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On Philosophy and Natural Philosophy in the Seventeenth Century

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That seventeenth-century usage did not distinguish science from philosophy is, I suppose, widely known; but perhaps it is less widely regarded as a matter of consequence. I think the usual view is that the practice of restricting the sense of the word "philosophy" to some set of more general or more fundamental kinds of inquiry makes a useful distinction, and one that is in effect to be found in practice throughout what we regard as the "modern" period of philosophy.

I do not wish to claim that this is entirely wrong. A difference that has some kinship with our own departmentalization of disciplines can certainly be discerned among works of seventeenth-century authors; if that were not so, the view that I have called the usual one could hardly have been maintained at all. But I think the view is misleading—which is a more insidious thing than to be conspicuously wrong. I want to present two broad theses, which I shall try to make plausible by a number of concrete examples: first, that the historical understanding both of what *we* call "philosophy" and of what *we* call "science" in the early modern period is significantly better served if we pay more attention than has usually been done to the relation they had for their practitioners; second (and, for me, more important), that a certain shift of perspective *upon philosophical issues*—issues that we still trace back to the seventeenth and eighteenth centuries—may result; a shift that I myself regard as a philosophic gain and that at any rate I hope will, less controversially, be seen as worth reflecting upon.

Let me begin with a rather blatant example—one that I have discussed before (as long as twenty-five years ago). It is taken from a work no longer much regarded, but quite influential in its day; a work to whose stimulation I owe something, for at the time I was a student it stood as a pioneering attempt to bring the history of philosophy into contact with that of science. I speak of the late E. A. Burtt's *The Metaphysical Foundations of Modern Physical*

Science. In his chapter 7, "The Metaphysics of Newton," Section 4(B), "Space and Time," Burtt writes the following:

> When we come to Newton's remarks on space and time . . . he takes personal leave of his empiricism, and a position partly adopted from others, partly felt to be demanded by his mathematical method, and partly resting on a theological basis, is presented, and that in the main body of his chief work. Newton himself asserts that in "philosophical disquisitions", which apparently means here when offering ultimate characterizations of space, time, and motion, "we ought to abstract from our senses, and consider things themselves, distinct from what are only sensible measures of them."[1]

There are several things wrong with this; but what I call "blatant" is the construction Burtt so casually puts upon Newton's phrase "in philosophical disquisitions." Burtt's target in this entire passage is, of course, the celebrated scholium of Newton on time, space, place, and motion, with its distinction of each of these into "absolute and relative, true and apparent, mathematical and common." Speaking there of time in particular, Newton says:

> Absolute time is distinguished from relative in Astronomy by the equation of the common time. For the natural days are unequal, which are commonly used, as if equal, for a measure of time. The Astronomers correct this inequality, that they may measure the celestial motions by a truer time. . . .The duration or perseverance of the existence of things remains the same, whether the motions are swift or slow, or none at all: and therefore it ought to be distinguished from what are only sensible measures thereof; and out of which we collect it, by means of the astronomical equation. The necessity of which equation in determining phenomena is evinced as well from the experiments of the pendulum clock, as by eclipses of the satellites of Jupiter.[2]

This one might have expected to give Burtt some pause, both in his claim that Newton has taken "personal leave" of his empiricism in asserting a distinction of "absolute, true, and mathematical" from "relative, apparent, and common" quantities—for Newton refers to *experiments* (with the pendulum clock) and *observations* (of the satellites of Jupiter) as providing evidence of the need to distinguish true from apparent times—and in his interpretation of the sort of context in which Newton says this distinction ought to be made (namely, "in philosophical disquisitions"). But what is most ludicrous here is that Burtt has forgotten the very title of the book—rightly called by him "[Newton's] chief work"—in which the discussion he is criticizing occurs. The title is *Mathematical Principles of Natural Philosophy*; and for clarification of the sense attached by Newton to the phrase "philosophical disquisitions," Burtt would have done well to reflect on this fact, rather than to rely on his sense of what that phrase "apparently means."

A second passage that had a significant effect on me as a student is one from Descartes; but I read it first in Norman Kemp Smith's *New Studies in the Philosophy of Descartes*. "Writing to Beeckman," Smith says, "Descartes admits that the whole body of his physics [*totam meam Philosophiam*] would be shaken to its very foundations, should light not travel instantaneously."[3] Although he gives Descartes's own phrase in brackets, Smith's translation implies the clarification: "here by *philosophy* Descartes just means physics." But what Descartes actually says is "my whole philosophy would be utterly overthrown" (or "overthrown from its foundations": *totam meam Philosophiam funditus eversam fore*). This seemed to me at the time rather striking; I had previously assumed that Descartes's physics was of minor interest compared to what I myself then thought of as his "philosophy"—but the passage, even if it is taken as hyperbole, suggested that perhaps the physics ought to be looked at more seriously as part of an organic whole.

Here is a more recent comment—again from a philosopher who, like Burtt and Smith, is aware of and interested in the connection, in the seventeenth century, between what *we* call "physics" and "philosophy"; and who, in this passage, is concerned to emphasize this point.

> The notion that there is an autonomous discipline called "philosophy," distinct from and sitting in judgment upon both religion and science, is of quite recent origin. When Descartes and Hobbes denounced "the philosophy of the schools" they did not think of themselves as substituting a new and better kind of philosophy—a better theory of knowledge, or a better metaphysics, or a better ethics. Such distinctions among "fields of philosophy" were not yet drawn. The idea of "philosophy" itself, in the sense in which it has been understood since the subject became standardized as an academic subject in the nineteenth century, was not yet at hand. Looking backward we see Descartes and Hobbes as "beginning modern philosophy," but they thought of their own cultural role in terms of what Lecky was to call "the warfare between science and theology." They were fighting (albeit discreetly) to make the world safe for Copernicus and Galileo.[4]

But what Rorty tells us here is wrong. Descartes emphatically did think of himself as "substituting a new and better kind of philosophy" for that of the schools: a better metaphysics, a better physics, and in prospect a better ethics—"fields of philosophy" that he explicitly did distinguish. Of course I have included one field—physics—that Rorty does not; Descartes's own list (sufficiently celebrated) contains two more: *mechanics*—that is, more or less what we should call "engineering"—and *medicine*. As to making the world safe for Copernicus and Galileo, there is no doubt that Descartes deeply deplored the condemnation of the latter for teaching the doctrines of the former—a condemnation by which he felt himself very seriously threatened; but his comments on the actual work of Galileo are generally negative and dismissive.

Here is the view of Christiaan Huygens (whose father was a friend of Descartes, and who was himself in his youth an enthusiastic reader of Descartes's works):

> M. Descartes, who seems to me to have been very envious of the renown of Galileo, had that great desire to pass for the author of a new philosophy. Which is apparent from his efforts and his hopes to have it taught in the academies in place of that of Aristotle; from the fact that he wished the society of the Jesuits to embrace it: and lastly because he maintained indiscriminately [*à tort et à travers*] the things he had once put forward, although they were often quite false.[5]

Huygens is indisputably right in saying that Descartes wished to be seen as the author of a new philosophy—that is, of a new science. He wished more than that: he wished to *be*, *in truth*, the author of a new philosophy—and moreover of a true one; or rather, of *the* true one. Further, he thought that he *was so* in truth.

One should understand what this claim of Descartes's meant. I have referred to the fields of philosophy as Descartes names them; the locus is the letter to Picot that serves as a preface to the French edition of the *Principia Philosophiæ*. In that place there occurs his famous metaphor of philosophy as a tree, whose roots are metaphysics, its trunk physics, and its branches—which bear the fruit—the other three fields I have named: medicine, mechanics, and morals. Of these, it is medicine above all that was Descartes's preoccupation. Thus in January 1630 he writes to Mersenne:

> I am distressed over your erysipelas, and over the illness of M. [Montais]; I beg you to preserve yourself [*de vous conserver*], at least until I shall know whether there is a way to find a Medicine founded on infallible demonstrations, which is what I now seek.[6]

And again on April 15 of that year:

> I am now studying in chemistry and anatomy together, and learn something every day that I do not find in the books. I wish I had already come to the point of research into diseases and their remedies, so that I could find one for your erysipelas, with which I am sorry you have been afflicted for so long.[7]

In the concluding paragraph of the *Discours de la Méthode*, he says:

> I have resolved to devote the rest of my life to nothing other than trying to acquire some knowledge of nature from which we may derive rules in medicine which are more reliable than those we have had up to now.

