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The wisdom in wood rot: Finding God in early-modern scientific explanation

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This chapter presents a historical study of how science has developed and of how philosophical theories of many sorts – philosophy of science, theory of the understanding, and philosophical theology – both enable and constrain certain lines of development in scientific practice. Its topic is change in the legitimacy or acceptability of scientific explanation that invokes purposes, or ends; specifically in the argument from design, around the turn of the eighteenth century.

We tend to explain various features of the world by invoking purposes. Philosophers of science and scientists also tend to accept this kind of explanation as legitimate, as is most obvious in our time in, for example, archaeology. It does not stretch credibility to suggest that the specific orientation of a building footprint or the pattern of elements in assemblages of monumental architecture arose due to the builders’ regard for the alignment of the sun at noteworthy times, such as briefest and lengthiest days of the year, the days on which night and day are of equal length (the vernal and autumnal equinox), or the beginning of a planting season. A comprehensive explanation for why Mayan temples and cities are just as they are will include reference to the intentions of their designers. Of course, the same holds for buildings through time, the world over.ⁱⁱ

But what are we to make of an introduction of purposes such as the following, which was provided by a prominent French author of the mid-eighteenth century?

...where is the Goodness, it may be objected, in [God] having created ... destructive Worms, for Example, which insensibly eat and consume the Sides of our Ships, the piles of our Dikes, and the Timber of our Houses?

These Worms, like all others, do by the Corruption of one thing contribute to the Generation of another, and serve to promote the general Circulation of the Commodities and Productions of different Countries, on which Commerce necessarily depends. So mean an Animal, in Appearance, as the Pipe-Worm, by usefully employing the vigilance of the Dutch, not only maintains but brings Riches to the inhabitants of Sweden. ... Were they not under a perpetual Necessity of tarring and sometimes repairing their Vessels and Dikes at Amsterdam, in vain would the Muscovite and Norwegian barrel up the Pitch, which distils from their Pines; in vain would the Swedes cut down the Oaks and Lofty Fir-Trees that grow in their Forests. Thus does this little Animal, which we so much complain of as troublesome and injurious to us, become the very Cement, which unites these distant Nations in one common Interest. ... The Prospect we have taken of Nature, does in every part sufficiently prove that the Good of Man was the chief End proposed by Providence in the Works of the Creation, even in those very things, which seem hurtful or offensive.ⁱⁱⁱ

The explanation invokes purposes, much like the human purposes found in the archaeological explanation noted above. Yet we would consider the two cases very different: the wood rot explanation invokes God's purposes, and in that respect, it is explanation of a very different sort than we expect to find within current archaeology and social sciences generally.

The purpose for wood rot suggested here might move a 21st century audience to laughter. It appears to be much the sort of claim that Voltaire's Dr. Pangloss would make within the pages of *Candide*. Compare, for example, the Panglossian explanation of the arrival of syphilis in Europe following contact with the New World:

It was a thing unavoidable, a necessary ingredient, in the best of worlds! For if Columbus had not landed upon an island in America, and there caught this disease – which contaminates the source of life, frequently hinders generation, and is evidently opposite to the great end of nature – we should have neither chocolate nor cochineal.^{iv}

Indeed, the similarity is not accidental: Voltaire was ridiculing this sort of explanation, and the very author of the discussion, the abbé Noël Pluche, in particular.^v Pangloss provides his disquisition for the education and spiritual edification of a promising and inquisitive youth.

Pluche had a similar end: his example of wood rot appears in a remarkably popular publication, a multi-volume compendium of science, human invention and piety entitled, in its English translation, *Nature display'd: Being discourses on such particulars of natural history as were thought most proper to excite the curiosity and form the minds of youth.*

Though the above explanations pertain to “goodness” and “the best of worlds” respectively, they both have very much to do with detailed accounting of natural and human history. Both educators draw our attention to the ubiquity, even within literary culture, of a little-studied aspect of early modern scientific explanation: the rise of references to God’s purposes within the study of nature, starting in the second half of the seventeenth century. The most influential theorists of scientific knowledge shortly before that time, Francis Bacon and René Descartes, would summarily ban such explanation from natural philosophy. References to divine purposes and divine beneficence would gain philosophical credentials – for the first time in the context of modern science – in English natural philosophy, under the influence of prominent scientists and philosophers who were members of the Royal Society of London for the Improving of Natural Knowledge (henceforth Royal Society), particularly in the final quarter of the century. Robert Boyle would produce the major philosophical justification for such explanation and significant roles promoting it would be played by a network of members, including Isaac Newton. From those beginnings, the form of explanation that soon came to be known as physico-theology would become a well-considered topic for theologians and popularizers of science such as Pluche and would gain respectability as a pursuit for practicing scientists over the course of two hundred years.

Naturalists from Aristotle on have made reference to purposes in their treatment of plants and animals, including both goals toward which apparently mindless activity is directed and the uses or the functions of the parts of organisms. Goals and uses would appear to be the product of intention and design respectively, and so of a mind or a designer. But discussion of that designer grew rapidly late in the seventeenth century, and was pursued by scientists as well as clergy and popularizers of science. Pluche’s surprising thesis was not far off of what a respected scientist might write. His contemporary Carl von Linné (Carolus Linnaeus) repeatedly wrote on the characteristics of the divine designer. In 1751 he would write, “What genius, what art, can imitate one of those fibres whose various and infinite complications form the human body? In its most minute filament we see the

finger of God, and the seal of the great Artificer of Universal Nature.”^{vi} It was his custom to work collaboratively on the dissertations of his doctoral students, and so, two years earlier, either he or Isaac Biberg wrote that “Goats ... have feet made for jumping.” The co-authors extended the purposes that pertain to animals beyond the roles of the parts of the organism, beyond activity advantageous to the organism, and beyond kin and species benefits as well. They argued for goals for activities that also appear to entirely escape the creatures’ understanding and learning, in flights of analysis almost as memorable as those of Pluche:

As the excrement of *dogs* is of so filthy and septic a nature, that no *insect* will touch them, and therefore they cannot be dispersed by that means, care is taken that these animals should exonerate upon stones, trunks of trees, or some high place, that vegetables may not be hurt by them. *Cats bury their dung*. Nothing is so mean, nothing is so little, in which the wonderful order, and wise disposition of nature does not shine forth.

