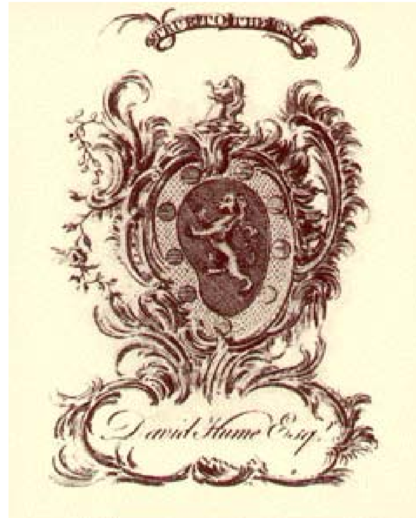

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Abstract: Hume follows Newton in replacing the mechanical philosophy's demonstrative ideal of science by the *Principia*'s ideal of inductive proof (especially as formulated in Newton's Rule III); in this respect, Hume differs sharply from Locke. Hume is also guided by Newton's own criticisms of the mechanical philosophers' hypotheses. The first stage of Hume's skeptical argument concerning causation targets central tenets of the mechanical philosophers' (in particular, Locke's) conception of causation, all of which rely on the a priori postulation of a hidden configuration of primary qualities. The skeptical argument concerning the causal inductive inference (with its implicit principle that nature is, in Newton's words, "ever consonant with itself") then raises doubts about what Hume himself regards as our very best inductive method. Hume's own "Rules" (T 1.3.15) further substantiate his reliance on Newton. Finally, Locke's distinction between "Knowledge" and "Probability" ("Opinion") does not leave room for Hume's Newtonian notion of inductive proof.

> In Newton this island may boast of having produced the greatest and rarest genius that ever arose for the ornament and instruction of the species.
>
> —David Hume, *The History of England*[1]

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Introduction

From the 1690s until at least the second half of the eighteenth century, European scientific and literary circles standardly perceived Locke's and Newton's systems as resting on very similar principles and methods; these systems were commonly blurred together as forming a single vision composed of natural and moral philosophy.[2] Moreover, a long tradition of Locke scholars extending to our time has found close links between Locke's and Newton's views on the methodology of natural science. Indeed there is no denying that Locke and Newton share a similar conception of scientific method, if this is simply described as one based on rational and regular experiments and observations, and the use of generalization and deduction. Thus G. A. J. Rogers writes:

> [W]hat Locke found in the *Principia* was the exemplification of a method to which he himself already subscribed. He already believed that a combination of observation, generalization or induction, and deduction was the only route to knowledge of nature and that the *Principia* exhibited just that method in its most fruitful manner. . . . It confirmed for him all his own methodological conclusions. . . . The *Principia* was for Locke the vindication of a general methodological approach to which he had subscribed for perhaps twenty years.[3]

Hume also explicitly associates his work and his method with Newton's, aspiring to be the Newton of a new science of human nature; this is very prominent, in particular, in the Introduction to the *Treatise*[4] and section 1 of the first *Enquiry*.[5] Thus, if both Locke and Hume are Newtonians, one could plausibly identify Hume's conception of the methodology of science with Locke's. Nevertheless, as I shall argue, there is a clear and sharp distinction to be drawn between Hume's Newtonian inductivism and Locke's conception of the methodology of natural science in the *Essay*.[6] In his conception of both the scientific method and the origin and meaning of our idea of causation, Hume is deeply indebted to what he takes to be the Newtonian inductive methodology for the study of nature. This is not to deny Locke's enormous influence on Hume: as with any historical development of philosophical ideas, Hume's epistemological views would not have been possible without the contributions of his predecessors, especially Locke's.[7] Yet Locke represents a crucial transition between Cartesian rationalism and the full-blown empiricism of Hume, and, in particular, there are very important vestiges of rationalism in Locke's epistemology influencing his conception of scientific methodology: the idea of the containment of the effect in the cause, the postulation of a hidden microstructure of primary qualities or properties of bodies, the attendant notion of a metaphysical necessary connection between cause and effect, and the (for Locke unattainable) ideal of an a priori demonstrative knowledge or science of nature.

