Locke's Newtonianism and Lockean Newtonianism

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I explore Locke's complex attitude toward the natural philosophy of his day by focusing on (1) Locke's own treatment of Newton's theory of gravity and (2) the presence of Lockean themes in defenses of Newtonian attraction/gravity by Maupertuis and other early Newtonians. In doing so, I highlight the inadequacy of an unqualified labeling of Locke as "mechanist" or "Newtonian."

I. Introduction

As many historians have noted, Lockeanism and Newtonianism were frequently blended in the eighteenth century, to the point that the pairing of Newton and Locke became a commonplace (Aarsleff 1994, p. 255). Indeed, this blending has continued through our own time; in broad-scale histories of ideas (a genre currently somewhat out of favor), one almost invariably encounters a Newtonian or proto-Newtonian Locke.[1] In recent literature in the history of philosophy,

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1. See, for example, Feingold (1988) and Buchdahl (1961). A particularly egregious example of this, cited in Rogers (1978, p. 218), is John Herman Randall's *The Career of Philosophy*, which states that "Locke assumed to begin with and without question the whole of Newtonian science, both its verdict on the nature of science and on the nature of the world." Rogers refutes this claim and effectively argues that Locke's *Essay* was little influenced by his reading of Newton.

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however, one encounters, for the most part, a different sort of Locke: a corpuscularian or Boylean Locke.[2] More specifically, the sort of corpuscularianism typically attributed to Locke is a strict or reductive corpuscularianism according to which the ultimate parts of bodies possess only size, shape, solidity, and mobility, and all other apparent qualities must be explained in terms of the motions and impacts of these solid particles.[3]

There is, however, a tension between this corpuscularian Locke and a Newtonian Locke, as can be seen by considering the question of gravity. Strict corpuscularianism implies that gravity must be accounted for in terms of the impacts of particles possessing only size, shape, and motion and that gravity cannot be attributed to an attractive force or power possessed by all bodies. Indeed, it was exactly this sort of strict corpuscularianism that fueled attacks on Newtonianism as bringing back the occult qualities of the scholastics. The scope of "Newtonianism" is notoriously difficult to define, but for the purposes of this article I will use it in a central sense prevalent in late seventeenth– and early eighteenth–century debates in England and France, according to which a Newtonian is someone who advocates some significant portion of the physical and cosmological theories of Newton and who is an attractionist.[4] Of course, this definition then raises the question of what an attractionist is. An attractionist, most broadly, is someone who maintains that hypotheses (most prominently, Cartesian vortex theories) that reduce gravitational attraction to ordinary mechanical impulse are not needed and not promising. This might be the case because the Newtonian in question was willing to posit attraction as an intrinsic quality of matter (e.g., Cotes), or to suppose that

2. Indeed, the point that Locke was heavily influenced by Boylean mechanical philosophy and that the *Essay* must be understood in this context has assumed the status of a truism. The most influential recent work to lay the greatest stress on this point is Peter Alexander's *Ideas, Qualities, and Corpuscles* (1985), which argues that the *Essay* can be regarded an attempt to elaborate and confirm the corpuscular hypothesis. See also, for example, Atherton (1991), McCann (1985), Curley (1972), and Mandelbaum (1964).

3. For the purposes of this article, this strict or reductive corpuscularianism is what I shall mean by "corpuscularianism" or "mechanism." I call this sort of corpuscularianism Boylean, but it is representative in particular of Boyle's most programmatic works, especially *The Origin of Forms and Qualities according to the Corpuscular Philosophy* and *About the Excellency and Grounds of the Mechanical Hypothesis* (Boyle 1772). As many scholars have shown, Boyle's approach in other contexts, especially in more experimental works, is considerably more flexible. See, for example, Henry (1986) and Clericuzio (1990).

4. That this understanding of Newtonianism was commonplace in the period is clear from Voltaire's *Lettres Philosophiques* ([1734] 1964).

God performs attraction directly (e.g., Clarke), or that a nonmechanical ether somehow effects it (e.g., Newton, in some periods), or simply that we can make use of the law of attraction without settling the question of how it works and that this counts as perfectly adequate science (e.g., 's Gravesande).[5]

So there is at least a prima facie conflict between reading Locke as Newtonian and reading him as a strict corpuscularian. And indeed, as one would expect, this conflict, or puzzle, can be generated without reference to the secondary literature on Locke, simply by considering Locke's own texts. On the one hand, Locke's admiration for Newton and Newton's system seems manifest. Locke singles out "Mr. Newton" as "incomparable" in the *Essay*'s introductory "Epistle to the Reader" ([1700] 1975, p. 8), from among the four Master-Builders there listed. In *Some Thoughts Concerning Education* Locke praises the *Philosophiæ naturalis principia mathematica* as providing a "good and clear account" of "our Planetary World" that might serve as a model for future work (Locke [1693] 1989, p. 248). Nevertheless, the natural philosophy that

5. The question of what sort of Newtonian Newton himself was, is, of course, a much vexed one. He was certainly an attractionist, as defined above, although one fixed point in his thought was that ordinary matter, in and of itself, is passive and does not possess attractive power as an intrinsic and essential quality. Further, macroscopic action at a distance was not to be tolerated; some sort of intermediary had to be involved in the gravitational attraction between two bodies (as stated in the famous third [1693] letter to Bentley [Newton 1958, pp. 302–3]). However, another relatively constant feature of his mature work was the belief that gravitation attraction could not be explained in terms of purely mechanical impulse, that is, in terms of the mutual impacts of solid particles. See the "General Scholium" to the *Principia*, introduced in the second edition of 1713, wherein Newton attacked vortical explanations of gravity and noted that mechanical causes operate according to surface area, not mass (Newton [1726] 1972, 2:759–65), and also a draft letter in which Newton rejected Leibniz's demand for a mechanical explanation of gravity (Newton 1959–77, 5:300). It seems, however, that Newton briefly entertained a favorable opinion of Fatio de Duillier's mechanical explanation of gravity in the early 1690s, although he did not positively endorse it. See Westfall (1980, p. 495) and Newton (1962, pp. 312–13). Newton described gravity as an active principle, but this description alone did not seem to settle much about its nature. The mode of action of this active principle seems to have been understood by him, at various points, as being divine (i.e., an immediate effect of God), (al)chemical, or electrical. According to this last conception, articulated in the new queries added to the 1717 *Opticks* (Newton [1730] 1952), gravitational attraction is produced by an electrical ether made up of tiny particles exerting repulsive forces on one another (McGuire 1977, p. 117). Thus, microscopic action at a distance was posited in order to explain apparent macroscopic action at a distance (Heimann and McGuire 1971, p. 242). For more on Newton's shifting views on the causes of gravity, see, for example, McGuire (1968*a*, 1977), Heimann and McGuire (1971), and Harmon (1982, pp. 22–29).

appears in the *Essay* is undeniably a strict corpuscularianism that attributes to bodies only size, shape, solidity, and mobility. When Locke provides lists of the primary qualities of bodies, it is clearly programmatic Boylean corpuscularianism that inspires them. Locke often describes the real essences of bodies in these same corpuscularian terms. Most significantly, Locke never deviated from the belief that the only intelligible mode of causal interaction in the corporeal realm is mechanical impulse, effectively declaring gravity or attraction unreduced to impulse to be unintelligible.