By whom was “care taken?” The source of the “wise disposition of Nature” toward the preservation of vegetables was swiftly identified as divine providence intended foremost for human good. The authors conclude, “all these treasures of nature so artfully contrived, so wonderfully propagated, so providentially supported throughout her three kingdoms, seem intended by the Creator for the sake of man.”^{vii}

Physico-theology would be pursued with reduced vigor on the continent of Europe after 1750, but it would remain strong in England and would see an impressive resurgence early in the following century. The English movement reached a second peak with a cast of British scientists including William Whewell, William Buckland and William Prout producing full volumes on cosmology, geology chemistry and other fields under the series title *Bridgewater Treatises on the Power, Wisdom and Goodness of God, as Manifested in the Creation* (1833-36, 8 vols.).^{viii} The criticism of David Hume and Immanuel Kant hardly affected the pursuit of physico-theology; Darwin ushered it off the stage during his lifetime.^{ix} *The Origin of Species* (1859) presents Darwin’s theory of natural selection, in which, over generations, heritable natural variation and selective retention of reproducing organisms provides an alternative explanation of order that design may resemble.

1. Natural theology in flux

Natural theology isn't what it used to be. Around the turn of the eighteenth century it developed a particularly close association with science that was reflected in the introduction of a new term, 'physico-theology.' The rise of this association is evident in authors' characterizations of the term in philosophical works from different historical periods, as I will endeavor to show below.

Natural theology – a term used interchangeably with 'natural religion' – finds a brief and clear characterization that reflects a close association with natural philosophy in *Of the Principles and Duties of Natural Religion* (1675). The English cleric and polymath John Wilkins (1614-1672), very near to the end of his life, writes, "I call that *Natural Religion*, which men might know ... by the meer principles of Reason, improved by Consideration and Experience, without the help of *Revelation*." Wilkins' treatment presents a balance between reason and experience: the former is contrasted with and aided by the latter in the production of knowledge. This is an approach we might expect of a European philosopher after the middle of the seventeenth century, in a field shaped especially by the discussions of Descartes and Hobbes. Wilkins, who does not himself "pretend to the invention of any new arguments," launches into "the most plain and convincing" independent lines of natural theological argument. He finds the best basis for knowledge of God in: "(1) the Universal consent of Nations, in all places and times. (2) The Original of the World. (3) That excellent contrivance which there is in all natural things. (4) The works of Providence in the Government of the World."^x In Wilkins' first three topics, the ground is prepared for the connection of natural religion to areas of study that would later be classified as sociology, cosmology, physics and biology.

Natural theology is much older, however, and its past is very different. Wilkins' treatment tacitly dismisses the greater proportion of what would have been central to its study by all previous generations of philosophers. Consider, for comparison, the difference in emphasis found in two other treatments, one from long before by Varro Reatinus (116-27 BCE) and one from early in Wilkins' own century by Francis Bacon (1561-1626).

Varro's text survives through quotations contained within the writing of Augustine (354-430 CE). Varro characterizes natural theology as:

that concerning which philosophers have left many books, in which they treat such questions as these: what gods there are, where they are, of what kind and character they are, since what time they have existed, or if they have existed from eternity; whether they are of fire, as Heraclitus believes; or of number, as Pythagoras; or of atoms, as Epicurus says; and other such things, which men's ears can more easily hear inside the walls of a school than outside in the Forum.^{xi}

Polytheism is a going concern here, but the relation of reason to experience is not noted. Different times reflect different philosophical concerns: Varro's reference to eternity evokes one topic of philosophical theology that is common in the history of philosophy, which we know as the cosmological argument. Aquinas' familiar arguments for the existence of God, the Five Ways, include two formulations of the argument: one concerns the necessary existence of an unmoved mover, the second argues for a first cause that is necessary for all that follows. Natural theology isn't what it used to be: though each author might find some of the arguments noted by the other to be agreeable, there is no overlap among Wilkins' preferences and Varro's references.^{xii}

Aquinas does present some overlap with Wilkins in his Five Ways. The fifth way, in its entirety, follows:

The fifth way is taken from the governance of the world. We see that things which lack intelligence, such as natural bodies, act for an end, and this is evident from their acting always, or nearly always, in the same way, so as to obtain the best result. Hence it is plain that not fortuitously, but designedly, do they achieve their end. Now whatever lacks intelligence cannot move towards an end, unless it be directed by some being endowed with knowledge and intelligence; as the arrow is shot to its mark by the archer. Therefore some intelligent being exists by whom all natural things are directed to their end; and this being we call God.^{xiii}

The argument is among the ancestors of physico-theology. Traces of a related argument were voiced by Socrates, as reported by Xenophon. Socrates follows a discussion of the utility of eyebrows, eyelids and eyelashes with two queries:

Does it not strike you then that he who made man from the beginning did for some useful end furnish him with his several senses—giving him eyes to behold the visible

word, and ears to catch the intonations of sound? ... I ask you, when you see all these things constructed with such show of foresight can you doubt whether they are products of chance or intelligence?^{xiv}

Socrates' move shows a specific similarity to the wood rot argument, and more particularly, to physico-theological arguments that concern the functions of parts of animals, like those of Linnaeus and Biberg. These arguments differ from the cosmological argument in that, though the cosmological argument refers to the observed universe, it does not refer to a divine "end" or "foresight" to be found in the production of a specific feature within the universe. Arguments of this sort have since become known as teleological arguments for the existence of God, or, in a phrase, 'argument from design': argument from a survey of the design of the world or a portion of the world to a conclusion concerning the existence or characteristics of the designed object's maker. It is evident from Xenophon's writing that teleological argument is longstanding in philosophy.