Hume follows Newton in substituting the ideal of inductive proof for the ideal—characteristic of the mechanical philosophy—of a demonstrative science of nature based on a postulated hidden microstructure. Although he does not fully do justice to a fundamental aspect of Newtonian methodology—the mathematization of nature[8]—Hume adopts the basic ideas of Newton's inductive method as presented in the Rules for the Study of Natural Philosophy in *Principia*, Book III, especially as articulated in the crucially important Rule III.[9] Hume's notion of inductive proof, which is at the heart of his conception of causation and scientific methodology, consists in a universalization (whenever possible and subject to future experimental revisions) of our past and present uniform experience, with the attendant assumption that nature is, in Newton's words, "ever consonant with itself" (*Principia*, 795). Hume's embrace of Newton's inductive method marks a central point of departure from Locke's conception of scientific methodology, for, as I argue below, the desideratum of achieving Newtonian inductive proofs *replaces* the ideal of demonstrative knowledge of nature and *liberates* scientific method from the a priori hypotheses of the mechanical philosophy. In particular, the inductive derivation of laws from manifest uniform phenomena takes priority over the hypothetical postulation, prior to what experience can teach us, of a hidden microstructure of primary qualities—which, according to the mechanical philosophy (shared by both Descartes and Locke), necessitates the causal relations among bodies and between bodies and our senses. Therefore, despite his extensive debt to Locke, Hume does not have a Lockean conception of causation and scientific methodology.

In section I, I explain five important differences between Newton's and Locke's conceptions of scientific methodology. I emphasize that Newton conceives his inductive method as an antidote to the hypotheses of the mechanical philosophy standing in the way of his universalization of the law of gravitation, and I argue that Locke, in the *Essay*, does not take the step of embracing the Newtonian method of inductive proof, precisely because, in addition to endorsing the ideal of a demonstrative knowledge of bodies, the *Essay* is still wedded to the mechanical hypothesis that there is a hidden configuration of microscopic primary qualities ultimately responsible for all observable effects.

In section II, I argue that the first stage of Hume's radical skeptical argument concerning causation simultaneously targets central interdependent tenets of the mechanical philosopher's conception of causation: the containment of the effect in the cause, the notion of singular causation, the ideal of a priori causal explanation, and the notion of a metaphysical necessary connection between cause and effect—all of which rely on the hypothesis of a hidden configuration of primary qualities. In particular, I take Hume's criticism to be directed not only against the rationalists' view that we can attain a priori insight into observable causal relations, but also, more importantly, against Locke's demonstrative (albeit unattainable) ideal of knowledge of nature and Locke's notion of metaphysical necessity. Hume's criticism is guided by his understanding of Newton's inductive method, as embodied especially in Rule III, and Newton's own criticisms of the mechanical philosophers' hypothetical method.

In section III, I consider Hume's skeptical argument at *Treatise* 1.3.6 and first *Enquiry*, section 4, part 2, concerning the justification of the causal inductive inference with its implicit principle of the uniformity of nature. At this stage, Hume raises radical skeptical doubts about what he himself takes to be our best possible inductive method—Newton's method—to which Hume himself appeals throughout his science of human nature. From this discussion we can appreciate that Hume's skepticism about our knowledge of causal relations is very different from Locke's and, more generally, so is his conception of causal necessity. In particular, for Hume, when he sets his radical skeptical doubts aside, the application of our best inductive methods leads (in accordance with Newton's Rules) to the formulation of universal, exceptionless laws of nature, which, as such, we are compelled to treat as necessary until experience teaches us otherwise. I substantiate Hume's reliance on Newton's "Rules for the Study of Natural Philosophy" (especially Rule III) by a discussion of Hume's own "Rules by which to judge of causes and effects" (T 1.3.15); and, finally, I further substantiate the differences between Hume's and Locke's conception of scientific methodology by pointing out the contrast between Locke's notion of probability and Hume's Newtonian notion of inductive proof as a species of probability in general.