And writing to the Marquess of Newcastle in October 1645 he says, "The preservation of health has always been the principal end of my studies."[8] The sincerity of these professions seems guaranteed above all by the evidence that

the medical problem of greatest interest to Descartes was that of longevity—and that this was very much a *personal* concern: a desire for *his own* longevity. On this subject he writes, December 4, 1637, to Constantijn Huygens:

> I have never taken so much care to preserve myself as now, and whereas I used to think that death could snatch from me no more than thirty or forty years at the most, it would not henceforth surprise me if the deprivation could amount to more than a century: for I seem to see very clearly, that if we just beware of certain mistakes that we habitually make in the conduct of our lives, we should be able without any other discoveries [*inventions*] to arrive at a far longer and happier old age than we [now] do; but because I have need of much time and many experiments to investigate everything of use for this subject, I am now working to compose a digest of Medicine, drawn partly from the books and partly from my reasonings, that I hope to be able to use provisionally to obtain some reprieve from nature, the better afterwards to continue with my plan.[9]

Although further evidence of Descartes's optimism in this matter is somewhat variable, there is some indication that at least at times—and to *some* of his followers—Descartes offered even far more favorable estimates, not only of the possibilities, but of what he had actually achieved. One report, deriving from "the chevalier [that is, Sir Kenelm] Digby," has it that Descartes assured the latter that "although to render man immortal is what he would not dare to hope for [*se promettre*], he was quite sure of being able to render his [that is, presumably, "man's"] life equal to that of the Patriarchs."[10] Digby is, to be sure, not an informant who inspires the greatest confidence (one contemporary characterizes him as "the very Pliny of our age for lying");[11] but whether or not Digby exaggerated, there is other testimony in a quite similar vein. Thus Baillet tells us that when the news of Descartes's death in Sweden was received in Paris, the Abbé Picot at first would not believe it; and afterwards said that his death could only have resulted from the derangement of his system by the unhealthy north—since "in the absence of such an alien and violent cause, . . . he would have lived five hundred years, after having discovered the art of living several centuries."[12] Finally, and perhaps most telling, Queen Christina herself—who had been discussing the question of longevity, among other matters, with Descartes just before his final illness—commented wryly when he died that "his oracles have quite deceived him."[13]

But what has this to do with *our own reading* of Descartes's philosophy? For *us*, surely, Descartes's dream of establishing physics (and medicine!) on "infallible demonstrations" is just a quaint delusion of the time and the person, which ought not to prejudice our judgment of the epistemological and metaphysical discussions that *he* thought would serve to found such a science. To this I merely reply: prejudice, no; but influence—yes. In his metaphor of the tree, and his remark that "just as it is not the roots or the trunk of a tree from which one gathers the fruit, but only the ends of the branches, so the principal benefit of philosophy depends on those parts of it which can only

be learnt last of all," Descartes clearly had in mind chapter vii, verse 20 of the Gospel of Matthew: this criterion forms, in a certain sense, a part of his own epistemology, and simply to ignore it in our reading of that epistemology is in some degree a distortion. Furthermore, the criterion of judging by the fruits has this merit: that on some matters it really does put an end to dispute. Now, dispute on ticklish questions of Cartesian epistemology and metaphysics has been endless and subtle. But I have been struck by the fact that some of the cruces of Cartesian argumentation and doctrine—for instance, the much-debated issue of the circularity of the main argument of the *Meditations*, or the doctrine of the arbitrary creation of the eternal truths (which Descartes himself advises us not to think about too much)[14]—bear, in the puzzling character of the argumentation or the apparent inconsistency of the principles invoked, a remarkable resemblance to passages of Descartes's physics whose coherence no one could reasonably be tempted to defend; some of these contain even astonishing *mathematical* sophisms.

I do not wish to embark here on a detailed discussion of science and philosophy in Descartes, for although I think him a very important figure and a very interesting one, my conclusions tend (as the remarks already made will suggest) to be rather negative. Such conclusions demand especially careful citation and argument—inappropriate for a brief essay; and they are after all not very attractive or exhilarating. Let me just say summarily that, in the first place, Descartes's philosophical work was devoted to the aim of establishing a new philosophy in the fullest possible sense of that phrase; in the second place, that his view of this new philosophy was *not* that of a collective enterprise to be pursued independently by inquirers like Galileo and himself: rather, it was his ambition—and to the end of his life, his *hope*, in which he continued to express confidence—that he could *by himself*, with the aid only of artisans to make equipment and to carry out experiments under his direction, bring this project to essential *completion*; and, finally, that my own study of this work has led me to conclude that Descartes *as a philosopher in our own sense of the word* fell victim to something he thought he had fundamentally guarded himself against: a deceiver. For in my view, Descartes is an astonishing example of a self-deceiver.

Descartes's influence upon the metaphysics (including epistemology) and physics of the later seventeenth century was of course very great. In the piece from which I have already quoted, Huygens—after remarking that, from having thought in his own mid-teens that in Descartes's "*livre des Principes. . . tout alloit le mieux du monde,*" he had gradually come to change his opinion, until, at age sixty-four, "I find hardly anything that I could approve as true in all his physics or metaphysics"—goes on to deplore that influence:

> He should have proposed his system of physics as an essay in what one might say with probability in that science admitting mechanical principles only, and have invited good minds to investigate on their own part [note: something like what Rorty supposes Descartes to have done]. This would

> have been very laudable. But in wishing it to be believed that he had found the truth, as he did in everything, in founding himself upon and glorying in the sequence and the beautiful connection of his expositions, he has done a thing that is of great prejudice to the progress of philosophy.

But at the end of this set of notes on Descartes—made by Huygens during his reading of Baillet's life of that philosopher—he comes to a more generous estimate: that Descartes's grandiose attempt did at any rate show much genius; that his example, and the celebrity he achieved by his work, has inspired others to try to do better; and that if one considers only his achievements in geometry and algebra, he must be accounted a great mind.[15]

I cite this particularly because Huygens himself is one of the two investigators in physics to whom his own remark, that Descartes's example has inspired others to try to do better, most conspicuously applies. The second, of course, is Newton; and a comparison of the two, in point both of their own philosophical achievements and their philosophical relations to Descartes, seems to me a very instructive thing.

Huygens disavows both Descartes's metaphysics and his physics; and he entirely abandons Descartes's epistemology, which demanded that science be based upon principles secured by intuition, and demonstrative reasoning—that is, must be so constituted as to avoid the possibility of error. In contrast, Huygens tells us that the deeper investigations of physics lead to "demonstrations of those kinds which do not produce as great a certitude as those of Geometry, and which even differ much therefrom, since whereas the geometers prove their Propositions by fixed and incontestable Principles, here the Principles are verified by the conclusions to be drawn from them; the nature of these things not allowing of this being done otherwise."[16] (To be sure, this can be seen as influenced by Descartes's own practice; but it contradicts his principles.) However, despite his rejection of the Cartesian identification of the corporeal with the extended, and his embrace of the entirely un-Cartesian doctrine of the atomic constitution of matter, Huygens remained deeply committed to a pair of principles that can be seen as constitutive both of a conception of knowledge and a conception of the world—principles in this sense epistemological and metaphysical—that he did share with Descartes. This is already suggested by a remark in the passage I have quoted above: his reference to the praiseworthiness of "an essay in what one might say with probability [this, of course, is what contrasts with Descartes] in [physics] *admitting mechanical principles only*."

The phrase "mechanical principles," in the seventeenth century, connoted two things. The first of these is stated with admirable clarity by Huygens at the beginning of his discussion of the nature of light (*Treatise on Light*, p. 3), where he says: "It is inconceivable to doubt that light consists in the motion of some sort of matter"; and then, after listing kinds of phenomena that support this view, adds: "This is assuredly the mark of motion, *at least in the true Philosophy, in which one conceives the causes of all natural effects in terms of*

mechanical motions." And finally: "This, in my opinion, we must necessarily do, or else renounce all hopes of ever comprehending anything in Physics."