Like Socrates and Aquinas, Wilkins and other moderns who will be considered below survey observable aspects of the world to support argument to establish that God exists. But such proof – probable rather than necessary, or, in Wilkins' terminology, "morally certain," rather than "mathematically certain" – the moderns consider very easy to achieve. The arguments of physico-theology are greatly expanded in detail and altered in purpose: beyond using empirical considerations to demonstrate God's existence, the target of physico-theology is proof of the "Power, Wisdom and Goodness of God," as the series title of the *Bridgewater Treatises* suggests. Providence, which is just hinted at by Socrates, is the focus of investigation.

Wilkins' text is an early indicator of the consolidation of an intellectual shift comprised of two complementary aspects. One aspect is the rise of a modern theological sensibility regarding to nature, a sensibility that develops as a consequence of a diminution of the symbolic significance of nature that is evident in Renaissance humanism. The second and subsequent aspect is the rise of a modern scientific and philosophical sensibility concerning the divine, a change that comes as a consequence of the development of both empiricism and the new theory of the understanding. Modern philosophy changes the game, redefining the possibilities for natural theology and ushering in the new physico-theology after theology has itself altered to become more consonant with the ideals that would be expressed in

modern empiricism. The first aspect of the double shift is already evident in the work of Francis Bacon; both faces appear in Wilkins.

Concerning the first aspect, the development of a theological perspective that is modern in some respects, consider the narrow band of experience that is relevant to natural theology as indicated (in italics I have inserted) in our third characterization of natural theology, from Bacon's *Advancement of Learning* (1605):

as concerning divine philosophy or natural theology, it is that knowledge or rudiment of knowledge concerning God, which may be obtained *by the contemplation of His creatures*; which knowledge may be truly termed divine in respect of the object, and natural in respect of the light.^{xv}

This indicates a narrowing of the topic, as is evident also in Wilkins, such that natural theology no longer contains all of philosophical theology: it is no longer a topic that stands in straightforward contrast to revealed religion. Philosophical theology such as Anselm's ontological argument for the existence of God would not actually fall within Bacon's characterization, for example. Arguments that focus upon metaphysical necessity, such as cosmological arguments, are not excluded, since contemplation of creation is rather abstractly involved in thinking about chains of causes, but such metaphysical argument does not leap to one's mind when reading this characterization, either. The narrowing directs us toward philosophical theology that highlights empirical considerations.

Bacon also shows a modern theological sensibility concerning nature, and illuminates the shift itself, within the following:

for our Saviour saith, *You err, not knowing the Scriptures, nor the Power of God*; laying before us two books or volumes to study, if we will be secured from error; first, the Scriptures, revealing the will of God; and then the creatures expressing His Power; whereof the latter is a key unto the former; not only opening our understanding to conceive the true sense of the Scriptures, by the general notions of reason and rules of speech; but chiefly opening our belief, in drawing us into a due meditation of the omnipotency of God, which is chiefly signed and engraven upon His works.^{xvi}

This image of "two books" provided for our enlightenment by God, along with the exhortation to study both, has a long history. It becomes an authoritative rationale for the

pursuit of natural philosophy as it develops from a sketch of the various paths to knowledge of God presented in the writing of Aquinas.^{xvii} It finds support in a variety of biblical passages and it inspired Raymond Sebond's *Theologia Naturalis* (1436), which styles the world as "composed of a great multitude of creatures, like a collection of letters in a book."^{xviii} Lessons intended for man are written in the book of nature by God, particularly indicating "the ladder of nature that man climbs up to understand himself and his creator." Sebond's nine-hundred page treatise includes teleological argument concentrated over just a few pages, and that discussion is set within an effort to use observation of nature as an aid to understanding the unity of the natural order, with God, the most perfect being, at its top, and humanity second.^{xix} Sebond's natural theology, then, is not so much a reflection upon design as it is a meditation upon order, particularly as displayed in hierarchy, or the chain of being. Sebond focuses upon specific lessons concerning that order that are thoughtfully introduced into the scheme, and so provided for us, by God.

Bacon's assumptions regarding the uses of the book of nature are far more parsimonious than Sebond's, and the lessons to be learned are also less extensive. In Bacon, nature is stripped of the allegorical significance that is found in Sebond and displayed much more broadly in the vogue for an emblematic interpretation of the world that blossomed in the second quarter of the sixteenth century.^{xx} Bacon is a modern, rather than a Renaissance humanist: he will not argue that nature is arranged expressly for our philosophical instruction, even if he might consider such a thing plausible, for that would reflect an extravagance of hypotheses not fitting with the empirical character of natural philosophy, in which "the basis is natural history; the stage next the basis is physic; the stage next the vertical point is metaphysic."^{xxi}

Though Bacon suggested that the study of nature would provide a "due meditation of the Omnipotency of God," his own meditation was abstract and limited by comparison with those appearing later in the century. For Bacon, natural theology sketches the "rudiment" of knowledge concerning God: "that God exists, that he governs the world, that he is supremely powerful, that he is wise and prescient, that he is good, that he is a rewarder, that he is an avenger, that he is an object of adoration – all this may be demonstrated from his works alone." Bacon limits natural theology both by erecting methodological walls and by expressing doubts. First, he promotes a division of disciplines that ensures that science

and metaphysics are pursued separately. Bacon opposes the invocation of design in explanation for natural science, or “physic”: he limits natural science to inquiry into material and efficient causes and he charges that the search for answers regarding purposes tends to stunt empirical study, leading thinkers to halt their inquiry into material and efficient causes. He writes:

that the clouds are for watering of the earth; or that the solidness of the earth is for the station and mansion of living creatures; and the like, is well inquired and collected in metaphysic, but in physic they are impertinent. Nay, they are, indeed, but *remoras* and hindrances to stay and slug the ship from farther sailing, and have brought this to pass, that the search of the physical causes hath been neglected and passed in silence.^{xxii}

Bacon does not make it apparent how one might pursue these lines of inquiry in metaphysics. He would have been skeptical of detailed natural theology of the sort that appears late in the century: he writes, “I hold it is not possible to be invented by that course of invention,” and quotes Ecclesiastes 3:11: “The work which God worketh from the beginning to the end, it is not possible to be found out by man.” He holds no expectation of future advance in this area: “the summary law of nature, we know not whether man’s inquiry can attain unto it.” In a passage concerning purposes that lays bare Bacon’s views on politics as well as divine mystery, he suggests:

For as in civil actions he is the greater and deeper politician, that can make other men the instruments of his will and ends, and yet never acquaint them with his purpose, so as they shall do it and yet not know what they do; than he that imparteth his meaning to those he employeth: so is the wisdom of God more admirable, when Nature intendeth one thing, and Providence draweth forth another; than if He had communicated to particular creatures, and motions, the characters and impressions of His Providence.^{xxiii}

Descartes would even exceed Bacon in caution concerning final causes in science. In the *Principles of Philosophy* (1641) he would argue very briefly that “We should not be so arrogant as to suppose that we can share in God’s plans.”^{xxiv}

2. Natural theology and the Royal Society

Later in the century and generations before Pluche, English philosophers shook off such skepticism. Bacon's writing was taken to align with the empirical ideals of the new natural science developed in the Royal Society, of which Wilkins was a founding Fellow and the Secretary from inception in 1660. Indeed, Bacon was found to be prescient: Abraham Cowley's ode "*To the Royal Society*" (1667), casts Bacon's *New Atlantis* of 1623 as a work that prophesies the formation of the Royal Society. In an image that neatly ties the religious and the scientific, Cowley places Bacon as the Mosaic leader of English empirical philosophy:

Bacon, *like Moses, led us forth at last,*
The barren Wilderness he past,
Did on the very Border stand
Of the blest promis'd Land,
And from the Mountain's Top of his exalted Wit
Saw it himself, and shew'd us it.^{xxv}

Within the promised land, the teleological argument began its expansion into the fresh fields of physico-theology. Henry Power unequivocally announced a proper wedding of natural theology and the new mechanical philosophy in 1662:

all things are Artificial; for Nature it self is nothing else but the Art of God. Then, certainly, to find the various turnings, and mysterious process of this divine Art, in the management of this great Machine of the World, must needs be the proper Office of only the Experimental and Mechanical Philosopher.^{xxvi}

Robert Hooke presented similar sentiments, casting God as engineer in *Micrographia* (1665). The relatively crude shaping of a pin's point seen under magnification compared poorly to the fineness of "the *hairs*, and *bristles*, and *claws* of multitudes of *Insects*." He concluded that the microscope reveals that, in man's efforts, there is "rudeness and bungling of *Art*":

the more we see of their *shape*, the less appearance will there be of their *beauty*: whereas in the works of *Nature*, the deepest Discoveries shew us the greatest Excellencies. An evident Argument, that he was the Author of all these things, was

no other than *Omnipotent*; being able to include as great a variety of parts and contrivances in the yet smallest Discernable Point, as in those vaster bodies (which comparatively are called also Points) such as the *Earth, Sun, or Planets*.

Hooke extends the teleological argument over new ground here, but physico-theology is still in early development. *Micrographia* is frequently cited as a key text by figures in the late seventeenth century and recent scholars, yet it contains only fleeting references to “the Authour of all,” plus several hundred words of directed physico-theological argument.^{xxvii} The new empirical science would radically reshape natural theology as it came to develop among members of the Royal Society in the final quarter of the century. Like Socrates, John Wilkins argued from the good design of the human body, concluding, “From whence it will follow, That it must be a Wise Being that is the Cause of these Wise Effects.” Wilkins would develop his argument at a full chapter’s length, much greater than Socrates and Hooke, citing both ancient and contemporary science: Galen on the complexity of the human body and Hooke’s observations of God’s craftsmanship through the microscope.^{xxviii}

The importance of the new empirical science to his effort actually appears to lead Wilkins to downgrade other approaches to natural theology, such as the cosmological argument. There is another philosophical factor, however, that reduced their value further. The cosmological argument, which before had claimed the status of demonstrative or apodictic argument, appears to be ignored or tacitly dismissed in *Natural Religion*. Wilkins’ book does include discussion of a necessary existent and a first mover but his taste for such argument is greatly tempered and is clearly affected by a theory of the human understanding that is in the process of reshaping English philosophy. Wilkins does not attempt to develop a cosmological proof for God’s existence, instead he writes: “The most general Notion that men have of God, is that He is the first cause, and a Being of all possible Perfection.”^{xxix} The reference to a “general notion,” suggests the place of the idea of God within a developing theory of ideas that suffuses Wilkins’ text and is a recognizable antecedent of the account to be found in John Locke’s *Essay Concerning Human Understanding* (1690).

The second aspect of the intellectual shift noted above, concerning new philosophical trends that reshape natural theology and is displayed in Wilkins’ approach. First, natural philosophy has swept Wilkins’ discourse of natural theology, to such an extent that scant attention is paid to what were before considered the more secure apodictic forms

of argument, such as the cosmological argument. Second, the new theory of the human understanding evidently plays a large role in undermining the claim to certainty held by those other forms of argument. The efforts in natural philosophy and theory of ideas were seen as linked by Wilkins, who explicitly proposed the improvement of language as an important task to the Royal Society in 1668, and by Locke, who implicitly did the same, referring to himself as an “under-labourer” to “master-builders” such as Newton, Boyle and Huygens, “removing some of the rubbish that lies in the way of knowledge.”^{xxx} The new theory of ideas posed a significant barrier to most traditional forms of natural theology. The proposal that the mind is a *tabula rasa* upon which experience is impressed presented an acute challenge to innate ideas, and so, to arguments for the existence of God that were not suitably grounded in experience. Consequently, many of the most prominent physico-theologians chose to soft-pedal or entirely forego “metaphysical” argument for the existence of God, referring readers to other sources or skipping traditional apodictic argument entirely. They would gesture at such paths, indicating that little attention was required on routes well-trodden by others; or they would straightforwardly declare that they “always esteemed the strongest” approach to natural theology to be physico-theology.^{xxxi}