I. Newton and Locke on Scientific Methodology

The central idea of the Newtonian inductive method, as summarized in his Rules, is that exceptionless or nearly exceptionless universal laws are inductively derived from "manifest qualities" or observed "phenomena," and only further observed phenomena can lead us to revise these laws. In his official methodological pronouncements, Newton explicitly and emphatically opposes the purely hypothetical explanations of the mechanical philosophy standing in the way of his inductive argument for the law of universal gravitation. For example, Newton asks his editor, Roger Cotes, to insert a passage in the general Scholium added to the *Principia*'s second edition of 1713—the famous passage containing the phrase "hypotheses non fingo": "I have not as yet been able to deduce from phenomena the reason for these properties of gravity, and I do not feign hypotheses. For whatever is not deduced from the phenomena must be called a hypothesis; and hypotheses, whether metaphysical or physical, or based on occult qualities, or mechanical, have no place in experimental philosophy. In this experimental philosophy, propositions are deduced from the phenomena and are made general by induction" (*Principia*, General Scholium, 943). Rationalist proponents of the mechanical philosophy like Descartes and Leibniz had hoped to gain a priori insight into causal relations by uncovering the microstructure of bodies in such a way that all natural causes would be reduced to the interaction of these fundamental microscopic parts. And the sole form of interaction allowed to these parts was impact or impulse (the "mechanical cause" of motion), taken to be the paradigm of a rationally intelligible connection. Newton has been accused by the rationalist proponents of the mechanical philosophy of introducing an occult quality, in the form of universal gravitational action at a distance, and this is how he defends himself.

Both Leibniz and Huygens, for example, accepted Newton's demonstration that the orbits of the satellites of the major astronomical bodies in the solar system obey the inverse-square law (the planets with respect to the sun, the moons of Jupiter and Saturn with respect to their planets, the earth's moon with respect to the earth).[10] They were also convinced by Newton that the inverse-square law in astronomy accords with Kepler's laws. Nonetheless, these two profound and knowledgeable philosophical scientists, despite being extremely qualified to understand Newton's theory, rejected Newton's law of universal gravitation: that all bodies (and all parts of bodies) whatsoever accelerate towards one another in accordance with the inverse-square law and the product of their masses. They rejected this universalization precisely because they were wedded to the mechanical philosophy's hypothesis (first formulated by Descartes) requiring that the mechanical cause of gravity reduce to the microscopic impacts exerted by the matter of the celestial vortices. For them, the inverse-square law could be accepted in astronomy by taking the major bodies of the solar system as each being surrounded by vortices affecting only the bodies relatively near to them, namely, their satellites. And, in this way, the validity of the inverse-square law would be restricted to precisely this finite region, so that it could not be extended arbitrarily far (the acceleration of Jupiter toward Saturn, for example, would have decayed to zero). As Howard Stein has emphasized, it is precisely Newton's adoption of his inductive method as self-consciously unimpeded by the mechanical philosopher's hypotheses that allowed him to take the bold step of *universalizing* the law of gravitation.[11]

Newton's Rules III and IV were added to the second (1713) and the third (1726) editions of the *Principia* in response to the objections of the mechanical philosophers:

> Rule III: Those qualities of bodies that cannot be intended and remitted [i.e. qualities that cannot be increased and diminished] and that belong to all bodies on which experiments can be made should be taken as qualities of all bodies universally. (*Principia*, 795)[12]

> Rule IV: In experimental philosophy, propositions gathered from phenomena by induction should be considered either exactly or very nearly true notwithstanding any contrary hypotheses, until yet other phenomena make such propositions either more exact or liable to exceptions. (*Principia*, 796)