Thus, Alexandre Koyré's offhand reference to the "curious mingling" of Locke and Newton should, I think, be taken seriously (1965, p. 18). In part I, I approach this issue by examining Locke's own attitude toward Newton's physics as expressed in his published writings. Although Locke's Newtonianism as surveyed in part I is reserved and heavily qualified, several important early Newtonians employed Lockean themes in defending the scientific status of Newton's theory of gravity (Heilbron 1982, pp. 47–55). In part II, I highlight Lockean elements in the work of some early Newtonians, focusing in particular on one highly influential text, Maupertuis's *Discours sur les différentes figures des astres* (1732). In his "discussion métaphysique sur l'attraction," Maupertuis put forward the most sustained philosophical defense of Newtonian attractionism that had yet been mounted,[6] a defense containing strong echoes of prominent Lockean doctrines. In the course of analyzing Maupertuis's defense of attractionism, I establish the appropriateness of this appropriation by examining its basis in Locke's own work. I argue that there are many prominent strands in Locke's thought that make it ripe for conversion to Newtonian ends. I contend, further, that comparison with Maupertuis brings out aspects of Locke's thought that have been somewhat underemphasized in recent scholarship and that strongly suggest that Locke's commitment to mechanist corpuscularianism does not go as deep as is often supposed.[7] By thus exhibiting the inadequacy of an unqualified labeling of Locke as "mechanist" or "Newtonian," I intend to provide a more nuanced understanding of Locke's complex attitude toward natural philosophy.

6. This is the case, with the possible exception of Berkeley's *De Motu* (1721), which, despite its critical tone, ought in my view to be understood as a sort of defense of attractionism.

7. In maintaining that, in the *Essay*, Locke does not express a foundational commitment to Boylean mechanism, I am, however, in agreement with Michael Ayers's *Locke* (1991).

II. Locke on Newton's Theory of Gravity

Newton's theory of gravity was surrounded by philosophical controversy from its formulation through the mid-eighteenth century and beyond. The central question at issue was whether it was legitimate to attribute gravity, attraction, or repulsion to bodies without any gesture at reducing those qualities to mechanical ones (e.g., explaining gravity in terms of the action of a purely mechanical ether).[8] Locke's own position on this issue is an interestingly subtle one. On the one hand, he is an admirer of the *Principia,* and he regards Newton as having established the fact of universal gravitation.[9] On the other hand, he never abandons the claim that gravity is unintelligible to us, and his endorsements of Newton's system are always crucially qualified as to the status of that system.

In a 1671 draft of the *Essay Concerning Human Understanding,* Locke notes that "we can hardly conceive [bodies'] efficacy to consist in any thing but motion" but then sets the issue aside (Locke [1671] 1990, 1:256). By the time of the *Essay*'s publication, however, Locke was prepared to elaborate and defend that claim. The first three editions of the *Essay* (1689, 1694, 1695) contain a very strong assertion of the priority of impulse in any account of the operations of bodies:[10] "The next thing to be consider'd, is how *Bodies operate* one upon another, and that is manifestly *by impulse,* and nothing else. It being impossible to conceive, that Body should operate on what it does not touch, (which is all one as to imagine it can operate where it is not) or when it does touch, operate any other way than by Motion" (2.8.11).[11] This passage

8. As is indicated above, Newton himself was somewhat ambivalent on this question. His official stance in the *Principia* was that gravity could be treated as a manifest effect and then used in legitimate and explanatory scientific theories, without speculation as to its cause. Despite this, however, Newton was clearly extremely concerned with the status of gravity and considered various ways of accounting for it.

9. He was also, by 1690, a friend and admirer of Newton himself. Despite their long friendship, however, little direct evidence remains of any discussions between them on questions of natural philosophy, epistemology, or metaphysics. Their correspondence centered mainly on their strong mutual interest in biblical interpretation (Locke 1976–89, esp. vol. 4). Pierre Coste, who knew them both, reports in a footnote to his French translation of the *Essay* that Newton told him that Locke's speculation about the creation of matter, hinted at in 4.10.18, was Newton's own, derived from a conversation with him (Locke 1742, p. 523).

10. Similarly strong (indeed, perhaps somewhat stronger) formulations can be found in Draft C (1685) of the *Essay.* See Mattern (1981).

11. All references to Locke's published *Essay* are to Locke ([1700] 1975) and are given by book, chapter, and section number. This edition is based on the fourth (1700) edition, but variations among the first five editions are specified in the notes to the volume.

clearly implies that any appeal to gravity or attraction unreduced to impulse, in Locke's view, would amount to attributing an inconceivable action at a distance to bodies.

Locke's strong stance here is noteworthy and perhaps surprising, given that he is known to have been familiar with the contents of Newton's *Principia* by 1688. Moreover, as Colie (1960) and Axtell (1965) have convincingly argued, Locke wrote the anonymous review of the *Principia* that appeared in Le Clerc's *Bibliothèque universelle et historique de l'année 1688* (Locke [1688] 1968). The review, however, while respectful, hardly reveals the enthusiasm of a convert. Locke begins the review by suggesting that modern philosophers have "imagined" that God has prescribed geometric laws to his creation in the hopes of giving mechanics the exactitude and perfection of geometry. Newton's opus is depicted as the latest work in the vein. Locke thus projects a certain distance here from this sort of natural philosophy. Moreover, in recounting Newton's understanding of "attraction," Locke shows that he interprets Newton's attempted neutrality as to the cause of attraction as decided preference for impulse: "Before beginning this section, the author explains how he understands 'attractive force' and 'attraction,' which should rather be termed 'impulse,' speaking physically. But the author has kept this popular term in order not to involve himself in philosophical disputes" (Locke [1688] 1968, p. 438).[12] Despite noting that Newton "proves that the planets are not carried along by corporeal vortices," Locke shows little appreciation, at this point, for the challenge Newton's work ultimately posed to a strictly mechanical world view. Thus, Locke did not, in 1688, see any need to revise his views on the priority of impulse.

