may (though the History of the Creation cannot) be known by the meer Light of Natural Reason" (*Works*, 3: 219).

Of course, Boyle had no reason to doubt "the Literal and Historical sense" of the Genesis creation story, and no reason to think that very much could be known about the origin of the world and living things "by the meer Light of Natural Reason". Natural

history was not very advanced, knowledge of the ancient Near East and its literature was quite limited, and the Big Bang theory was still three hundred years down the road. There were no persuasive theories of biological, geological, or cosmological development, no one could read Egyptian hieroglyphics, and the Enûma Eliš and the Atrahasis Epic had not yet been discovered. For Boyle and most other early modern Christians, the world could not have been created in any other way than by the miraculous acts plainly narrated in Genesis. He also believed in miracles after the creation week, and that God still works miraculously all the time. In a manuscript from the 1680s not published until the twenty-first century, he wrote, "I do not deny but that there have been *Divine* Miracles properly so call'd. For I take the *Creation* of the *Rational Souls* that are daily United to Humane Embryo's to be a Work of an Almighty Power. And I take ‹also› the *Raising* of ‹*Jesus Christ* our *Saviour* & of› *Lazarus* from the *Dead*, to be Miracles of the same sort" (MS 198, fol. 22; MacIntosh 2005, p. 271; in quotations from manuscripts ‹angle brackets› surround words added above the line during revision). Not all miracles were of this type, however: his understanding of miracle texts was no less sophisticated than his handling of other biblical stories. In another manuscript from the same period, he confessed, "I am not ignorant that most men are wont to think, that *Miracles & Things contrary to the Laws of Nature* are of the same extent, & therefore they scruple not to employ those Terms promiscuously, as equivalent". Boyle thought that "they hereby confound Things that on divers occasions ought to be distinguish'd", since "there are divers Miraculous Operations recorded in the holy scripture, that are rather *Preternatural* or *Supernatural*, than (if I may so speak) *Contra-natural*". In his view, some miracles "were perform'd by the ‹direct or› immediate action of immaterial Spirits upon the Minds of Men", or by God himself, in ways that did not involve violations of natural law (MS 199, fol. 126v; MacIntosh 2005, p. 268). Although he did not believe that miracles proved God's existence, they had a crucial role in Boyle's apologetics—their sheer abundance in the New Testament, he believed, showed that Christianity was more likely to be true than Judaism, which had fewer miracles (*Works* 14: 253–54; MacIntosh 1994; MacIntosh 2005, pp. 200–15, 261–77, 301–15, and elsewhere; Davis 2020).

Nevertheless, Boyle rejected miracles in natural philosophy: there he accepted methodological naturalism. For example, the English Jesuit philosopher Francis Line sought to explain how a given quantity of air can expand without creating empty spaces between atoms, an idea that Line opposed. To preserve the Aristotelian principle that "nature abhors a vacuum", he proposed that God could give atoms a "virtual extension" by his absolute power, thereby filling thousands of times more space simply by increasing in size. Boyle replied,

> our Controversie is not what *God can do*, but about what can be done by *Natural Agents*, not elevated above the sphere of Nature. For though *God* can both create and annihilate, yet *Nature* can do neither: and in the judgment of true Philosophers I suppose our *Hypothesis* would need no other advantage to make it be preferred before our Adversaries, then that in ours things are explicated by the ordinary course of Nature, whereas in the other recourse must be had to miracles. (*Works* 3: 48)

Those "Schoolmen and Philosophers [who] have deriv'd [substantial] Forms immediately from God", Boyle protested in *The Origin of Forms and Qualities* (1666), have "put Omnipotence upon working I know not how many thousand Miracles every hour, to performe that (I mean the Generation of Bodies of new Denominations) in a supernatural way, which seems the most familiar effect of Nature in her ordinary course" (*Works* 5: 342). He responded similarly when Thomas Hobbes invoked God's absolute power in a discussion of the infinite divisibility of matter. "When Mr. *Hobbs* has recourse to what God *can* do, (whose Omnipotence we have both great reason to acknowledge) it imports not to the Controversie about Fluidity to determine what the Almighty Creator *can* do, but what he actually *has* done" (*Works* 3: 168).