It would be interesting to know upon what Huygens conceived this "opinion" of his to be based. In particular, did he believe there was convincing evidence of some kind—and if so, of what kind—supporting what he calls "the true Philosophy": evidence that *in truth all natural effects are caused by mechanical motions?* (The phrase "mechanical motions," here, is to be understood simply to mean *motions of bodies in space* [or—Huygens was in fact a relativist—"with respect to their spatial relations to one another"]: the Aristotelian φορά, as opposed to κίνησις) Of course, if one does have convincing reasons to believe that the world is so, one will *ipso facto* believe it is only by conceiving the causes of natural effects in such a way that one can hope to comprehend them. But it seems to me more likely that Huygens was moved by what I may call a modest transcendental argument: the possibility of advancing physical knowledge along such a path, which had inspired him in his youth, continued to look promising; he saw no alternative possibility that appeared to him worth pursuing; and he concluded—expressly as an "opinion" (although he also characterizes this view as "the true Philosophy"; thus, certainly, a very *firm* opinion)—that *the world must be so, if we are to comprehend it.* In any case, we have, in parallel, a view of the world itself, and an ideal of what science ought to (or *must*) be.

If all phenomena are the effects of motions, then to understand their causes two sorts of knowledge are required: one must know something about the kinds of motion that produce phenomena—appearances—of given types (heat; light—and, in more detail, light of various specific *qualities*, especially colors; weight; smell; etc.)—let us say, one must know the "mechanical" *nature* of such phenomena; and one must know something about how those underlying motions of bodies *affect one another*—that is, one must possess a system of principles of *mechanical interaction.* This latter Descartes had claimed to provide, in his three general "laws of nature," in *Le Monde* and in the *Principles of Philosophy.* The latter work offers also more specific "rules" for determining the effects of impacts of bodies upon one another; and the *Dioptrics* contains examples of reasoning, of a "mechanical" kind (in the sense understood by Descartes), for deducing the laws of light from postulates about its "mechanical nature." It is these detailed principles of interaction, and in the first instance most particularly the rules of impact, that Huygens early became disillusioned with, coming to see them not only as false, but even as unreasonable and absurd. On the other hand, one characteristic of Descartes's conception of the principles of interaction—of what exclusively deserve to be regarded as *conceivable* principles of interaction—continued to dominate the thought of Huygens, and formed an essential part of what he regarded as the "true Philosophy": namely, that (a) motion of itself tends to *persist*—to remain constant in both magnitude and direction; and (b) only when two bodies are in contact, in such a way that the conservation of the motions of both would entail their mutual penetration, can any direct "interaction" occur

between them. (For Descartes, from a fundamental metaphysical point of view there is even in that case no "direct" interaction, since "God is the primary cause of motion": he "imparted various motions to the parts of matter when he first created them, and he now preserves all this matter in the same way, *and by the same process* by which he originally created it" [*Principles*, II, §36; emphasis added]. Nevertheless, Descartes admits in a "secondary" sense—so-called "second causes"—what he calls the "force" of a body "to continue its motion or rest," or to "drive or resist another" [ibid., and §§40ff, esp. 43 and 45]; and it is on his estimates of these "forces," these "second causes," that he bases his reasoning in physics.)

This is what I have referred to as the second connotation of the term "mechanical principles": the view that the only intelligible form of interaction is what was called "mechanical action," namely the alteration of the motion of one body by another *through contact*, and more specifically through such contact as *necessitates a change in motion to avoid mutual penetration.* This conception continued to dominate the thought, not only of Huygens, but of all the "mechanical philosophers" of the seventeenth century (most definitely including Leibniz, for instance)—with the single exception of Newton (who for this reason should not be listed, without qualification, among the mechanical philosophers).

Note once more that the mechanical philosophy involves both an ideal of science and a fundamental view of what the constitution of the world is. Of course, in saying that it involves an ideal of science, I do not mean a clear and univocal conception of the *grounding* of knowledge—since, for instance, on this point Descartes and Huygens radically differ—but rather an ideal of the *form*, or "shape," of science. Note too that the view of the constitution of the world is a view of *the nature of causation.* Since the latter involves the notion that all causation among bodies is "mechanical" in the sense I have explained, it follows that for the mechanical philosophy to know *the* fundamental principles of nature—what Descartes calls to "know what a natural power in general is"[17]—is to know *the laws of the communication of motion by contact.* In principle, therefore, in Descartes's own system, his rules of impact ought to be regarded as the laws of fundamental interaction—the foundation of principles of all "second causes." (One striking index of the peculiar texture of Descartes's actual reasoning is Descartes's own assurance to Queen Christina that these rules need not be studied with care, for they are unnecessary to an understanding of the rest of the work.[18])

Huygens—and Leibniz—at any rate did indeed regard the laws of impact as the fundamental laws of physics; the counterpart today would be the elusive unified theory of the so-called four fundamental forces. And it is one of Huygens's very great achievements to have discovered a viable theory of impact. In doing so—by a very beautiful series of theoretical arguments, grounded in part in Galileo's results concerning falling bodies, and in part in two principles of the greatest generality: the principle, borrowed from Galileo but stated for the first time with full clarity by Huygens, that we now call that of Galilean relativity;

and the principle of the impossibility of perpetual motion (or more exactly, of the *creation of energy*)—he contributed essentially to what we ourselves call the science of mechanics. Newton, in his scholium to the laws of motion and their corollaries in his *Principia*, characterizes the laws he has stated as already contained in the work of his predecessors. But, as I have already intimated, "mechanics" as it appears in Newton has been significantly transformed.

In order to explain how transformed, I want first to return to a comparison I have made before: of Newton and Locke. If Descartes is a fascinating figure because of his astoundingly grandiose purpose, his monumental assurance, and (as I think) his grotesque but possibly instructive mistakes, Locke is fascinating for his very serious and honest engagement with problems of knowledge and its advancement, and for his willingness—part of that seriousness and honesty—to *vacillate* over fundamental issues. Locke can be exasperatingly repetitious, and exasperatingly inconsistent; but his repetitions are a sign of his persistent preoccupations, and his inconsistencies are a sign of genuine perplexities. On the other hand, what is surely his most profound vacillation, inconsistency, and—I believe—objectively and in principle his revolutionary *change of mind*, is *not* conspicuous in the text of the *Essay*, but on the contrary is almost undetectable there. The revolutionary change is due directly to Newton.

Among the central motifs of Locke's *Essay concerning Human Understanding*[19] are the doctrine of primary qualities, the problematic "idea" of *substance*, and an altogether skeptical view of the possibility of a science of nature. These themes are deeply interconnected. Locke's view of science in the *Essay* is Cartesian in one important respect that contrasts with Huygens: a body of doctrine has no standing as science unless its constituents are either *intuitive*, or derived from intuitive principles by *demonstrative reasoning*. (To be sure, Locke admits a third degree of knowledge—*sensitive* knowledge; but this not only has a lower degree of certainty than the former two, what is of far greater moment, it does not contribute to what I have called "a body of doctrine"; for it has as object nothing but "the existence of particular external Objects, by that perception and Consciousness we have of the actual entrance of *Ideas* from them" [*Essay*, IV, ii, §14]—that is, it does not extend beyond the objects of *present* sensation.) On the other hand, Locke rejects Descartes's theory of innate ideas and principles; and, in particular, rejects not only Descartes's own view of the nature of corporeal substance, but rejects also—if I may editorialize: quite properly!—the very possibility of knowledge of corporeal nature demonstrated from intuitive principles.