Locke's eventual realization that the success of Newton's *Principia Mathematica* demanded some qualification of his position as expressed in the *Essay* is documented by the correspondence with Stillingfleet (Locke 1823, 4:467):

> It is true, I say, "that bodies operate by impulse, and nothing else." And so I thought when I writ it, and can yet conceive no other way of their operation. But I am since convinced by the judicious Mr. Newton's incomparable book, that it is too bold a presumption to limit God's power, in this point, by my narrow conceptions. The gravitation of matter towards matter, by ways inconceivable to me, is not only a demonstration that God can, if he pleases, put into bodies powers and ways of operation above what can be derived from our idea of body, or can be explained

12. This is my translation from the French.

> by what we know of matter, but also an unquestionable and every where visible instance, that he has done so. And therefore in the next edition of my book I shall take care to have that passage rectified.[13]

Locke certainly accepted Newton's universal law of gravitation and apparently held out no hope that gravitation could be explained in terms of impact. Nevertheless, Locke's actual alterations to the *Essay* were minimal. In later versions (1700 and 1706), he writes, "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" (2.8.11). Locke deletes the table thumping "and nothing else" of the earlier version and converts the claim into a claim about how bodies produce ideas in us, thus avoiding the question of how bodies may operate on each other. He retains however, the crucial conceivability claim. The only natural explanation of corporeal change intelligible to us is explanation in terms of impacts among extended, solid, mobile particles. Despite his remarks to Stillingfleet, Locke did not undertake to directly address the issue of gravity in the revised *Essay*. The correspondence, however, clearly indicates Locke's position: Faced with the phenomenon of gravitation, the only explanation available to us is to chalk it up to God's superaddition (i.e., to his bestowing this power on bodies in some way that surpasses our comprehension).[14]

Locke's most revealing discussion of Newtonian physics is found in his 1693 work, *Some Thoughts Concerning Education*. As he would later do in the Stillingfleet correspondence, Locke maintains here that gravity is "impossible to be explained by any natural Operation of Matter, or any other Law of Motion, but the positive Will of a Superior Being, so ordering it" (Locke [1693] 1989, p. 246). Locke also includes, however, an importantly qualified testimonial to the merits of Newtonianism:

> Though the Systems of *Physicks*, that I have met with, afford little encouragement to look for Certainty, or Science, in any Treatise, which shall pretend to give us a body of *Natural Philosophy* from the first Principles of Bodies in general; yet the incomparable Mr. *Newton* has shewn, how far Mathematicks, applied to some Parts of Nature, may, upon Principles that Matter of Fact justifie, carry us in the knowledge of some, as I may so call them, particular

13. The passage is from Locke's third letter, which was published in 1699.

14. In "Elements of Natural Philosophy," a draft for an elementary textbook that Locke composed some time after 1698, Locke similarly indicates that universal gravitation must be accepted as a fact, albeit a fact "inexplicable by us" (Locke 1823, 3:304–5).

> Provinces of the Incomprehensible Universe. And if others could give us so good and clear an account of other parts of *Nature*, as he has of this our Planetary World, and the most considerable *Phænomena* observable in it, 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 stupendious Machin, than hitherto we could have expected. (Locke [1693] 1989, pp. 248–49)

The foundation of Newton's system, according to Locke, is "Principles that Matter of Fact justifie," a characterization that Newton himself could not find fault with. For Locke, however, these sort of principles (i.e., empirical generalizations) represent judgment, or probable opinion, rather than knowledge in the strict sense. A philosophical knowledge, or science, of bodies would require an account of the real essences of bodies that exhibits how their properties flow deductively from those essences. Such knowledge, Locke holds, is beyond our reach. Lacking a grasp of the relevant necessary connections, we can only appeal to experience: "Because, as before, there is no necessary connexion, or inconsistence to be discovered betwixt a complex *Idea* of a Body, *yellow, heavy, fusible, malleable,* betwixt these, I say, and *Fixedness,* so that I may certainly know, that in whatsoever Body these are found, there *Fixedness* is sure to be. Here again for assurance, I must apply my self to *Experience;* as far as that reaches, I may have certain Knowledge, but no farther" (4.12.9). That is, we may have certain knowledge of the particular observed instances of fixedness, but knowledge of general truths is not to be had; the best to be hoped for is "assurance," which in 4.16.6 turns out to be a technical term representing the highest degree of probability. Although experience must teach us what reason cannot, what experience procures us is convenience not science:

> I deny not, but a Man accustomed to rational and regular Experiments shall be able to see farther into the Nature of Bodies, and guess righter at their yet unknown Properties, than one, that is a Stranger to them: But yet, as I have said, this is but Judgment and Opinion, not Knowledge and Certainty. This *way* of getting and *improving our Knowledge in Substances only by Experience* and History, which is all that the weakness of our Faculties in this State of *Mediocrity,* which we are in in this World, can attain to, makes me suspect, that natural Philosophy is not capable of being made a Science. (4.12.10)

Thus, although in a popular work like the *Thoughts Concerning Education,* Locke is willing to use the word "knowledge" in conjunction

with Newton's results, the following points should be noted: (1) Those results are not described as certain simpliciter but rather as "more true and certain" than we could have expected.[15] (2) Although the propositions are described as "well-proven," this indicates only that they follow deductively from the premised principles. Most important, (3) Newton's work is not described as giving us a natural philosophy from the first principles of bodies, not even a partial and incomplete one, but as doing something quite different.[16]

III. Lockean Newtonianism

Despite Locke's reservations about Newton's system, there are clearly elements in his thought that cohere very well with Newtonianism. In what follows, I highlight the genuinely Newtonian side of Locke's thought through an exploration of the use of Lockean themes in some early defenders of Newton. I focus especially on Maupertuis's *Discours sur les différentes figures des astres*, a work of considerable philosophical interest in its own right. By elucidating the doctrines shared by both the *Discours* and the *Essay*, both works are illuminated. Most significantly, however, comparison with Maupertuis helps to identify aspects of Locke's *Essay* that motivate a reevaluation of the role that corpuscularianism plays therein.