Given that Boyle kept miracles out of his laboratory and maintained the age-old distinction between two divine revelations (nature and Scripture), where and how did science

meet biblical ideas? Mostly in his theological works, which did not report experimental results but often explored meta-level questions in natural philosophy. Many early modern natural philosophers engaged in serious theological speculation inspired by questions arising in natural philosophy, an activity that Amos Funkenstein called "secular theology" (Funkenstein 1986; cf. Davis 1984, 1999). They were doing what only professional theologians had been permitted to do in medieval universities. The arts masters who taught natural philosophy to undergraduates were forbidden from discussing theology (in most situations), but the theologians were free to discuss natural philosophy—as they often did (Grant 1996, pp. 174–76; Grant 2001, pp. 185–86). Galileo had this in mind, when in 1615 he told Monsignor Piero Dini, "Yet for all of me any discussion of the sacred Scripture might have lain dormant forever; no astronomer or scientist who remained within proper bounds has ever got into such things" (Drake 1957, p. 165). No other major early modern natural philosopher did secular theology more than Boyle, though Funkenstein mentions him only briefly, mostly in connection with his views on the plurality of worlds (Funkenstein 1986, pp. 192–94). In a full-length study of that topic, Steven J. Dick stated flatly that Boyle "did not specifically address himself to the question of other worlds", which indicates only that Dick did not realize how much attention Boyle gave to natural philosophical questions in his many theological works (Dick 1982, pp. 199–200, n18).

In fact, Boyle discussed multiple worlds—an early version of multiverse theory that he found plausible and attractive—in multiple places. He thought God might by his absolute power have made other worlds displaying his wisdom, circling other stars, that are very different from our world, having different arrangements of matter and laws of motion and therefore inhabited by creatures unlike the ones we know, with whom God might have different relations, perhaps even displaying divine attributes and excellencies unknown to us. We cannot deny that God could do such things (*Works*, 10: 162, 172–75, and 185–86; *Works*, 11: 122–23; *Works*, 12: 485 and 498). The bulk of that material is found in a treatise whose title indicates the theological context within which Boyle placed those ideas: *Of the High Veneration Man's Intellect owes to God; Peculiarly for His Wisedom and Power* (1685). The six paragraphs outlining his views on multiple worlds constitute two separate passages, each surrounded by square brackets. An advertisement at the front of the book advises readers that they "may with the Author's consent (or rather by his desire) be skip'd over; being but *Conjectural thoughts*, written and inserted for the sake of a *Virtuoso*, that is a great Friend to such kind of adventurous speculations" (*Works*, 10: 159). This almost certainly refers to his protégé David Abercromby, the Scottish physician and former Jesuit who in the 1680s translated *High Veneration* and four more books by Boyle into Latin (on Abercromby, see Davis 1994). The preface to the Latin edition, which bears the date 1684 and might therefore precede the English version, mentions "ideas scattered throughout with which the mind will not only be refreshed, but will also be rapt in wonder". Overriding Boyle's cautious attitude, Abercromby announced that Boyle "completely embraces certain subjects—the multiplicity of worlds, the creation of new creatures very different to those that now exist—which could fully satisfy even the most curious", admitting that he had "dared in this translation to act in one respect contrary to the author's opinion", by persuading Boyle not to omit those passages (*Works*, 10: 201–2). Nevertheless, the sheer joy and wonder Boyle displayed in contemplating the extent of God's creative power, even perhaps in worlds different from ours, was surely a powerful motive to study natural philosophy and to extend its explanatory scope to unknown realms.

Christian faith also provided other motives for doing natural philosophy. More than almost anything else, Boyle wanted people to serve others instead of their own pride and lusts. A lifelong desire to improve medicine and to make pharmaceuticals more widely available to the poor set the example. His very first publication, one of nine essays without the authors' names written for Samuel Hartlib, a disciple of the Czech educational reformer John Amos Comenius, was called "An Invitation to a free and generous Communication of Secrets and Receipts in Physick [medicine]". The opening paragraph did not pull theological punches. "Our Saviour assureth us, that it is more blessed to give than to

receive", so "the less selfish and mercenary our good actions are, the more we elevate our selves above our own, and the neerer we make our approximations to the perfections of the Divine nature". We all know "the strong obligation, that not charity onely, bare humanity layeth upon us to relieve the distresses of those, that derive their pedigree from the same father we are descended from, and are equal partakers with us, of the Image of that God, whose stamp we glory in" (*Works* 1: 3).

Boyle did what he could to follow through. According to the eyewitness testimony of the Florentine natural philosopher Lorenzo Magalotti, Boyle dispatched servants throughout London, bringing medicines from his laboratory, "helping poor epileptics with the comfort of very powerful remedies which they were accustomed continually to take with them for this very purpose alone" (*Correspondence*, 4: 266). We find extensive discussions of various treatments, including instructions for making and using medicinal substances, in both tomes of *Some Considerations touching the Usefulnesse of Experimental Naturall Philosophy* (1663–1664 and 1671). In the last decade of his life, Boyle expanded his reach to households throughout the English realm, especially settlers in New England, by publishing (at first for a limited private audience, but soon for wider circulation) recipes for fifty pharmaceuticals he believed to be efficacious. The original version was given for free "not only to physitians, & surgeons, but chiefly to divines & Ladyes, & other persons residing in the countrey that were wont out of charity to give medicins to the poor" (MS 186, fols. 119v-20; *Works*, 11: xxviii). Boyle's executor John Locke, who had studied and taught medicine at Oxford while Boyle was in residence there, was involved with publishing supplemental volumes after Boyle's death. Although there is no evidence of a direct influence, John Wesley's famous *Primitive Physick* (1747) is essentially the same thing, for the same charitable purpose.