Thus, these rules state that the method of inductive universalization—the very method by which the law of universal gravitation is established—must be applied without the interference of hypotheses.[13]

In the explanations of these Rules, Newton explicitly depicts the hypotheses of the mechanical philosophy as obstructing his method. In the explanation of Rule III, for example, Newton writes:

> For the qualities of bodies can be known only through experiments; and therefore qualities that square with experiments universally are to be regarded as universal qualities. . . . Certainly idle fancies ought not to be fabricated recklessly against the evidence of experiments, nor should we depart from the analogy of nature, since nature is always simple and ever consonant with itself. The extension of bodies is known to us only through our senses, and yet there are bodies beyond the range of these senses; but because extension is found in all sensible bodies, it is ascribed to all bodies universally. We know by experience that some bodies are hard. Moreover, because the hardness of the whole arises from the hardness of its parts, we justly infer from this not only the hardness of the undivided particles of bodies that are accessible to our senses, but also of all other bodies. That all bodies are impenetrable we gather not by reason but by our senses. We find those bodies that we handle to be impenetrable, and hence conclude that impenetrability is a property of all bodies universally. That all bodies are movable and persevere in motion or in rest by means of certain forces (which we call forces of inertia) we infer from finding these properties in the bodies that we have seen. . . . Finally, if it is universally established by experiments and astronomical observations that all bodies on or near the earth gravitate [*lit.* are heavy] toward the earth, and do so in proportion to the quantity of matter in each body, and that the moon gravitates [is heavy] toward the earth in proportion to the quantity of its matter; and that our sea in turn gravitates [is heavy] toward the moon, and that all planets gravitate [are heavy] toward one another, and that there is a similar gravity [heaviness] of comets toward the sun, it will have to be concluded by this third rule that all bodies gravitate toward one another. Indeed, the argument from phenomena will be ever stronger for universal gravity than for the impenetrability of bodies, for which, of

> course, we have not a single experiment, and not even an observation, in the case of the heavenly bodies. Yet I am by no means affirming that gravity is essential to bodies. (*Principia*, 795–6)[14]

Newton here illustrates the use of his method by first describing the inductive inference to the universal law that all bodies are extended—which proposition, contrary to Descartes, is not taken to be an a priori assumption known by the pure intellect alone. Thus, in a way very congenial to Hume, Newton claims that we inductively infer that all bodies—observed and unobserved—are extended only on the basis of having uniformly observed that the bodies which are in the range of our senses are extended.

Moreover, Newton here explicitly contrasts the strength of the argument for universal gravitation with the case of the impenetrability of the heavenly bodies, for which, as he points out, nobody in his time has a single experiment or observation on which to ground an induction. Locke and Boyle, contrary to Descartes, assume that impenetrability is one of the essential (primary) qualities of all bodies. Indeed, for these empiricist mechanical philosophers, the property of impenetrability is the most fundamental grounding of what they, as mechanical philosophers and contrary to Newton, take to be the most intelligible form of causation in physical nature: motion by impact or impulse. Thus, one of the morals of Rule III is that the use of the inductive method is contrary to a procedure which begins from the hypothetical assumption that impenetrability is a primary quality essential to any piece of matter whatsoever. From a Newtonian perspective, laws that might govern the hypothetical impenetrable parts of celestial bodies could gain equal standing with the law of universal gravitation only if one could derive these laws from observations by means of his inductive method. Rule IV emphasizes that the conclusions of an inductive universalization from observations should be regarded as true or nearly true until observed exceptions lead to their revision. And, in the explanation of Rule IV, Newton states: "This rule should be followed so that arguments based on induction may not be nullified by hypotheses" (*Principia*, 796). The laws inductively derived from phenomena are regarded as truly universal (or very nearly so)—and thus are taken to be exceptionless (or very nearly so)—until more observations lead to restrictions on their accuracy or scope. But no mere mechanical hypothesis (such as the vortex theory) can lead to such restrictions. Only uniform and constant manifest experience can lead to revisions of the inductively established laws of nature; and the goal of this entire process is to lead, eventually, to completely exceptionless universal laws where no further restrictions are necessary.

