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10 Physics in the Broad Sense

Boyle, Newton, and the Baconian Metaphysical Physics

Philippe Hamou

The purpose of this chapter is to consider and contextualize some early-modern British views on the relation between physics and metaphysics—namely in Bacon, Boyle, and Newton. I do not claim to offer a detailed description of their positions here. The aim is to sketch the big picture and try to find out whether these influential figures share a common ground. There are good textual reasons to think that, ~~on the one hand~~, Boyle's and Newton's views were framed as critical responses to Descartes' understanding of the relation. However, these responses should not be interpreted in the positivist guise that was long prevalent in the standard account of British science. The positions of Newton, Boyle, and a number of other “experimental philosophers” are distinctive not so much because they reject what Daniel Garber¹ has labeled “*Descartes' metaphysical physics*,” but because they provide an alternative conception of the intimate relation between physics and metaphysics, which is partly grounded in the Baconian understanding of the architecture of natural knowledge. This allows physics, *in an enlarged sense of the word*, to include the metaphysical consideration of primary and final causes, as well as *forms* and essences.

In Descartes' view, metaphysical considerations are prior to physical ones, both in a constitutive sense and in an epistemic one. Metaphysics, or *philosophia prima*, contains all the foundations of physics,² and the knowledge of these foundations should be acquired before delving into physical considerations. *Philosophia prima* provides, in the first place, a standard of *certainty* (the *cogito*) and a *rule of truth* according to which things are just as our clear and distinct ideas represent them to be. Second, it furnishes us with a clear and distinct idea of matter as tridimensional extensional quantity, the parts of which (individual bodies) together with their modes (shapes and motions) are the primary object of physics. Third, it considers the prime source of motion, God's efficiency and His immutable will, from which the most general laws of nature—which describe the conservation and communication of motion—are safely and directly (that is *a priori*) deduced, together with a number of general effects concerning the general structure of the world and its elements.³ Although Descartes concedes that a brief “history of the phenomena” is necessary to go further into physical

investigations,⁴ and that the discovery of the specific mechanisms underlying the more particular phenomena of nature requires that one proceeds through hypotheses and experimental confirmation, he adamantly rejects any *early* use of such an experimental method. Refined experiments, to one who is not already acquainted with first principles, cannot be properly interpreted and are very likely to lead astray.⁵

I want to point out two striking features in these well-known Cartesian conceptions. One concerns order: metaphysics is no longer the science “that comes after the physics” and the crowning of the whole enterprise of natural knowledge, as it was in the Aristotelian view; it is the science *to begin with*, however arduous and abstract it may seem, a prime philosophy, without which nothing can be properly secured in the edifice of knowledge. The second feature is organic continuity. In the tree of the sciences, roots and trunk are made of one and the same continuous substance. Metaphysical considerations are not only preliminaries; they are an integral part of the physical enterprise. Natural philosophy is at the start, or *in principle*, a *metaphysical physics*. And this is true, whether Descartes’ metaphysical interests were wholly invested in the project of founding a new physics, or whether they were not—which is a controversial issue.⁶ While these two features are tightly knitted in Descartes, we should bear in mind that they are in principle independent. It would be possible for metaphysics (the knowledge of the primary causes, and what counts as the basic constituents of nature) to be an integral part of physical enquiries and yet be considered as second in an epistemic sense if it succeeded empirical investigation and derived from it its epistemic value. As we shall see, this is exactly what holds true for some of the leading British natural philosophers.

It is however customary to present the British empiricist scientific tradition as directly opposed to the Cartesian view of the metaphysical foundations of science, not only at the methodological level but also at the substantive one. There are several ways of making that point, depending on which author one considers as primary. A Boyle-oriented perspective may want to express the opposition to Descartes in the contrast between “speculative natural philosophy” and “experimental natural philosophy”: Descartes’ *metaphysical physics* would be an example (among others—notably the scholastic physics) of an enquiry into nature that has been corrupted by an overconfidence in the powers of reason and a neglect of experiments. That would amount to rejecting a *speculative* physics and replacing it with an experimental one. Another way to make a strong case for the opposition is to stress the importance of Newton’s *Principia* for a new definition and new understanding of physics as *mathematical physics*. Newton’s carefully crafted title, “*Mathematical principles of natural philosophy*,” is taken here as a direct reference to and rebuttal of Descartes’ [metaphysical] *Principes de la Philosophie*. Metaphysics is no longer the science which gives us an intuitive, self-evident access to physical principles. The definition of matter and space, the laws of motions, and the characterization of

forces are not derived from our innate notions of the nature of substance or God, nor derived from any other metaphysical considerations, but are cautiously introduced in the first book of the *Principia* as “mathematical hypotheses”—that is, an initial set of definitions, axioms, and postulates, in quite the same manner as Archimedes would have done in other branches of rational mechanics. From such mathematical principles, one can predict and quantify the behavior of imagined bodies in various circumstances. The agreement of these predictions with experience—for example, with the way actual planets behave in our solar system—is what makes these mathematical principles the true principles of natural philosophy. Nothing more is to be wished for. So, according to this view, at no point, neither at the start nor at the end, does metaphysics have a role to play—mathematical principles are the *only principles* of natural philosophy that one needs.⁷

Finally, one may also appeal to Locke and consider his own contribution to epistemology as being in effect a patient dismantlement of the Cartesian or Cartesian-like *metaphysical physics*. In the *Essay Concerning Human Understanding*, in a well-known passage of the Epistle to the Reader, Locke presents himself as the “under-laborer” employed, for the sake of master-builders such as Huygens, Boyle, or Newton, in “removing some of the rubbish that lies in the way to knowledge.”⁸ It is tempting to interpret this famous declaration as follows: while men such as Huygens, Boyle, or Newton make their positive contribution to the construction of a new physics purged from any metaphysical ingredients, Locke would do the dirty work, showing why, since our intellectual equipment is what it is, metaphysical physics—call it speculative physics, aprioristic physics, etc., is doomed to failure.⁹

These approaches to the opposition between Descartes and the British on the nature of physics may be called, with some caution, positivist approaches, at least if the term is construed as capturing the notion that physical science in its mature form should be cleared of any metaphysical ingredients. What may perhaps lend some support to the idea that such a positivist view prevailed amongst these authors is the fact that they very seldom use the term *metaphysics*. When they employ it, it is often in a pejorative sense, as a synonym for what is abstruse, verbose, conceited, and scholastic. Thus Boyle opposes the superfluity of “Logical and Metaphysical Notions and Niceties” to the solidity of “Physical Observations and Reasonings.”¹⁰ However, one should not draw conclusions too hastily. First, it does not seem that Descartes’ practice of *philosophia prima* is the target of these pejorative uses. The adjective “metaphysical” is most often used to refer to scholastic verbosity and to either trivial or seemingly incomprehensible metaphysical definitions, such as the definition of motion as “the act of what is potential, in so far as it is potential.” For the denunciation of such metaphysical niceties, it seems that the Englishmen could easily recruit Descartes on their side. One may even argue that it was Descartes who actually taught them to despise “the learned but frivolous use of uncouth, affected, or unintelligible terms”¹¹ that supposedly prevailed in scholastic

metaphysics. Second, these semantic facts certainly show that metaphysics as an autonomous discipline had somehow fallen into disgrace in the second half of the century, and this perhaps may be revealed in certain shifts in the academic curriculum of English universities during the time. However, this is not to say that the metaphysical enterprise as such had fallen into oblivion. Metaphysical pursuits could still be undertaken in other less discredited disciplines, such as theology, or taken afresh in other parts of the philosophical curriculum—namely in logic, in ethics, and of course in *physics*. As a matter of fact, the very idea that physics, understood in a broad sense, should incorporate at least part of the traditional metaphysical program had been stated and vigorously defended in Bacon. As this source is more likely to have been a common ground for the later British natural philosophers than any Cartesian or anti-Cartesian commitment, it provides an appropriate starting point for discussing British accounts of the relation between physics and metaphysics.