According to Boyle's confessor Gilbert Burnet, who had substantial knowledge of his largesse, his donations sometimes exceeded GBP 1000 per year, at least one-third of his income, probably equivalent to several million dollars today. Burnet told the large crowd at Boyle's funeral that, "His Charity to those that were in Want" was "so very extraordinary", because "he considered himself as part of the Humane Nature, and as a Debtor to the whole Race of Men" (Hunter 1994, p. 20). This attitude arose from Boyle's Christian morality and strong sense of vocation, which were only enhanced by watching some of his older brothers violate their marriage vows and behave like wastrels. "A Convenient civil Calling" benefitting others, Boyle wrote before turning twenty-one, "is a sovveraigne Preservative agenst Idleness, (that mother of Vices) and an excellent prevention of a world of Idle, Melancholick and exorbitant thouhts, and un-warrantable Actions". One who lacks "som honest particular Calling" is "but an useless wastful Droane, and unworthy of the Benefits of Humane Society". The person who "make[s] Vacation his only Vocation, . . . must have a stronger Charity than Iudgement, that believes that God and Nature intended onely this for that man's Calling" (Boyle and Harwood 1991, pp. 85, 88).

The title of his largest single project, *The Usefulnesse of Experimental Naturall Philosophy*, declares a theme of great importance to Boyle for religious reasons. Taken together, its two long parts comprise about nine percent of his published work. Additional essays surviving only as Latin or English manuscripts that were originally intended for inclusion in the second tome would push the total word count past ten percent. The project's purpose, frequently stated in these or similar words, was "to advance the Empire of Man over other Creatures" (*Works*, 3: 193). The unpublished Latin essay on the usefulness of chemistry indicates that "creatures" included non-living created things, such as various forms of matter. It addresses how "the Empire of Man may be advanced by the skill of Physicists [or naturalists, *Physicorum*] in Chemical matters". Using "those arts by which Nature is more critically examined, such as geometry, mechanics, and those other parts of knowledge such as chemistry and trades", it was possible to "unfold Nature to us to her furthest extent, so she is stirred up, extended, and indeed finally subjected to man" (*Works*, 13: 321–22). The "Empire" references the mandate God gave humans in Gen. 1: 28, "Be fruitful, and multiply, and replenish the earth, and subdue it: and have dominion over the fish of the sea, and over the fowl of the air, and over every living thing that moveth upon the earth". With

Francis Bacon, Boyle thought the new post-Aristotelian science held the key to material and intellectual progress, enhancing our ability to obey this divine decree and therefore theologically superior to Greek science.

3. God and the Mechanical Philosophy

There were further theological reasons to jettison the Greek scientific legacy. Above all, the Aristotelian-Galenic conception of "Nature" as a wise, intelligent being—something not wholly unlike the modern Gaia hypothesis—was "prejudicial . . . to the Discovery of [God's] Works", because "the veneration, wherewith Men are imbued for what they call *Nature*, has been a discouraging impediment to the Empire of Man over the inferior Creatures of God", making it "something of *impious* to attempt, the removing of those Boundaries which *Nature* seems to have put and setled among her Productions. And whilst they look upon her as such a venerable thing, some make a kind of scruple of Conscience, to endeavour so to emulate any of her Works, as to excel them" (*Works*, 10: 450). However, the mechanistic alternative he favoured had a checkered history. Atomism in the ancient world, as taught by Leucippus, his student Democritus, and Epicurus, was associated with an atheistic philosophy in which "chance" rather than purpose reigned supreme, human souls disintegrated at death, and no role was allowed for any gods. Our universe, only the latest in an infinite series of worlds, was a chaos of uncreated atoms, moving randomly in an infinite space, blundering into one another from time to time to form larger bodies, including even the bodies of living things. Fortunately for Boyle, the French priest and theologian Pierre Gassendi had carefully cleansed atomism of its irreligious ties: matter and the laws of nature had been freely created by an omnipotent Creator whose actions were not bound by his creation (Osler 1992). The physician Walter Charleton adapted and popularized Gassendi's ideas in England. From reading both authors, Boyle concluded that Gassendi's position was solid biblical theology. For example, the axiom in natural philosophy, that necessary causes always do what they can, did not mean "that the Fire must necessarily burn *Daniel's* three Companions or their Cloaths, that were cast by the *Babylonian* King's Command into the midst of a Burning fiery Furnace, when the Author of Nature was pleas'd to withdraw his Concourse to the Operation of the flames, or supernaturally to defend against them the Bodies that were exposed to them" (*Works*, 8: 252). Passages such as this display Boyle's theological voluntarism, an emphasis on God's freedom in creating the universe and working within it now, unconstrained by our limited knowledge of God's purposes. This too was part of Gassendi's legacy, alongside nominalism, empiricism, and a love for design arguments—a combination that went together logically (Osler 1992, pp. 181–82).