Newton distinguishes between the status of universal conclusions established by inductive proof and his own procedure of using experiments to show the probability of a conjecture or hypothesis. He regards propositions proved or "deduced from the phenomena" and "made general by induction" as having the "highest evidence that a proposition can have in this [experimental] philosophy." By contrast, he explicitly denies that his own hypotheses (or conjectures) have the attributes of inductive proofs. For example, in a letter to Cotes, 1713, Newton writes:

> [A]s in geometry the word 'hypothesis' is not taken in so large a sense as to include the axioms and postulates, so in experimental philosophy it is not to be taken in so large a sense as to include the first principles or axioms which I call the laws of motion. These principles are deduced from phenomena and made general by induction: which is the highest evidence that a proposition can have in this philosophy. And the word 'hypothesis' is here used by me to signify only such a proposition as is not a phenomenon nor deduced from any phenomena but assumed or supposed without any experimental proof.[15]

At the end of a letter to Boyle, February 1678–1679, after proposing various conjectures about the ether, including one concerning the cause of gravity, Newton writes: "[B]ut by what has been said, you will easily discern, whether in these conjectures there be any degree of probability, which is all I aim at."[16]

Newton's distinction can be best illustrated by appreciating the proper status of the corpuscularian theory of matter in his own approach. For example, Newton develops a corpuscularian theory of light in the *Opticks*[17] (in particular, Query 29, together with Query 28—Query 28 attempts to eliminate the rival wave hypothesis). But he does not regard these Queries as containing inductive proofs as characterized by his Rules. He is well aware that there is no "deduction from the phenomena" here, in contradistinction to the results of the *Principia* and the earlier parts of the *Opticks* (which are expressed in "definitions," "axioms," and "propositions" rather than in "queries"): the corpuscularian account of light is not among the "propositions inferred by general induction from phenomena" or "proofs by experiments." That he conceives his corpuscularian hypothesis in this way is emphasized in a letter to Oldenburg, June 1672, where Newton responds to a criticism by Hooke who accuses him of assuming the hypothesis that light is composed of bodies: "'Tis true, that from my Theory I argue the *Corporeity* of Light; but I do it without any absolute positiveness, as the word *perhaps* intimates; and make it at most but a very plausible *consequence* of the Doctrine, and not a fundamental *Supposition*, nor so much as any part of it; which was wholly comprehended in the precedent Propositions."[18]

Newton's theory of "the *Corporeity* of Light" shows that he is by no means hostile to corpuscularianism in general, in spite of his rejection of the corpuscularian hypotheses of the mechanical philosophy. Nevertheless, the hypotheses or conjectures used by Newton himself have a very different methodological status from the hypotheses of the mechanical philosophers he rejects (such as the vortex theory). Newton's corpuscularian hypothesis concerning light, as the letter to Oldenburg puts it, is merely a plausible "consequence" of a doctrine inductively demonstrated by observations—not a fundamental a priori "supposition" about the unobservable microstructure of matter, with which, according to the mechanical philosophy, all observations must accord. Newton's emphasis on the words "consequence" and "supposition" calls attention to precisely this contrast between his own use of hypotheses and the mechanical philosophers' use.[19]