What, then, it might be asked, is the allegedly deep connection of the three motifs I have mentioned? The account I have just given of Locke's skepticism concerning natural philosophy does involve reference to "corporeal nature," and so to "substance"; but the connection is pretty thin and altogether negative, consisting simply in the denial that we have any source of general knowledge thereof; and the motif of "primary qualities" has not occurred at all. Moreover, so far as this point goes, it would seem that Locke's aim in the *Essay*—"to enquire into the Original, Certainty, and Extent of humane

Knowledge; together with the Grounds and Degrees of Belief, Opinion, and Assent" (I, i, §2)—could, as regards the first topic, *Knowledge*, and this main branch, *of corporeal nature*, have been disposed of in very short order indeed. (Of course, Locke himself tells us that when he first put pen to paper, he thought that one sheet would have sufficed for all he had to say.)

The official program of the *Essay*, announced in the immediate sequel to the passage just quoted, is to avoid entirely what Locke calls "the Physical Consideration of the Mind"—including under this any consideration of the dependence of our "Ideas" upon matter—and to study only mental *phenomena*, or "the discerning Faculties of a Man, as they are employ'd about the Objects, which they have to do with." In this program, "speculations" are to be avoided; Locke characterizes his proceeding as "this Historical, plain Method"; and, on his own final teaching, its product can have no standing as "science," or "knowledge."

There may be such an essay embedded in the *Essay*; and if so, the "thin" argument sketched above might—I am not sure: perhaps it could not—find its place there. But the work Locke has given us departs very far from that program, and he is (perhaps somewhat uncomfortably) aware that it does. This is most clearly acknowledged in chapter viii of Book II, which introduces the distinction of "qualities" into primary and secondary: in §22 of that chapter, Locke apologizes for having "been engaged in Physical Enquiries a little farther than, perhaps, I intended"; and asks to be "pardoned this little Excursion into Natural Philosophy," on the grounds that "to distinguish the *primary*, and *real Qualities* of Bodies, which are always in them," from the others, is "necessary in our present Enquiry."

The primary importance of the primary qualities for Locke is twofold, and both aspects bear crucially upon his conception of what natural philosophy should be and what the prospects for it are. In the first place, those qualities, in Locke's express view, constitute the *foundation*, the *principles (principia*; this is the direct connotation of the word "primary"–or, as Locke also calls them, *original*), intrinsic in bodies, of all their other properties; that is, they are *causally fundamental*. Thus, of the "secondary" qualities, Locke says that they are "powers" of a body, "*by* Reason of *its* insensible *primary Qualities*, to operate. . . on any of our Senses" (§23); and of a very important third class of properties, for which Locke subsequently (§26) proposes the designation *"Secondary Qualities, mediately perceivable,"* he says (§23) that they are powers of a body, "*by* Reason of the particular Constitution of *its primary Qualities, to* make such a *change* in the *Bulk, figure, Texture, and Motion of another Body*, as to make it operate on our Senses, differently from what it did before." (Locke's peculiar way of using italics in these passages serves to highlight what he regards as summarizing their essential force. In each case, the phrase *by its. . . primary Qualities* is made to stand out.)

Locke does not tell us how, in his view, we know that the primary qualities are causally fundamental. Indeed, he vacillates on the question *whether* we know this. For instance, he refers (IV. iii. §11) to the secondary qualities of

bodies as "depending all (*as has been shewn*) upon the primary Qualities of their minute and insensible parts; *or if not upon them, upon something yet more remote from our Comprehension*" (emphases added). The parenthetic phrase "as has been shewn" seems to imply something like a previous *demonstration*; but the reservation that follows belies this, and raises interesting and puzzling questions. One thing that seems to me unclear is whether Locke considered it as secure knowledge (if so, that knowledge must, I think, be "intuitive") that the primary qualities are *among* the causally fundamental ones, and doubtful only whether there may be other causally fundamental properties as well, that are "more remote from our Comprehension"; or whether he also regarded it as doubtful that the qualities he lists as primary are truly so—whether they themselves may be "secondary"—that is, *derivative* from something "more remote from our Comprehension." (It is worth noting that this last is the teaching of the natural philosophy of the twentieth century.) There are passages in Locke that suggest the latter, more radical, view may have occurred to him as a troubling possibility; but I do not have space to pursue this matter further here.

At any rate, whatever the reservations may be that attach to the position—and the more far-reaching conception of the corpuscular constitution of bodies (with all their properties depending upon the primary qualities of *ultimate indivisible particles*) is explicitly characterized by Locke as a "hypothesis" (IV. iii. §16)—it is certainly the "official" view of the *Essay* that we neither have *nor can have* any clear ideas of causative principles of bodies *beyond* the primary qualities detailed by Locke (all of which, it should be noted, are characterized by him as corresponding to *simple ideas of sensation*). So the twofold importance for Locke's conception of science is this: first, to *have* a natural science would be to have a genuine—intuitively grounded and demonstratively elaborated—causal account of appearances (and, thus, in Locke's conception, *of our "ideas of sensation"*) that should derive the latter exclusively from Lockian primary qualities of the minute parts of bodies. But second, this is (in effect) *demonstrably impossible*—for two reasons: (a) we have no sensory access to the necessary *information* about bodies—"the size, figure, and texture of Parts" on which everything else depends (IV. iii. §11); (b) even worse (Locke says: "a more incurable part of Ignorance"), we have no conception of how the primary qualities of bodies could produce in us any "ideas" whatsoever (IV. iii §§12–13). (In fact, Locke mentions only ideas of *secondary* qualities in this connection; it remained for Berkeley to point out that the same problem arises for our ideas of primary qualities.)

As a summary of this aspect of Locke's position, and at the same time a wonderful example of his characteristic mode of decisive ambivalence, the following passage from his chapter "Of our *Complex Ideas* of Substances" may serve:

> To conclude, Sensation convinces us, that there are solid extended Substances; and Reflection, that there are thinking ones: Experience assures us of the Existence of such Beings; and that the one hath a power to

> move Body by impulse, the other by thought; this we cannot doubt of. Experience, I say, every moment furnishes us with the clear *Ideas*, both of the one, and the other. But beyond these *Ideas*, as received from their proper Sources, our Faculties will not reach. . . . From whence it seems probable to me, that the simple *Ideas* we receive from Sensation and Reflection, are the Boundaries of our Thoughts; beyond which, the mind, whatever efforts it would make, is not able to advance one jot; nor can it make any discoveries, when it would prie into the Nature and hidden Causes of those *Ideas*. (II. xxiii. §29.)

That these simple ideas—of which Locke offers several lists, all short—are "the Boundaries of our Thoughts; beyond which the mind. . . is not able to advance one jot" is Locke's central doctrine, stated here in pithy and sinewy prose; but with the qualification: *"it seems probable to me"*! And I say, "Admirable Locke!"

The idea of substance is of course a critical problem in Locke. He himself regards it as a critical problem, and expresses the greatest perplexity about it; and his expressions of perplexity are themselves notoriously perplexed, so that this has become a *crux* for interpreters of the *Essay*. There are a number of issues simultaneously involved in this problem, and as it is out of the question to discuss them here with any claim to adequacy, I shall just summarize those aspects of the theme that are most germane to what I wish to discuss.

One obvious point of difficulty—not for the interpretation of Locke, perhaps not for Locke himself, but for *science*—in Locke's view of science and of substance, is implicit in what has already been said: it is knowledge of the true natures (the "real essences," in Locke's terminology) of substances that he finds barred to us by the limitations of our faculties. (Since Locke says that the "idea of substance in general" is formed *by abstraction* from the ideas of *particular substances* [III. iii. §9], the obscurity—or, rather, "confusion"—that Locke says inescapably attaches to the former idea presumably derives from an imperfection inherent in the latter class; and—although the point seems ticklish—this may somehow concern our ignorance of "real essences.") Very closely related to this—perhaps just an aspect of the very same point—is the fact that, as Locke emphasizes, *"Powers. . . make a great part of our complex* Ideas *of Substances"*; and, more especially, powers *to affect one another*—that is, Lockian "secondary qualities, mediately perceivable" (II. xxiii. §§9, 10). It is, after all, precisely "qualities" of this type that form the characteristic object of investigation of empirical science: for what else does one study in the laboratory but the "powers of substances to affect one another"?