As Dmitri Levitin has shown, initially Boyle accepted Gassendi's picture of Epicurus as an empirically oriented atomist, over and against the speculative Aristotle, as seen in "Of the Atomicall Philosophy" (*Works* 13: 227–35), an incomplete manuscript from the early 1650s. He also embraced Gassendi's peculiar view that Aristotle believed in a world soul (*anima mundi*). However, within a few years, Boyle and others involved with the early Royal Society came increasingly to view Epicurean atomism as dogmatic, reductionistic and no less speculative than Aristotelianism. Influenced by the German physician and chymist Daniel Sennert, Boyle became persuaded that there had been pre-Aristotelian proponents of a "corpuscularian", not necessarily atomistic theory that was more compatible with his own laboratory work. Then (as we shall see) he went even further, constructing a *theological* critique of both Epicurean and Aristotelian notions in his great treatise on God and the mechanical philosophy, *A Free Enquiry Into the Vulgarly Receiv'd Notion of Nature*, which he started writing in 1666 but did not finish until shortly before its publication twenty years later (Levitin 2014; Hunter and Davis 2007).

We have already seen Boyle's voluntaristic affirmation of God's freedom to create multiple worlds with different natural laws. We find a similar attitude in an unpublished Appendix to his treatise on final causes. "The Primordial System of the Universe" was

> arbitrarily Establish'd by God. Not that he created things without accompanying, and as it were regulating, his Omnipotence, by his boundless Wisdom; and consequently did nothing without weighty reasons: but because those reasons are *à Priori* undiscoverable by us: such as are the number of the fixt Stars; the collocation as well as number of the Planetary Globes; the Lines and Periods of their Motions; the Gyration of Jupiter and Mars about their Centers, compard with the Libration of the Moon; the paucity of Stars near the Antartick Pole; the bignesse shapes and differing Longævities of living Creatures, and many other Particulars: of which the only reason we can assigne, is, that it pleas'd God at the begining of things, to give the World and its parts that disposition. (MS 185, fol. 29; *Works*, 14: 168)

A nominalist view of natural laws resonated with his voluntarism. Scientific laws "did not necessarily spring from the Nature of Matter, but depended on the Will of the Divine Author of things" (*Works*, 11: 302). They were "collected or emergent" truths, "gathered from the settled *Phaenomena* of Nature", rather than "Axioms Metaphysical, or Universal, that hold in all Cases without reservation" (*Works*, 9: 414; cf. Davis 2020). Strictly speaking, a law is merely "a *Notional Rule of Acting according to the declar'd Will of a Superior*". Only "an Intellectual Being can be properly capable of receiving and acting by a *Law.* For if it does not understand, it cannot know what the Will of the *Legislator* is; nor can it have any Intention to accomplish it, nor can it act with regard to it; or know, when it does, in Acting, either conform to it or deviate from it". It makes sense that God "at the Beginning" would give motion to particles, "guide them, as he thought requisite, for the Primordial Constitution of Things", and then "by his ordinary and general Concourse, maintain those Powers" he gave mindless particles to transmit motion. However, "*I cannot conceive*, how a Body, devoid of understanding and sense, truly so call'd, can moderate and determine its own Motions; especially so, as to make them conformable to Laws, that it has no knowledg or apprehension of" (*Works*, 10: 457).

Contrary to Kepler, Galileo, and Descartes, who thought humans could attain at least some knowledge of nature that was objectively certain and equal to God's own understanding, Boyle stressed our vast ignorance of God's knowledge and the consequent need to construct science from the ground up by experience, not from the top down by abstract reasoning—and this attitude had a biblical warrant. "If we believe God to be the author of things, it is rational to conceive, that he may have made them commensurate, rather to his own designs in them, than to the notions we men may best be able to frame of them". According to Genesis, since the world was created before humans, "the author of nature consulted not, in the production of things, with human capacities; but first made things in such manner, as he was pleased to think fit, and afterwards left human understandings to speculate as well as they could upon those corporeal, as well as other things" (*Works*, 12: 397–98).