A. First Facts versus Causal Explanations

Maupertuis's discourse is notable for both its historical influence and its philosophical content. It contains one of the best developed defenses of attractionism of the period, and it represents, moreover, a crucial stage in the advance of Newtonianism into the Cartesian

15. Likewise, when, in *On the Conduct of the Understanding*, a 1697 manuscript that Locke never finished but that was posthumously published, he calls Newton's discovery that all bodies gravitate toward one another a "fundamental truth" on which many other truths rest, this leaves open the question of whether this truth is certain or merely probable. See Locke (1823, 3:223, 282).

16. Newton would presumably have agreed that neither the *Principia* nor the *Opticks* provided science in Locke's strong sense. In the "General Scholium," Newton indicates that we know bodies only by their properties, whereas their inner substances eludes both sensation and reflection. (See also the draft version of the "Scholium," Newton [1962, pp. 348–66], which is more explicit on this issue.) Indeed, it is not unlikely that Locke influenced Newton on this point. Thus, Newton did not aspire to supply a deductive science of bodies, starting from real essences. My point here is not that Locke's view of the achievement of the *Principia* is un-Newtonian but rather that his enthusiasm for Newton's theory is carefully and thoughtfully circumscribed by the status he assigns it. For an interesting comparison of the empiricisms of Locke and Newton, see Rogers (1979).

stronghold of France.[17] The second chapter of Maupertuis's discourse is devoted to a "discussion métaphysique sur l'attraction," in which Maupertuis seeks to identify and defuse sources of resistance to Newton's theory of gravity. As Maupertuis depicts it, the central dispute between Cartesians and Newtonians concerns the question of whether gravity ought to be regarded as the effect of circulating vortices of matter or whether it may be treated "as if it were an inherent property of bodies" "without looking for its cause" (Maupertuis 1732, p. 10).[18]

Maupertuis's first defense of the Newtonian position emphasizes this last proviso, noting that Newton himself officially treats universal attraction or gravitation as a fact, not a cause, thus leaving open the possibility of a deeper causal explanation in terms of subtle matter, perhaps even a fully mechanistic one. Indeed, the point that Newton did not claim to have settled the causes of gravity was a sort of Newtonian piety, found, for example, in the writings of Keill (1758, p. 4), Desaguliers (1734, pp. 6, 21), Maclaurin ([1748] 1968, p. 10), and Voltaire (1741, p. 186). This strategy, however, motivates the following question: Does a theory that fails to provide an acceptable causal explanation of the phenomena it discusses count as an acceptable piece of natural philosophy? This is a question that Maupertuis addresses head-on. Whatever gravity may be, he argues, it is always a "first fact," from which one can depart in order to explain the other facts that depend on it. "Every regular effect, though its cause be unknown, may be the object of the Mathematicians" (1732, p. 12), and the resulting theory is indeed explanatory: it explains the phenomena that can be deduced from it. Here Maupertuis is making the methodological point that universal attraction may be taken as a first principle for physics, whether or not it is metaphysically primary, that is, whether or not there is an underlying causal explanation of gravity. Maupertuis buttresses this position by arguing that ultimate causal explanations elude us in any case, so it would be a mistake to insist on them when it comes to gravity: "I do not believe that it is permitted to us to ascend

17. See Beeson (1992) and Brunet (1931). It should be noted that the views Maupertuis expresses so ably in this early work are not necessarily representative of those he held later in his career. In particular, although Maupertuis retains a Lockean skepticism about knowledge of the essence of body, his views about the relation of physics and metaphysics clearly evolved from those suggested in the *Discours*. For example, when it came to his principle of least action, Maupertuis seemed willing to allow that metaphysical argument might have direct implications for natural philosophy. This fact presumably reflects the increasing Leibnizian influence on his later thought.

18. Translations of Maupertuis's text are my own.

to first causes, nor to comprehend how bodies act upon one another" (1732, p. 13). He concludes this part of his case for Newtonian gravity by suggesting that the search for the cause of this force be left "to more sublime Philosophers" (1732, p. 13).

A very similar line is taken by the Dutch Newtonian 's Gravesande, whose *Mathematical Elements of Natural Philosophy* exerted considerable influence on Maupertuis. 's Gravesande maintains, "when we are once come to the general Laws, we cannot penetrate any further into the Knowledge of Causes" (1721, p. xiii). Nevertheless, "the Study of Natural Philosophy is not however to be contemn'd, as built upon an unknown Foundation. The Sphere of humane Knowledge is bounded within a narrow Compass. . . . Though many things in Nature are hidden from us; yet what is set down in Physics as a Science, is undoubted. From a few general Principles numberless particular Phænomena or Effects are explain'd, and deduced by Mathematical Demonstration" ('s Gravesande 1721, pp. xii–xiii). That is, theories such as Newton's, which start from general laws or observed regularities and do not pretend to causal explanations, are nevertheless genuinely explanatory and count as fully adequate natural philosophy or science.

's Gravesande's invocation of the "narrow Compass" of human knowledge strikes a Lockean chord and ought to encourage us to search for deeper parallels. Both Maupertuis and 's Gravesande argue that natural philosophy ought to confine itself to the modest goal of searching for general regularities among the effects. But this, of course, is one of the primary morals of the *Essay*. As was noted in part I, Locke holds that a scientia of bodies, which would display how all their properties flow necessarily from their essences, eludes us. If we want scientia, Locke tells us, we ought to turn to moral philosophy (4.12.8); if we want to do natural philosophy, we had better learn to content ourselves with probable opinion based on experience: "In the Knowledge of Bodies, we must be content to glean, what we can, from particular Experiments: since we cannot from a Discovery of their real Essences, grasp at a time whole Sheaves; and in bundles, comprehend the Nature and Properties of whole Species together" (4.12.12). There are differences, of course, between Locke and the later Newtonians, but when they are characterized precisely, the similarities are perhaps more striking. Locke still reserves the term "science" for scientia; thus we find Locke denying that natural philosophy can be made a science (4.12.10), that scientifical philosophy in physical things is within our reach (4.3.26), that the works of nature may be reduced to a science (Locke [1693] 1989, pp. 244–45). Scientia represents for him an ideal knowl-

edge of nature and thus in some sense the true aim of natural philosophy.[19] It is an aim, however, that cannot be attained and so must be revised: experimental philosophy must be our substitute for a "*Natural Philosophy* from the first Principles of Bodies in general" (Locke [1693] 1989, p. 248). Nevertheless, Locke emphasizes that he "would *not therefore* be thought to dis-esteem, or *dissuade the Study of Nature*" (4.12.12). Thus, although Newton's *Principia* does not qualify as science (or even, in the strict sense, knowledge) for Locke, it does represent the best sort of results that the study of nature is likely to achieve. And Locke acknowledges as much by 1693, as his treatment of Newton in *Some Thoughts Concerning Education* reveals.