Reading Newton's inductive Rules in combination with the above-quoted passages from the Scholium and the letters strongly suggest that he is explicitly targeting the mechanical philosophers in his formulation of the Rules. His central target is the rationalist version of this philosophy—as defended by Descartes, Leibniz, and their followers—and he is most concerned to prevent their a priori demonstrative ideal from hindering or "nullifying" his own use of universalizing induction. However, the differences between Newton and Locke are more complicated and subtle than the differences between Newton and these rationalists philosophers, for the obvious reason that both Locke and Newton hold that observations and experiments are, in the end, all the evidence we have in the study of nature. Nevertheless, despite this general common ground, Locke remains wedded to central assumptions of the rationalist mechanical philosophers, and these prevent him from anticipating, in the *Essay*, the key ideas of Newton's inductive method as characterized in his Rules. Indeed, this should not be at all surprising, since, as I noted above, the crucial Rule III, where Newton first explicitly emphasizes the tension between his method and the hypotheses of the mechanical philosophy, was first added to the second edition of the *Principia* in 1713, and Rule IV, where Newton completes this polemic by warning of the dangers of "nullifying" the inductive method by hypotheses, was only added to the third edition in 1726—both long after Locke's death in 1704.

The first important difference between Locke and Newton is that Locke is an advocate of the mechanical philosophy (Locke is likely to have in mind Boyle's empiricist version)—which he calls the "corpusculatean Hypothesis"—as providing the most intelligible explanation of the operations and qualities we observe in bodies. The most intelligible such explanation, common to *both* rationalist and empiricist mechanical philosophers, conceives all fundamental causal action as communication of motion by impact or impulse. Locke is very explicit about this in the first three editions of the *Essay*, where, at II, VIII, 11, he writes: "*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" (Nidditch edition, critical apparatus at the bottom of page 135).[20] Newton, by contrast, is not committed to the privileged intelligibility of the mechanical communication of motion by impact or impulse, and, in particular, he explicitly distinguishes the action of the (so far unknown) cause of gravity from that of all "mechanical causes."[21]

There is a related aspect of the model of intelligibility shared by the rationalist mechanical philosophers and Locke which has significant methodological implications and thus marks a second important difference between Newton and Locke. This is the assumption that any proper causal explanation of the operations and qualities we observe in bodies reduces to a hidden configuration of the primary qualities of their "insensible Parts." In particular, the microstructure of "insensible Corpuscles" (characterized by their primary qualities) underlying all observable phenomena is supposed to explain and necessitate the effects of bodies on one another and on ourselves:

> These insensible Corpuscles, being the active parts of Matter, and the great Instruments of Nature, on which depend not only all their secondary Qualities, but also most of their natural Operations, our want of precise distinct *Ideas* of their primary Qualities, keeps us in an uncurable Ignorance of what we desire to know about them. I doubt not but if we could discover the Figure, Size, Texture, and Motion of the minute Constituent parts of any two Bodies, we should know without Trial several of their Operations one upon another, as we do now the Properties of a Square, or a Triangle. (*Essay* IV, III, 25)[22]

To be able to penetrate into the exact configuration of the assumed primary qualities of bodies is the guiding methodological desideratum for achieving proper causal explanations, and thus what Locke calls "Knowledge" or "Science" of nature. To be sure, Locke, unlike the rationalists, emphasizes a skeptical gap (suggested here and further explained below) between what our faculties can actually perceive and the particular microstructural configuration of primary qualities underlying the phenomena. Nonetheless, for both the rationalist mechanical philosophers and for Locke, the ultimate causal explanations of what we observe reside in precisely this hypothetical hidden microstructure. By contrast, Newton, as we have seen, is especially concerned that the favored hypothetical causal explanations of the mechanical philosophy do not interfere with his use of the inductive method.

A third important difference between Locke and Newton concerns how they conceive of "primary" properties. Whereas Newton does talk of "primary," "original," or "simple" properties, these, for him, are discovered only by observations and experiments—as a product of his inductive method. In a groundbreaking analysis of the extent to which Locke differs from Newton concerning the methodology of science, Howard Stein argues that, unlike Locke, Newton does not take his primary and original properties as constituting an antecedently fixed list, prior to and independently of what experimental inductive investigation may then discover.[23] In particular, Newton uses the terminology of "primary," "original," or "simple" properties of light in the early parts of the *Opticks*, where these include, for example, the intrinsic degrees of refrangibility of differently colored rays revealed in his famous prism experiments.[24] Thus, as Stein points out, Newton's conception of "primary" or "original" properties is always open to what experience can teach us by the application of his inductive method.[25]

