‘What (Else) was Behind the Newtonian Rejection of ‘Hypotheses’?

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> [I]t is proper to acquaint you that his great application in his inquirys into Nature did not make him unmindfull of the great Author of Nature; they were little acquainted with him, who imagine that he was so intent upon his studys of Geometry & Philosophy as to neglect that of Religion & other things subservient to it. And this I know that he was much more fellicitous in his inquirys into Religion than into Natural Philosophy; & that the reason of his showing the errors of Cartes’s Philosophy, was because he thought it was made on purpose to be the foundation of infidelity. (Letter from John Craig to unidentified recipient, dated 7 April 1727 Keynes Ms. 132, King’s College, Cambridge, UK.
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> ‘Vain wisdom all and false Philosophy’ (John Milton, *Paradise Lost* II.565).

In Query 27 of the second English edition of his *Opticks*, appearing in 1717, Isaac Newton stated that ‘the main Business of natural Philosophy is to argue from Phaenomena without feigning Hypotheses, and to deduce Causes from Effects.’[1] More than forty years earlier, Newton had professed himself reluctant to advance ‘any Hypothesis of light & colours’ fearing that ‘it might be a means to ingage [him] in vain disputes,’[2] and the *Principia mathematica philosophiae naturalis* of 1687 was proposed as a mathematical demonstration of an attractive force between masses that, in combination with straight line inertial motion, explained the planetary and lunar orbits. By contrast, Descartes’s solution in his *Principia philosophiae* of 1644 to the problem of orbital motion was to say that, although motion was normally rectilinear, God had formed numerous vortices of fluid matter in space that carried the solid planets around in them like planks caught in a whirlpool.[3] Descartes’s solution was

neither a demonstration, nor a mathematical construction, but an explanation based on the closest terrestrial analogy that Descartes was able to think of.

The Newtonian repudiation of hypotheses suggests the existence of a wide methodological and epistemological gulf between Cartesian and Newtonian science, and evidence for such a gulf is not lacking. Roger Cotes, in the Preface to the second edition of the *Principia* (1713), inveighed against the Cartesians who, he complained, 'take the liberty of imagining that the unknown shapes and sizes of the particles are whatever they please, and of assuming their uncertain positions and motions.'[4] Peter Anstey has argued that Newton's declaration should be seen in light of a distinction between speculative and experimental natural philosophy of wide generality and deep consequence that was employed in some form or other in texts produced from the 1650s to the early 1700s. The distinction, he says, provided the 'primary methodological framework within which natural philosophy was developed and practiced in the seventeenth century.' It 'crystallised in the 1690s when opposition to hypotheses in natural philosophy methodology intensified.' It furnished the terms of reference, he says, for interpreting Newton's famous '*hypotheses non fingo*'.[5]

Anstey was careful to point out that the experimental-speculative distinction did not sort individual natural philosophers of the late 17th century into two camps, one composed of those who performed experiments and eschewed speculation and the other of those who speculated and condemned experiment as useless and uncertain. But he went on to suggest that

> These terms [experimental and speculative] 'save the phenomena' of our historical data in a manner that is far more satisfactory than the 'fancies' of nineteenth and twentieth century historiographers. Indeed it may be that the very origins of the categories rationalism and empiricism are to be found in the philosophical deployment of this unduly neglected distinction.[6]

And this suggestion reappears in the more recent article of Anstey and Alberto Vanzo.[7] They point to Diderot's distinction between *philosophie experimentelle* and *philosophie rationelle*, and his predilection for the former, and to some late 18th century criticisms of Kant as a speculative philosopher by empirically-minded German contemporaries.[8]

The concepts of experimental and speculative are unquestionably actor's categories and central to our understanding of the period. The original exposition in Anstey's paper raised a number of questions for further exploration that I would like to address in this paper. As Desmond Clarke observed, '[T]he phenomenal success of the *Principia*…provided a misleading model for the natural sciences, according to which the certainty of mathematical inferences and the certainty of sensory observations compensated for the uncertainty that is necessarily involved in the confirmation of hypothetical explanations of natural phenomena.'[9] Newton himself, he comments, expended 'almost obsessive efforts to avoid admitting that his natural philosophy necessarily used hypotheses.' In light of the following points, one might wonder why Newton and his followers adopted this stance and whether they were justified in doing so:

First, the best-known 'experimental' philosophers—Bacon, Boyle, and Hooke—present speculative philosophy as complementary to and furthered by experiments. Boyle propounded criteria for good hypotheses, entitled a treatise *The Excellency and Grounds of the Mechanical Hypothesis,* and advanced many mechanical hypotheses of his own.[10] What distinguished acceptable hypotheses that had a place in experimental philosophy from unacceptable hypotheses that did not, when all were alike indemonstrable?

Second, 'speculative' philosophy is sometimes identified with scholastic natural philosophy and criticised as empty verbiage, but at other times it is identified with Cartesianism. Descartes was a sharp critic of scholastic natural philosophy as failing to give satisfactory causal accounts of physical phenomena; his micromechanical models inspired the Royal Society experimentalists. Why would he be considered another speculator?

Third, despite his reservations, Newton decided to present his 'hypothesis' of light and colour in 1674. Moreover, his published writings on natural philosophy, including the *Principia* and the *Opticks*, as well as his unpublished alchemical and chronological enquiries, not only abound in references to invisible micromechanisms, but indicate the possession of a free-ranging cosmological imagination that expressed itself in an enthusiastic manner and for which no controlled experimental evidence whatsoever was available. By what right could Newton and his followers claim to eschew hypotheses?

To answer these questions, we need to consider an important factor relevant to the expressed mistrust of hypotheses, namely the role of physico-theology. On the account I propose here, the Royal Society in the second half of the 17th century was not averse to many forms of speculation, and certainly not to the presentation of micromechanical hypotheses like Boyle's springy air particles or John Mayow's nitro-aerial corpuscles, or Newton's supposition that the size and density of the particles of a substance is related to its colour[11] to 'explicate' experimental observations even when there was no possibility of demonstrating them. Further, the Newtonians welcomed experience-transcendent cosmological speculation as legitimating their basic adherence to the mechanical philosophy. The grounds for their suspicion about a certain class of hypotheses were theological, not epistemological in origin. The 'new' mechanico-corpsucular philosophy was an updated version of the old atheistic atomism of Democritus, Epicurus, and Lucretius. The Cartesian account of the world given in his *Principles of Philosophy* was understood all over Europe as a threatening work reviving this old tradition. Although he stipulated that God was the author of nature, the preserver of the human soul, and the guarantor of all correct reasoning, Descartes presented nature as a self-contained mechanical system and the cosmos and the animal as a self-forming and self-maintaining entity. [12]

The Newtonians had to extricate their master—and Newton had to extricate himself—from the accusation that he was going further down the road of elaborating a theory of self-sufficient nature in which—even more alarmingly than in Descartes' cosmology and physics —activity was intrinsic to matter. To ensure that Newtonian natural philosophy was sharply differentiated from putative Cartesian corpuscularian atheism, Newton and his followers attacked the Cartesian accounts of the emergence of the world and its inhabitants as merely hypothetical and promulgated a rival cosmology, the character of which was—necessarily—rather speculative, at least in our own sense. This was accomplished by reintroducing a divine presence and agency into physics to show that 'figures and motions' were radically insufficient to explain the origins of the cosmos, or its maintenance, or life, sensation, and thought. Attraction was treated as a manifestation of God's mysterious but undeniable ubiquity, inexplicable in mechanical terms.