Just as he saw empirical science as theologically and biblically sanctioned, Boyle found the "mechanical philosophy", as he called it, theologically and biblically superior to the prevailing concept of nature based on the Greeks—according to which, a reified "Nature" did nothing in vain, abhorred a vacuum, and always did what was best. "This Belief, that the World and divers of its Principal Parts, as the Sun, Moon, Stars, *&c.* were animated and endowed with Intelligent Minds, was so Contagious", that it "help'd to seduce the Emperor *Julian* from Christianity to Heathenism" and "Mis-lead such Great Persons" as Moses Maimonides and even Boyle's friend Menasseh ben Israel. Against this notion, Boyle raised a significant objection from the Bible, which lacks any "Hebrew word that properly signifies *Nature*, in the sense we take it in". The Greek notion was frankly idolatrous. "Instead of the True *God*, they have substituted, for us, a kind of a Goddess, with the Title of *Nature*: Which, as they look upon as the immediate Agent and Director in all excellent Productions, so they ascribe to Her the Praise and Glory of Them". The mechanical philosophy, on the other hand, "does much better than its Rival comply with what Religion teaches us, about the *extraordinary* and *supernatural* Interpositions of *Divine*

Providence". Whenever "it pleases God to over-rule, or controul, the establish'd course of things in the World, by his own Omnipotent Hand, what is thus perform'd may be much easier discern'd and acknowledg'd to be *miraculous*", by those who "admit, in the ordinary course of Corporeal Things, nothing but Matter and Motion, whose Powers Men may well judg of". Those holding that "there is besides, a certain *Semi-Deity*, which they call *Nature*", are unable to estimate "how great [its powers] are, and how far they may extend". Thus, "the Miracles of our Saviour and his Apostles, pleaded by Christians on the behalf of their Religion", were "very differingly look'd on by *Epicurean* and other Corpuscularian Infidels, and by those other Unbelievers who admit of a Soul of the World, or Spirits in the Stars, or, in a word, think the Universe to be Governed by Intellectual Beings, distinct from the Supream Being we call *God*" (*Works*, 10: 474–75, 459, 487, and 448–49). By helping us identify genuine miracles, especially those found in the Bible, the mechanical philosophy supported Christianity.

According to Dmitri Levitin, Boyle's emphasis on the idolatrous character of pagan notions of nature and the need to combat them with design arguments was heavily influenced by *Tentamina physico-theologica de Deo*, a book published in 1665 by Samuel Parker, later Bishop of Oxford. The following year, Parker became a Fellow of the Royal Society and Boyle began writing *Notion of Nature* (Levitin 2015, pp. 349–50). There he compared the world to "a rare Clock, such as may be that at *Strasbourg*, where all things are so skilfully contriv'd, that the Engine being once set a Moving, all things proceed according to the Artificers first design". There was no need for "the peculiar interposing of the Artificer, or any Intelligent Agent imployed by him", because the various parts "perform their functions upon particular occasions, by vertue of the General and Primitive Contrivance of the whole Engine" (*Works*, 10: 448). Here and elsewhere, Boyle frequently spoke of the universe and its parts in mechanical terms, but he hardly originated the metaphor. Mechanical planetariums existed in the ancient world, including the device found near the Aegean island Antikythera in 1900 and those made by Archimedes and Posidonius that were known to Cicero, who emphasized that "these contrivances are the work of reason". Comparing them to the heavens, he concluded that the "marvelous velocity" and "perfect regularity" of the heavenly motions leaves no "doubt that all this is effected not merely by reason, but by a reason that is transcendent and divine" (Cicero 1933, pp. 207–19). At the University of Paris during the Middle Ages, astronomer John of Sacrobosco and natural philosopher Nicole d'Oresme described the world as a "machine" or "clockwork". A former philosophy student at Paris, John Calvin, spoke of "the machine of the world" (*mundi machina*) in the *Institutes of the Christian Religion* (Calvin 1559, book 1, chp. 10). A generation later Huguenot apologist Philippe de Mornay used the clock metaphor prominently in a work that profoundly influenced Boyle's intellectual development, *A Woorke Concerning the Trewnesse of the Christian Religion* (French 1581, English 1587). Do the heavens move randomly "by adventure", or do they move themselves? Neither, he argued, "for nothing moueth it selfe", and whenever things moved one another, "in the end men must be faine to mount vpto a first beginning". For example, "from the hammer of a Clocke wée come too a whéele, and from that whéele too another, and finally too the wit of the Clockmaker, who by his cunning hath so ordered them, that notwithstanding that he maketh them all too moue, yet he himselfe remoueth not". Similarly, he described the sky "as the great whéele of a Clocke", amounting to "the very instrument of tyme", needing "a Worker that putteth him to vse, a Clockkéeper that ruleth him, a Mynd that was the first procurer of his mouing (de Mornay 1587, pp. 5, 99). In the next century, Puritan divine John Robinson wrote, "it addes to the honour of the skilfull Artificer, so at the first to frame his Clocke or other works of like curious devise, as that the severall parts should constantly move, and order each other in infinite varietie, hee, as the Maker, and first Mover moving, and ordering all". Immediately after this, he pointed out a crucial difference that "must alwayes be minded, that the Artisan leaves his worke being once framed to it selfe; but God by continuall influx preserves, and orders both the being, and motion of all Creatures. Here also we except both unnaturall accidents; and specially, supernaturall, and miraculous

events; which are, as it were, so many particular creations, by the immediate hand of God" (Robinson 1638, pp. 31–32).