I have said that perhaps this is not a problem for Locke—having in mind his "official" position that the nature of our faculties makes possible only natural *history*, not natural philosophy (cf. IV. xii. §10). But that depends upon taking a rather narrow view of the "official" position. Let me cite a remark by one of Locke's most penetrating and sympathetic commentators. Michael Ayers writes: "[I]f he let in the possibility that powers or phenomenal

properties should belong to things as a matter of brute or miraculous fact not naturally intelligible, Locke's whole carefully constructed philosophy of science and his support for the corpuscularian case against the Aristotelians would collapse."[20] Ayers, therefore, does regard corpuscularianism and the commitment to "mechanical" principles as essential to Locke's doctrine. But Ayers has missed something crucial. The view that interaction consists in the change of motion of bodies in impact makes the laws of impact, as I have said before, the basic laws of physics. Locke points out (in effect) that the process of impact involves a "primary quality" of bodies that Descartes failed to make an explicit part of his conception of body: the property of *resistance to penetration*, which Locke calls "solidity," and which he makes out to be an idea "we receive by touch" (II. iv. §1). But the laws of impact cannot be formulated in terms of the "solidity," or "impenetrability," of bodies alone. They require another concept, first formulated with full clarity by Huygens (in unpublished notes) and by Newton (in the first Definition of his *Principia*): the concept of *mass*. And *this is not "a simple* Idea *we receive from Sensation*" (and of course not one "we receive from. . . Reflection"); it is an attribute we can determine *only* from the study of the actions of bodies upon one another—it is prototypically something to determine in the laboratory—and at the point at which he defines it, Newton tells us that the mass of a body can be determined by weighing it, *as he has found by very accurate experiments* (experiments on pendulums), *which he will detail later in the treatise*. In short, when we juxtapose Locke's claim that our knowledge of the "primary" qualities of bodies is *strictly limited to the simple ideas of sensation* with his claim that the "mechanical" transfer of motion is, in Ayers's phrase, "naturally intelligible," we are confronted with a deep discrepancy.[21] *And it is much to Locke's credit that he recognized this*; although—again his characteristic vacillation—he continued to affirm the principle against his own recognition. For example (II. viii. §11): "The next thing to be consider'd, is how *Bodies* produce *Ideas* in us, and that is manifestly *by impulse*, the only way which we can conceive Bodies operate in"; but (II. xxiii. §28): "Another *idea* we have of Body, is the power of *communication of Motion by impulse*; and of our Souls, the power of *exciting of Motion by Thought*. These *Ideas*, the one of Body, the other of our Minds, every days experience clearly furnishes us with: But if here again we enquire how this is done, *we are equally in the dark*. For in the communication of Motion by impulse, wherein as much Motion is lost to one Body, as is got to the other, . . . we can have no other conception, but of the passing of Motion out of one Body into another; which, I think, is as obscure and unconceivable, as how our Minds move or stop our Bodies by Thought; which we every moment find they do." Clearly, in this latter passage, Locke is recognizing (not, to be sure, the specific role of the concept of mass, but) the general fact that *the "powers" recognized by the mechanical or corpuscularian philosophy do after all belong to bodies* as (in Ayers's words) "a matter of brute or miraculous fact not naturally intelligible."

Now, this is a thing of which Newton was evidently aware, with full clarity, from an early date in his career. Newton, too, in an important investigation, uses the language of "primary qualities"; but in a way that differs very interestingly from that of Locke. In his first published account of an investigation, the "New Theory about Light and Colors," Newton informs us that he has discovered colors to be "*Original* and *connate properties*" of the "Rays of light." He characterizes these properties of the "Rays" more precisely as "their disposition to exhibit this or that particular colour"; and he is led to distinguish, among the colors of light generally, between those he calls "original and simple," or also "[t]he Original or primary colours"—not what *we* call "primary colors," in either of the senses now usual, but the colors of spectrally pure ("homogeneous") light—and those he calls "compounded."[22] The point is that the "original," "simple," "primary" colors are those colors—more exactly, those "dispositions" or (Locke's terminology) *powers*—that are "connate properties" of *individual "rays,"* and so are *causally* "primary"; known to be so *de facto*—"as a matter of brute fact"—through the results of Newton's experiments.

It is important to note, along with the contrast I have made (and those I am about to make), this affinity of Newton with Locke (and thereby also with the "new" natural philosophy of the seventeenth century generally): that the "relational" character of qualities as "powers" was entirely clear to him. This is explicit in the "dispositional" language I have just quoted from his first paper; it is most fully articulated later, in the *Opticks*:

> [T]he Rays to speak properly are not coloured. In them there is nothing else than a certain Power and Disposition to stir up a Sensation of this or that Colour. For as Sound in a Bell or musical String, or other sounding Body, is nothing but a trembling Motion, and in the Air nothing but that Motion propagated from the Object, and in the Sensorium 'tis a Sense of that Motion under the Form of Sound; so Colours in the Object are nothing but a Disposition to reflect this or that sort of Rays more copiously than the rest; in the Rays they are nothing but their Dispositions to propagate this or that Motion into the Sensorium, and in the Sensorium they are Sensations of those Motions under the Forms of Colours.[23]

What distinguishes Newton from Locke—and, ultimately, from the whole orthodox "mechanical philosophy"—is that he does not equate causal primacy *or* "simplicity" with what is in some sense "nonrelational" *in our apprehension*; and, further, that he does not believe that *any* "causally primary" qualities of bodies are manifest to us otherwise than by *inference* from experience.

Such views, I have said, date from early in Newton's career. If the consensus of expert opinion is right in dating the fragmentary treatise known (from its opening phrase) as *De gravitatione et æquipondio fluidorum*) to the 1660s, when Newton was in his twenties, one can (in my opinion) go further and say that the views in question were connected by Newton, very early in his career, with most remarkable metaphysical conceptions. There is not space

here to offer a really adequate discussion of the metaphysics expounded in that piece; but let me try to sketch its chief points.[24]

The whole metaphysical discussion is motivated by Newton's remark that his conceptions of place, body, rest, and motion differ fundamentally from those of Descartes. Its first part is devoted to the discussion of motion and space ("extension"), and has a certain affinity with the scholium to the Definitions in the *Principia*; but it is more far-reaching than the latter—or than any other passage in Newton—in its account of his conception of the metaphysical status of space. Newton's doctrine here is that, in the first place, extension has a mode of existence unique to itself. It is not a substance: first, because it does not subsist "absolutely of itself" (*absolute per se*), but "as it were as an emanative effect of God, and a certain affection of every being." These words are rather obscure—what exactly is the meaning of "emanative effect"; and why, if extension is an "affection" of every being (or thing), is it not an accident? As to the latter question, Newton goes on to say that extension is more like a substance than an accident, because it can be conceived as existing without any subject—i.e., we can conceive of void space (or spaces). But both points are clarified in a later passage; and this later passage—something that has not been generally seen, and that I cannot emphasize too strongly—makes it absolutely clear and explicit that, despite Newton's statement that extension is *tanquam Dei effectus emanativus*, he does *not* derive space from his theology. What he says is this:

> Space is an affection of a being just as a being (*Spatium est entis quatenus ens affectio*). No being exists or can exist that does not have relation in some way to space. God is everywhere, created minds are somewhere, and bodies in the spaces that they fill, and whatever is neither everywhere nor anywhere is not. And hence it follows that space is an emanative effect of the first-existing being; for if I posit any being whatever I posit space.

My gloss: space is an "emanative effect" (that is, not something *caused*, but simply "a consequence") of whatever first exists—and this is God; but if God were not the "first-existent being," and something did exist, space would be an "emanative effect" of whatever thing that was: "for if I posit any being whatever, I posit space." For his doctrine that space is not a substance Newton offers a second reason: although it is not part of the received definition of substance that *it can act upon something*, philosophers all tacitly understand this as a distinguishing mark of substances; but space does not *act upon* (interact with) things, it is simply "an affection" of them ("No being exists or can exist that does not have relation in some way to space.")