To be sure, the need for conjecture was frustrating for the first generation of 17th century neo-corpuscularians who had hoped to see with their microscopes the

corpuscular substructure of the world, or to infer by it Baconian methods. Yet, it was seemingly—and in reality—the way forward. There were profound and lingering effects of the Newtonian pronouncements, but they did not crystallise opposition in the sense either of staunching the promulgation of hypotheses or discouraging speculation (as distinct from furnishing a misleading model of scientific methodology) across the board. For the 17th and 18th centuries, then, there is little sign of a sharp cleavage between a stream of proper scientific method involving experiment and mathematical demonstration and a stream of hypothetical reasoning. Rather, there is ongoing anxiety over the truth status of the Christian revelation leading to a condemnation of deistic hypotheses awarding self-organising powers to matter. Nevertheless, the empiricism-rationalism distinction, which is not an actor's category, but one constructed by later historians, does capture, as I will explain later, two divergent ways of dealing with the threat of the elimination of Providence in a theory of self-sufficient nature, two ways often pursued by one and the same natural philosopher.

1. Experimental and Speculative Philosophy

Anstey describes experimental natural philosophy as 'the collection and ordering of observations and experimental reports with a view to the development of explanations of natural phenomena based on these observations and experiments' and speculative natural philosophy as 'the development of explanations of natural phenomena without prior recourse to systematic observation and experiment. '[13] The term 'experimental philosophy' is ascribed to Samuel Hartlib who employed it in 1635, but the notion is implicit in Bacon, as he observes. In his influential *De dignitate et augmentis scientiarum* (1623), Bacon distinguished between 'operative' and 'speculative' undertakings.[14]

The experimental-speculative distinction as applied to natural philosophy is evidently derived from the earlier distinction between practical and speculative forms of knowledge-seeking or just thinking. Experimental natural philosophy came to be understood as involving multi-sensory experience of sights, smells, colours, tastes, and hands-on practice employing machines, optical and measuring instruments, surgical tools, and specially fabricated devices such as mirrors, flasks, tubes, and furnaces. The distinction remains neutral, however, as Anstey himself points out, in

many contexts throughout the 17th century, with practice and speculation presented as good friends to one another. Bacon himself maintained that 'true and fruitful natural philosophy' required both, 'first ascending to axioms, then descending to works.'[15] His distaste for the verbal philosophy of the schoolmen and the fantasies of the chemical philosophers thus lies in a different critical plane from his operative-speculative distinction. There are purely classificatory references in the literature of the period to speculative geometry and practical, speculative physiology and practical, to speculative and practical atheism,[16] and even speculative and practical self-pollution.[17] Archimedes, for example, was praised for 'his divine knowledge, both in the Speculative and Practical part' –the former comprising his mathematical methods and demonstrations, the latter his inventions, such as 'Engines for peace and war.'[18] Burgess, in his treatise of original sin (1654) declared that despite man's polluted state, he retains 'some imbred principles both speculative and practical, which can no more be separated from the soul, then the beams from the Sunne.'[19] And Locke contradicted this claim in 1689, arguing against this view noting however that 'There is nothing more commonly taken for granted, than that there are certain Principles both *Speculative* and *Practical* (for they speak of both) universally agreed upon by all Mankind….'[20]

The official ontology of the Royal Society experimentalists, the 'corpusculo-mechanical philosophy,' implied the conjunction and complementarity of speculative and experimental. Boyle and Hooke both conceived hypotheses as necessary and complementary to experiment and observation for providing the understanding and control that they were seeking. Hooke's *Micrographia* (1665) interwove his detailed observations of insects, plant parts, and artefacts, with his conjectures about how effects are produced by subvisible causes. Elsewhere, Hooke speculated about memory, employing the analogy of phosphorus, which absorbs and remits light;[21] about the extinction of ancient animals;[22] about the causes of combustion,[23] and about many other phenomena not amenable to controlled experimentation. He referred to what he termed the 'speculative and rationall part' of any artisanal practice. Defending his literary practice, and anxious to be considered, despite his subaltern status as a demonstrator for the Royal Society, as the gifted mathematician and physicist he was, he asserted that it would be 'more advanced by teaching 'perpetuall and universal knowledge' than by teaching mechanical knowledge; that when

lecturing on trades, practices and industrial production, one ought to discuss reasons and causes, and begin with 'first principles;' and that his own pursuit of 'unheard of discoveries and inventions,' ought not to be interfered with and that he should be allowed to follow his 'fancy.'[24]

Boyle alternated between experimental reports and conjectures regarding invisible mechanisms, offering, in his treatise on Colours (1663) 'divers new *speculative* Considerations and hints, which perhaps may afford no despicable Assistance towards the framing of a solid and comprehensive Hypothesis,'[25] He testified to the usefulness of his investigations for painters and dyers, but he kept his eye on the other side of the speculative-experimental divide as well.[26] 'Since we are treating of Emphatical Colours,' he declared, 'we shall add what we think not unworthy of your Observation, and not unfit to afford some Exercise to the Speculative.'[27] He stressed, as did Bacon, that he could supply only a few suggestions, leaving most of the work for future inquirers armed with more and better systematized data.[28] In his *Free Enquir*y (1686), Boyle remained persuaded that the 'framing a right or a wrong *Idea* of *Nature* must be in Reference both to the Speculative and Practical Part of Physiology.'[29]

At the same time, disparaging references to 'empty Conjecturalists;[30] the philosophy of Notion and Dispute, *which still runs round in the Labyrinth of Talk, but advanceth nothing*'[31] and 'the meer Speculative Philosopher;'[32] abound in the programmatic writings of those early Royal Society figures who were less involved with day-to-day experimental practice than were Boyle and Hooke. And, from the early 17th century, a valorisation of praise for immediate experience and engagement with 'things' circulates between theology, pedagogy, and natural philosophy. Books, words, arguments, logic, and disputations are all downgraded.[33]

2. 'Vaine Philosophy' and Cartesian Fantasy

A long literary history important for understanding this issue opposes Christian doctrine to 'vaine philosophy.' Philosophy was declared by theological writers to be marred by sectarian contradiction and conflict, infected by pagan naturalism, and uncertain by contrast with the unique truth of Revelation. Indeed, as a machine-based survey of book titles and contents will quickly confirm, the term

'truth' was principally used in theological contexts and was not associated in the 17th century, except, notably, by Descartes and the Cartesians,[34] with knowledge of nature. Early modern texts are replete with references to refer to the 'emptieness of vain philosophy;' [35] to 'soules polluted with this vayne Philosophie,'[36] to the 'poysoned distinctions,' of 'vaine philosophie,'[37] to the subtleties and sophistries of vaine philosophy;[38] to those seduced and spoiled or blinded or bewitched by vaine philosophy. [39] As it is difficult to see scholastic discourse as beguiling, poisonous, and polluting, rather than as boring or of no practical use, these epithets need to be understood as directed to pagan nature philosophy specifically. Incessantly, the critics of philosophy echo or slightly misquote Paul's warning in Chapter 2 of his Letter to the Colossians,

> Beware lest any man spoil you through philosophy and vain deceit, after the tradition of men, after the rudiments of the world, and not after Christ.

Who were the deceitful philosophers of Paul's era? They may have been magicians and astrologers, fixated on the stars and fate,[40] or, as Calvin supposed, the Platonic speculators, like pseudo-Dionysius, who discoursed of angels and celestial hierarchies.[41] But Paul was also familiar with the writings of Stoics and Epicureans, with whom he carried on a confrontational relationship. In any case, Christian theology had little love for the ontological and eschatological doctrine of the main schools of ancient philosophy, and even Aristotle was recruited to the cause with much residual difficulty.[42] Philosophy can be vain because it is empty and notional, but this is not what Paul has in mind. It can also be vain because it overrates the powers of nature and is engaged with and curious about material things, natural causes, and the 'rudiments of the world' to the neglect of Providence, divine agency, and spiritual things.