Having in effect taken Locke's moral to heart, 's Gravesande and Maupertuis have ceased to take scientia to be a goal for natural philosophy.[20] For Maupertuis, the ability to deduce further facts from first facts is sufficient for the physicist. 's Gravesande, moreover, clearly holds that the simplicity, generality, and systematicity of Newton's physics earn it the name of "science," despite its agnosticism about causes (i.e., its willingness to take regularities as starting points without ascertaining the causes of those regularities).

19. "*Natural Philosophy* being the Knowledge of the Principles, Properties, and Operations of Things, as they are in themselves" (Locke [1693] 1989, p. 245).

20. This cannot, of course, be regarded as a simple effect of their reading of Locke's *Essay*. As Van Leeuwen has emphasized, Locke is part of a tradition of moderate or constructive skepticism that included Glanvill, Boyle, and Newton and that was widely influential in the Royal Society and beyond. Nevertheless, the *Essay* represents the most extended philosophical development of this position, and the fact that it was so widely read made Locke a sort of patron saint of the position. The *Essay* was widely available in Pierre Coste's French translation, which first appeared in 1700 and went through a number of editions. Indeed, the first publication of the doctrines of the *Essay* was in Holland, in French: Locke's abstract of the *Essay* for the *Bibliothèque Universelle et Historique* of 1688. For more on Locke's influence on early Newtonianism and Enlightenment thought more generally, see, for example, Heilbron (1982, p. 48), Jimack (1996, p. 229), Cassirer (1951, p. 55), Aarsleff (1994), and Bonno ([1947] 1990). Bonno emphasizes that the *Essay* was known in France even before Voltaire's *Lettres Philosophiques* (1734) spread its fame more widely. Maupertuis's admiration for Locke's *Essay* is made explicit in his 1743 address to the Académie française. He describes Locke as having shown that "grammar" (what Locke, at 4.21.4, calls the "doctrine of signs," which includes both words and ideas) lies at the foundation of the other sciences (Maupertuis 1756, 3:264), a belief that fuels his own *Réflexions philosophiques* (1740). My point, however, is not to establish that Maupertuis derived the views discussed here from reading Locke but rather to establish the existence of strong isomorphisms between the two texts. Although I think these isomorphisms are representative of Locke's uncontroversially strong influence on philosophical thought in this period, what interests me about them is the way in which an appreciation of them helps to clarify the doctrines of both thinkers and, in particular, to bring out underemphasized aspects of Locke's *Essay*.

B. Attraction, Real versus Nominal Essences, and Primary Qualities

As we have seen, Maupertuis's initial defense of Newtonianism invokes agnosticism about causes. Nevertheless, his next step is to address the question of whether a causal account that makes gravity the effect of an inherent attractive power in matter can be ruled out a priori as a "Monstre métaphysique" (Maupertuis 1732, p. 13). A first question to ask here is why Maupertuis felt compelled to address this question. If regularities may be taken as first principles, why is any further defense of attraction required? Maupertuis's willingness to answer this challenge at length suggests that he sees that, if the possibility of an inherent property of attraction in matter can be ruled out a priori, the Newtonian is in trouble. The difficulty is that, under those conditions, the Cartesian insistence that an impulse-based explanation must be available and ought to be sought looks extremely compelling. This Newtonian predicament is neatly flagged by Maupertuis in his subtle first characterization of Newtonianism: the Newtonians treat gravity as if it were an inherent property. Maupertuis seeks to legitimate the "as if" by arguing that the possibility that attraction is an inherent property of bodies cannot be eliminated.[21]

We would be in a position to definitively rule out or affirm attraction, Maupertuis asserts, were our epistemic situation quite different from our actual one:

> If we had complete ideas of bodies, such that we well understood what they are in themselves, and what their properties are to them, how and in what number they reside in them; we would not be at a loss to decide whether attraction is a property of matter. But we are very far from having such ideas; we only know bodies by a few properties, without knowing at all the subject in which these properties are united.
>
> We perceive some different collections of these properties, and that suffices for us to designate the ideas of such or such particular body. (Maupertuis 1732, pp. 13–14)

The counterfactual situation described by Maupertuis here is one in which we would know the real essences of bodies—that which they are in themselves and that which gives them their properties. Our actual situation, however, is one in which we know only the nominal essences of bodies, that is, we know what coexistent observable prop-

21. Two other obvious ways to escape the predicament, other than by conceding to Cartesianism, would be to eliminate the "as if" by appealing to God's action (Samuel Clarke and Richard Bentley's solution) or to intensify the "as if" by treating the entire Newtonian theory instrumentally (Berkeley's solution).

erties we take to be characteristic of such and such a body (e.g., Rover) or such and such a type of body (e.g., gold).

This is, of course, a thoroughly Lockean point, missing only Locke's technical terminology. A similar contrast between known observable properties and unknown real essence is employed to a similar effect by 's Gravesande and Keill: "We are not, I own, to affirm or deny any Thing concerning what we do not know. But this Rule is not followed by those who reason in Physical Matters, as if they had a compleat Knowledge of whatever belongs to Body, and who do not scruple to affirm, that the few Properties of Body which they are acquainted with, constitute the very Essence of Body" ('s Gravesande 1721, p. xi).[22] Maupertuis's way of putting the point, in terms of our inability to understand how a thing's observable properties hang together, bears a striking resemblance to some of Locke's formulations in the earlier drafts of the *Essay:* "Hence it comes to passe that we have noe Ideas nor notion of the essence of matter, but it lies wholy in the darke. Because when we talke of or thinke on those things which we call material substances as man horse stone the Idea we have of either of them is but the complication or collection of those particular simple Ideas of sensible qualitys which we use to find united in the thing cald horse or stone . . . which because we cannot apprehend how they should subsist alone or one in an other we suppose they subsist & are united in some fit & common subject" (Locke [1671] 1990, pp. 129–30).