Bacon's Metaphysical Physics

A description of the division and hierarchy of the sciences was to Bacon of central importance to his very project of “great reformation.” Indeed, whoever wanted to invent and advance human learning had to become acquainted with the true state of our knowledge, make an inventory of what was known and what was still unknown, and have a sense of how the sciences are related to one another and ordered. Bacon undertook this description twice: first in English, in the second book *Of the Advancement and Proficiency of Learning* (1605), and then in the expanded Latin version *De Dignitate et Augmentis scientiarum* (1623), which became what was certainly his most widely read book.

On the place allotted to metaphysics, the Baconian account did not change substantially between 1605 and 1623. Bacon considered that the old concept of metaphysics had to be revised, and that its place and unity had to be reconsidered. He was aware that such reconsideration was so drastic that it might have led him to change the very name of the discipline. However, at least in these texts, he refrained from such a change, both because of his respect for antiquity,¹² and, I would argue, because he thought that the very name metaphysics has a truth about it, insofar that it implies a strong connection to physics. His redefinition of metaphysics aimed precisely at restoring this proximity to physics that the traditional discipline, as developed by the Aristotelians, did not reflect sufficiently. Bacon's central tenet was that metaphysics is a part of natural philosophy and deals with natural beings just as specifically as physics and natural history do. For that reason, the discipline should be stripped of foreign elements that the tradition has incorporated into it, namely *natural theology* and what Bacon called *philosophia prima* or *summary philosophy*.

Natural theology, the knowledge of God through His works, is no part of the knowledge of nature; it properly belongs to “divine philosophy” ~~and~~

aims at a (provisional) knowledge of God and helps us to shun atheism—but it is not concerned with the elucidation of natural beings.

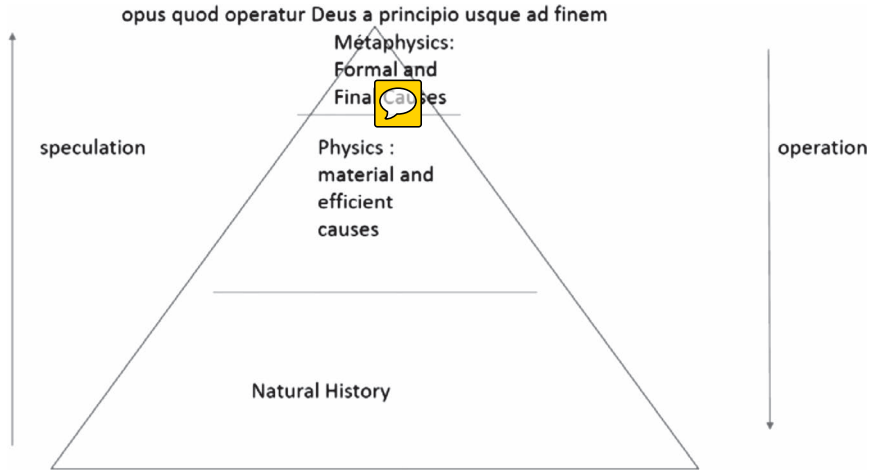
Bacon's *philosophia prima* can be defined as the science of “common notions.” It deals with the most abstract axioms that are in use in every science, such as the axioms concerning “quantity, similitude, diversity, and the rest of those extern characters of things.”¹³ Although his knowledge may be of some concern for physical and/or metaphysical enquiries, it appears no more specifically related to natural beings, than it is to *human* or *divine*. So here, it is because of its extreme generality and abstraction that *philosophia prima* is excluded from the realm of metaphysics.¹⁴

In *De Augmentis* (book III, chapter IV), Bacon explains somewhat more specifically in which sense many of the traditional objects of the old “metaphysics” should be forwarded either to *prima philosophia* or to *natural theology*: the common notions and the so-called “transcendentals” (listed as *Multum, Paucum, Idem, Diversum, Possibile, Impossibile*), which used to be subject matters for a general metaphysics (or what will be called later *ontologia*) belong only to *prima philosophia*, whereas the traditional objects of the so-called *metaphysica specialis*, such as *Deus, Unus, Bonus, Angelus*, and *Spiritus* are indeed the affair of natural theology. After such a severe trimming, metaphysics appears reduced to what should be its sole and unique purpose: the study of natural beings. Thus, physics and metaphysics belong to one and the same enterprise. They do not differ in subject matter, but simply in the mode of consideration: metaphysics looks at what is essential and permanent in natural beings, whereas physics deals with the more “transitory” and “accidental” aspects of matter and bodies. Bacon (using the old division of causes) also says that metaphysics is assigned to the study of formal and final causes, whereas physics is concern with material and efficient ones. Thus understood, physics and metaphysics are two connected parts of the “speculative” theory of nature. They both rest on natural history, and form with it the pyramid of natural knowledge:

For knowledges are as PYRAMIDES, whereof HISTORY is the basis: So of NATURAL PHILOSOPHY, the BASIS is NATURAL HISTORY: the STAGE next the BASIS is phisicke; the STAGE next the vertical point is METAPHISICKE. As for the verticall point, *Opus quod operatur Deus a principio usque ad finem*,¹⁵ the Summary law of nature, we knowe not whether Mans enquirie can attain unto it.

(*Advancement of Learning*, 85)

Here, speculation is the upward (preferably slow) movement along the three stages of the pyramid which leads from material facts of natural history to the disclosure of physical (efficient) causes, from them to the apprehension of forms and essence, and finally reaches (if possible) the ultimate apex of metaphysical enquiry (the final cause of all things, or the “condensed law of nature” to which Bacon equates Salomon’s words: *opus quod operatur Deus a principio usque ad finem* (the work that God made from the beginning to the end).



The contrary move, from metaphysics to physics and from physics to the discovery of new facts, deeds, and useful devices, is the “operation.” Speculation aims at intelligibility. Operation aims at utility. *Pace* the usual Baconian vulgate, it is to be stressed that, to Bacon, the farther we go into speculation, the better we can choose our means and promote operation, and this is what make metaphysics an especially *useful* science:

It [Metaphisicke] doth enfranchise the power of Man unto the greatest libertie and possibilitie of workes and effects. For Phisicke carrieth men in narrow and restrained waies, subject to many accidents and impediments, imitating the ordinaroe flexuous courses of nature. But *Latae undique sunt sapientibus viae*;¹⁶ to sapience (which was anciently defined to be *Rerum divinarum, & humanarum scientia*) there is ever a choice of Meanes. For *Phisicall causes* give light to newe invention in *Simili materia*. But whosoever knoweth any forme knoweth the utmost possibilitie of *superinducing* that *Nature* upon *any varietie of matter*; and so is less restrained in operation, either to the *Basis* of the *Matter*, or the *condition* of the efficient.

(emphasis in original, *Advancement of Learning*, 85–6)

In describing metaphysics, Bacon insists that it should be pursued with confidence, as something that is not, as skeptics often believe, out of reach of the human understanding:

For METAPHISICKE, we have assigned unto it the enquirie of FORMAL and FINAL CAUSES; which assignation, as to the former of them may seeme to be Nugatorie and voide, because of the received and inveterate Opinion, that the inquisition of Man is not competent to finde out *essentiall formes* or *true differences*; of which opinion we will take this hold: That the invention of Formes is of al other Parts of

Knowledge the worthiest to bee sought, if it bee Possible to be found. As for the possibilitie, they are ill discoverers, that thinke there is no land, when they can see nothing but Sea.

(emphasis in original, *Advancement of Learning*, 83)

Bacon adds to this an important *proviso*: we do not really want to inquire into the form of each natural species, because those are potentially infinite, but we want to find out the real alphabet out of which each one of these forms is made:

to enquire the form of a Lyon, of an Oake, of Gold; nay, of Water, of Aire, is a vaine pursuite; but to enquire the *formes* of Sence, of voluntary motion, of vegetation, of colours, of Gravitie and Levitie, of Densitie, of Tenuitie, of Heate, of Cold, & al other Natures and qualities, which, like an *Alphabet*, are not many, & of which the essences (upheld by Matter) of all creatures do consist.

(emphasis in original, *Advancement of Learning*, 84)

So what we have here is a limited number of primitive natures and qualities whose diverse compositions make the whole of this natural world. The true end of Baconian metaphysics is to find out these elementary natures and to understand what natures there are and how they interact to compose all the phenomenal diversity.