As Anstey notes, Boyle lists Leucippus and Epicurus, along with Aristotle, and the so called Italian naturalists, Telesio and Campanella as 'speculative Devisers of new hypotheses.' [43] The association between materialistic pagan ontologies, conflict and uncertainty, and 'hypotheses' was ubiquitous in theological writing of the mid-17th century. Samuel Annesley conceded that God has left 'some Idea's or Footsteps of himself on the things that are made,' so that the hypotheses of Aristotle, Epicurus, Gassendi, and Descartes all solved some phenomena, but, he complained, they conflict with one another, and the Works of God are ultimately

incomprehensible.[44] Boyle, in one of his doubting moods, tried to persuade the reader (and himself) not to 'flie from the Difficulties that attend the granting of a Deity and Providence to Hypotheses, whether Epicurean or other, that are themselves incumber'd with confounding Difficulties.'[45] He declared that with regard to 'the Hypotheses and Opinions of the several Sects of Philosophers, especially in those points wherein they hold things repugnant to Theological truths, we shall find many of them so slightly grounded, and so disagreeing among themselves' that they warrant neither their acceptance nor the rejection of Christianity.[46]

Robert Dixon stated in his book (1676) on *The nature of the two testaments* that 'here will be no tottering Hypotheses, nor crooked Conclusions…' And Theophilus Gale (1677) attacked 'that conceited, windy, empty, speculative Knowledge of Philosophie [that] does but puffe up the mind and fil it with Pride, Vanitie and Ostentation, which is but conceited ignorance…. an Epidemic Disease and Universal Contagion, which tainted al Pagan Philosophie and Philosophers.'[47] He quoted the 3rd century Christian apologist Marcus Minutius Felix as saying that although 'proud and vain Philosophie' received its first rudiments of theological knowledge from 'the sacred Oreacles,' yet it hath ever rejected, yea opposed the same, endeavouring by its vain and curiose searches into sacred Mysteries, to comprehend and reduce the same to the measures of its proud conceivings.'[48] Francis Gastrell (1697) said that the 'General Proof of Religion,' can 'stand good, no particular difficulties either in the real Phenomena of Nature, or in the arbitrary Schemes and Hypotheses of Men,' especially those concerning the 'Origin, Duration, and present state of the World.' [49] In 1700, Robert Jenkin in *The Reasonableness and Certainty of the Christian Religion,* accused men who had too much Philosophy and no Religion of seeking 'New and Surprising' Hypotheses, and 'New Systems of the World' especially a 'New Account of the Origin of the Universe' which will become 'as common as New Romances.'[50]

Bishop Stillingfleet's massive *Origines Sacrae*, the first of whose five editions appeared in 1662, confirms the suspicion that the most mistrusted speculative philosophy of the second half of the 17th century corresponded to the vainest of all the vain philosophies of the ancients. Stillingfleet contrasted their '*jejune unproved hypotheses* in *Philosophy*,' which threatened the doctrines of '*Creation, Providence,*

if not *immortality* of *souls*, and the *Being* of *God* himself,' with the '*sublimer mysteries* of the *Trinity, Divinity* of *Christ, Resurrection*.'[51] At issue for Stillingfleet as well was the Mosaic history of the world versus that of the '*Philosophers* in their *speculations*.'

> It was certainly the great defect of the *natural philosophy* of the *Greeks,* (as it hath been ever since in the world) that they were so ready to form *Theoryes* upon some *principles* or *hypotheses* which they only received by *Tradition* from others, without fetching their *knowledge* from the *experiments* of nature; and to these they *suited* all the *phenomena* of *nature;* and what was not *suitable* was rejected as *monstrous* and *Anomalous: Truth* and *Antiquity wrestle* so much with the *corruptions* which eat into them through the *pride* and *ignorance* of the *Greeks.*[52]

The chief criminals in this regard were 'the '*Aristotelian and Epicurean Atheists*.' We find, Stillingfleet said,

> the *reasons* on which they *reject* a *Deity* so lamentably *weak,* and so easily *retorted* upon themselves, and the *hypotheses* they substitute instead of a *Deity* so *precarious, obscure* and *uncertain,* that we need no other argument to evince the *reasonableness* of *Religion,* then from the manifest *folly* as well as *impiety* of those who oppose it.[53]

Where the origins of the world and its atomic composition were concerned, Stillingfleet insisted that 'this *Hypothesis* of *Epicurus* was very *precarious,* and is built on no *foundation* of *reason.'* [54] Worse, the willingness of corpuscularians to accept precarious, obscure, hypothetical reasoning—presumably forsaking sense-experience, revelation, and authority—has led them to assign religion to the category of the unproved and hypothetical:

> I may confidently say the great *gullery* of the *world* hath been, taking *philosophical dictates* for the *standard of reason,* and *unproved hypotheses* for certain *foundations* for our *discourse* to rely upon. And the seeking to reconcile the *mysteries* of our faith to *these,* hath been that which hath almost *destroyed* it, and turned our Religion into a meer *philosophical speculation.*[55]

Joseph Glanvill for one protested against the attempted interference of the clergy with experimental philosophy.[56] But to fend off such attacks on the new philosophy under its experimental and speculative headings, it became increasingly important to respond to accusations of impiety and to dissociate it from the ancient pagan materialism and atheism from which it had in fact taken a good deal of inspiration.

It is in this light that Sir Robert Moray's ban on speculation in the Royal Society regarding 'Originall causes' is to be understood. 'This Society,' he asserted, 'will not own any Hypothesis, systeme, or doctrine of the principles of Naturall philosophy, proposed or maintained by any Philosopher Ancient or Moderne, nor the explication of any phenomenon, where recourse must be had to Originall causes,…'[57] The question of the origins of the world and of its plants and animals were here as well the central focus of concern, and Descartes's hypotheses furnished the provocation.

3. The Trouble with Cartesianism

Descartes was not, as noted, a purveyor of 'notions' or empty verbiage. The Baconian criticisms did not apply to him in this regard. But the sincerity of his arguments for the existence of God and the immortality of the soul were widely questioned. He was seen as prideful, as a modern exemplar of vain philosophy, and as engaged in forbidden speculations regarding the origins of the world and of animals. His own protective references to his account of the world as a 'fable' or, alternatively, as only the most likely reading of the code of nature, or even as just false furnished ammunition to his critics.

In *Le Monde*, first published in Paris in 1664,[58] but written much earlier, Descartes invited the reader to allow his thoughts to 'wander beyond this world to view another world –a wholly new one which I shall bring into being before your mind in imaginary spaces' [59] and the fictional device was employed again in the *Principia philosophiae*, published in Amsterdam in 1644 and in London in 1664.[60] There, Descartes stated that 'there is no doubt that the world was created right from the start with all the perfection that it now has,' with sun, moon, stars, and Adam and Eve as fully grown adults.' However, if we want to 'understand the nature of plants or of men,' he suggested, we should 'consider how they can gradually grow from seeds:'

> Thus we may be able to think up certain very simple and easily known principles which can serve, as it were, as the seeds from which we can demonstrate that the stars, the earth, and indeed everything which we observe in this visible world could have sprung. [61]

'The falsity of these suppositions,' he added, referring to his assumptions regarding matter and motion and the first instants of creation, 'does not prevent the consequences deduced from them from being true and certain.'[62] There followed the exposition of his applied physics which was supposed to account for everything from celestial motion to magnetism, to fire, snow, and the formation of salt. The formation of the foetus from particles in motion was a subject reserved for another book.