Newton does not tell us what he conceives to be the grounds of this doctrine—to my own great regret. But he makes a sharp contrast between its epistemic status and that of the next part of the metaphysical passage, which is concerned with the nature of body. He says the following:

> Extension having been described, for the other part corporeal nature remains to be described. Of this, however, as it exists not necessarily

> but by the divine will, the explanation will be more uncertain; because it is not at all given us to know the limits of divine power, namely whether matter could be created in one way only, or whether there are several ways by which other beings similar to bodies could be produced.

Thus, by implication, according to Newton, it *is* given to us to know the necessary connection between the existence of anything whatever and that of space, and to know the intrinsic properties of the latter—of which, he emphasizes, we possess "an Idea the clearest of all." Of bodies, however, we have knowledge only from our interactions with them and the sensations that result. This gives us information about properties—and *precisely* about "interactive" properties, i.e., Lockian "powers"—of bodies; but what underlying, metaphysical constitution—what "real essence"—is responsible for these powers, or (as Newton in effect puts it) just "what God would have to do to *make* a body," is something about which we can only conjecture. Nevertheless, in describing at least one possible way, intelligible to us, in which God *could* make beings having all the properties of bodies as we know them, we do as it were clarify for ourselves our own fundamental conception of corporeal nature.

Accordingly, Newton's exposition of a *possible* metaphysical view of body takes the form of a "fable"—undoubtedly modeled upon the creation fable of Descartes—of how God might create a new body in the world. What we may conceive him to do is, first, to choose some definitely delimited region of space, and to prevent any body from entering this region. (If it is asked *how he can do this*, Newton says, we are no more able to answer than we are able to say how we ourselves, by an act of thought and will, can move our own limbs. But we do so; and conceive ourselves able to do so. In this sense [what follows is my gloss], we are able to conceive with full clarity of the *possession and exercise* of a certain power, even though we lack a clear conception of the *intrinsic constitution* of that power—that is, of the *conditions* of its possession.) Next, having willed (as I shall put it) this *distribution of impenetrability*, God may *conserve* this distribution, not in a fixed part of space, but so as (in Newton's words) "to be transferred hither and thither according to certain laws, yet so that the quantity and shape of that impenetrable space are not changed." If these laws are such that, in any *encounter* between the region of impenetrability and an ordinary body—or, supposing God to create more than one such (mobile) region, in any encounter between parts of the distributed impenetrability themselves—the motions of the ordinary bodies *and* the migrations of the regions of impenetrability satisfy the conditions that have been determined to hold between actual bodies in impact, then, Newton says, we shall not only be able to *detect* these regions (by their effects upon ordinary bodies), but we shall find no reason to consider them as anything but ordinary bodies themselves.

It may be objected that there is a gap in this account—that Newton has had to assume the existence of "ordinary" bodies, "ordinarily" detectable, to get his story started, and that without these to use as probes we should remain completely uninformed as to the alleged new bodies. Newton was far too acute

a philosopher to be guilty of such a lapse; on the contrary, he not only fills the gap, but does so in a way that simultaneously offers a sharp new criticism of the received view of what is "essential" to matter. Ordinary bodies, too, are—ordinarily—detected by their interactions with other bodies; for instance, we see bodies on account of their interaction with light (and Newton agrees with Huygens that optical phenomena ought to be conceived of as some sort of corporeal motions and interactions). But, of course, the light must affect the eye; and then the optic nerve; and then the brain; and finally—somewhere—in a sensitive region, presumably of the brain, the motions of parts of matter must affect the mind for perception to occur. And contrariwise, in some way mental processes must affect the motions of bodies, if we are able to move our limbs by volition. Therefore, Newton concludes, this property, this power of *interacting with minds*, must be reckoned as no less an essential attribute of matter than its extension, solidity, and mobility. If we suppose God to endow the spatial regions of distributed impenetrability with this power as well (acting according to the laws—unknown to us—by which bodies and minds do interact), our account will be complete.

This fragmentary treatise of Newton's is certainly prior—probably much prior—to Locke's *Essay*. Locke came to know something of the theory it contains, apparently in conversation with Newton. As a result, he made a small revision in the second (1694) edition, changing the statement that the creation out of nothing of a material being and that of a thinking thing are equally beyond our comprehension, to say instead that "we might be able to aim at some dim and seeming conception" of the first, whereas the second is "more inconceivable" (IV. x. §18).[25] But quite apart from the question of the comprehensibility of creation, Newton offers here a solution to—or, at least, a different and interesting way of thinking about—the problem of "the confused [*Idea*] of Substance, or of an unknown Support and Cause of [the] Union" of the "several distinct simple *Ideas*—more properly, the corresponding *qualities*—that make up a particular substance.[26]

If we distinguish between "Support" and "Cause" in Locke's formula and take him (as Berkeley does—see *Principles of Human Knowledge*, I, §11; Ayers, on the other hand, has strongly opposed this reading) to mean by "Support" something that conflates the Aristotelian notion of an "ultimate subject of properties" with the scholastic notion of "prime matter, denuded of all properties," then Newton's analysis may be put thus: The notion of substance as support may be dispensed with entirely. For bodies, in particular, we may employ an ultimate grammar—a set of categories—in which space, or regions of space, are the subjects to which *corporeal substantial attributes* are ascribed. He says this explicitly: "Between extension and the form imposed upon it [impenetrability, laws of motion of the distributed regions, etc.] there is almost the same relation that the Aristotelians posit between the *materia prima* and substantial forms. . . .They differ, however, in that extension has more reality than *materia prima*, and also in that it is intelligible, as likewise is the form that I have assigned to bodies"; and "[S]ubstantial reality [is] rather

[to be] ascribed to these kinds of Attributes which are real and intelligible in themselves." What makes the attributes "substantial" is precisely that they are what determine *interactions*: they are "*powers*." (I remind you that Newton has identified the power to act as the mark of substantiality; the metaphysics of this work is one of "*substantiality* without *substance*.") As to the *cause* of the coexistence of attributes, that coexistence is in effect *simply an ultimate fact*—thus, for Newton's way of thinking, a fact of the arbitrary exercise of God's will—or in Ayers's phrase, "a matter of brute or miraculous fact not naturally intelligible": like, I should add, *any* postulate regarded as ultimate by the science of one's day.[27]

The metaphysics of *De gravitatione* is discernible beneath the surface both of Newton's *Principia* and his *Opticks*—as fundamentally compatible with, and (in my opinion) illuminating, the teachings of those works; although not fully *implied* by them—and although those works entail an important amendment of that metaphysics. In the terminology of these later treatises, the "primary qualities" (as *I* have here used that term, in explicating both Locke and Newton) of corporeal nature are called the "natural powers" (a Cartesian term, it should be recalled) or *forces of nature*. In the *Opticks* (p. 401) Newton tells us that these are to be conceived of as—or characterized through—"general Laws of Nature, by which the Things themselves are form'd" (cf. the laws of the migration of regions of impenetrability, which constitute *a part of the nature itself of the bodies created* in Newton's "fable"). One such force of nature is the *Vis inertiæ*, a passive Principle by which Bodies persist in their Motion or Rest, receive Motion in proportion to the Force impressing it, and resist as much as they are resisted" (p. 397): the law characterizing this principle is, thus, the three Laws of Motion of the *Principia* taken together. But there are in addition, as Newton says "it seems to him," "active Principles," by which bodies are moved (p. 401); the *action upon a body* of a *vis naturæ* of this latter kind Newton in his *Principia* calls *vis impressa*: "impressed force."

The *Principia* of Newton, taken as a whole, is described by him in the Author's Preface—accurately, as is his wont—as presenting a particular (in fact, although he does not explicitly say this, a *new*) "method of Philosophy." It is a method based upon the concept of causes or principles of motion to be expressed in the form of laws of interaction, themselves subject to the three laws of motion that constitute the Axioms of the *Principia*. This departs from the Cartesian, and more generally from the orthodox "mechanical," philosophy, by substituting for *pressure or impact* as the basic causal mode the far more general notion of a Newtonian "force of nature." Of this method, he says, he offers an example in the third book of the *Principia*, in which he derives, by a very beautiful, subtle, and—as I have elsewhere argued (in disagreement, on this point, with Newton's own view)—*bold and risky* (and, thus, "hypothetical") argument, the first case ever known of what we still regard as a "fundamental force": the force (and law) of universal gravitation.