Locke stands as the most important proponent of the new and influential theory of ideas. Robert Boyle is the most important theorist of natural philosophy for this new philosophical turn. He would address the topic of final causes in science at length in *A Disquisition About the Final Causes of Natural Things: WhereIn it is Inquir'd, Whether, And (if at all) With what cautions a Naturalist should admit Them?* (1688) Boyle’s “cautions” are limited, showing only vestiges of Bacon’s concerns. He opens his disquisition by commending the importance of the subject, admonishing his reader, “if we neglect this Inquiry, we live in danger of being Ungrateful, in overlooking those Uses of Things that may give us Just Cause of Admiring and Thanking the Author of them...” Boyle argues that knowledge of final causes is attainable through empirical inquiry: in this he opposes Epicurean mechanists and Cartesian skeptics who “suppose all the ends of God in Things Corporeal to be so Sublime, that ‘twere Presumption in Man to think his Reason can extend to Discover them.”^{xxxii}

Boyle takes great care to distinguish four categories of ends that may be the subject of inquiry. The first category is the purpose for the entirety of the cosmos, “Exercising and Displaying the Creators immense power and admirable Wisdom.” The second category

comprises large-scale systems within the cosmos: “Ends design’d in the number, fabrick, placing, and wayes of moving the great Masses of Matter, that, for their Bulks or Qualities, are considerable parts of the World ... sun, moon, and fixed stars, and the terraqueous Globe...” The third covers “the Parts of Animals ... destined to, and for the welfare of the whole Animal himself, as he is an entire and distinct System of organiz’d parts, destined to preserve himself and propagate his *Species* ...” Finally, Boyle cites a fourth sort of Ends, “call’d *Human* Ends, which are those that are aim’d at by Nature, where she is said to frame Animals and Vegetables, and other of her productions, for the use of Man.”^{xxxiii} The scheme appears to be incomplete and arbitrary in at least this respect: the second category includes purposes pertaining to properties of and interrelations among very large bodies, but it tacitly excludes purposes that pertain to interrelations among middle-sized objects, both animate and inanimate. Such interrelations among bodies – worms and wood, dogs and vegetables, *etc.* – appear to be neglected by Boyle. I will call such collections “assemblages,” regardless of whether they are large or middle sized (and we might add “small” to the list, to complete it and find a place for chemistry). Relations characterized as assemblages are to be contrasted with the relations among parts of an organism.

Consider how Boyle might have, but did not, discuss the assemblage that produces wood rot. It would appear that the divinely designed role that burrowing worms play in breaking wood down reflects an end that might have fit within his second category. Boyle’s discussion of the divine purposes for assemblages includes mention of the role of the sun in furnishing the earth with heat and light, and the relation of the “two Chief parts” of the globe, the continents and the oceans. Boyle does not descend to a smaller scale, however: from these global assemblages he jumps to discussion of the design of the parts of organisms.^{xxxiv} Late in the work, Boyle explains his choice: he finds that one might discern God’s “particular providence” concerning the purposes of parts of animals, whereas “it is not an easie Task” to inspect assemblages and discern the plan of “General Providence.” How worms are designed to eat is easy to see; how worms and ships fit together, and into the general plan of providence, is not easy to see. The best that Boyle can offer he identifies as supposition: that there is “One Grand Motive” to the whole of creation, that “might, by so many and so very differing Contrivances, as are to be met with in the Structure of Men, Four-footed Beasts... etc., Exercise and Display ... *the Multifarious or Manifold Wisdom of God. (Ephesians 3.10)*”^{xxxv}

To go beyond conjecture and explain the interrelations of such assemblages, Boyle adds two supports in combination: anthropocentrism and revelation. Anthropocentrism puts such relations into the fourth category of Boyle's division, but to acquire knowledge in that division it is not sufficient for the "Naturalist to discourse merely on physical grounds." When we add "Revelations, contained in the Holy Scriptures, we may Rationally believe more, and speak less Hesitantly, of the Ends of God, than bare philosophy will warrant us to do." With the supplement of revelation, then, Boyle comes to be comfortable discussing assemblages that are similar to the pair of worms and wood. For example, he quotes the book of Genesis to support a detailed claim: "God *deliver'd all Terrestrial Beasts, and Fowle and Fishes, and Every moving thing that lives, into the hands of Men;* and intended that they should eat Animals..." In this context, Boyle states that the sun was meant by God to grow plants "that Men and Cattel must live upon," and he quotes Genesis 9:23 and 1:29 in this section. Contrast his positive claim with the hedging of a similar claim in which "bare philosophy" has not been supported by revelation, regarding which he concludes, "Whether this be a demonstrative collection I shall not now debate..." Nevertheless, bare philosophy is sufficient to show "*That the Sun, Moon and other Coelestial Bodies, Excellently Declare the Power and Wisdom, and consequently the Glory of God.*"^{xxxvi}

Boyle's extensive discussion closes: "*That all Consideration of Final Causes is not to be Banish'd from Natural Philosophy: ... 'tis rather Allowable, and in some Cases Commendable, to Observe and Argue for the Manifest Uses of Things that the Author of Nature Pre-ordain'd those Ends and Uses.*" He finds that "'tis Warrantable" to consider the parts of animals, "Pre-ordained to such and such Uses, relating to the Welfare of the Animal (or Plant) itself, or the *Species* it belongs to." But he cautions against the capacity of natural philosophy, when not aided by revelation, to elucidate the second among his categories of ends: "from the Supposed Ends of Inanimate Bodies, whether Coelestial or Sublunary, 'tis very Unsafe to Draw Arguments to Prove the Particular Natures of Those Bodies, or the True System of the Universe." This caution about "particular natures" would appear not to apply to lesser claims – the quotation that concludes the paragraph just above is one example – but it does apply to discerning specific purposes from assemblages both large and middle-sized, including worms and wood, where those claims are not supported by scripture.

Boyle finishes with another caution that faintly echoes Bacon's reservation as he

writes, “a *Naturalist*, who would Deserve that Name, must not let the Search for Knowledge of *Final Causes*, make him Neglect the Industrious Indagation of *Efficients*.”^{xxxvii} Thus Boyle has chased back Bacon’s separation of final causes from physick. The difficulty Boyle saw in divining general providence does not present a bar in principle against such explanation for wood rot. Nevertheless Boyle was skeptical of the degree to which the Naturalist could successfully pursue such explanation. That skepticism concerning topics within his second category would be chased back by others within the Royal Society following his death.