I shall not enter here in the description of how Bacon tried to implement this metaphysical program. I do not think that his undertakings on this score were considered successful, even by his keenest supporters in the second half of the century. I do think, however, that the Baconian commitment to physics understood in a broader sense was still very much accepted and implicit in the way later experimental philosophers and British natural philosophers understood their own contribution to natural science. The new science of nature was called to take the place both of an actual physics that was still too narrow (following too closely the tortuous course of efficient causes) and of an actual metaphysics, which was ill founded and badly defined. This at least is what Bacon seemed to imply in his letter to Father Baranzan (June 1622):

De metaphysica ne sis sollicitus. Nulla enim erit post veram physicam inventam.

(“As for metaphysics, you should not be concerned: it will entirely disappear, when true physics is invented.”)¹⁷

I take these words to mean not that the future would dispense altogether with metaphysical considerations, but rather that “true physics” will be the right location for them.

Some will find that this presentation of Bacon, as an advocate for a “speculative” and even “metaphysical” physics, flies in the face of the common

view according to which Bacon was promoting experimental philosophy, precisely against a *speculative* approach to natural philosophy. As Peter Anstey has shown in an important paper,¹⁸ the very word *speculative* tended to become, in the seventeenth century, an antonym for *experimental*, and these terms became the *actual* categories in which people of the time represented their aims and battles. This might have been true for subsequent authors, but Bacon did not oppose the *speculative* and the *experimental*. The duality that is singled out in the passages from the *Advancement of Learning* and *De Dignitate* is between speculative and operative; these terms, as we just saw, refer to two different legitimate aims, and two opposite directions, which are found in the practice of natural experimental science. Of course, Bacon's methodology, as stated for example in the *Novum Organum*, is full of strident warnings against what Bacon often calls the "premature flights" toward the more speculative parts of philosophy. This habit of going directly to axioms and conclusions, after considering superficially a small number of experiments, or even without any experimental grounding, simply on the basis of preconceived ideas or "idols"—is certainly one of the main obstacles on the road to true and certain induction. And this is also the *rashness in speculation* that will be eventually labeled the "speculative" way of natural philosophy, of which Descartes was supposedly the very paradigm, and against which the whole "Bacon-faced generation" of the early Royal Society period unanimously objected.

Nonetheless, neither in Bacon nor amongst the "experimental philosophers" of the Royal Society do we find the idea that physics should simply renounce its speculative aim and content itself with operation and usage. It is certainly the case that many Baconians and experimental philosophers thought that the time of speculation had not yet arrived, that the great business of the period was to reconstruct natural histories, and that the task of erecting higher superstructures was reserved for later generations of future philosophers. But these declarations, in addition to being sometimes rhetorical and hiding a not completely blank speculative agenda, did not mean that understanding nature "as it is" was not considered a proper aim for physical enquiries or that practical utility was their only purpose. This should appear all the more true when one considers that utility itself, or in Boyle's terms the "usefulness of natural philosophy,"¹⁹ includes, as one of its most valuable parts, the pure benefit that true knowledge gives to the mind that possesses it.

Metaphysical Cosmogony and Final Causes in Boyle's "Corpuscularian hypothesis"

Robert Boyle is certainly the paradigmatic example of an experimental philosopher of the second half of the century. It could be said that, through his many writings and unremittent practice, he is the very one who framed the identity of the "experimental philosopher." In my view, this identity is somewhat mixed: it involves a Cartesian ingredient as well as a Baconian

one. On the one hand, experimental philosophers were undoubtedly true Baconian disciples: they shared with Bacon the view that natural philosophy should be reformed, and that the only way this reform was going to succeed was to make it start where science first began, that is with sensible matters of facts, experiments, and natural history. On the other hand, experimental philosophers, no less undoubtedly, strongly felt the spell of Descartes' grand idea of mechanical philosophy, the idea that all that happens in the material realm can be explained as the result of the mechanical operations of insensible particles. They might not agree with Descartes about how one ought to justify this claim or how its details should be fleshed out—they may even have rejected it altogether, but in some sense they all recognized its attractiveness as far as intelligibility and heuristic values were concerned.

These two ingredients are no doubt present in Boyle, who advocated both the superiority and usefulness of the “experimental (natural) philosophy” and the “excellency of the mechanical hypothesis,” and never found any contradiction in doing so.

Of course, Boyle was keen to distinguish his mechanical hypothesis from the Cartesian one both at a methodological level and in regard the very content of the hypothesis. Boyle has been rightly described as the “diffident naturalist,”²⁰ as having been extremely reluctant toward claims for evidence and absolute certainty in physical matters. As he writes in the *Excellency of Theology* (1674), hinting, no doubt, at Descartes: “the most even of the modern Virtuosi are wont to fancy more of clearness and certainty in their physical Theories than a Critical Examiner will find” (*The Works of Robert Boyle*, 8, 66). He then explains that the premises of most theories are only founded on moral certainty, and so are the inferences that are taken from them, “as geometrical as they could be” (*ibid*). In his methodological *Proemial Essay*, of his *Certain Physiological Essays* of 1669, Boyle defends the ideas that theoretical superstructures should be grounded on “a considerable number of experiments, in proportion to the comprehensiveness of the theory to be erected upon” (*The Works of Robert Boyle*, vol. 2, 14). Although this consideration applies here to local theories (particular mechanical explanations), there is no reason to think that it should not hold as well for the general one, that is, for the mechanical or “corpuscularian” hypothesis as such. And indeed it seems that Boyle's very program in natural philosophy was to provide some sort of massive inductive proof of the mechanical hypothesis, exhibiting a large range of experiments and observations of all sorts, showing again and again how far our understanding of them could be enhanced when set in the general framework of the mechanical hypothesis, taking only matter and motion as explanatory principles. So, to Boyle, the mechanical philosophy recommends itself inductively for its capacity to account for an increasingly wide range of phenomena. It is what Boyle calls its “comprehensiveness.” Each step made in advancing mechanical explanations makes the general theory more plausible. But even though Boyle never seriously considered that another explanatory hypothesis could

be a viable replacement candidate, the mechanical philosophy (and of course its metaphysical content) was deemed to remain a *hypothesis*.

Boyle usually presents his own “Corpuscularian hypothesis” in a careful way, always insisting on what makes it different from the Epicurean atomism on the one hand and the Cartesian mechanical hypothesis on the other. The three doctrines share the same basic “physical” idea, namely that whatever is produced in the material world is the direct effect of local motion on particles of matter, but they differ markedly in their underlying metaphysical premises. On the one hand, whereas Epicurean philosophers consider that the only reason why atoms go in such or such direction and make such or such composition is mere chance, Descartes and Boyle concur in assigning the first source of motion to God’s will and efficiency. On the other hand, in Descartes, as Boyle reads him, it seems that no more is required to form the “system of the world” than the initial introduction into the world of an invariable quantity of motion, “the material parts being guided by their own unguided Motions to cast themselves into such a System.” Boyle has another view of the matter, which he expresses (for example) in the *Excellency and Ground of the Mechanical Hypothesis*.

But I plead onely for such a philosophy, as reaches but to things purely corporeal, and distinguishing between the first *original of things* and the subsequent *course of Nature*, teaches, concerning the *former* not only that God gave Motion to Matter but that in the beginning He so guided the various Motions of the parts of it, as to contrive them into the World he design’d they should compose, (furnish’d with the seminal principles and structures or Models of Living Creatures,) and establish’d those *Rules of Motion*, and that order amongst things Corporeal, which we are wont to call the *Laws of Nature*. And having told this as to the *former*, it may be allowed, as to the *latter* to teach, That the Universe being once fram’d by God, and the Laws of Motion being settled and all upheld by His incessant concourse and general Providence, the Phaenomena of the World thus constituted, are physically Produced by the Mechanical affections of the parts of Matter, and what they operate upon one another according to Mechanical Laws.