On Descartes's 'philosophical' principles, God lays down the eternal truths – logic, mathematics, the laws of motion—and creates matter, which, once its parts are set in motion, is at first distributed into parcels chaotically (or, as the later version of the *Principles* has it, uniformly, and so in a more orderly manner befitting God).[63] That is all God ever does. Everything else –the formation of the cosmos and the world, the appearance of plants and animals, generation and growth, everything that happens in a person's mind except their volition, rational cognition, and invention unfolds without assistance or intervention from then on.[64] Descartes's 'original principles' are the doctrine that there is nothing in external objects except shapes, sizes, and motions and that sensations are produced by the motions they set up in our nerves which give rise to or are correlated with ideas in our minds. He disclaimed any particular connection with Democritus (though he professed to admire Epicurean morality in his private letters), insisting that his ontological framework was non-sectarian and in fact the 'oldest and most common of all.'[65] Nevertheless, the well-founded suspicion that Descartes was a neo-pagan, a self-confessed representative of deceitful philosophy, was widespread both on the Continent and in England, as is evident from the outcries of his many late 17th century critics.[66]

Clearly Descartes was overreaching himself, and his rhetoric contrasts with the cautious, apologetic formulae of Boyle operating within the same corpusculo-mechanical framework.[67] He claimed in the *Principles of Philosophy* that 'there is no phenomenon of nature which has been overlooked in this treatise'[68] and that 'if people look at all the many properties relating to magnetism, fire and the fabric of the entire world, which I have deduced in this book from just a few principles' they will at least

be impressed by his explanatory achievement.[69] Once his framework is accepted, he declares, 'all the other phenomena, or at least the general features of the universe and the earth... can hardly be intelligibly explained except in the way I have suggested.'[70] But it is what Descartes did not say in his various treatises that was as telling—sometimes more telling—than what he did say. Although his *Meditations* were carefully contrived to prove the existence of God and the immortality of the soul, Descartes's proofs for the existence of God did not mention visible nature. He discussed rather his own origins and the origin of his idea of God, and then he rehashed the ontological argument of Aquinas. His argument for the immortality of the soul was similarly divorced from the observation of nature. It is perfectly abstract (the 'real distinction argument'). Descartes failed to say what natural philosophers were supposed to say to establish their *bona fides*, that visible nature testified to the existence of a caring God and that providential planning; that the existence of the immortal human soul was revealed by Scripture and did not need to be proved by abstruse and roundabout logical arguments. In making God to be the condition of all exchanges of motion in the universe, Descartes prevented God from doing anything outside the ordinary course of nature.

If we look upon Descartes' suppositions, said Sir Matthew Hale in *The Primitive Origination of Mankind* (1677),

> what colour of evidence have we of the various Configurations of his Atomes, the grinding of them round by their mutual attritions, the coalition of the Globular Atomes into the Heavenly Bodies, the filling of Chinks and Interstices by the *Ramenta* of the greater, whereby a *Materia Subtilis* is diffused through the Universe, which is invisible, performs most of those motions that we see in things, that the Animals are only Engins, and actuated by the mobility of this subtil matter? These, and infinite more artificial Inventions of his there are, that neither Sense nor Reason could ever acquaint him or us with; but they are an ingenious Creature of his own fruitful Invention, wittily framed to explicate not so much the Nature of things, but those Conceptions he entertained thereof, and to reduce and range them into an Order contrived by him, not by Nature.[71]

Hale went on to evoke the Baconian distinction between solutions of the phenomena derived directly from reality and the products of the human imagination, including systems of the world and explanations of particular phenomena

> And hence it is, that if we consider the various *Hypotheses* of the ancient and modern Philosophers, touching the general Systeme of the World, and those more Universal and Cardinal Solutions of the common and great Appearances in Nature, we shall find them or the greatest part of them, to be little else than excogitated and invented Models, not so much arising from the true Image of the things themselves, or resulting from the real Existence of them, as certain instituted and artificial Contrivances of mens Wits and Fancies. And these Suppositions being thus invented, they distort, stretch and reduce the Orders of things in a conformation to those pre-conceived Suppositions. [72]

And John Cockburn in his *Enquiry into the nature, necessity and evidence of Christian faith* (1699) piled on the criticism, declaring that in laying down hypotheses, Descartes had 'turned his Back upon the only true Light that was to have guided him; he has groped in the Dark and produced nothing but useless Conjectures and the extravagant Ravings of the Brain, which tickled Men at first, as all Novelties use to do, but which wise, inquisitive, and thinking Men-will, and must disgust, because there wants Solidity.'[73]

Accordingly, the careful probabilistic language of the Royal Society,[74] implied not only a newly sophisticated, fallibilist approach to methodology, but a concern not to invade the realm of the Truth with vain philosophy. This policy did not exclude bringing Truth into alignment with speculative hypotheses about the nature of the universe.

Cartesianism's lacunae and its substitution of dubious abstract reasoning for physico-theological extrapolation produced a bouquet of corrective metaphysics which conceded mechanism a partial, but only a partial role in physics and physiology. Henry More and Ralph Cudworth were concerned to add on subordinate spiritual agents such as hylarchic principles and plastic natures and to insist on divine planning, supervision, intervention and even permeation of nature. G.W. Leibniz claimed that the metaphysical substratum of corpuscularian physics was vital and

mental and that the world was specially selected by God. Their advocacy of the corpuscularian hypothesis as the partial though not the exclusive truth enabled *these* speculators and propounders of mere hypotheses to escape the unfortunate branding of vain philosophy. They provided assurance of the philosophers' commitment to providential design and final causes—the antithesis of Epicurean chance and vain philosophy. As Pierre Gassendi had earlier, Boyle stepped into the role of apologist, lacing his physico-chemical treatises with references to God, and treating the transcendental subjects not amendable to experiment and conjecture—soul, God, life after death, and the origins of the world –as best he could. He presented a counter philosophy—his providential universe. And he elaborated this picture in numerous essays—the *Free Inquiry*, the *Usefulness of Theology*, and the *Christian Virtuoso*.

Like the other revisionists just cited, Newton added even more speculative elements, in the form of active powers, to the spare Cartesian system of matter and motion in the Queries to his *Opticks*, 'Have not,' he asks, 'the small Particles of Bodies certain Powers, Virtues, or Forces by which they act at a distance… upon one another for producing a great part of the Phaenomena of Nature? For it's well know that Bodies act one upon another by the Attractions of Gravity, Magnetism and Electricity… and… there may be more attractive Powers than these. For Nature is very consonant and conformable to her self.'[75] Speculations of this type were permissible because theology and non-material powers were carefully and explicitly built into them.