No less concerned than Robinson about the possibility of drawing a deistic inference from the clock metaphor, Boyle underscored the necessity of God's ongoing activity to maintain the universe and its creatures in existence and to guide matter as it moved. His invocation of the clock metaphor described only its created nature, not its very real creaturely dependence on the Creator. "If God should at any time withdraw his preserving Influence", he reflected on the sight of his shadow on the water, "the World would presently Relapse, or Vanish into its first Nothing", for "God is so the preserver of all his Creatures, that one may say of the rest, as the Psalmist speaks of many of them, where addressing himself to God, he says, *Thou hidest thy Face, they are troubled; Thou takest away their Breath, they Dye, and return to their Dust; Thou sendest forth thy Spirit, they are Created*". He went on to say, "that irresistible Agent finds as little more difficulty to produce the greatest changes among the Creatures, than to produce the least; as I find it harder to move the whole Arm of my Shadow, than to move its little Finger" (*Works*, 5: 109–10; cf. *Works*, 8: 23–24 and 28). In the last theological work published during his lifetime, *The Christian Virtuoso* (1690), he affirmed, "this most Potent Author, and (if I may so speak) Opificer of the World, hath not Abandon'd a Masterpiece so worthy of him, but does still Maintain and Preserve it". He regulates "the stupendiously swift Motions of the great Globes, and other vast Masses of the Mundane Matter", so they do not "disorder the grand System of the Univers, and reduce it to a kind of Chaos, or confus'd State of shuffl'd and deprav'd things" (*Works*, 11: 300). Perhaps echoing Boyle, a few years later Newton told David Gregory, "that a continual miracle is needed to prevent the Sun and the fixed stars from rushing together under gravity", a view briefly echoed in Query 28 of the *Opticks* (Newton and Trumbull 1959–1977, 3: 336; Newton 1718, p. 344).

Divine guidance of mindless matter was a crucial component of Boyle's natural philosophy. Knowing the "Intermediate Causes" of things did not "make it needless to admit a First and Supreme Cause", for "That Order of Things, by vertue of which these Means become sufficient to such Ends, must have been at first Instituted by an Intelligent Cause". It was "Irrational to Ascribe the Excellent Fabrick of the Universe, *such as it now is*, and the Actions that have manifest Tendencies to Determinate Useful Ends, To so Blind a Cause as *Chance*", and equally irrational to think, "that at the *First Framing of the World*, there was a *Sufficiency* in the Stupid Materials of It, without any *Particular Guidance* of a most Wise Superintendent, to Frame Bodies so Excellently Contriv'd and Fitted to their respective Ends" (*Works*, 11: 150–51). To hammer down that point, Boyle had his own version of monkeys with typewriters accidentally creating Shakespeare. It was "much more unlikely, that so many admirable Creatures that constitute this one exquisite and stupendous Fabrick of the World should be made by the casual confluence of falling Atoms", than that "a multitude of small Letters" in a printing shop, "being thrown upon the Ground, should fall dispos'd into such an order, as clearly to exhibit the History of the Creation of the World, describ'd in the 3 or 4 first Chapters of *Genesis*, of which History, it may be doubted whether chance may ever be able to dispose the fallen Letters into the Words of one Line" (*Works*, 3: 253).

An unpublished "Post-script" intended at some point as an appendix to his treatise on nature reveals precisely how Boyle baptized the mechanical philosophy (Hunter and Davis 2007). First, he distinguished between "the Epicurean ‹Corpuscularians› that wholly exclude the Diety from having any thing to do in the Makeing or ‹Preserving› the world & the Cartesian Mechanists, if I may so call them, who allow that God ‹have› Created the Matter of the universe but did ‹no more then› impress such a determinate quantity of Locall Motion upon the whole Mass, which he constantly preserves in it without increase or diminution". Then he defined a third group: those who are "far from thinkeing the Mechanicall affections of matter sufficient to have brought the parts of it into so goodly & admirably artificiall a frame as ‹that of› our world without the direction of a Most Wise & powerfull Agent that is in one word, of God". To the best of his knowledge, "Anaxagoras