(emphasis in original, *The Works of Robert Boyle*, vol. 8, 104)

The passage is consistent with many others similar pronouncements in Boyle’s writings. It makes it clear that Boyle is not only committed to the “physical” thesis that whatever happens in the material realm is the result of corpuscular local motions. What he presents here in a condensed form is clearly a full-blown metaphysical physics, which offers the same kind of genetic—or, if I may say so, “cosmogonic”—intelligibility as the Cartesian principles of natural philosophy. As in Descartes, what is sought here is not only local mechanical explanations of the phenomena, but a general frame in which such explanations make sense and can be traced back to

their first principles. Second, in this general frame, Boyle distinguishes the “first original of things” and the “subsequent course of nature.” Whereas the description of the second phase (as the efficient course of motions ruled by (blind) mechanical laws and preserved by God’s continuous concurrence) does not depart markedly from Descartes’ views, the first phase is clearly different: in the first original of things, the first phase in the history of Creation, one has to consider not only God’s efficiency in the production of motion, but also his “design,” that is the ends He pursued in “directing the motions” of matter, arranging together the different parts of the universe, or following “Models” in the production of living creature of different species. Boyle mentions here the creation of “seminal principles,” namely the (still unknown) grounds for the generation of living beings, principles that were put in our first parents and that are still acting now in the formation of each new living being. It seems clear that the hint here is that we need more to explain the living beings that simply matter and unregulated motion: some systems of matter must have been specifically organized in the beginning in order to allow for the generation of living Creatures and for the perpetuation of seminal principles. Admitting this however does not prevent those specifically designed seminal principles to act mechanically (as if they were some sorts of molds) in the processes of generation during the subsequent course of time.

This significant departure from Descartes amounts to a specific consideration of *final causes* in the account of the creation of natural beings, and specifically the account of the creation of *species* of living beings. As it turns out, Boyle’s most cogent consideration of the role of final causes in physics, his *Disquisition about the final causes of natural things*, contains also his most explicit discussion of the disciplinary boundaries between physics and metaphysics and of how Boyle’s conception of them relates to those of Descartes. In this text, Boyle takes Descartes to task for having excluded the consideration of final causes from physical enquiries. He considers in particular Descartes’ answer to Gassendi in the Fifth replies, wherein, without denying that God had specific wills in creating the world, he says that those final causes are entirely hidden from us²¹ and entirely foreign to the naturalist. Descartes reiterates the same argument in his Letter to Hyperaspistes of August 1641,²² and then, most explicitly in *Principles* 1.28:

When dealing with natural things we will then, never derive any explanations from the purposes which God or nature may have had in view when creating them and we shall entirely banish from our philosophy the search for final causes. We should not be so arrogant as to suppose that we can share in God’s plans. We should instead consider him the efficient cause of all things; and starting from the divine attributes which by God’s will we have some knowledge of, we shall see, with the aid of our God-given natural light, what conclusions should be drawn concerning those effects which are apparent to our senses.²³

So, according to Descartes, we are not to consider the ends of God in creating such or such sensible thing, because our physical enquiries aim at explaining how those things are produced by discovering the chain of efficient, mechanical causes that concurred in producing the forms that we see. Any physical enquiry which would avail itself of teleological discourse would be altogether presumptuous, uncertain, anthropomorphic, and likely to revert to the old discarded Aristotelian view of nature, where things are deemed to be so and so because their production obeys some inherent form or *telos* that determines them to be so and so.

Boyle's answers to these Cartesian doctrines constitute the larger part of the first section of the *Disquisition*. In a first line of argument, he refutes and somehow inverts the accusation of presumption. To pretend to know (some of) God's ends "is not a presumption, but rather, to take notice of them is a Duty" (*Works of Robert Boyle*, 11, 89). He then explains:

For there are some things in Nature so curiously contrived, and so exquisitely fitted for certain Operations and Uses that it seems little less than Blindness in Him, that acknowledges, with the *Cartesians*, a most wise Author of things, not to conclude that, tho' they *may* have been design'd for *other*, and perhaps higher, Uses; yet they *were* designed for *this* Use.

(emphasis in original, *The Works of Robert Boyle*, 11, 89)

Boyle is clearly referring to living bodies and parts of living bodies, which are so exquisitely framed that it seems impossible (and somehow "blind") to conceive that chance alone could have produced them. We cannot understand the structure of the eye without considering its use in seeing. And seeing is such a manifest and obvious end that it would seem absurd to think that it is not for us to know it, or that it lays "hidden in the abyss of the divine wisdom."

A second line of argument depends on the diagnosis of why Descartes thought proper to exclude final causes in physics. To Boyle, such exclusion bears on a too-narrow conception of what may count as solid reasons in physics. Although physics strictly conceived deals specifically with mechanical reasons and efficient causes, its most fundamental principles are not, on Descartes' own account, strictly "physical," as they make use of God as an immaterial agent:

I readily admit, that in Physicks we should indeed ground all things upon as solid reasons as may be had; But I see no necessity that those Reason should be always precisely Physical: especially if we be treating . . . of the *first* and general Causes of the world it self; from which Causes, I see not why the Final Causes, or Uses, that appear manifestly enough to have been design'd should be excluded. And to me it is not very material, whether or no, in Physicks or any other Discipline, a thing be prov'd by the peculiar Principles of that Science or Discipline;

provided it be firmly proved by the common grounds of Reason. And on this occasion, let me observe, that the fundamental Tenents of Mr Descartes's own philosophy are not by himself prov'd by Arguments strictly physical; but either by Metaphysical ones, or the more Catholick dictates of Reason, or the particular testimonies of Experience.

(emphasis in original, *The Works of Robert Boyle*, 11, 91)

Boyle goes on to show that God, an immaterial being, is the efficient cause of motion in matter, since matter, whose essence does not include motion, must owe its motion to some being that is not material.²⁴ He also points out that when Descartes argues that God's immutability proves the conservation of the same quantity of motion, he is not using "a physical argument strictly so called, but rather a Metaphysical one." This of course it not an objection against the Cartesian proof (although Boyle, on other grounds, expresses some doubts about the absolute truth of the conservation thesis). It only shows that we should not exclude final causes from physical considerations in order to preserve some pretended "purity" of physics. Disciplinary boundaries do not apply here; a metaphysical argument can be used in physics, provided that it is founded on "the common grounds of reason." The point ironically has a Cartesian ring: all the sciences are one and proceed from the same natural light. Here is how Boyle puts it:

And to me 'tis not very material, whether or no in Physicks or in any other Discipline; a thing be prov'd by the peculiar Principles of that Science or Discipline; provided it be firmly proved by the common grounds of Reason.

(*The Works of Robert Boyle*, 11, 91)

The whole discussion calls for a few conclusive remarks. First, and quite strikingly, Descartes is not here taken to task for having made his physics too metaphysical, but rather the contrary. Descartes has unduly restricted the scope of natural enquiry to efficient causes. His metaphysical physics is all about efficiency and divine power, but provides no room for design and divine wisdom. To Boyle, the (metaphysical) consideration of final causes is necessary on two different grounds: on the one hand, it is necessary for the task of *physics* itself, insofar as it provides an explanatory resource for phenomena that are manifest everywhere in nature and in which there is evidence of design, fitness, and organization, especially in living beings, but also in the general frame and composure of the universe. In Boyle's view, "unregulated mechanism" (if I may so call the blind determinism that he tends to attribute to Descartes) is simply unfit for the task of accounting for such phenomena. On the other hand, final causes are also especially important to the physicist because they justify his calling on religious grounds. They make us aware of the superior wisdom, intelligence, and benevolence of the Creator, and the very fact that the study of nature offers a constant

occasion for contemplating these divine attributes, and even for refining our understanding of them, is in itself a sufficient justification for the *study of the book of nature*.