It is in response to that achievement of Newton that Locke made what I have called his revolutionary change of mind—not reflected in the *Essay*.

Again, I have discussed this elsewhere; but let me cite two striking passages to illustrate the point. In his *Thoughts concerning Education,*[28] published in the same year (1690) as the first edition of the *Essay*, Locke first repeats his decisively skeptical view about physics as a science: "Natural philosophy, as a speculative [that is, of course, *theoretical*] science, I imagine, we have none; and perhaps I may think I have reason to say, we never shall be able to make science of it" (§190). But a few pages later (§194) he qualifies this significantly. Having referred first to what has been achieved, "in the knowledge of some, as I may so call them, particular provinces of the incomprehensible universe" by "the incomparable Mr. Newton," he adds:

> And if others could give so good and clear an account of other parts of nature, as he has of this our planetary world, in his admirable book "Philosophiæ naturalis Principia Mathematica," we might in time hope to be furnished with more *true and certain knowledge* in several parts of this stupendous machine, than hitherto we could have expected. [Emphasis added.]

The second passage I wish to call attention to occurs in Locke's posthumously published treatise *The Conduct of the Understanding*, which he originally intended to form a new chapter of the *Essay* but decided to omit because of its length.[29] It is in a section (§43) titled: "Fundamental Verities." These fundamental verities, Locke says, are "teeming truths, . . . and, like the lights of heaven, are not only beautiful and entertaining in themselves, but give light and evidence to other things that without them could not be seen or known." Of such pregnant principles he gives two examples. The first of these is "the discovery of Mr. Newton, that all bodies gravitate to one another, which may be counted as the basis of natural philosophy"; the second is "our Saviours great rule, that *we should love our neighbor as ourselves*": by this alone, Locke says, he thinks "one might without difficulty determine all the cases and doubts in social morality." Setting aside any questions raised by the audacity of the personal parallel, we ought to remember that according to the "official" doctrine of the *Essay*, morals, unlike natural philosophy, *is* capable of being made a science. The passage I have just cited drastically narrows the difference between the two.

Of course it might be argued that Locke in this is simply untrue to his own philosophical principles and arguments—that he has succumbed to *enthusiasm*, that disease of the mind which in the *Essay* he so earnestly deprecates. For there is no sense in which Newton's achievement can be seen as establishing natural philosophy as a *demonstrative science grounded in intuitive principles.* I do not wish to dismiss such an argument as simply wrong but only to suggest the interest and importance of another point of view. What I emphasized at the outset was that the concern of seventeenth-century philosophers with the *foundations* of knowledge was most intimately connected with a concern for the *advancement* of knowledge, and in particular, with finding a new and more fruitful way for that advancement. If one views the *Essay*, and the change of

mind I have described, in this light, one can describe this change as follows: In the *Essay*, Locke adopts a conception of knowledge that in point of its *grounds* is a kind of modified Cartesianism (knowledge must be based upon intuition and deduction), and that makes the objective ideal of knowledge of bodies also a modified Cartesianism (only mechanical principles are intelligible, and therefore only such are admissible). Unlike Descartes, Locke came to a pessimistic conclusion: no such knowledge of corporeal nature is attainable. But Newton convinced him that something else *was* attainable; and that this was something whose objective content was so surprising and so important, whose evidence was after all so convincing, and whose systematic structure was so deserving of appellations like "speculative, demonstrative science," that a sterile consideration of the old, unattainable ideal ought to give way to the adoption of the new method and new ideal whose fruitfulness had been proved.

To be sure, this overstates the matter so far as concerns Locke: he did *not* revise or renounce the *Essay*, and he expressed himself (as he knew so well how to do) at once eloquently and emphatically and yet guardedly. So we may conclude that he was tempted by conversion to the new faith, but remained in a state of interesting hesitation.

In speaking of Huygens's commitment to the mechanical philosophy, I referred to the likelihood that he was motivated by what I called a "modest transcendental argument." It has been the usual fate of transcendental arguments to be defeated by *modus tollens*: one defines *science* in a certain way; demonstrates that things must be such-and-such, or science will be impossible; and it is then found that things are not such-and-such, so that *in this sense of the word* there is no science. It is not the *obvious* duty of a philosopher then to continue to insist on the definition.

I should like to conclude with two points that have a bearing upon the philosophy of Hume—who, as we all know, took Newton's work as a paradigm of science.

The first of these concerns the notion of *cause*. There has been a tendency to read Newton as if "force" equals "cause," more particularly "cause of change of motion"—that is, Newton's "impressed force" (and when the concept is made quantitative, what he calls "motive force"). On this reading, basic Newtonian causes are the analogue of traditional "efficient" causes.

That is a misattribution to Newton of the point of view of the orthodox mechanical philosophy—where, however, pressure and percussive forces rather than the more general Newtonian forces are the only ones allowed. (In his very early days, when he shared the "mechanical" viewpoint, Newton himself wrote: "force is ye pressure or crouding of one body upon another."[30] When the *Principia* appeared, Newton was tasked with having reintroduced Aristotelian "occult qualities" into physics. There is something quite correct about this: the fundamental *causes* in Newton's developed philosophy of science are not *vires impressæ* or *vires motrices* but *vires naturæ*—"forces of nature"; and these Newton himself, in the *De gravitatione*, likens to Aristotelian "substantial forms" (or, in the *Opticks*: "general Laws of Nature, *by which the Things*

themselves are form'd)—but with this crucial difference, that the substantial forms of the scholastics are obscure and useless, whereas the forms invoked by Newton are clear, his principles not occult but made manifest by phenomena.

But Hume has certainly not understood this. Claiming to follow Newton, he tells us that three relations together make up the essential conditions of the relation of cause to effect: contiguity, temporal priority of the cause, and constant conjunction. A crucial proposition of Newton's *Principia* states that the behavior of the moon in its orbit and that of falling bodies on the earth have *the same cause*: namely, *gravity*, or *weight, towards the earth*. It is very hard to see how Newton's proposition makes sense by Hume's analysis of the idea of cause.

The second point I shall cite is not unrelated to the first, and again suggests that Hume has not understood the nature of Newton's real achievement. He offers his own theory of human nature as the analogue of Newton's theory of corporeal nature, and his own principle of the association of ideas as "a kind of *Attraction*, which in the mental world will be found to have as extraordinary effects as in the natural" (*A Treatise on Human Nature*, I. i. §iv). Now, Hume's theory of *belief*, most intimately connected with his theory of the causal relation, is that belief is a kind of "feeling" or "sentiment," which he describes in terms of the "force" or "vivacity"—one might say, the compellingness—that an "idea" has for us. He employs this analysis in a most striking way in the *Enquiry concerning Human Understanding* to dispose of a far-fetched metaphysical theory (that of the universal and exclusive efficacy of the Supreme Being). Here is what he says (§vii, part 1):

> It seems to me, that this theory . . . is too bold ever to carry conviction with it to a man, sufficiently apprized of the weakness of human reason, and the narrow limits, to which it is confined in all its operations. Though the chain of arguments, which conduct to it, were ever so logical, there must arise a strong suspicion, if not an absolute assurance, that it has carried us quite beyond the reach of our faculties, when it leads to conclusions so extraordinary, and so remote from common life and experience. We are got into fairy land, long ere we have reached the last steps of our theory; and *there* we have no reason to trust our common methods of argument, or to think that our usual analogies and probabilities have any authority. Our line is too short to fathom such immense abysses. And however we may flatter ourselves, that we are guided, in every step which we take, by a kind of verisimilitude and experience; we may be assured, that this fancied experience has no authority, when we thus apply it to subjects, that lie entirely out of the sphere of experience.[31]

How then, I ask, can Hume himself believe Newton's theory of gravitation—the theory, that is, that *every particle of matter in the universe attracts every other particle*, and does so according to a precisely stated quantitative law? By what line does Hume suppose Newton was able to fathom *that* abyss? If one just reflects upon the enormous scope of the law Newton propounds, how

far it extends, not only beyond "common life and experience," but beyond *any* observation or experiment in any way accessible to Newton as evidence, one may in fact come to sympathize with such scientifically well-informed judges as Huygens and Leibniz, who rejected the law as unproved and incredible. Hume has failed to appreciate the depth and subtlety both of the issue and of Newton's actual reasoning; and this has had a damaging effect both on his epistemology generally, and on his conception of what is *required* to establish a science of human nature.