was the first of the Mechanicall Philosophers that made [here there is a blank space; *noûs* is the word Boyle must have dictated to his amanuensis] or mind by which 'tis knowne he meant God to be that first cause that putt matter into motion & by those two principles fram'd the Corporeal universe". Therefore, Boyle announced, "I shall for distinction sake call ‹the› 3d sect of Mechanicall Philosophizers by the name of Anaxagoreans which sect ‹as to the maine› I ‹declare› myselfe to prefer to both the others". Although he admitted that the Cartesian hypothesis "is not Atheisticall", he considered it "not much more rational", since it is "utterly improbable (not to say altogether unconceivable) that a numberless multitude of fragments of ‹stupid› matter devoid of all knowledge sence & designe should ever be able to justle themselves into such admirably contriv'd Engines as the Bodyes of Men & other Animals & into those other ‹wonderfully differing› Master peices of workmanship that are yett all of them together but ‹small› parts of this great & stupendious Automaton the World". Overall, "the ‹impious› Errours of those that excluded God from the formation of the world are not to be imputed to the Mechanicall principles themselves but to the Personall arrogance of those Philosophers that rashly & unskillfully ‹misapply'd› those innocent principles by straineing them to do a work for which they were insuffitient" (BP 7, fols. 186–88 and 192v; *Works*, 14: 147–49 and 154).

For Boyle, then, a rational explanation of the world must include the activity of Anaxagoras' *noûs*, or mind. The clockwork universe requires a clockmaker, without which its intricate, interconnected mechanisms would not exist and could not function. Surely, they could not have assembled themselves by chance. Any other view was irrational. This is the final reason why Boyle accepted and promoted the mechanical philosophy: it gave us a powerful, seemingly irrefutable argument for a Creator from the self-evident design of the machines he had made. Yet, mere intellectual assent to God's existence was not enough. As he said in *A Disquisition about the Final Causes of Natural Things* (1688), he especially desired "that my Reader should not barely observe the Wisdom of God, but be in some measure Affectively Convinc'd of it". Affectively, not effectively, was the adverb deliberately chosen. Boyle's version of the mechanical philosophy demonstrated not only "the Greatness of God's Power" evident from the Cartesian version, but also his wisdom and goodness. In that way, Boyle believed, "Men may be brought, . . . both to *acknowledge* God, to *admire* Him, and to *thank* Him" (*Works*, 11: 145 and 95). The simple admission of God "may keep a man from being a downright atheist, yet it will not ordinarily suffice to make him a pious man", and he wanted to live in a world inhabited by pious men and women. Nevertheless, one's "piety, as well as his other virtues, will usually be proportionate to the firmness of the assent he gives to that fundamental article of religion, that there is a Divine Maker and Ruler of the world" (*Works*, 12: 483). At the same time, "Natural religion" was "the foundation, upon which revealed religion ought to be superstructed, and is as it were the stock, upon which Christianity must be ingrafted". Although natural religion was "*insufficient*, yet I think it very *necessary*". It is pointless "to press an infidel with arguments drawn from the worthiness" of Christian doctrine and biblical miracles "if the unbeliever be not already persuaded, upon the account of natural religion, that *there is a God*" (*Works*, 12: 432).

4. Conclusions

Biblical and theological ideas fundamentally shaped Boyle's natural philosophy. The sheer joy of uncovering the Creator's wisdom throughout the creation, the desire to imitate Christ by providing medical care to the poor, and the duty to obey the Genesis mandate were powerful motives for doing science. The intellectual humility proper to our status as mere creatures strongly encouraged an empirical approach to nature that was ideally suited to laboratory life. Finally, the mechanical philosophy was far more attractive than the impious Greek conception of "Nature". It focused our attention not on an immanent semi-divine being, but on properties and powers given to matter by the Creator, whose power, wisdom and goodness were clearly seen in the complex machines he had made, while advancing the "Empire of Man over the Creatures".