One might wonder, however, whether Maupertuis has not overstepped Locke here. Maupertuis suggests that we are ignorant, not just of the real essences of particular bodies and types of bodies (e.g., of what makes Rover friendly and gold shiny) but of the nature of corporeal substance, matter, or body in general. In view of this ignorance, he argues, we cannot rule out attraction's being a genuine property of body. Locke, however, in employing a corpuscularian model for the real essences of particular bodies, seems to presuppose a particular, corpuscularian conception of the real essence of body in general: as something whose characterization is exhausted by size, shape, solidity, number, and motion. Indeed, most recent commentators have read Locke this way—as assuming in effect that the real essences of particular bodies are corpuscular constitutions. On this interpretation, while Locke emphasizes our ignorance of the particular constitutions/real essences of particular bodies, he exhibits no parallel skepticism about our knowledge of the real essence of body itself. This interpretation

22. See also Keill (1758, p. 8).

draws its strength from the many passages like 4.3.11: "For not knowing the Root they spring from, not knowing what size, figure, and texture of Parts they are, on which depend and from which result those Qualities which make our complex *Idea* of Gold, 'tis impossible we should know what other Qualities result from, or are incompatible with the same Constitution of the insensible parts of *Gold*."

The analogy with Maupertuis, however, suggests the possibility of resisting this interpretation. And, indeed, there are both logical and textual grounds for resisting it. The logical point is highlighted by Maupertuis: If indeed we know only the nominal essence of bodies (i.e., we know them only through their salient observable properties, leaving open the possibility that their true nature, the causal source of those properties, is quite different), why should this not apply also to our knowledge of body or matter in general, as suggested by the above quoted passage from Draft B?

Further textual evidence is provided by 3.3.15–17, in which Locke first develops the notion of real essence. Here Locke articulates an abstract conception of real essence, according to which the real essence of any thing is that which makes it the thing that it is, the true causal source of its "discoverable Qualities." Locke then notes that there are at present two opinions concerning the real essences of substances, the scholastic and the corpuscularian. He characterizes the corpuscularian opinion as the more rational opinion, but it is nevertheless clear that the status of corpuscularianism here is that of a theory or hypothesis as to what the real essences of particular corporeal substances might be like (and as to what the real essence of body in general is). This is crucially reinforced by 4.3.16:

> I have here instanced in the corpuscularian Hypothesis, as that which is thought to go farthest in an intelligible Explication of the Qualities of Bodies; and I fear the Weakness of humane Understanding is scarce able to substitute another, which will afford us a fuller and clearer discovery of the necessary Connexion, and *Co-existence*, of the Powers, which are to be observed united in several sorts of them. This at least is certain, that which every Hypothesis be clearest and truest, (for of that it is not my business to determine,) our Knowledge concerning corporeal Substances, will be very little advanced by any of them, till we are made see, what Qualities and Powers of Bodies have a *necessary Connexion or Repugnancy* one with another; which in the present State of Philosophy, I think, we know but to a very small degree:

> And, I doubt, whether with those Faculties we have, we shall ever be able to carry our general Knowledge (I say not particular Experience) in this part much farther. (4.3.16)

Furthermore, one may ask with Maupertuis, what grounds could we have for identifying the corpuscularian list of qualities—solidity, extension, figure, and mobility—as exhausting the nature of body? It might be thought that Locke provides such grounds in his discussion of the primary/secondary quality distinction. The crucial passage here is 2.8.9:

> Qualities thus considered in Bodies are, First such as are utterly inseparable from the Body, in what estate soever it be; such as in all the alterations and changes it suffers, all the force that can be used upon it, it constantly keeps; and such as Sense constantly finds in every particle of Matter, which has bulk enough to be perceived, and the Mind finds inseparable from every particle of Matter, though less than to make it self singly be perceived by our Senses. *v.g.* Take a grain of Wheat, divide it into two parts, each part has still *Solidity, Extension, Figure,* and *Mobility;* divide it again, and it retains still the same qualities; and so divide it on, till the parts become insensible, they must retain still each of them all those qualities. For division (which is all that a Mill, or Pestel, or any other Body, does upon another, in reducing it to insensible parts) can never take away either Solidity, Extension, Figure, or Mobility from any Body, but only makes two, or more distinct separate masses of Matter, of that which was but one before, all which distinct masses, reckon'd as so many distinct Bodies, after division make a certain Number. These I call *original* or *primary Qualities* of Body, which I think we may observe to produce simple *Ideas* in us, *viz.* Solidity, Extension, Figure, Motion, or Rest, and Number.

Perhaps the most obvious reading of this passage is as giving criteria (empirical constancy and conceptual inseparability) for identifying the essential qualities of bodies and as claiming that those criteria dictate that the essential qualities of bodies are the corpuscularian ones of solidity, extension, figure, and mobility.

A way of resisting this interpretation, however, is again suggested by a comparison with Maupertuis, who employs his own version of a primary/secondary quality distinction. Maupertuis articulates a notion of primordial, primitive, or first-order properties as follows: "We distinguish these properties into different orders. We see that while some vary in different bodies, some others are always the same; and

from that we regard the latter as primordial properties and as the grounds of the others" (1732, p. 14). The universality of extension and impenetrability, Maupertuis continues, leads us to put them in the order or category of primordial properties, and thus to regard them as essential to matter. He then distinguishes other properties that are less universal, belonging to bodies only when they are in a certain state (e.g., the property of moving other bodies at impact, which is found in all bodies in motion). Maupertuis argues, however, that these experience-based distinctions among properties do not allow us to exclude any properties from bodies, other than those that are actually contradictory to universal properties: We are right to exclude from a subject only the properties contradictory to those which we know are found in it: mobility being found in matter, we can say that immobility is not; matter being impenetrable, is not penetrable" (Maupertuis 1732, p. 16).

Without an understanding of how the primordial properties stick together, so to speak, we cannot require that all other properties obviously reduce to them: "But again, was the collection of these properties necessary? And do all the general properties of bodies reduce to them? It seems to me that it would be to reason badly to wish to reduce them all to them" (Maupertuis 1732, p. 15). If we saw necessary connections among the known properties of body (e.g., if we apprehended that a body cannot be extended without being impenetrable) we might have some grounds to suppose that we understood the real essence of body.[23] Lacking this, however, we ought to be more modest in our claims: "It would be foolish to wish to assign to bodies properties other than those which experience has taught us are found in them; but it would perhaps be more foolish to wish, with a small number of properties scarcely known, to pronounce dogmatically the exclusion of all others; as if we had the measure of the capacity of the subjects, when we are acquainted with them only by this small number of properties" (Maupertuis 1732, pp. 15–16).