To return in conclusion to the two theses I said I wished to present, they may be rephrased as follows: If epistemology is to be concerned with knowledge in the sense—or *a* sense—of that term that characterizes what history has shown us capable of *actually acquiring* about the world we inhabit; and if metaphysics is to be concerned with fundamental aspects *of that world, as we have come to know it*; then both of these fields of inquiry must have some serious relation to the disciplines we call "scientific," which have produced that "knowledge." Philosophers of the seventeenth and eighteenth centuries took it for granted that there was such a serious relationship (and employed the word "philosophy" itself accordingly). To pay attention to this fact is therefore deeply pertinent to our historical understanding of what those philosophers were about; and deeply pertinent, also, to the possibility that we ourselves may learn cogent philosophical lessons from their work and their experience.

NOTES

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1. E. A. Burtt, *The Metaphysical Foundations of Modern Physical Science* (reprinted Garden City, N.Y., 1955), 244. (The work dates from 1924; rev. ed., 1932.)

2. Isaac Newton, *Philosophiæ Naturalis Principia Mathematica*, edited by Alexandre Koyré and I. Bernard Cohen, the third edition (1726), with variant readings from the first two (1686 and 1713), 2 vols. (Cambridge, Mass., 1972) 1:48. (The translation in the text is my own; it corrects some inaccuracies in the published translations.)

3. Norman Kemp Smith, *New Studies in the Philosophy of Descartes* (London, Macmillan, 1952), 120, n.2.

4. Richard Rorty, *Philosophy and the Mirror of Nature* (Princeton, N.J., 1980), 131.

5. *Œuvres complètes de Christiaan Huygens*, published by the Société hollandaise des sciences, vol. 10 (La Haye, The Hague, 1905), 404.

6. *Œuvres de Descartes*, edited by Charles Adam and Paul Tannery, vol. 1, rev. ed. copublished by the Centre National de la Recherche Scientifique (Paris, 1969), 1056. This edition will henceforth be referred to as "AT *Œuvres*."

7. Ibid., 137.

8. AT *Œuvres*, vol. 4, rev. ed. (Paris, 1972), 329.

9. AT *Œuvres*, 1:649.

10. The story is quoted in AT *Œuvres*, vol. II, rev. ed. (Paris, 1967), 670–71, from *La Vie de Saint-Evremond* by Des Maizeaux (that is, Pierre Desmaiseaux). Des Maizeaux reports it as having been told him by the subject of his biography, Charles de Marguetel de Saint-Denis, Seigneur de Saint-Évremond, who heard it from Digby.

11. See the article "Digby, Sir Kenelm," *Encyclopædia Britannica*; 11th ed., 8:262.

12. Des Maizeaux, who evidently had some reservations about the reliability of Digby, continues at the place cited in n. 11 above by indicating the existence of further evidence of Descartes's view; and cites, among other things, this passage from Baillet, *La Vie de Monsieur Descartes* (2 vols.) 2: 452–53. See also Charles Adam, *Vie et Œuvres de Descartes*, supplement to the Adam and Tannery edition, republished with the assistance of the Centre National de la Recherche Scientifique (Paris, 1957), 552, note a.

13. Cited by Adam, *Vie et Œuvres*, in the same footnote to which reference has just been made (p. 552, note a.): "This [namely, the indefinite prolongation of human life] was still the subject of his conversations during the last months of his life; or at least it was this that most struck Christina: but then, '*ses oracles l'ont bien trompé*,' she says of Descartes, in a letter to Saumaise."

14. AT *Œuvres*, 4:119 (letter to Mesland, May 2 1644).

15. Huygens, *Œuvres*, 10:403, 405–6.

16. Huygens, *Treatise on Light*, translated by Silvanus P. Thompson (Chicago, 1945), p. vi (Note: this translation was originally published in 1912.)

17. Descartes, *Rules for the Direction of the Mind*, under Rule VIII; e.g., in *The Philosophical Writings of Descartes*, translated and edited by John Cottingham, Robert Stoothoff, and Dugald Murdoch, vol. 1 (London, 1985), 29.

18. Letter to Chanut, Feb. 26 1649; AT *Œuvres*, vol. 5 (Paris, 1974), 291.

19. I shall cite the *Essay* by book, chapter, and section, for the sake of invariance over editions. My own quotations are taken from John Locke, *An Essay concerning Human Understanding*, edited by Peter H. Nidditch (Oxford, 1975; reprinted with corrections 1979). (It should be noted that the chapter referred to below as 'I,i' is the Introduction, placed by some editors before Book I—so the chapters that Locke numbered ii–iv of Book I are, by those editors, called i–iii of that Book.)

20. M. R. Ayers, "The Ideas of Power and Substance in Locke's Philosophy," *Philosophical Quarterly* 25 (1975):22.

21. R. S. Woolhouse, *Locke's Philosophy of Science and Knowledge* (Oxford, 1971), 111, without any comment, names mass first in a list of Lockian primary qualities. This has no justification whatever.

22. See *Isaac Newton's Papers and Letters on Natural Philosophy*, edited by I. B. Cohen (Cambridge, Mass., 1958), p. 53 and p. 54 ¶5.

23. Isaac Newton, *Opticks* (reprint, following the 4th ed. [1730]; New York, 1952), Book I, Part II, pp. 124-5 ("Definition," preceding Proposition III of that Part).

24. The fragment has been published in *Unpublished Scientific Papers of Isaac Newton*, edited by A. Rupert Hall and Marie Boas Hall (Cambridge, 1962), 90–121, with an English version following; pp. 121–156. That version has serious defects; the translations used here are my own.

25. For an account of some of the circumstances of this revision, and of the source of our knowledge of what lay behind it, see the edition of A. C. Fraser, *An Essay Concerning Human Understanding* by John Locke, collated and annotated [etc.] by Alexander Campbell Fraser, 2 vols. (Oxford, 1894; reprinted New York, 1959) 2:321–22, n.2.

26. Cf. Locke, *Essay*, III, vi, §21: "[I]n Substances, besides the several distinct simple *Ideas* that make them up, the confused one of Substance, or of an unknown Support and Cause of their Union, is always a part."

27. Cf. the comments on this point in my article "Yes, but. . . Some Skeptical Remarks on Realism and Anti-Realism," *Dialectica*, 43:64.

28. Locke, *Some Thoughts concerning Education*, in *The Works of John Locke: a New Edition, Corrected*, 10 vols. (London: Thomas Tegg *et al.*, 1823), 9: iii–v, 6–205.

29. Locke, *Of the Conduct of the Understanding*, in *The Works of John Locke*, 9 vols., 12th ed. (London, 1824) 2: 323–401.

30. In the extracts from Newton's so-called "*Waste Book*" published by John Herivel,

The Background to Newton's Principia: *A Study of Newton's Dynamical Researches in the Years 1664–84* (Oxford, 1965), 138.

31. Here quoted, for the sake of Hume's original orthography, from the edition of T. H. Green and T. H. Grose, David Hume, *The Philosophical Works*, 4 vols., "reprint of the new edition London 1882" (Darmstadt, 1964) 4:59–60. (To avoid a possible confusion, it should be noted that this is vol. 4 of the entire edition, but at the same time vol. 2 of Hume's *Essays: Moral, Political, and Literary*, within that edition.) The passage is to be found in the more easily accessible edition of Selby-Bigge/Nidditch—David Hume, *Enquiries Concerning Human Understanding and Concerning the Principles of Morals*, edited by L. A. Selby-Bigge; 3rd ed. revised by P. H. Nidditch (Oxford, 1975)—on p. 72.