So Descartes, according to Boyle, has missed the role that the physicist could play in promoting *natural religion* and refuting *atheism*. And this failure seems to be directly correlated with Descartes' dismissive attitude toward the idea that sound metaphysical conclusions may be drawn from the contemplation of nature. Metaphysics, for Descartes, begins in a meditative conversion, in which the mind, discarding the false testimony of the senses, looks into itself and finds there the very idea of the Infinite cause. In this perspective, there cannot be any empirical constraint on metaphysics: neither brute sensory experience nor experiments, however numerous and regulated, could yield a clear and distinct idea of the essence of matter, and even less could they provide a clear and distinct idea of the primary cause of all things. This is precisely why Descartes was extremely reluctant toward physico-theological arguments (and indeed to my knowledge never used them). He avoided them not because he thought nature was the reign of blind fate, but rather because these arguments, grounded as they are on sensory experience, were deemed to remain confused and their conclusions uncertain. Accordingly, they should be banned if one wants to keep physics on the safe tracks of science. Boyle, for his part, saw in the Cartesian aspiration to absolute certainty in physical matters a form of blindness—a misunderstanding both of the limits of human reason and of the fact that physics, or natural philosophy, serves nobler ends than the mere satisfaction of curiosity. It is deemed to express God's glory, to manifest His providence, and to contribute to disclosing what he calls "the great and universal system of God's contrivances." To achieve that objective one must engage in discussions that overlap with metaphysics and religion. Boyle expresses this most clearly in the *Excellency of Theology*:

But neither the fundamental doctrine of Christianity, nor that of the effect of power and matter and motion seem to be more than an epicycle (if I may so call it) of the great and universal system of God's contrivances and makes but a part of a more general theory of things, knowable by the light of nature, improvable by the information of scriptures. So that both these doctrines, though very general, in respect to the subordinate parts of theology and philosophy, seem to be but members of the universal hypothesis, whose object I conceive to be the nature, counsels and works of God, as far as they are discoverable by us.

(*The Works of Robert Boyle*, 8, 32–3)

Physics, or natural philosophy, gives only a partial view of the universal hypothesis; it is just like an epicycle, in the old astronomical systems, which offers only a partial representation of the movement of a planet. I take this comparison to mean that the same truth may be expressed in opposite,

seemingly contradictory ways in different sciences, just as the retrograde motion of a planet may be represented as the effect of the composition of wholly compatible revolutions of several celestial circles. Similarly, apparent contradictions certainly may occur between physics and religion, between the knowledge of efficient causes and the knowledge of final causes, and between physics and metaphysics. But it would be foolish to think that we are forced to choose between these sciences and to reject one in favor of the other. At some level, all sciences are one and the contradictions must vanish, even though we might never be able in this life to understand how.

Newton's Empiricized Metaphysics

Newton's pronouncements on metaphysical matters are scant but quite significant. A striking one from a late manuscript, which was intended for a revision of the General Scholium, may provide a useful starting point. Here is I. B. Cohen's English translation of the passage:²⁵

What is taught in metaphysics, if it is derived from divine revelation, is religion; if it is derived from phaenomena through the five external senses, it pertains to physics; if it is derived from knowledge of the internal actions of our mind through the sense of reflection, it is only philosophy about the human mind and its ideas as internal phaenomena likewise pertain to physics. To dispute about the objects of ideas except insofar as they are phaenomena is dreaming. In all philosophy we must begin from phenomena and admit no principles of things, no causes, no explanations, except those which are established through phenomena. And although the whole of philosophy is not immediately evident, still it is better to add something to our knowledge day by day than to fill up men's minds in advance with the preconceptions of hypotheses.

This text lends itself to two opposite readings. On the one hand, it may appear as challenging the very idea of metaphysics: that discipline is entirely omitted and needs to be replaced by more legitimate enterprises. This reading makes sense when metaphysics is understood as a science whose main defining feature is an epistemic one. If one construes metaphysics as the science whose objects are addressed in a purely intellectual way (and somehow this is indeed the Cartesian construal), then metaphysics is an awakened dream, it is vain disputes about ideas or hypotheses "that fill up men's minds." The similarity between the two last sentences of the passage and other well-known methodological texts (especially the fourth *regula philosophandi*²⁶), sheds some light on Newton's usual dismissive attitude toward *hypotheses*: they are not dismissed because they are probable conjectures or methodological tools of reasoning (since Newton in fact constantly used *hypotheses* in these senses). Rather, "hypotheses," in the pejorative sense, refers to empty reasoning about pure ideas (with no reference to empirical

content), which is especially prevalent in metaphysics. It was particularly apparent in Cartesian metaphysics, in which one is supposed to access, in a purely intellectual way, some fundamental truths about the world.

The second reading is more positive. If metaphysics is defined not by an epistemic trait, but rather by its subject matter (eminent objects of knowledge, such as essences, forms, and primary causes), then it is not so much dismissed as redistributed into three distinct disciplines. Revealed religion, physics, and what Newton calls the “philosophy about the human mind and ideas” would each have a metaphysical part that is grounded on phenomena. The three sciences would nevertheless be distinct because the phenomenal realms on which they ground their conclusions are distinct: physics deals with the sensible external world, discovered to us by our five senses; philosophy of the mind considers the internal (but no less phenomenal world) discovered to us by reflection; and revealed religion also deals with something that is phenomenally given, and has to be read and interpreted, namely the Scriptures.

The passage is highly interesting. For one thing, it is a clear and rare expression of Newton’s own view of the *distributio operis* that obtains in the intellectual world. In particular, one can recognize in Newton’s description of the philosophy of the human mind a clear hint of Locke’s enterprise in his *Essay concerning human understanding*. The exploration of an inner field of empirical phenomena, discovered through the inner sense of reflection, may be seen here as a sort of counterpart to Newton’s own explorations of the external world. As Newton points out, following a suggestion of Locke himself,²⁷ the philosophy of mind belongs to physics understood in a broad sense and includes among its subject matters immaterial as well as material natural beings. Another striking point is the vindication of the methodological unity of these three great provinces of human science: they all derive their conclusions from the phenomena. Even theology finds in the words of the Scriptures its own sort of empirical constraints: there is no room for dogma here, no more than there is any in physics or in the philosophy of the mind. Finally, and it is the main point here, all three disciplines may be conceived as having a metaphysical part: they are not only descriptive disciplines, showing how the phenomena are connected, but they ought to offer some basis for speculation about true essences and primary causes.

Now, if we accept this reading, the question for us is how this “metaphysical part” could be developed in the specific case of physics (the science of bodies). I would suggest that we have two possible answers: whereas most of the published texts offer a rather “Boyliau” or physico-theological answer to this question, unpublished manuscripts present a somewhat different and perhaps stronger version of the Newtonian metaphysical physics.

It would perhaps not be amiss to mention that neither the *Principia* nor the *Opticks* proved to be very hospitable places for metaphysical considerations. For example, Newton deliberately suppressed any references to

God that were still lingering in his first versions of the *scholium* on space. Newton's aim in the *Principia* was precisely circumscribed:

For the basic problem [*lit.* the whole difficulty] of philosophy seems to be to discover the forces of nature from the phenomena of motions, and then to demonstrate the other phenomena from these forces.²⁸

The purpose is not to find out “the physical causes and sites of forces” (*Principia*, 407)—a question that Newton considers out of his scope—but rather to establish from phenomena the very “fact” of forces, to exhibit their abstract (or mathematical) structure, and finally show how they could be applied to the explanation of other phenomena. This is all the *Principia* is concerned with, and this is certainly enough of a task for one book and for one man. The main text of the *Opticks*—whose object is not forces but rather *the abstract constitution* of light—is similarly devoid of any explicit metaphysical considerations. Whatever metaphysical content is present in both texts, its official expression arrives only at the very end and appears as second thoughts, queries, or appendices.

In the *Scholium Generale* (published in the second edition of the *Principia*, 1713), Newton writes of God: “we know him by his most wise and excellent contrivances of things and final causes.” And after a couple of pages about how God (“pantokrator”) exerts his dominion on the material world by being substantially present to it, he famously concludes: “This concludes the discussion of God, and to treat of God from phenomena is certainly a part of natural philosophy.”²⁹ Similarly, in two final queries of the *Opticks*, after describing phenomena that include the attraction and the providential disposition of organs in living beings, Newton offers a few considerations (including the famous reference to space as God's sensorium) about how God might have formed matter at the beginning and how he is still present and providentially acting in the world.