Furthermore, he later suggests, we cannot rule out the possibility that gravity is a primordial property. The context here is Maupertuis's response to what he describes as the most solid argument that can be made against attraction (1732, pp. 18–19). This argument seeks to show that gravity is less intelligible than contact action by establishing that we see the necessity of some sort of contact action, since it logically follows from motion and impenetrability, two established properties of

23. Maupertuis clearly implies that we do not see any such connection (1732, pp. 14–15).

bodies, whereas we do not see the necessity of gravity. As Maupertuis puts it, if bodies are impenetrable, and one body moves against another, it cannot continue to move without penetrating it, therefore God must establish some law of impact (1732, p. 18). However, it is not clear that God must establish a law of attraction. To this Maupertuis responds: "But if gravity were a property of the first order; if it were attached to matter, independently of the other properties; we would not see that its establishment was necessary, because it would not owe its establishment to the combination of other properties" (1732, p. 20). Maupertuis's basic point is that the fact that attraction is not evidently necessary in the way that contact action arguably is (i.e., logically derivable from uncontroversial properties of bodies, impenetrability and motion) does not count against its being a primordial property/property of the first order. This passage is crucial to understanding Maupertuis's conception of a primordial property. What it demonstrates is that the primordial properties are not simply the universally experienced ones (i.e., the concept of a primordial property is not the concept of a universally experienced property). If it were, there would be no open question as to whether gravity is a primordial property: if it is universally experienced, it is, if not, not. Rather, the primordial properties are properties that are genuinely basic to body (i.e., irreducible to other properties). Gravity, Maupertuis suggests, may for all we know be one such property. In the above cited passages where universality is invoked, Maupertuis's point is to explain how it is that we come to take certain properties as primordial: we suppose that the properties we universally experience in body are its basic and irreducible properties. Although it seems that Maupertuis regards this as an acceptable working assumption, it is clear from the example of gravity that he does not suppose that it settles the question.

With all this in mind, let us return to Locke's perplexing 2.8.9. This first sentence is in keeping with the hypothesis that Locke's basic conception of primary quality is the same as that later employed by Maupertuis: a fundamental and inseparable quality of bodies that characterizes them as they are in themselves and serves as the causal source of other, nonfundamental, derivative qualities. This interpretation is confirmed by the way in which Locke habitually contrasts primary with secondary (e.g., "the *primary*, and *real Qualities* of Bodies, which are always in them" [2.8.22] and which *"are really in them*, whether any ones Senses perceive them or no" [2.8.17] as contrasted with "those *secondary* and *imputed Qualities*, which are but the Powers of several Combinations of those primary ones" [2.8.22]). Does he really suppose, however, that empirical constancy and conceptual inseparability func-

tion as criteria for identifying the real, intrinsic, and irreducible qualities of bodies? I submit that the answer should be no. As Locke tells us at 2.13.24, "our Senses . . . are scarce acute enough to look into the pure Essences of Things." Moreover, Locke certainly countenances no Cartesian intellectual faculty that might allow us to identify essences by thought experiments.[24] The function of Locke's criteria is to explain two things: (1) how we arrive at our commonsensical view of what the intrinsic and irreducible qualities of bodies are—that is to say, how we arrive at the nominal essence we assign to the term "body"—and (2) how we arrive at the very idea of a distinction between the foundational qualities of bodies and others that may be reduced to them.[25] Maupertuis, as we have seen, likewise aims to explain the first point, although his explanation makes reference only to the constancy of sense experience.[26] In Locke's *Essay,* our commonsense conception of body is distilled from sense experience via the sort of conceptual considerations brought out by the example of the grain of wheat. But, it would seem, neither sense experience nor intellectual distillation definitively identify what the primary qualities of bodies in fact are. Thus, on this interpretation, Locke's discussion of the primary/secondary quality distinction is compatible with the view we saw earlier, in his treatment of real essences, that corpuscularianism represents one hypothesis about what the real essences of bodies are like (i.e., what the primary qualities of bodies are). It thus serves as a sort of example or illustration of the abstract notions of real essence and primary quality.[27] What the primary/secondary quality discussion also reveals, however, is the sense in which corpuscularianism is more than a mere example in the *Essay:* it is a peculiarly natural and intelligible example for us because it starts from our commonsense conception of body (i.e., it starts from the nominal essence we assign to the term "body").[28]

24. This point was made by Hatfield (1990, p. 57).

25. I owe this second point to Larry Nolan.

26. In this way, it resembles Newton's rule III at least as much as it does Locke's formulation. The question of whether Newton's formulation of rule III was influenced by Locke's discussion of primary qualities is intriguing and unsettled. McGuire has suggested that Locke may have been a stimulus to Newton's thought (1968*b*, pp. 239–40).

27. For further elaboration and defense of this interpretation of Locke's primary/secondary quality distinction, see Downing (forthcoming).

28. In proposing that Locke's point here is to highlight the fact that corpuscularianism accords with our ordinary conception of body, I am in agreement with McCann (1994, pp. 60–67). I borrow the phrase "commonsense conception of body" from that insightful article. McCann also interprets Locke as not being officially committed to the truth of strict corpuscularianism, although it seems to me that ultimately McCann sees Locke as being somewhat more attached to corpuscularianism than I do.

We should not, however, assume that the real essence of body corresponds to the nominal essence.

C. Impulse and Solidity versus Attraction and Attractive Power

Maupertuis also acknowledges the naturalness of mechanism and mechanist explanations but maintains that this consideration ultimately ought to carry little weight. He argues that impulse is no more intelligible than attraction; experience has made the phenomenon of impulse familiar, but philosophers find that impulsive force is no more conceivable than attractive: "Common people are not at all astonished when they see one body in motion communicate this motion to others; because they are accustomed to seeing this phenomenon, they are prevented from perceiving the marvelousness of it; but Philosophers . . . take care not to believe that impulsive force is more conceivable than attractive. What is this impulsive force? How does it reside in bodies? Who would have been able to divine that it resided in them before having seen bodies collide?" (1732, pp. 16–17). Here Maupertuis expands on a point made by Locke himself, that impulse itself is not ultimately intelligible, for we cannot comprehend the communication of motion at impact.[29] Locke puts the problem this way:

> 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, which is the ordinariest case, 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. (2.23.28)

This leads Locke, in 4.3.29, to include the communication of motion, along with cohesion and the production of sensation, on the list of phenomena that we cannot explain except by appealing to God's omnipotence.[30] Maupertuis concludes that impulse and attraction are on

29. Locke, of course, was not the first to discuss this problem. Malebranche, for example, uses it as one basis from which to argue for occasionalism.