3. Physico-theology matures

When Robert Boyle died in 1691 his will included the following provision:

Fifty Pounds *per Annum* for ever, or at least for a considerable number of years, to be for an annual Sallary for some Learned divine ... To preach *eight* Sermons in the Year, for proving the *Christian Religion*, against notorious Infidels, *viz. Atheists, Theists, Pagans, Jews, and Mahometans*, not descending lower to any *Controversies* that are among Christians themselves.^{xxxviii}

Boyle had named a board of five trustees for the bequest, including a lawyer, a gentleman who promoted religion in the new world, and two eminent churchmen. The fifth trustee was John Evelyn, a London intellectual and Fellow of the Royal Society who played a crucial role as an agent of Isaac Newton in steering the Boyle lectures. Margaret Jacob and Henry Guerlac have argued that Newton, at the height of his influence, is likely to have suggested either the name of the first lecturer or the specific focus upon physico-theology to Evelyn at a meeting shortly after Boyle’s funeral. Even before Boyle’s death, Newton would indicate an interest in promoting argument from design that relates to Boyle’s second category: David Gregory, a contemporary observer and correspondent of Newton’s, indicated that Newton promoted Bentley for the first Boyle Lecture as a counter to John Ray, who focused upon the third category. Guerlac and Jacob write that “Newton was obviously suggesting that his discoveries in celestial physics would serve the argument from design better than that reliance upon the ‘contrivances’ in animals and plants which John Ray had recently catalogued.”^{xxxix}

Newton’s interest in physico-theology is also intimated at the opening of a frequently

quoted letter of 1692: “When I wrote my treatise about our Systeme I had an eye upon such Principles as might work wth considering men for the beliefe of a Deity & nothing can rejoyce me more than to find it usefull for that purpose.” Richard Bentley was the recipient of Newton’s letter and he would become the first Boyle lecturer in 1693, repeating the role in 1694. Bentley appears to have calibrated his arguments to Newton’s instruction, as is apparent from correspondence that includes four letters from Newton to Bentley during 1692-3.^{xi} Bentley’s final three lectures, collectively entitled “A Confutation of Atheism from the Origin and Frame of the World,” particularly fill Newton’s bill. The previous three lectures concern “A Confutation of Atheism from the Structure and Origin of Human Bodies,” and, as the title indicates, these largely concern the fitness to their uses of the parts of the human body. Bentley is one of several influential physico theologians who, at the turn of the eighteenth century, set the agenda for its future. One earlier outlier on the continent, François Fénelon’s *Traité de l'existence de Dieu et de la réfutation du système de Malebranch sur la nature et sur la Grâce* (1685), contains argument approaching 100 pages that sketched physico-theology. Another author of note is John Ray, whose important empirical work on botany and fossils is complemented by *The Wisdom of God Manifested in the Works of the Creation* (1691).

All of the abovementioned Englishmen were Fellows of the Royal Society and as I have attempted to indicate, most had significant professional and philosophical interconnection, reflecting both association and rivalry. The connections, beginning in the early days of the Society, are bountiful. John Ray’s balance of scientific and theological work is reminiscent of that of Wilkins, who put Ray to work on the botanical sections of his *An Essay Towards a Real Character and a Philosophical Language* (1668) – the work noted above as an intellectual precursor to aspects of Locke’s *Essay*. Newton promoted Bentley over Ray, and another close associate of Newton’s, Samuel Clarke, would follow as another Boyle lecturer a decade later. Clarke would present Newtonian, metaphysical and physico-theological themes in *A demonstration of the being and attributes of God* (1705). The next Boyle lecturer to write a book focused on physico-theology would be William Derham, who achieved a great literary success with *Physico-Theology, or a Demonstration of the Being and Attributes of God from his Works of Creation* (1713). Derham would be among a few eighteenth century physico-theologians whose work experienced popularity, to be followed by the even greater success of Noël Pluche, whose writing could be found in a good portion of well-stocked libraries over the following half-century.^{xii}

Conclusion

I have argued that empirically detailed writing in natural theology received a particular boost and a specific modern cast in late seventeenth century England. Francis Bacon separated natural theology from natural philosophy early in the century, but his methodological prescription was quite reversed by authors late in the century, most especially Boyle, who nevertheless retained an affinity to Bacon's objectives by underlining the importance and the priority of inquiry into efficient causes over the search for final ones in science. Boyle was skeptical of success for inquiry into final causes particularly concerning what I have called assemblages, but he saw sufficient additional evidence available for some conclusions within scriptural support. His skepticism, I have argued, was not well supported philosophically, which might serve to explain why it was so thoroughly trammelled by later generations, including Pluche, Biberg and Linnaeus. Indeed, Boyle was open to ignoring the caution himself when he begged license to speculate, even in the pasges of the *Disquisition about the Final Causes of Natural Things*:

I am not averse from thinking, that Humane Ends, (or uses that relate to Men,) may have been designed by God in several Creatures, whose *Humane Uses* Men are not yet aware of... And therefore, it cannot sagely be concluded That every thing whose Usefulness to Man is not yet obvious, nay, That every thing that seems hurtful to him, can never be made beneficial to him. ... *Vipers* are Venomous Animals; but yet their Flesh is a main Ingredient of that famous Antidote *Treacle*... As the excessive Rains that cause the over-flowings of Rivers in divers parts of *Africk*, and some other Countries, tho' they seem rather Destructive than profitable, do yet, by their seasonable Inundations, make *Egypt* and some other Countries exceedingly Fertile, that without them would be very Barren.^{xlii}

Boyle might, then, have quietly held a position concerning providence that Pangloss would have applauded.