Other interesting public pronouncements may be found in the 1692 correspondence with Richard Bentley, which took place just after Boyle's death, when Bentley was preparing the first Boyle Lectures.³⁰ Bentley asked Newton for suggestions about how his new natural philosophy might be put to use for promoting natural religion against the dangers of atheism and materialism; Newton was quite keen to detail for him a few interesting examples of such possible uses, and to show that the disposition of planets and the very measure of the laws of attraction were fit for providing the right sort of dwelling place for mankind, and thus could not be the result of mere natural causes.³¹

These texts quite undisputedly show that the late Newton had an interest in metaphysical questions, especially in the kind of physico-theological considerations that were so important to Boyle. These interests engaged him in the same sort of cosmogonic considerations that we found in Boyle: how did God arrange matter at the beginning? How did he dispose it in space, and to

which ends? It may seem, however, that Newton's Boylianism (if it may be so named) is still a rather superficial feature of his physics. Although Newton said to Bentley, in his first letter, that he had always had an eye for the service that physics could do to religion,³² Newton's explicit considerations on this specific topic are terse, and their public expression came quite late in his career. All in all, the defense of natural religion does not seem to have been such a strong driving force behind all of Newton's enterprises, as it was indeed in the works of Boyle, the "Christian virtuoso." Newton's interests in revealed theology were certainly much stronger, and it could be argued that they have helped to frame the actual contents of his view of God.³³

A good case for the thesis that Newton actually had a metaphysical physics of a stronger sort (concerned not only with the design and arrangement of matter but also with its creation and very essence) may be made through an examination of the manuscript *De Gravitatione*.³⁴ Although the text is most probably³⁵ of an early date and was written before Newton came to the idea of universal gravitation, its contents are consistent with a number of other metaphysical hints posterior to the publication of the *Principia*. For that reason, it cannot be considered as some kind of youthful foray into metaphysics, which was soon to be entirely dismissed in favor of a sounder and soberer approach to physics.³⁶ The manuscript, for the most part, is a dialectical discussion of central concepts of Cartesian physics, showing that they are mutually inconsistent and, in fact, contradicted by Descartes himself. It argues that it is simply impossible to assign any determined speed or direction to motion, if motion is defined, as it is in Descartes, as the translation of the body from the vicinity of one contiguous body to the vicinity of another. If motion is something real, we need to refer it not simply to other bodies, but to an immobile being, pure extension, or absolute space. This in turn imposes metaphysical strictures on the conception of such immobile space, namely the idea that it exists "without subject" and thus cannot be a substance or an accident of a substance. As space is the very system organizing the relation of "places" of existent beings, it should be rather conceived as an emanative effect (that is a necessary concomitant) of the existence of beings. As Newton says, "when a being is posited, space is posited"³⁷ and so an infinite, absolute space has to be the emanative effect of the existence of a first, eternal, infinite being, the one that occupies all places, in all times. Even though the very idea of an omnipresent God might have a theological origin, the inferential process used in the argument has a very characteristic *regressive* or *analytical* dimension. It begins with a consideration of the phenomenon of motion, and it shows that in order to make coherent the various features of this phenomenon, absolute space is needed. That conclusion in turn presupposes a number of other metaphysical decisions concerning substantiality, existence, and God's omnipresence. So what we have here is indeed an upward speculative movement from the phenomena, ending in a consideration of the primary cause. It is not simply the logically spurious inference from effects to cause, as in the physico-theological argument.

Rather each new step expresses the condition of the possibility, or the essential presupposition, of the preceding one.

The *De Gravitatione* comes then to a striking discussion of how bodies could have been created. Again, considering that impenetrability is the phenomenal datum that makes bodies differ from space, Newton offers a sort of metaphysical fable, in order to account for how bodies (or something indistinguishable from bodies) could have been created. If God had chosen by an act of his will to render some regions of space impenetrable (to the real bodies) and had decided to transfer continuously this field of impenetrability from one part of space to another in accordance with the laws of the communication of motion (the ones that we know in effect to obtain among the phenomena), these seemingly moveable impenetrable regions of space would be indeed undistinguishable from “actual” bodies, at least for all their mechanical properties. This account of the creation of matter is assuredly adventurous, and it raises a number of questions that cannot be examined here.³⁸ Newton recognizes that, since God’s will is contingent, God could have made bodies in another manner. The discussion is presented only as a conjecture, set in the frame of a cosmogonic fable and concerned only with *quasi bodies*.³⁹ But nevertheless, it could be argued that it is a discussion of how *physics* drives us naturally to conceive of the essence of bodies and bodily interactions, and how they could, or perhaps should, be constituted in nature to behave in such and such a manner. Here again, the style of reasoning is remarkable: Newton is not trying to deduce impenetrability from any innate idea of the essence of bodies, and even less the laws of collision from a preconceived idea of what God’s immutability amounts to. The impenetrability and the laws of collision are taken for granted: they are matters of fact provided by empirical description and rational mechanics. Metaphysics enters the picture only when one asks the question: how could we genetically explain the fact that bodies have such or such qualities or obey such or such laws? What sort of essential constitution must have been given to them? As it appears, the answer in the *De Gravitatione* draws heavily on God’s will and God’s continuous action, and seems to dispense entirely with any substantial substratum that is understood as some sort of elusive *materia prima* in which the qualities of extension and impenetrability inhere. As a quasi-substantial subject, space suffices for sustaining the bodily qualities that God’s will imparts to it.⁴⁰

In his chapter on Newton’s metaphysics, Howard Stein has suggested that we should take the metaphysics of the *De Gravitatione* as a kind of template for understanding the (still implicit) metaphysics of the *Principia*. As he writes:

If all this is brought into relation to the metaphysical analysis in *De Gravitatione et aequipondio fluidorum* it implies that in creating a body, God, or in the constitution of a body, nature, must impose, not only the field of impenetrability and the laws of motion appropriate thereto, but other fields as well, with their laws characterizing forces of

interaction of the kind that have been described—which fields, according to the preface to the *Principia*, it becomes the presumed task of natural philosophy to discover.⁴¹

Stein's descriptions are certainly quite suggestive. They make Newton a rather radical metaphysician, for whom the basic constituents of material reality are not substances or accidents, but fields of force (that is, dispatches of divine will) lawfully distributed in pure space. However, I am not sure that such a picture could always be easily reconciled with all of Newton's physical or metaphysical pronouncements. For example, in the last queries of the *Opticks*, Newton seems to hesitate between various causal interpretations of attraction. Attraction might be indeed the immediate action of God's will, which keeps the planets in their orbits and creates the field of force simply by being omnipresent to them. But it might also be operated through the mediation of some *active principle*, of a still unknown nature, which permeates space and interacts with bodies in a way that is also still unknown to us.

In any case, it cannot be doubted that there was a legitimate place, in Newton's eyes, for a metaphysical physics, provided that we understand its method in the Baconian sense—that is a physicalized metaphysics, an empirically constrained metaphysics of nature. As for its actual content, considering how scarce, terse, and sometimes cryptic the textual evidence is, the interpretive debate is still open and probably deemed to remain so.

Conclusion

Bacon's original views on the metaphysics of physics, together with Descartes' principles of philosophy, set the stage for British science in the second half of the seventeenth century. By no means were the British philosophers of nature hostile in principle to the idea that physics aims at discovering the true constitution of matter and the final cause of its arrangements. This speculative aim was still very much a driving force behind their devotion to physical investigations, together with service to natural religion and practical utility. They may have been more or less optimistic⁴² about the prospect of such metaphysical speculations, but they never failed to recognize them as an integral part of their physical undertakings.

Descartes' role in framing the very idea of what a modern metaphysical physics should be cannot be underestimated. In order to present their metaphysical hypothesis, both Newton and Boyle borrowed from Descartes the device of a cosmogenetic fable. To make intelligible how things are constituted in nature, it shows how the course of efficient causes could have made them, if God, rather than creating the world and the creatures in their actual shape (as Genesis tells us), had chosen to create some other, simpler state of things, together with their laws—for example, brute matter and regulated motion, brute matter and unregulated motion, or infinite space and dispatches of God's will. There is no need to say that for Descartes, Boyle, and

Newton the cosmogenetic account is markedly different, but its form has an indisputable common stamp in all three authors.