Newton's own optical theory of 'fits'[76] was intended to be visualized in corpuscularian terms, as was his account of the solution of gold and silver in *aqua regia* and *aqua fortis*, which he discusses in the same terms as the mechanical philosophers—probably Hartsoeker and Lemery—whose chemical writings Cotes meant to disparage.[77] But regardless of his favourable attitude towards atomism,[78] his early fascination with and use of Descartes's *Principles*, [79]and his own theological unorthodoxy, [80] Newton did not want to be identified as a developer of Cartesianism.[81] He was well aware of the Pauline sentiment, which he quotes several times, commenting:

> By philosophy & vain deceipt after the traditions of men [Paul] understands the opinions of old Philosophers handed down by tradition concerning the origin & nature of body & spirit, the origin of the world, the origin nature number {sons}

power qualities & actions & genealogies of the Gods, the preexistence & transmigration of souls & doctrines of Ghosts or Dæmons & all other philosophical doctrines or opinions not revealed whether they be false or uncertain. All disputes about these matters are in respect of the true religion & the salvation of mankind, vane bablings & oppositions of science falsly so called, & therefore are here forbidden by the Apostle.[82]

4. Newton and the 'Confutation of Atheism'

Newton's famous Descartes-condemning General Scholium added to the second edition of the *Principia,* begins with the observation that 'the hypothesis of vortices is beset with many difficulties'.[83] Newton could see, what initially escaped both Leibniz and Huygens for all their mathematical brilliance, that vortices could not work for physical reasons. But an equally serious problem with the vortex theory was that it depicted a self-sufficient mechanical system; it was the fundamental element of Descartes's overall self-sufficient mechanical system that included soulless animals and human survival machines. What might have counted as a defect of Newton's own account—that the cosmos was not self-sustaining and that Mercury and eventually all the planets would eventually crash into the sun—was converted into a virtue: proof of God's power and care in not letting this happen. The General Scholium rushed to establish in paragraph 3 that 'this most beautiful System of Sun, Planets, and Comets, could only proceed from the counsel and dominion of an intelligent and powerful being' [84] Newton assures us that God rules all things 'not as the world soul, but as the lord of all', that he is 'Omnipresent, not only virtually, but also substantially.' When he goes on to insist that gravity is not a hypothesis that he has feigned, but a deduction from the phenomena, his point is continuous with what went before. Gravity is an element of the divinely-fashioned order of a personal God, not, as one might otherwise suppose, an alternative that substitutes for it. Attraction was not, he emphasized in his famous letter to Bentley, an intrinsic property of matter,[85] as the Epicureans supposed the weight and motion of atoms to be. 'The hypothesis of deriving the frame of the world by mechanical principles from matter spread evenly through the heavens [is] inconsistent with my system.'[86]

In the *General Scholium*, Newton expounded his view of God's nature and presence in the world in a lengthy paragraph. Then, after pronouncing his famous *non fingo,* the next paragraph asserted, speculatively:

> '…[A]nd now we might add something concerning a certain most subtle Spirit, which pervades and lies hid in all gross bodies; by the force and action of which Spirit, the particles of bodies mutually attract one another at near distances, and cohere, if contiguous; and electric bodies operate to greater distances, as well repelling as attracting the neighbouring corpuscles; and light is emitted, reflected, refracted, inflected, and heats bodies; and all sensation is excited, and the members of animal bodies move at the command of the will, namely, by the vibrations of this Spirit, mutually propagated along the solid filaments of the nerves, from the outward organs of sense to the brain, and from the brain into the muscles.'[87]

Newton admitted that '[W]e [are not] furnish'd with that sufficiency of experiments which is required to an accurate determination and demonstration of the laws by which this electric and elastic spirit operates.' The vibrational Spirit was an hypothesis, a far wilder, more imaginative, more speculative hypothesis than anything propounded by the Cartesians. But, embedded as it is in a proper theological discourse, it wasn't the kind of hypothesis to be found in vain philosophy.

The message that physical science leads to an understanding and appreciation of God and not away from Him was reinforced in the Queries to the *Opticks*, where Newton cited observational data from the surface of the world. 'The Uniformity in the Bodies of Animals… [a]lso the first Contrivance of those very artificial Parts of Animals, the Eyes, Ears, Brain, Muscles… and other Organs of Sense and Motion; and the Instinct of Brutes and Insects, can be the effect of nothing else than the Wisdom and Skill of a powerful ever-living Agent.'[88] These additions were successful in the eyes of his followers. In his 'Plan of Education for a young Prince,' Andrew Ramsay recommended Newtonianism with its 'ethereal fluid that pervades all Things' 'purer than Light itself, …the Body of God,' that is 'like the Sensorium of the Deity.' This metaphysics, he said, will elevate the mind and teach it to despise 'all these imaginary, dark, and impious Systems that tend to explain Nature by blind mechanical Springs, without the continual influence and Action of a sovereign intelligent Cause.'[89]

To summarise, while Cartesianism was criticised for presenting imaginary micromodels, its models in fact differed from those favoured in mainstream Royal

Society experimental philosophy, and in his own epistemological stance towards them Descartes was far from being the certitudianarian he purported to be in metaphysics. Cartesian 'speculation' was less fanciful than Newton's own, outside of the strictly 'mathematical philosophy' portions of the *Principia*. But as an accurate appreciation of Descartes's beliefs and intentions took hold in English as well as other European circles, and as it became clear in what direction Spinoza had taken the Cartesian philosophy, the dissociation of Newtonian physics, methodology and implications from that of the Cartesians became a priority. The English responded by asserting a commitment to Providential regulation, creationist physico-theology, and spiritual principles active in nature, and by treating Newtonianism as a 'confutation of atheism.' The eight Boyle lectures of 1692 by Bentley,[90] the sixteen sermons of Samuel Clarke in 1704-5[91] and the 'Astro-theology' of William Derham (1714),[92] fall within this category.

5. Rationalism and Empiricism?

Anstey suggested that the experimental-speculative distinction might have given rise to the division between empiricism and rationalism, and in the next-to-final section of this paper I want to address that claim.

It is a commonplace that no 17th or 18th century philosopher self-identifies as an empiricist or as a rationalist. Apart from a mention in Bacon, the term 'empirici' and its cognates appear in only a sprinkling of English writers, none of them canonical, before the mid-19th century. Leibniz contrasted his own Platonism with Locke's alleged Aristotelianism, but the term *philosophia rationalis* referred amongst 18th century textbook writers to logic and epistemology, not to the polemical stance associated by Leibniz with Platonism's invocation of abstract ideas and incorporeal substances. Diderot's reference to *philosophie rationnelle* to refer to metaphysics also appears to be isolated, though a posthumous work of 1836 by Joseph de Maistre employs the term in its title contrastively. [93] When the terms are used earlier, the sense is not the modern one.[94]

These philological points do not affect the claim under discussion, that 'empiricism' in our sense evolved from anti-rationalist, in our sense, experimental philosophy. However, that claim is, I believe, defeated by the observation that the so called rationalists—Descartes, Leibniz, Spinoza cited the results of experiments and observations in physiology, optics, natural history, anatomy, microscopy, etc.

frequently as vindicating or illustrating their metaphysical claims. By contrast, Locke and Hume, with their preference for naked-eye observation, made no such extrapolations. Locke was on the experimental sidelines, even with his medical degree, and the superempircist Hume completely outside experimental practice. Both empiricists emphasize the *limits* of experimentally derived knowledge.

Nevertheless, there is something profoundly right about the association between rationalism and philosophical invention, indeed, between rationalism and the fantastic. Instead of reflecting an armchair vs. hands-on orientation, 'rationalism' and 'empiricism' can be seen as constituting divergent responses to the anxiety—in the natural philosopher's own case or in that of their readers and observers—over the implications of the mechanical-corpuscular philosophy for religion and morality.

The rationalist way of responding was to insist that philosophy had a form of access to the truth that did not depend on the senses alone but on the grasp of certain logical implications and necessary conditions and in doing so to develop new conceptions of God, the soul, and the life to come that could frame or be dovetailed with the experimental-mechanical philosophy. The imagination was allowed to rove freely in constructing these accounts even when they were presented as rigorous deductions. The Cartesian Malebranche made all perception and motion take place 'in God;' Spinoza adopted the framework of Cartesian mechanism but made every finite substance a mode of God. Leibniz took over the corpuscularian philosophy but designated immortal, incorporeal monads, elements of the best possible world, as its true rudiments. Kant proposed a noumenal world where free will and vital principles reside and declared God and the soul to be conceptually indispensable 'ideas.'