The context that produced physico-theology was clearly religious and political. It is unsurprising that a large body of Protestant intellectuals well-placed in a relatively peaceful society with a strong tradition of open speech, would develop links between science and

critical discussion of both divinity and the Bible.^{xliii} There were also bounds to the discussion, as Newton, who chose to sit on the sidelines, knew well.^{xliv} Many others on Europe's continent lived much more intimately with religious division as well as the reminder, in 1633, of Galileo's failure to arrange a peaceable arrangement between science and religion.^{xlv} These aspects of the rise of physico-theology have not been the focus of this chapter, which has surveyed the philosophical and social origins found in the English context. Science, philosophy of science and other English philosophical currents – most particularly the theory of ideas and understanding that we are familiar with in its later development by John Locke – were formative for a field that might alternatively have been called 'empirical natural theology.' Prior shifts in religious sensibility that emptied the Book of Nature of much of its content also prepared the ground. Other philosophical and theological currents not discussed here – most notably theories of divine agency and predestination – and other philosophical trends – the rise of Spinoza's challenge to such natural theology on the continent – also had both shaping and limiting influences upon the field.^{xlvi} Finally, philosophers, including natural philosophers, did much more to promote physico-theology than just write about it: Boyle in particular provided a very important launch pad for the further development of an already healthy tradition of natural theology with his named lectureship, which drew the interest of others in the Royal Society, most notably Isaac Newton, and which spawned two of the most influential physico-theological tracts shortly before and shortly after the turn of the eighteenth century.

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ⁱⁱ See, for example, James J. Aimers and Prudence M. Rice, "Astronomy, Ritual, and the Interpretation of Maya 'E-group' Architectural Assemblages," *Ancient Mesoamerica* 17 (2006): 79-96.

ⁱⁱⁱ Noël Pluche, *Spectacle de la Nature* (8 vols., Paris: Veuve Estienne, 1732-1750). Translation is from the 4th English edition, *Nature Display'd*, trans. Humphreys (London: R. Davis *et al.*), Vol. 3: 394. This text and other passages by Pluche that give a taste of his exposition of science may be found in the supplementary readings included in Voltaire, *Candide*, ed. Eric Palmer; trans. unknown (Peterborough & New York: Broadview Press, 2009).

^{iv} Voltaire, Chapter 4, 55.

^v See Voltaire, *Candide*, editor's introduction, 24-26. Voltaire gives a quick kick to Gottfried Leibniz as well, in the first sentence of the quotation.

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- ^{vi} Carolus Linnaeus *et al.*, *Select dissertations from the Amoenitates Academicae: a supplement to Mr. Stillingfleet's tracts relating to natural history*, trans. F. J. Brand (London: G. Robinson, 1781), Vol.1: 74.
- ^{vii} Carolus Linnaeus *et al.*, *Miscellaneous Tracts relating to Natural History, Husbandry, and Physick*, Third Edition, trans. Benjamin Stillingfleet, (London: J. Dodsley, 1775), 98, 123, 123. Stillingfleet attributes all of these texts to Linnaeus as collaborator or sole author and he cites an example in which Linnaeus took as his own words those published under the name of one of his students in the *Amoenitates Academicae*. (v) Some recent scholarship supports that judgment: see John L. Heller, "Notes on the Titulature of Linnaean Dissertations," *Taxon* Vol. 32, No. 2 (May, 1983): 218-252, 245.
- ^{viii} For an introduction to the Bridgewater Treatises see John Robson, "The Fiat and Finger of God: The Bridgewater Treatises," in *Victorian Faith in Crisis: Essays on Continuity and Change in Nineteenth-Century Religious Belief*, eds. Bernard Lightman and Frank Turner (Stanford: Stanford UP, 1990), 71-125.
- ^{ix} David Hume, *Dialogues Concerning Natural Religion* (1779). Immanuel Kant, *Kritik der Urteilskraft [Critique of the Power of Judgment]* (1790). Regarding Darwin's contribution, see Adrian Desmond & James Moore, *Darwin* (New York: Norton, 1994).
- ^x John Wilkins, *Of the Principles and Duties of Natural Religion* (London: Maxwell, 1675), Chapter 4, 39-41.
- ^{xi} Varro, *Antiquitates rerum humanarum et divinarum libri XXI*, a lost work quoted and summarized in Augustine of Hippo, *City of God*, Book 6. Augustine, *The Works of Augustine*, ed. & trans. Marcus Dods, (Edinburgh: T. & T. Clark, 1871), Vol. 1, 239.
- ^{xii} Perhaps Varro, and certainly Augustine, would have classified Wilkins' first topic not as philosophical, but as civil theology, and of no use as support for claims concerning God's existence or nature: see *City of God* Book 6, ch. 6. Wilkins' second topic, argument for the existence of God "From the Original of the World," does touch on the eternity of the world, so there might be overlap with Varro's topics in that respect. But it is reasonable to expect that Varro's reference is to argument that concerns the *necessity* of a first cause or prime mover (e.g., Aristotle, *Metaphysics* 12). Wilkins explicitly restricts himself to probable arguments concerning cosmological topics (Ch.5). His views on whether theology is even capable of necessary argument – of "mathematical certainty," as opposed to "moral certainty" – are difficult to discern, as they are connected to further theological views concerning the possible inconsistency between God's justice in judgment of sinners and a rational compulsion to belief: see Wilkins, Ch.3, point 5, 30-33.
- ^{xiii} Thomas Aquinas, *Summa Theologica*, Ia Part 2 Article 3. *The Works of St. Thomas Aquinas* Second Edition, trans. Fathers of the English Dominican Province (London: Burns Oates and Washbourne, 1920): Vol. 1.
- ^{xiv} Xenophon, *Memorabilia*, trans. H. G. Dakyns (MacMillan & Co. 1894), Ch. 4.
- ^{xv} Francis Bacon, *The Works of Sir Francis Bacon* (London: Bayne & Son, 1844), Book II, 96.
- ^{xvi} Bacon, Book I, 46. The italicized quotation is Matthew 22: 29 or Mark 12: 24.