This said, the Baconian strand of metaphysical physics is certainly the dominant feature in both Boyle's and Newton's accounts. Both considered that the metaphysical part of physical enquiries is dependent on instructions from phenomena. This shared conviction is the source of their common rejection of Descartes' ways in metaphysics, his belief that the basic truths about nature were to be found in a purely intellectual way, through an examination of only the content of our ideas. This intellectualist bias was to Boyle the very reason why Descartes missed the main metaphysical benefit of experimental philosophy, i.e., the disclosure of God's wisdom and design through the contemplation of his works. In this, Newton certainly concurred, and he said so in a number of public declarations. However, his main motive for rejecting Descartes' way of ideas in metaphysical physics seemed to have been somewhat more epistemological and somehow more internal to the physical project itself. Physical certainty, if any such is ever to be found, must be grounded on matters of facts and on the rules of induction, and certainly not on preconceived ideas of bodies, space, or even God. Physics, strictly conceived, aims at establishing the truth of the facts (such as the "fact" that matter everywhere attracts matter according to a certain law). In this sense, physics *stricto sensu* is nothing more than a refined (and mathematically instructed) way of extending the testimony of the senses to a larger and richer range of phenomena. But physics, in the broad sense, includes *metaphysical physics*, when one comes to the question of how, once the truth of the facts has been fully demonstrated, we ought to determine the meaning of our basic physical concepts (such as space, time, motion, essential qualities of matter, force) so that they may be used together consistently in our account of these (new) facts. Here, it seems that the metaphysical enquiry, however grounded on phenomena, is not so much, as it was still perhaps in Boyle, an inductive inference (a generalization from a large number of similar facts) or a retroductive move (such as the physico-theological argument concluding from the effects to the "presumed" cause). Rather, it assumes (at least in the example of the *De Gravitatione*) the form of *conceptual analysis*; it is a regression from conditioned to condition, where each step is (or ought to be) a necessary one. So it seems that, when it is properly conducted, this way of inferring from phenomena should yield not so much plausible conclusions, as most certain ones. This is the kind of achievement that Newton (who was in this regard certainly more Cartesian than any other of his British contemporaries) always sought.

Notes

- 1 Daniel Garber, *Descartes' Metaphysical Physics* (Chicago: University of Chicago Press, 1992).
- 2 See Descartes to Mersenne, 11 November 1640, AT III 297–8: "je vous dirai, entre nous, que ces six Méditations contiennent tous les fondements de ma physique."

- 3 Here is how Descartes describes this order: “*Mais l'ordre que j'ai tenu en ceci a été tel. Premièrement, j'ai taché de trouver en général les principes ou premières causes de tout ce qui est ou qui peut être dans le monde, sans rien considérer pour cet effet que Dieu seul qui l'a créé, ni les tirer d'ailleurs que de certaines semences de vérités qui sont naturellement en nos âmes. Après cela, j'ai examiné quels étoient les premiers et plus ordinaires effets qu'on pouvoit déduire de ces causes; et il me semble que par là j'ai trouvé des cieux, des astres, une terre, et même sur la terre de l'eau, de l'air, du feu, des minéraux, et quelques autres telles choses, qui sont les plus communes de toutes et les plus simples, et par conséquent les plus aisées à connoître*” (*Discours de la méthode*, AT VI 43).
- 4 “*breuem historiam praecipuorum naturae phaenomenon,*” *Principia philosophiae*, AT III 4.
- 5 “[J]e remarquois, touchant les expériences, qu'elles sont d'autant plus nécessaires qu'on est plus avancé en connoissance; car, pour le commencement, il vaut mieux ne se servir que de celles qui se présentent d'elles-mêmes à nos sens, et que nous ne saurions ignorer pourvu que nous y fassions tant soit peu de réflexion, que d'en chercher de plus rares et étudiées: dont la raison est que ces plus rares trompent souvent, lorsqu'on ne sait pas encore les causes des plus communes” (*Discours de la méthode*, AT VI 43).
- 6 See the discussion in Denis Kambouchner, *Les Méditations Métaphysiques de Descartes I* (Paris: Presses universitaires de France, 2005).
- 7 These views are well illustrated in I. B. Cohen's classical studies of Newton's *Principia*, for example in Cohen (1980), and the introduction to I. B. Cohen and G. Smith, *The Cambridge Companion to Newton* (Cambridge: Cambridge University Press, 2002). See also the discussion of these views in Andrew Janiak, *Newton as Philosopher* (Cambridge: Cambridge University Press, 2008), chapter 2.
- 8 John Locke, *An Essay Concerning Human Understanding*, ed. Paul Nidditch (Oxford: Oxford University Press, 1975), The Epistle to the Reader, 10.
- 9 A less positivist and more proper assessment of Locke's views on physics, metaphysics, and their relation to the philosophy of the mind is beyond the scope of this chapter. Let us simply remark that Locke's own definition of physics, in the last chapter of the *Essay*, is broadened to the effect of including God and finite spirits among the objects of this science: “The knowledge of things, as they are in their own proper beings, their constitution, properties, and operations; whereby I mean not only matter and body, but spirits also, which have their proper natures, constitutions, and operations, as well as bodies. This, in a little more enlarged sense of the word, I call *Phusike*, or natural philosophy. The end of this is bare speculative truth” (*Essay*, IV, 21, 2).
- 10 “The Origine of Formes and Qualities,” in *The Works of Robert Boyle*, eds. Michael Hunter and John Davies (Pickering and Chatto, London, 1999), vol. 5, 289.
- 11 Locke, *Essay*, 10.
- 12 See *The Advancement of Learning*, The Oxford Francis Bacon, IV, ed. M. Kierman (Oxford: Clarendon Press, 2000), 80–1: “I use the word METAPHISICKE in a differing sense, from that, that is receyued: and in like manner I doubt not, but it will easilie appeare to men of judgment, that in this and other particulers, wheresoever my Conception & Notion may differ from the Auncient, yet I am studious to keep the Auncient Termes . . . I am otherwise zealous and affectionate to recede as little from Antiquitie, either in tearms or opinions, as may stand with truth and the proficience of knowledge.”
- 13 Bacon defines it negatively, as “a Receptacle for All Such Profitable Observations and Axioms, as Fall Not Within the Compass of Any of the Special Parts of Philosophy, or Sciences, But Are More Common, and of a Higher Stage” (Bacon, *Advancement of Learning*, 77). He also says that it is the “inquirie touching the

operation of the Relative and adventive Characters of Essences, as Quantitie, Similitude, Diversitie, Possibilitie, and the rest.” (82).

- 14 It should be clear that Bacon’s *philosophia prima* is not primary in the foundational sense that Descartes’ *prima philosophia* is. It owes its precedence only to the fact that its results are so general that they may be applied to every science. But the generality of *philosophia prima* concerns only the “Relative and adventive Characters” of things, not their true essences. It does not seem that there is any necessity to know thoroughly everything that could be known concerning these common accidents before coming to terms with the more particular sciences. This explains why the deficiencies in *philosophia prima*, noted in the *Advancement*, do not entail *ipso facto* deficiencies of the sciences that come second in the Baconian ordering.
- 15 “The work which God works from beginning to end.” Eccles. 3:11.
- 16 “Broad are the ways on all sides to the wise.” Cf. Prov. 4:11–12.
- 17 *The Works of Francis Bacon*, eds. J. Spedding and al., (London: Longman, 1857–1874), 14. 375.
- 18 Peter Anstey, “Experimental Versus Speculative Natural Philosophy,” in *the Science of Nature in the Seventeenth Century*, eds. Peter Anstey and John Schuster (Dordrecht: Springer, 2005).
- 19 Cf. Boyle, *Some Considerations touching the Usefulness of Experimental Natural Philosophy*, in *The Works of Robert Boyle*, vol. 3, 189 ff.
- 20 As in Rose-Mary Sergeant’s fine book, *The Diffident Naturalist, Robert Boyle and the Philosophy of Experiment* (Chicago: University of Chicago Press, 1995).
- 21 See *Reply to the Fifth Objections*, AT VII 375: “toutes les fins de Dieu sont toutes également cachées dans l’abîme impénétrable de sa sagesse.”
- 22 See AT III 431–2. Boyle (*Works*, 11, 92), quoting the letter to Hyperaspistes (in Clerselier’s French translation) admits that Descartes, in this letter, is only opposing “the reasonings of those who think that God has no other ends in creating the world but that of being praised by men.” According to Descartes: “it would be childish and absurd for a metaphysician to assert than God as some vainglorious human being, had no other purpose in making the universe than to win men’s praise.” To Boyle however, Descartes overstates his case, and fails to consider our duty of praising God for his Creation.
- 23 See AT 8A 15, CSM I 202. For a balanced discussion of Descartes’ views on final causes, see Margaret Osler, *Divine Will and the Mechanical Philosophy* (Cambridge: Cambridge University Press, 2005).
- 24 Of course, this “cosmological” proof of the existence of God, with which Boyle tends to credit Descartes, is nowhere to be found in Descartes’ work. In the Third Meditation, the ‘*preuve par les effets*’ was strictly restricted to the unique fact of which we could be absolutely certain (the fact of our own thinking). For all we know, motion, a sensible phenomenon, might only exist in our dreams.
- 25 Cf. I. B. Cohen’s Introduction to *The Principia, Mathematical Principles of Natural Philosophy*, trans. I.B. Cohen and A. Whitman (Berkeley: University of California Press, 1999), 54. Here is the original Latin text, in *Newton’s Mathematical Papers*, VIII 459: “*Quod in Metaphysica docetur, si a revelatione divina deducitur, religio est; si a Phaenomenis per sensus quincibus externos, ad Physica pertinent; si a cognitione actionum internarum mentis nostrae per sensum reflexionis, philosophia est de sola mente humana & ejus ideis tanquam Phaenomenis internis & ad Physicam item pertinet. De Idearum objectis nisi quatenus sunt phaenomena somnium est. In omni Philosophia incipere debemus a phaenomenis, & nulla admittere rerum principia nullas causas nullas explicationes nisi quae per phaenomena stabiliuntur. Et quamvis tota philosophia non statim pateat, tamen satius est aliquid indies addiscere quam hypothesewn praejudicij mentes hominum praeoccupare.*”