30. "The coherence and continuity of the parts of Matter; the production of Sensation in us of Colours and Sounds, *etc.* by impulse and motion; nay, the original Rules and Communication of Motion being such, wherein we can discover no natural connexion with any *Ideas* we have, we cannot but ascribe them to the arbitrary Will and good Pleasure of the Wise Architect."

the same footing. In doing so, he was followed by Voltaire, in his influential *Elémens de la philosophie de Neuton* (1741, pp. 186–87). Indeed, one might well wonder why Locke refrains from drawing the same conclusion. Given Locke's explicit acknowledgment of the limitations on our understanding of impulse, the nature of the contrast he apparently sees in intelligibility between impulse and gravity/attraction may seem obscure. What makes impulse-explanation superior? What is wrong with supposing that bodies act where they are not if we cannot really understand how bodies act where they are?

Here we must consider the close connection between impulse and solidity, as Locke understands them:

> The *Idea* of *Solidity* we receive by our Touch; and it arises from the resistance which we find in Body, to the entrance of any other Body into the Place it possesses, till it has left it. (2.4.1)

> This is the *Idea* belongs to Body, whereby we conceive it *to fill space*. The *Idea* of which filling of space, is, That where we imagine any space taken up by a solid Substance, we conceive it so to possess it, that it excludes all other solid Substances; and, will for ever hinder any two other Bodies, that move towards one another in a strait Line, from coming to touch one another. (2.4.2)

> *Upon the Solidity of Bodies* also *depends their mutual Impulse, Resistance, and Protrusion.* (2.4.5)

Solidity, despite its status as a simple idea of sensation, is in effect a dynamic notion for Locke; solidity amounts to a body's ability to exclude other bodies from the place it occupies. Thus, if solidity is taken to be a primary quality of bodies, this itself licenses the claim that a body can act where it is, while leaving open the questions of (1) what exactly the effect of the action is (i.e., what "Rules of Motion" are observed by bodies that come into contact) and (2) how exactly the effect is accomplished (e.g., by the passing of motion from one body to another).[31]

At this point, however, Maupertuis would suggest that attraction can, in a parallel fashion, be assumed to be a primary quality of bodies. Positing such a quality then would license the claim that bodies can act at a distance, according to the inverse square law, while leaving

31. Arguably this is not a question one should expect mechanism to answer, since it seems to amount to an inappropriate demand for a further, underlying mechanism. It is thus not a legitimate question from the standpoint of mechanism itself. Locke, however, clearly sees it as a legitimate question for the philosopher, particularly in the context of a consideration of the relative obscurity of our notions of body versus mind.

open the question of exactly how this effect is accomplished. Indeed, it is just this sort of understanding of gravity that many of the early Newtonians endeavored to inculcate. Here it appears that the only Lockean ground left for privileging impulse above gravity is a relatively weak one: the overwhelming empirical familiarity of solidity/impulse: "There is no *Idea*, which we receive more constantly from Sensation, than *Solidity*" (2.4.1). Because of the omnipresence of solidity in our experience of body, it forms a part of our commonsense conception of body (McCann 1994), a part of the nominal essence we assign to "body," and thus mechanism is a natural theory for us in a way that an attraction-based physics never can be.

What this suggests, in my view, is that the privilege accorded to impulse in the *Essay* is simply that very modest one that Locke can justify: impulse-based explanation accords with our commonsense conception of body and so is peculiarly natural for us. This does not form the basis for a principled resistance to Newtonian gravity; accordingly, Locke puts up no such resistance. What Locke does maintain is that our conception of body leaves us unable to comprehend how bodies can affect each other at a distance, just as we are unable to comprehend how they can transfer motion among themselves, cohere, or produce sensations in us. In all these cases, if we seek a causal explanation of the effects, we can but attribute them "to the good Pleasure of our Maker" (sec. 4.3.6). But again, this does not settle the question of how they are actually caused; for all we know, the cohesion and the gravitation of bodies derive from the same real essence as their shape.

IV. Conclusion

We have seen that Maupertuis's sophisticated defense of Newtonian gravity/attraction trades on the following thoroughly Lockean points: (1) A general knowledge of the natural world based on a grasp of true causes eludes us; natural philosophy must therefore settle for experience-based regularities. (2) We know the nominal essences of bodies but not their real essences (i.e., there are regularly recurring observable properties through which we identify bodies, but we do not comprehend the causal nexus of those properties). (3) Impulse itself is not fully intelligible, for the communication of motion at impact is inexplicable by us, given our corporeal concepts. Attention to Maupertuis thus allows us to identify a genuinely Newtonian aspect of Locke's thought.

Moreover, the result of integrating these points with Locke's expressed reservations about gravity and his use of corpuscularianism in the *Essay* is an interpretation of Locke's natural philosophy that ac-

cords with a large number of central texts, which highlights what was historically influential about Locke's work and which stands as a serious rival to the widespread view of the *Essay* as being grounded on corpuscularianism.[32] On this interpretation, Locke does not commit himself, in the published *Essay*, to the truth of strict corpuscularianism. Rather, he holds that it is a peculiarly natural and intelligible theory, because it accords with the concept of body we distill from sense experience (i.e., the nominal essence we assign to "body") For this reason, he uses it to illustrate his notions of real essence and primary quality and, further, to illustrate what it would be like to have a scientia of body: were we to have a scientia of body we would understand all the properties of bodies in the way we understand how a key has the power to open a lock. Ultimately, however, he holds that scientia is beyond our grasp and that the concepts of body on which the intelligibility of mechanism rests are obviously limited: just as they do not allow us to understand gravity, they do not allow us to explain cohesion, the production of sensation, or the communication of motion. Accordingly, when Locke turns to experience-based, merely probable natural philosophy, he shows little sign of any special affinity for strict corpuscularianism; here he expresses admiration for Boyle's experimental works and, especially, for Newton.[33]

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32. Space does not permit the sort of exhaustive textual survey that would be required to counter all the evidence that could be put forward in favor of the "committed corpuscularian" interpretation. Nor do I wish to suggest that there are no tensions in Locke with respect to the status of corpuscularianism. In my view, those tensions are diminished considerably in the fourth edition by revisions of 2.8, but they are not entirely resolved.

33. See *Some Thoughts Concerning Education* (Locke [1693] 1989) and *Elements of Natural Philosophy* (Locke 1823). Although the last paragraph of the *Elements* looks like an endorsement of corpuscularianism, it cannot be strict corpuscularianism, since universal attraction was introduced in the first chapter.

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