Boyle's influence on the Anglo-American conversation about science and religion down to our own day has been nothing short of profound. Newton's views on natural theology mirrored Boyle's. He and other great scientists such as James Clerk Maxwell held Boyle's view that natural laws are simply our descriptions of God's ordinary activities in the creation while affirming God's sovereign freedom to perform miracles. In his famous book, *Natural Theology* (1802), William Paley used Boyle's ubiquitous term "contrivance(s)" in identical contexts, stressing the apparent design of highly complex structures in the organic creation, especially one of Boyle's favourite examples, the eye. When authors today appeal to cosmological fine-tuning to argue for a Creator, they are effectively treating the whole universe as a contingently created contrivance, silently echoing Boyle. Proponents of "Intelligent Design" have lauded Paley for many years, but recently they have acknowledged their prior debt to Boyle (Behe 1996, pp. 211–16; Meyer 2021, pp. 31–6). They share his view that mechanistic science gives rise to powerful arguments for an intelligent designer, not "blind chance", as the ultimate author of nature. When they use current scientific knowledge of what mechanistic processes *can* do to identify aspects of nature that (in their view) *cannot* be explained by unintelligent causes alone, they employ Boyle's argument for recognizing the authenticity of biblical miracles—even though they try to keep the Bible at arm's length. As the late ID founder Phillip Johnson said, "the first thing that has to be done is to get the Bible out of the discussion" (Johnson 1999; cf. Meyer 2017, pp. 207–8). Unlike Boyle, who lived in an officially Christian nation that made blasphemy a crime, Johnson lived in a post-Enlightenment, increasingly post-Christian nation whose courts have banned explicitly religious practices in public schools—a form of education unknown in Boyle's day. This has not stopped Boyle's intellectual descendants from making his case as well as they can.

Religion and popular culture have also been substantially influenced by Boyle, especially in the eighteenth century. Puritan leader Richard Baxter admired Boyle's devotional work, *Occasional Reflections on Several Subjects* (1665), which was satirized by Jonathan Swift and remained in print until the mid-nineteenth century. The reflection (in that book) on recovering from a fever likened the complex, finely tuned human body to "so curious an Engine, that consists of so many pieces, whose Harmony is requisite to Health", might "have some or other of them out of order, it being no more strange that a Man's Body should be subject to Pain, or Sickness, than that an Instrument with above a thousand Strings (if there were any such) should frequently be out of Tune" (*Works*, 5: 63–64). This passage inspired the great hymn writer Isaac Watts to pen a four-line stanza about the wondrous creation of our bodies, including the lines, "Strange! that a Harp, of thousand Strings, / Should keep in Tune so long" (Watts 1766, book II, no. 19, v. 3). In 1794 the American composer William Billings set Watts' text as the fuging tune, "Creation", in *The Continental Harmony* (Davis 2002). Watts' poetic version of Boyle's prose is ubiquitous in shape-note singing since the late eighteenth century and on the internet today. Another musical by-product was Georg Frederick Handel's favourite oratorio, Theodora (1750). Now regarded as a masterpiece after centuries of neglect, since 1990 it has been recorded seven times and staged four times as an opera at Glyndebourne, Salzburg, Covent Garden, and the Barbican. Thomas Morell's libretto was based on Boyle's *The Martyrdom of Theodora, and of Didymus* (1687), a work that Samuel Johnson described as the first "attempt to employ the ornaments of romance in the decoration of religion", although "*Boyle's* philosophical studies did not allow him time for the cultivation of style" (Boswell 1934, 1: 312). Boyle's best-known artistic influence is the magnificent painting by Joseph Wright of Derby, *An Experiment on a Bird in the Air Pump* (1768), closely based on the description of a demonstration in which a bird was subjected to a partial vacuum created by his air pump until women witnessing the experiment made him stop (*Works*, 1: 286–87). Cotton Mather's *The Christian Philosopher* (1721), which brought the new science from Europe to America, was originally to be called *The Christian Virtuoso* after Boyle's book of that name, which had been devoted to "*Shewing*, That by being addicted to *Experimental Philosophy*, a Man is rather Assisted, than Indisposed, to be a *Good Christian*" (*Works*, 11: 281).

Boyle's voluntarist conceptions of nature and natural law may not be widely accepted, but they still come to the surface, especially when scientists debate the nature of nature. When Albert Einstein said that he "really" wanted to know, "whether God could have made the world in a different way; that is, whether the necessity of logical simplicity leaves any freedom at all" (Holton 1978, p. xii), he unwittingly asked one of Boyle's greatest questions. Cosmologists, environmentalists, philosophers, and theologians continue to debate answers to other questions about God, nature, and humanity that Boyle formulated more than three hundred years ago. Silly claims by a few prominent scientists that philosophy is useless and irrelevant notwithstanding, science remains a form of natural *philosophy*. Boyle's legacy is still with us.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: No new data were created.

Acknowledgments: I gratefully acknowledge helpful comments from Michael Hunter, Michael Newton Keas, and four anonymous reviewers.

Conflicts of Interest: The author declares no conflict of interest.

Abbreviations

BP Royal Society Boyle Papers
MS Royal Society Manuscripts

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Correspondence = *The Correspondence of Robert Boyle*. 2001. Edited by Michael Hunter, Antonio Clericuzio and Lawrence M. Principe. 6 vols. London: Pickering & Chatto.

Works = Boyle, Robert. 1999–2000. *The Works of Robert Boyle*. Edited by Michael Hunter and Edward B. Davis. 14 vols. London: Pickering and Chatto.

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