- 26 *Principia*, book III, 796.
- 27 See the text quoted *supra* note 9.
- 28 *Principia*, Preface, 382. In the last page of the *Opticks*, Newton similarly described the same two-stage enquiry: one part was resolute from compound to ingredients, from motions to force, or from effects to their (immediate) causes, and one part was compositive, which goes in the other direction and extends the phenomenal realm of the explanation.
- 29 *Principia*, 943.
- 30 Under the terms of his will, Boyle endowed a series of lectures or sermons (originally eight each year) to be held at Saint Paul's Cathedral, with the explicit purpose of proving "the truth of the Christian religion against infidels, without descending to any controversies among Christians; and to answer new difficulties, scruples, etc." Richard Bentley's *Confutation of Atheism*, whose last part draws heavily on Newton's answers, was the first outcome of the lectures. Boyle's Lecture rapidly became the main stronghold, in the early eighteenth century, for the defense of a latitudinarian physico-theology, against the rise of freethinking. See Margaret Jacob, *The Newtonians and the English Revolution, 1689–1720* (Hassocks, Sussex: The Harvester Press, 1976).
- 31 The four Letters to Richard Bentley, together with the last part of Richard Bentley's *Confutation of Atheism from the Origin and Frame of the World* (London, 1693) are reprinted in *Isaac Newton's Papers and Letters on Natural Philosophy*, eds. I-B. Cohen and R. E. Schofield (Cambridge, MA: Harvard University Press, 1958), 279–352.
- 32 See the opening sentence of his first letter, "Sir, When I wrote my Treatise about our System, I had an Eye upon such Principles as might work with considering Men, for the Belief of a Deity; nothing can rejoice me more than to find it useful for that Purpose" (*Newton's Papers and Letters*, 280).
- 33 To some commentators, the tone of absolute certainty that Newton uses when he says how we should conceive of the divine attributes is more likely to have been derived from his own (and sometimes rather idiosyncratic) reading of the Scriptures than from any considerations of physical appearances, or phenomena. As Andrew Janiak, who defends this thesis, puts it, the conception of God found in Newton's writings is entirely "immune to revision regardless of any developments within physics" (*Newton as Philosopher*, 48).
- 34 *De Gravitatione et Aequipondio Fluidorum*, in *Isaac Newton, Unpublished scientific papers of Isaac Newton*, Alfred Rupert Hall and Marie Boas Hall ed. (Cambridge: Cambridge University Press, 1962). We are particularly indebted here to the inspiring chapter of Howard Stein, "Newton's Metaphysics," in *The Cambridge companion to Newton* (Cambridge: Cambridge University Press, 2002).
- 35 According to the first modern editors (Hall & Hall), the manuscript is from the mid-1660s. Although it has been argued since (notably by B.-J. Dobbs) that it comes from a later date, contemporary with the composition of the *Principia*, the early dating remains more plausible (see the discussions in Stein, "Newton's Metaphysics," and J-A Ruffner, "Newton's *De Gravitatione*: A Review and Reassessment," *Archive for History of Exact Sciences* 66, no. 3 (2012): 241–64).
- 36 The ontology of space as a divine affection appears in a later manuscript, posterior to the first edition of the *Principia*, the manuscript has been edited and translated in J-E. McGuire, in "Newton on Place, Time, and God: An Unpublished Source," *British Journal for the History of Science* 11 (1978): 114–29). According to the testimony of Pierre Coste, the translator of Locke's *Essay*, the account of the creation of matter that is found in *De Gravitatione* was still in Newton's mind at the time of his acquaintance with Locke, that is, after 1690. Locke cryptically refers to it in the second edition of his *Essay*. See *Essai sur l'entendement humain*, traduit par Pierre Coste, Amsterdam, 1729 (2nde éd.), Coste's note to paragraph 4.10.18.

- 37 Newton, *De Gravitatione*, 103: “*Et hinc sequitur quod spatium sit primario existentis effectus emanativus, quia posito quolibet ente ponitur spatium*” “And hence it follows that space is an emanative effect of what primarily exist, since when any being is posited, space is posited” (our translation).
- 38 See the rather severe discussion in Jonathan Bennett and Peter Remnant, “How Matter must first be made,” *Canadian Journal of Philosophy* 4 (1978): 1–11; and, for a qualified defense of Newton’s argument, Lisa Downing, “Locke’s Metaphysics and Newtonian Metaphysics,” in *Newton and Empiricism*, eds. Zvi Biener and Eric Schliesser (Oxford: Oxford University Press, 2014), 97–118.
- 39 The whole discussion, and especially this cosmogenetic fabulation (which evokes Descartes’ genetic way of presenting his physics in *Le Monde, l’Homme*, and his *Discourse on Method*) shows how much Descartes’ spirit and style was still present and influential in the *De Gravitatione*, even though the intellectualist bias of the Cartesian metaphysical physics was the main target of it.
- 40 See Newton, *De Gravitatione*, 106–7. “*Quod ad horum entium existentiam non opus est ut effingamus aliquam substantiam non intelligibilem dari cui tanquam subject forma substantialis, inheareat: sufficient extensio et actus divinae voluntatis. Extension vicem substantialis subjecti gerit in qua forma corporis per divinam voluntatem conservatur, et effectus iste divinae voluntatis est forma sive ratio formalis corporis denominans omnem spatii dimensionem in qua produci-tur esse corpus.*” Here is ~~the~~ revised version of the somewhat defective translation of this very significant passage by Hall and Hall (140): “For the existence of these beings it is not necessary that we feign some unintelligible substance to exist, in which a substantial form should inhere as in a subject; extension and an act of divine will are enough. Extension takes the place of the substantial subjects in which the form of the body is conserved by the divine will. And the effect of this divine will is the form (or formal reason) of bodies, denominating every dimension of space where body is to be produced.”
- 41 Stein, “Newton’s Metaphysics,” 288–9.
- 42 Even Locke, who was perhaps more pessimistic than his peers about how far we could make physics “scientific” (that is, raise it beyond the status of uncertain hypothesizing), still defines physics, not so much as a pragmatic enterprise, but as a “speculative” one, which aims at discovering the true constitutions of beings (see *supra* note and the reference to *Essay*, 4.21). Although he often declares that he does not want to “meddle” with physical considerations (*Essay* 1.1.2), the *Essay*, in many ways, makes room for them, at least at the level of probability, dealing both with the essence of the mind and that of matter. Since it shows how our metaphysical options are somehow constrained by the results of an empirical enquiry (the reflective enquiry on ideas), it would not be improper to say that Locke’s *Essay* also belongs to the Baconian tradition of “metaphysical physics” that has been illustrated here.