The way in which those whom we think of as the canonical empiricists dealt with the perceived threat to morality and religion was altogether different. It was to ban or severely limit discourse about experience-transcendent objects, not only about God and the soul, but also about 'matter.' We cannot discover how the corpuscular constituents of things may be arranged and what they may be doing to produce the appearances, or where thinking comes from, or even if it arises from the brain, as Locke himself supposed it may well, because all this is beyond the bounds of sense. For Hume, we have absolutely no idea what matter or the soul might be, and Kant's critical philosophy denied that we have knowledge and can make 'determinative judgements' about God, the soul, the ultimate constituents of the universe, and its original beginnings. Kant's so-called reconciliation of empiricism and rationalism,

was a combination of the two strategies of inventiveness and critique that quelled his worries about the foundations of morality and the social impact of naturalism and atheism.[95]

The third response, adopted by those philosophers who have always resisted incorporation into the two pedagogical categories of rationalism and empiricism, was to carry on with experiment and speculation as to the powers of matter and to frame naturalistic accounts of the origins of morality and political order. Diderot's rejection of *philosophie rationelle*, the professed admiration of the French Encyclopaedists for Bacon and Locke as experimental-experiential philosophers[96] and Buffon's anti-Leibnizianism, were consistent with the development of Cartesian-Newtonian hypothetical speculation about invisible mechanisms and active powers.[97] The *philosophes* advanced hypotheses, rather lightly rooted perhaps, but rooted nevertheless, in experiment and observation, on the origins of the world, the mechanisms of generation, and the distribution of sensitivity in nature; they are proponents of active matter, epigenetics, and transformism. Now, however, these speculations were turned against 'superstition,' i.e. religion, which, in a reversal of its old status as the Truth, exactly as Stillingfleet had commented, was presented ever more explicitly as a fiction invented and sustained by the human imagination.

6. Theism and Empiricism

The English attitude towards imagination, fancy, and speculation in scientific contexts may help to explain, finally, an important and curious phenomenon, namely the hostile reaction to Darwinism on the publication of the *Origin of Species* in 1859 and the *Descent of Man* in 1871, by contrast with the more favourable reception in Scotland, France and Germany. Darwin was straightaway accused of 'baseless vapourings of scientific credulity.'[98] As T.H. Huxley described it in his essay on the reception of Darwinism, '[Y]ears had to pass away before misrepresentation, ridicule, and denunciation, ceased to be the most notable constituents of the majority of the multitudinous criticisms of his work which poured from the press.'[99] British naked-eye empiricism and theology continued their longstanding alliance and made common cause here against a purely qualitative theory dependent on a purely conceptual analogy between the breeder and Nature. Even in 1871, the reviewer for the *Lancet* made the old connection between speculation and atheism:

> Until Mr. Darwin can overcome the strong evidence that undoubtedly exists adverse to his views, he cannot hope to carry conviction to the minds of those even disposed to accept the bold flights of a speculative mind. To those, on the other hand, who would require testimony of the strongest possible kind to substantiate views so utterly opposed to their conception of man's mental and moral attributes, and the responsibilities which the possession of them necessarily entails, Mr. Darwin's array of facts must appear quite inadequate, and his reasoning from them inconclusive, if not altogether false.[100]

Yet outside of England, the natural philosophers of the late 18th and early 19th century had embraced, or at least entertained such theses as materialism, transformism, an aged earth, and the natural formation of the cosmos. With Kant a notable exception after his highly speculative pre-critical period, they had addressed the problem of 'originall causes' with great enthusiasm. The Comte de Buffon—who claimed to be a Newtonian remaining on the surface of a veiled nature—was a shining and influential example, through his experiments on generation, his theory of organic molecules and 'moulds,' his studies of speciation, and the inferences he drew from geological evidence regarding the formation of the earth and the appearance of successive forms of life over the eons.

There are many differences in the Continental and English contexts to explain this difference of reception of Darwinian biology in England. One might point to clandestine nature of French publishing and distribution in the 18th century, which actually encouraged the promulgation of extreme, anonymous views, the clerical character and prestige of the English universities, and the post-Revolution association between terrorism, socialism and free-thinking, and materialist transmutationism. But I suggest that the success of Newton and the Newtonians in 'disappearing' the conflict between natural philosophy and theology via a combination of empiricistic and even phenomenalistic strictures on scientific methodology, and observation-based physico-theology may help to explain this striking division.

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[25] Robert Boyle, *Experiments and Considerations Touching Colours* (London: Printed for Henry Herringman, 1664) Preface.

[26] 'The emergency, *Pyrophilus*, of Colours upon the Coalition of the Particles of such Bodies as were neither of them of the Colour of that Mixture whereof they are the Ingredients, is very well worth our attentive Observation, as being of good use both Speculative and Practical,' *Experiments and Considerations*, p. 231.

[27] Boyle, *Experiments and Considerations*, p. 230. 'I shall *insert* an *Essay,* as well Speculative as Historical, of the Nature of Whiteness and Blackness, that you may have a *Specimen* of the History of Colours, I have sometimes had thoughts of...' 'I doubt not but the Curious will quickly obtain a better Account of Colours, than as yet we have, since in our Method the Theorical part of the Enquiry being attended, and as it were interwoven with the Historical, whatever becomes of the disputable Conjectures, the Philosophy of Colours will be promoted by the indisputable Experiments.' Ibid. p. 3.

[28] 'For first, as I elsewhere declare, it was not my chief Design to establish Theories and Principles, but to devise Experiments, and to enrich the History of

Nature with Observations faithfully made and deliver'd; that by these, and the like Contributions made by others, men may in time be furnish'd with a sufficient stock of Experiments to ground *Hypotheses* and *Theorys* on. And though in my *Physico-Mechanicall* Epistle and my *Specimens* I have ventur'd some Conjectures also at the Causes of the *Phaenomena* I relate, lest the Discourse should appear to inquisitive Readers too jejune; yet (as I formerly said) I propos'd my Thoughts but as Conjectures design'd (though not only, yet chiefly) to excite the Curiosity of the Ingenious, and afford some hints and assistance to the Disquisitions of the Speculative.' Boyle *A defence of the doctrine touching the spring and weight of the air…* (London: Printed by F.G. for Thomas Robinson, 1662), Preface.

[29] Boyle, *A Free Enquiry into the Vulgarly Receive'd Notion of Nature*, (London: Printed by H. Clark for John Taylor, 1685/6) Preface.

[30] Henry Power, *Experimental philosophy, in three books containing new experiments microscopical, mercurial, magnetical …* (London: Printed by T. Roycroft, for John Martin and James Allestry, 1664) Preface.

[31] Joseph Glanvill, A *further discovery of M. Stubbe in a brief reply to his last pamphlet against Jos. Glanvill* (London: Printed for H. Eversden, 1671) p. 9.

[32] Thomas Sprat, *The history of the Royal-Society of London for the improving of natural knowledge* (London: Printed by T. R. for J. Martyn and J. Allestry, 1667) p. 340.

[33] For the eloquent Puritan theologian, Richard Baxter, 'For to be able to speak or write a true Proposition about God or the Creature, is not properly to know *God* or the *Creature,* but to *know names* and *words* concerning them: It is but a Logical Knowledge of Notions, and not the knowledge of the Thing it self... Nothing more de|ceiveth mankind, both in point of *Learning* and of *Religion,* and *Salvation,* than mistaking the Organical or Logical Knowledge of second Notions, Words, Propositions, Inferences and Methods, for the *Real Knowledge* of the *Things* themselves; And thinking that they *know a thing,* because they know what to say of it.' *A treatise of knowledge and love compared in two parts* (London: Printed for Tho. Parkhurst…, 1689) p. 228. The passage echoes not only Bacon and Hartlib but the reformers Amos Comenius and John Webster.