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- ^{xvii} Thomas Aquinas, *Summa Contra Gentiles*, IV.1. *The Works of St. Thomas Aquinas* Second Edition, trans. Fathers of the English Dominican Province (London: Burns Oates and Washbourne, 1920): Vol. 15.
- ^{xviii} Supporting biblical passages include Job 12:7-9, Romans 1: 19–20, Psalm 19: 1. Raymond Sebond, *La Theologie Naturelle de Raymond Sebon*, transl. Michel de Montaigne (Rouen: Jean de la Mare, 1641), author’s preface, n.p.
- ^{xix} Sebond, 1, 10-14.
- ^{xx} William B. Ashworth, “Natural history and the emblematic world view,” in *Reappraisals of the Scientific Revolution*, eds. David C. Lindberg and Robert S. Westman (Cambridge University Press, 1990), 303-332.
- ^{xxi} Bacon, *Works*, Book II, 104.
- ^{xxii} Bacon, Book II, 106.
- ^{xxiii} Bacon, Book II 46; Book III, 341; Book II, 96, 106, 104; Book I, 8; Book II, 104, 107.
- ^{xxiv} René Descartes, *Principles of Philosophy* I. 28. In *The Philosophical Writings of Descartes*, Vol. 1, ed. & trans. John Cottingham, Robert Stoothoff and Dugald Murdoch (Cambridge: Cambridge University Press, 1985), 202.
- ^{xxv} Abraham Cowley in Thomas Sprat, *The history of the Royal-Society of London, for the improving of natural knowledge*, (London: J. Martyn, 1667).
- ^{xxvi} Henry Power, *Experimental Philosophy*, ed. Marie Boas Hall (USA: Johnson Reprint Corporation 1966), 190-1.
- ^{xxvii} Robert Hooke, *Micrographia, or, Some physiological descriptions of minute bodies made by magnifying glasses with observations and inquiries thereupon* (London: Royal Society, 1665). See pp. 2 (quoted in this chapter), 193-4. Note that Hooke does not refer to his effort as ‘physico-theology’: the noun appears not to have been used at the time, and the adjectival form ‘physico-theological’ may not have settled into the specific meaning that attaches it to argument from design before John Ray’s *Three Physico-Theological Discourses* of 1693.
- ^{xxviii} Wilkins, *Natural Religion*, Chapter 6: 84, 82-4.
- ^{xxix} Wilkins, 102-3, 122-3; quotation 102.
- ^{xxx} Royal Society, “An Abstract of Dr. Wilkins’ Essay Towards a Real Character and a Philosophical Language,” in *The Mathematical and Philosophical Works of the Right Reverend John Wilkins* (London: C. Whittingham, 1802). John Locke, *An Essay Concerning Human Understanding*, ed. P. H. Nidditch (Oxford: Clarendon, 1975), Epistle, p.10.
- ^{xxxi} François Fénelon, *Traité De L'existence Et Des Attributs De Dieu* (1685) in *Oeuvres Philosophiques de Fénelon*, Nouvelle Edition, ed. M. A. Jacques (Paris: Charpentier, 1845), 1; Bernard Nieuwentyt, *The religious philosopher: or, the right use of contemplating the works of the Creator ... designed for the conviction of atheists and infidels...*, trans. John Chamberlayne (London: J. Senex et. al., 1718), i.

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- ^{xxxii} Robert Boyle, *Disquisition about the Final Causes of Natural Things*, in *The Works of Robert Boyle*, ed. Michael Hunter and Edward Davis (London: Pickering & Chatto, 2000), Vol. 11, 81, 83.
- ^{xxxiii} Boyle, 64.
- ^{xxxiv} Boyle, 87; and see a case of Boyle's neglect of middle-sized assemblages at, for example, p. 94. For discussion of Boyle's concerns for teleology vis a vis the third category, the parts of animals (and plants), see James G. Lennox, "Robert Boyle's Defense of Teleological Inference in Experimental Science," *Isis* 74 (1983): 38-52.
- ^{xxxv} Boyle, 146.
- ^{xxxvi} Boyle, 107, 107-8, 96, 151.
- ^{xxxvii} Boyle, 151. "Indagation of *Efficients*": inquiry into efficient causes.
- ^{xxxviii} E. Budgell, *Memoirs of the lives and characters of the illustrious family of the Boyles*, Third Edition (London: Oliver Payne, 1737), Appendix, pp. 25-6.
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- ^{xl} Compare, for example, instruction toward the end of Newton's second letter (January 17, 1693), which appears to have directed Bentley's claims in Lecture 7, p.36. See pp. 168, 210 of *The works of Richard Bentley*, ed. A. Dyce (Francis McPherson: London, 1836), Vol. 3.
- ^{xli} Daniel Mornet notes, in *Les Sciences de la Nature en France, au XVIIIe Siècle* (Paris: Armand Colin, 1911), 31-2, that volumes of *Spectacle de la Nature* appeared in over 40% of auction catalogs in France between 1750-1780. *Spectacle* had great currency in England, where at least twelve editions in two English translations were published by 1758.
- ^{xlii} Boyle, 113, 115, 115, 116.
- ^{xliii} See David R. Oldroyd, *Thinking about the Earth: A History of Ideas in Geology* (London: Athlone, 1996), 47-54.
- ^{xliv} See Stephen Snobelen, "Isaac Newton, Heretic," *British Journal for the History of Science* 32 (1999) 381-419.
- ^{xlv} See Galileo, *Letter to the Grand Duchess Christina*, and note Descartes' hesitation to make available his cosmological treatise, *Le Monde*, in the light of the condemnation of Galileo by Church authorities. Details of this history may be found in Steven Gaukroger, *Descartes' System of Natural Philosophy* (Cambridge: Cambridge University Press, 2002), 19-21.
- ^{xlvi} See all of: Peter Anstey, "Boyle on Occasionalism: An Unexamined Source," *Journal of the History of Ideas* Vol.60 #1 (Jan 1999): 57-81. Margaret Cook, "Divine Artifice and Natural Mechanism," *Osiris*, 2nd Series 16 (2001): 133-150. Jonathan Israel, *Radical Enlightenment*, (Oxford: Oxford University Press, 2001).