[34] For example, Nicolas Malebranche, *La Recherche de la Verité* (Paris, 1674-5) about physiology, optics, etc.

[35] Henry More, *Philosophical poems* (Cambridge: Printed by Roger Daniel, 1647) p. 176.

[36] Francois de la Noue, *The politicke and militarie discourses of the Lord de La Nouue* (London: Printed for T[homas] C[adman] and E[dward] A[ggas] by Thomas Orwin, 1587/8) p. 316.

[37] Henry Barrow and John Greenwood, *A collection of certain letters and conferences lately passed betvvixt certaine preachers & tvvo prisoners in the Fleet* ([Dordrecht?: s.n.], 1590) p. 31.

[38] John Golburne (tr.), A*cts of the dispute and conference holden at Paris, in the moneths of Iuly and August. 1566. Betweene two doctors of Sorbon, and two ministers of the Reformed Church* (London: Printed by Thomas Creede, 1602) p. 139.

[39] Rudolf Gwalther, *An hundred, threescore and fiftene homelyes or sermons, vppon the Actes of the Apostles, written by Saint Luke* (London: Henrie Denham, 1572) p. 699.

[40] Clement of Alexandria, who, atypically, purports to admire pagan and even 'barbarian' philosophy, explains that '[P]hilosophy, a thing of the highest utility, flourished in antiquity among the barbarians, shedding its light over the nations. And afterwards it came to Greece. First in its ranks were the prophets of the Egyptians; and the Chaldeans among the Assyrians; and the Druids among the Gauls; and the Sarmanas among the Bactrians (Σαρμαναίοι Βάκτρων); and the philosophers of the Celts; and the Magi of the Persians, who foretold the Saviour's birth, and came into the land of Judaea guided by a star. The Indian gymnosophists are also in the number, and the other barbarian philosophers. And of these there are two classes, some of them called Sramanas (Σαρμάναι), and others Brahmins (*Βραφμαναι*).' The *Stromata, or Miscellanies,* Book I, Chapter XV [21].

[41] John Calvin, *Calvin's Commentaries*: *Philippians, Colossians, and Thessalonians*, tr. John Pringle (Grand Rapids, MI: Christian Classics Ethereal Library) p. 114.

[42] There were difficulties in Aristotelianism about eternal essences, its unloving and nonretaliatory God, and its denial of personal immortality. See Stephen Menn, 'The intellectual setting,' in *The Cambridge history of Seventeenth-century philosophy*, ed. Michael Ayers and Daniel Garber (Cambridge: Cambridge University Press, 1998) pp. 33-86.

[43] Anstey, 'Experimental vs. Speculative,' p. 222, citing Boyle's *Certain Physiological Essays*, p. 24.

[44] Samuel Annesley, '*A Continuation of morning-exercise questions and cases of conscience practicaly resolved by sundry ministers in October, 1682*. London: Printed by J.A. for John Dunton, 1683) p.510.

[45] Boyle, *Some considerations about the reconcileableness of reason and religion by T.E., a lay-man; to which is annex'd by the publisher, a discourse of Mr. Boyle, about the possibility of the resurrection* (London: Printed by T.N. for H. Herringman, 1675) Preface, xiv.

[46] Boyle, *Some considerations*, pp. 34- 35.

[47] Theophilus Gale, *The court of gentiles. demonstrated from its causes, parts, proprieties, and effects, namely pagan idolatrie, Judaic apostasie, gnostic infusions, errors among the Greek fathers*....(London: Printed by A. Maxwell ad R. Roberts for T. Cockeril, 1677) p. 11.

[48] Gale, *Court of gentiles*, 12.

[49] Francis Gastrell, *The certainty and necessity of religion in general, or, The first grounds & principles of humane duty establish'd in eight sermons preach'd at S. Martins in the Fields at the lecture for the year 1697, founded by the Honorable Robert Boyle, Esquire* (London: Printed for Tho. Bennet, 1697). Preface, p. xi, p. vi.

[50] Robert Jenkin, *The reasonableness and certainty of the Christian religion* (London: Printed for P.B. and R. Wellington, 1700) Preface, p. x.

[51] Edward Stillingfleet, *Origines sacrae*, *or, A rational account of the grounds of Christian faith, as to the truth and divine authority of the Scriptures and the matters therein contained* (London: Printed by R.W. for Henry Mortlock, 1666) p. 23-6-.

[52] Stillingfleet, *Origines sacrae*, p. 68.

[53] Stillingfleet, *Origines sacrae*, p. 375.

[54] Stillingfleet, *Origines sacrae*, p. 461.

[55] Stillingfleet, *Origines sacrae*, p. 131. See Sarah Hutton, 'Science, Philosophy, and Atheism: Edward Stillingfleet's Defence of Religion,' In Richard H. Popkin and Arie Johan Vanderjagt, eds., *Scepticism and Irreligion in the Seventeenth and Eighteenth Centuries* (Leiden: E.J. Brill, 1993).

[56] Glanvill, 'They set up a *loud* cry against *Reason,* as the great adver|sary of *free-Grace,* and *Faith,* and *zealously* endeavoured to run it down, under the mis-

applied names of *Vain Philosophy, Carnal Reasoning,* and the *Wisdom of this World.* Joseph Glanvill, *Philosophia pia, or, A discourse of the religious temper and tendencies of the experimental philosophy which is profest by the Royal Society* (London: Printed by J. Macock for James Collins, 1671) p. 150.

[57] Quoted by Anstey, 'Experimental vs. Speculative,' p. 225 from Michael Hunter, *Science and the Shape of Orthodoxy: Intellectual Change in Late Seventeenth Century Britain*, Woodbridge, Boydell, 1995, p. 173.

[58] *Le monde de mr. Descartes, ou le traité de la lumière et des autres principaux objets des sens* (Paris: Nicolas le Gras, 1664).

[59] René Descartes, *The Philosophical Writings of Descartes*, 3 volumes, tr. John Cottingham, Robert Stoothoff, and Dugald Murdoch and Anthony Kenny, Cambridge, Ca mbridge University Press, 1984-91. I:90.

[60] (Londini Excudebat J.F. pro Jona Hart, 1664). Cf. René Descartes, Antoine Le Grand, Richard Blome, *An entire body of philosophy, according to the Principles of the famous Renate Des Cartes, in three book : I. The institution ... II. The history of nature ... III. A dissertation of the want of sense and knowledge in brute animals ...* (London: Printed by Samuel Roycroft, 1694).

[61] Descartes, *Principles* III:45; *Philosophical Writings*, I: 256.

[62] Descartes, *Principles* III:47; *Philosophical Writings*, I: 257.

[63] Ibid. Cf. Descartes, *The World*, *Philosophical Writings*, I: 90-91; *Principles* III: 47.

[64] Despite some declarations on his part taken very seriously by Malebranche and LaForge and by John Norris in England, it is impossible to read Descartes himself as a consistent occasionalist. See Daniel Garber, "How God Causes Motion: Descartes, Divine Sustenance, and Occasionalism." *The Journal of Philosophy*, vol. 84, no. 10, 1987, pp. 567–580. .

[65] Descartes, *Principles* IV:200-203; *Philosophical Writings,* I: 286-8.

[66] See Alexander Jacob, 'The Neoplatonic Conception of Nature in More, Cudworth, and Berkeley,' in Stephen Gaukroger, ed., *The Uses of Antiquity* (Springer: Netherlands, 1991) pp. 101-121.

[67] See Wojcik, *Robert Boyle*, *passim*.

[68] Descartes, *Principles* IV: 199; *Philosophical Writings,* I:285

[69] Descartes, *Principles* IV: 205; *Philosophical Writings,* I:290

[70] Descartes, *Principles* IV: 206; *Philosophical Writings,* I: 291.

[71] Sir Matthew Hale, *The primitive origination of mankind, considered and examined according to the light of nature* (London: Printed by William Godbid for William Shrowsbery, 1677) p. 10.

[72] Hale, *Primitive origination*, p. 9.

[73] 'Let Philosophers set their Imaginations a work, let them dream and think as much as they please, and lay down what Hypotheses they will, they shall never be able to give a satisfactory Account of neither many daily Productions, nor yet of the first Production of all things, by meer Natural or Mechanical Causes.' The world could not have been produced ' after that *Romantick Manner* of *Cartesius;*… if he had …given us an History of Nature, and described the Wisdom of God in the Make, Order, Place, and Relation of particular things… the World would have been more obliged to him, his Philosophy should have been more rational and satisfactory; more useful to others, and of more lasting Fame to himself;' John Cockburn, *An enquiry into the nature, necessity, and evidence of Christian faith, in several essays part I [-II] of faith in general, and of the belief of a deity* (London, Printed for William Keblewhite, 1696) pp. 66-7.

[74] Barbara J. Shapiro, *Probability and Certainty in Seventeenth-Century England: A Study of the Relationships Between Natural Science, Religion, History, Law, and Literature* (Princeton, Princeton University Press, 1983).

[75] Newton, *Opticks*, ed. Cohen, Query 31, pp. 375-6

[76] Newton, *Opticks*, ed. Cohen, p. 281.

[77] See J.R. Partington, *A History of Chemistry*, 4 vols. (London: Macmillan, 1962). II:33.

[78] Newton, 'Certain Philosophical Questions', MS Add. 3996, Cambridge University Library, 89r. See Monte Ransome Johnson and Catherine Wilson, 'Lucretius and the History of Science.' In *The Cambridge Companion to Lucretius*, ed. Philip Hardie and Stuart Gillespie (Cambridge: Cambridge University Press, 2007) pp. 131-148.

[79] Newton, 'Certain Philosophical Questions,' *passim*.

[80] Stephen D. Snobelen, 'Isaac Newton, heretic: The strategies of a Nicodemite,' *British Journal for the History of Science* 32 (1999) pp. 381-419.

[81] Eric Schliesser, 'On Reading Newton as an Epicurean: Kant, Spinozism and the Changes to the *Principia*.' *Studies in History and Philosophy of Science*, 44:3

(2013) pp. 416-428. See also Sarah Ellenzeig, 'Who's Afraid of Inertia? The Cartesian-Newtonian Legacy Reconsidered,' in Sarah Ellenzweig and John Zammito, eds. *The New Politics of Materialism: History, Philosophy, Science* (New York: Routledge, forthcoming 2017).

[82] Newton 'Drafts on the history of the Church (Section 5)' Yahuda Ms. 15.5, National Library of Israel, Jerusalem, Israel. p. <79r> The citation is also endorsed in SL255.8, Location Unknown.

[83] Newton, *Principia,* ed. Cohen, p. 939.

[84] Newton, *Principia*, p. 940.

[85] Newton, Letter to Bentley 17 January 1692/3, in *Philosophical Writings*, ed. Andrew Janiak (Cambridge: Cambridge University Press) 2004, p.100.

[86] Newton, Letter to Bentley, 11 February, 1692/3, in Janiak, ed., p. 101.

[87] Newton, *Principia*, ed. Cohen, pp. 943-4.

[88] Newton, *Opticks*, ed. Cohen, p. 403.

[89] Andrew Michael Ramsay, 'Plan of Education, for a young Prince' (part 1), from 'Fog's Weekly Journal', No. 195. Keynes Ms. 129.14, King's College, Cambridge, UK.

[90] Richard Bentley, *The folly and unreasonableness of atheism demonstrated from the advantage and pleasure of a religious life, the faculties of humane souls, the structure of animate bodies, & the origin and frame of the world* (London: Printed by J.H. for H. Mortlock, 1699).

[91] Samuel Clarke, *A demonstration of the being and attributes of God: more particularly in answer to Mr. Hobbs, Spinoza, and their followers* (London, Printed by Will. Botham, for James Knapton, 1706) and *A discourse concerning the unchangeable obligations of natural religion, and the truth and certainty of the Christian revelation* (London: Printed by W. Botham, for James Knapton, 1706).

[92] William Derham, *Astro-theology: or a demonstration of the being and attributes of God, from a survey of the heavens* (London: W. and J. Innys, 1714).

[93] Joseph de Maistre, *Examen de la Philosophie de Bacon, ou: l'on Traite Différentes Questions de Philosophie Rationnelle* (Paris: Poussielgue-Rusand, 1836). See on the historical construction of the distinction, Alberto, Vanzo, 'Empiricism and

Rationalism in Nineteenth Century Histories of Philosophy,' *Journal of the History of Ideas*, 77: 2 (2016), pp. 253-284.

[94] For example, Francis Guybon*, An essay concerning the growth of empiricism; or the encouragement of quacks* (London: printed for R. Parker; and sold by J. Morphew, 1712).

[95] In his discussion of the ''Transcendental Doctrine of Method.' Kant says: 'In respect of the origin of the modes of 'knowledge through pure reason,' the question is as to whether they are derived from experience, or whether in independence of experience they have their origin in reason. *Aristotle* may be regarded as the chief of the *empiricists*, and *Plato* as the chief of the *noologists*. *Locke*, who in modern times followed Aristotle, and *Leibniz*, who followed Plato...have not been able to bring this conflict to any definitive conclusion, implying that he has successfully done so. Kant, *Critique of Pure Reason*, A854/B882 tr. N.K. Smith (New York: Macmillan, 1965) p. 667.

[96] Jonathan Israel has pointed out that this approval is misleading as to the actual content of their articles. 'French Royal Censorship and the Battle to Suppress the *Encyclopédie* of Diderot and D'Alembert, 1751-1759,' in Mogens Laerke, ed., *The Use of Censorship in the Enlightenment*, Leiden and Boston: Brill, 2009) 61-74, pp.64-5.

[97] C. Wilson, 'Philosophical and Scientific Empiricism in the 18th Century,' in Anne-Lise Rey and Siegfried Bodenmann, eds., *What does it mean to be an Empiricist? Empiricisms in Eighteenth Century Science* (Paris: Springer, forthcoming 2017).

[98] Andrew Bell, 'Bold flights of a speculative mind,' *Lancet* 372 (2008), 57-67, p. 58. David Hull argues that even the 'empiricism' of J.F. Herschel, J.S. Mill, and William Whewell did not recommend natural selection. '[J]ust as philosophers were beginning to investigate the nature of science in earnest,…they were confronted with a theory that seemed to strike at the very foundations of the views of scientific method then being promulgated.' David L. Hull, Foreword to Alvar Ellegard, *Darwin and the General Reader: The Reception of Darwin's Theory of Evolution* (Chicago: University of Chicago, 1990) p. 2.

[99] 'Within the ranks of the biologists, at that time, I met with nobody, except Dr. Grant, of University College, who had a word to say for Evolution—and his advocacy

was not calculated to advance the cause. Outside these ranks, the only person known to me whose knowledge and capacity compelled respect, and who was, at the same time, a thorough-going evolutionist, was Mr. Herbert Spencer, whose acquaintance I made, I think, in 1852, and then entered into the bonds of a friendship which, I am happy to think, has known no interruption.' T.H. Huxley, *On the Reception of the Origin of the Species* (London: Forgotten Books, 2008) p. 10.

[100] Bell, 'Bold flights,' p. 57, quoting 'Reviews and Notices of Books. *The Descent of Man, and Selection in Relation to Sex*' *Lancet* (1871) 1: 510.