In support of Stein's very crucial point, I should add, first, that whenever Locke gives lists of primary qualities in the *Essay*, he does not envision the possibility that we might modify this list in light of experience. Second, since Newton's Rules III and IV explicitly oppose the mechanical philosopher's method of starting with hypotheses that cannot be modified by experimental investigation, these Rules also imply the rejection of a hypothetical fixed list of primary properties in advance of what experience can teach us. Third, whereas Locke's primary-secondary quality distinction is associated with a skeptical gap between our perceptions and an underlying hidden reality that explains them, Newton's notion of "primary" or "original" properties is associated with no such gap: these, on the contrary, are continually made accessible to us by the inductive or experimental investigation of manifest phenomena.

The skeptical gap on Locke's account leads to a crucially important fourth methodological difference between himself and Newton: in spite of his skepticism, Locke retains the a priori ideal of knowledge of nature. As we have seen in our discussion of the second point of difference, Locke, at *Essay* IV, III, 25, claims that *if* we could discover the hidden configuration of primary qualities, then we *would* have a priori demonstrative knowledge ("without Trial") of the operations of bodies. However, since we cannot in fact penetrate to this hidden structure, we are left in "an incurable Ignorance." Locke's emphasis on this problem certainly distances him from the rationalist proponents of the mechanical philosophy. For Locke, however, we cannot achieve demonstrative knowledge or science of bodies precisely because we cannot acquire knowledge of what Locke assumes, together with the rationalists and independently of observation or experiment, to be the necessary, intrinsic connection between the primary qualities of bodies and their operations on other bodies and on ourselves.

In *Essay* IV, III, "Of the Extent of Humane Knowledge," Locke points out that there are different grounds for the limited extent of our knowledge. In many passages he emphasizes that the limitation issues from our lack of adequate ideas of the detailed configuration of the primary qualities of bodies (see, for example, *Essay* IV, III, 24–6).[26] In other passages he suggests that there is a "more incurable" aspect of our ignorance: there is no discoverable (necessary) connection between primary qualities and the secondary qualities we perceive (see, in particular, *Essay*

IV, III, 28–9; and, 12–4). Thus, Locke suggests that even if we knew the detailed configuration of primary qualities in bodies, we would not know which of the secondary qualities we perceive are necessarily connected with the primary qualities in the bodies themselves (flow from their essence, so to speak): "Besides this Ignorance of the primary Qualities of the insensible Parts of Bodies, on which depend all their secondary Qualities, there is yet another and more incurable part of Ignorance, which sets us more remote from a certain Knowledge of the *Coexistence*, or *Inco-existence* (if I may so say) of different *Ideas* in the same Subject; and that is, that there is no discoverable connection between any *secondary Quality, and those primary Qualities* that it depends on" (*Essay* IV, III, 12). In the next sections, he elaborates on and shows the relationships between these two aspects of our ignorance. For example, at *Essay* IV, III, 14, Locke writes:

> In vain therefore shall we endeavour to discover by our *Ideas*, (the only true way of certain and universal Knowledge,) what other *Ideas* are to be found constantly joined with that of our complex *Idea* of any Substance: since we neither know the real Constitution of the minute Parts, on which their Qualities do depend; nor, did we know them, could we discover any necessary *connexion* between them, and any of the *secondary Qualities*: which is necessary to be done, before we can certainly know their *necessary co-existence*. So that let our complex *Idea* of any Species of Substances, be what it will, we can hardly, from the simple *Ideas* contained in it, certainly determine the *necessary co-existence* of any other Quality whatsoever. Our Knowledge in all these Enquiries, reaches very little farther than our Experience. Indeed, some few of the primary Qualities have a necessary dependence, and visible connexion one with another, as Figure necessarily supposes Extension, receiving or communicating Motion by impulse, supposes Solidity. But though these, and perhaps some others of our *Ideas* have: yet there are so *few* of them, that have a *visible Connexion* one with another, that we can by Intuition or Demonstration, discover the co-existence of very few of the Qualities are to be found united in Substances: and we are left only to the assistance of our Senses, to make known to us, what Qualities they contain. . . . Thus though we see the yellow Colour, and upon trial find the Weight, Malleableness, Fusibility, and Fixedness, that are united in a piece of Gold; yet because no one of these *Ideas* has any evident *dependence*, or necessary connexion with the other, we cannot certainly know, that where any four of these are, the fifth will be there also, how highly probable soever it may be: Because the highest Probability, amounts not to Certainty; without which, there can be no true Knowledge.

Because of precisely this ignorance, although we can empirically arrive at probable connections and regularities among the secondary qualities we observe, we cannot establish certain and undoubted rules governing them. We can merely conventionally collect qualities under a general name—the nominal essence of a particular substance—guided by the observation of manifest qualities.[27] Thus, nominal essences allow us to sort individuals into species of things, but we will never know whether the observed qualities we compile under these nominal essences correspond with the real essences of things:

> Though the familiar use of Things about us, take off our Wonder; yet it cures not our Ignorance. When we come to examine the Stones, we tread on; or the Iron, we daily handle, we presently find, we know not their Make; and can give no Reason, of the different Qualities we find in them. 'Tis evident the internal Constitution, whereon their Properties depend, is unknown to us. For to go no farther than the grossest and most obvious we can imagine amongst them, What is that Texture of Parts, that real *Essence*, that makes Lead, and Antimony fusible; Wood, and Stones not? What makes Lead, and Iron malleable; Antimony, and Stones not? (*Essay* III, VI, 9)

According to Locke, the study of nature must rely on manifest qualities or phenomena because, since we cannot have knowledge of the inner constitution of bodies, there is nothing else to rely on:

> 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. Where our Enquiry is concerning Co-existence, or Repugnancy to co-exist [of qualities of kinds of substances], which by Contemplation of our *Ideas*, we cannot discover; there Experience, Observation, and natural History, must give us by our Senses, and by retail, an insight into corporeal Substances. (*Essay* IV, XII, 12)

Therefore, the general prescription to rely on experience and observation in the study of nature, which Locke undoubtedly shares with Newton and Hume, does not lead to a rejection of the explanatory ideal of the mechanical philosophy. On the contrary, it is only by fulfilling this ideal, for Locke, that we could ever attain true "Knowledge" or "Science," of nature;[28] and, in "experimental philosophy," we must instead be content with what Locke calls "Judgement" and "Opinion":

> 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 of Substances only by Experience* and History . . . makes me suspect, that natural Philosophy is not capable of being made a Science. (*Essay* IV, XII, 10)

Even more emphatically, Locke declares:

> [H]ow far soever humane Industry may advance useful and *experimental* Philosophy *in physical Things*, *scientifical* will still be out of our reach. . . . [W]e are not capable of *scientifical Knowledge*; nor shall ever be able to discover general, instructive, unquestionable Truths concerning [sorts of bodies]. *Certainty* and *Demonstration*, are Things we must not, in these Matters, pretend to. By the Colour, Figure, Taste, and Smell, and other sensible qualities, we have as clear, and distinct *Ideas* of Sage and Hemlock, as we have of a Circle and a Triangle: But having no *Ideas* of the particular primary Qualities of the minute parts of either of these Plants, nor of other Bodies which we would apply them to, we cannot tell what effects they will produce; Nor when we see those Effects, can we so much as guess, much less know, their manner of production. Thus having no *Ideas* of the particular mechanical Affections of the minute parts of Bodies, that are within our view and reach, we are ignorant of their Constitutions, Powers, and Operations: and of Bodies more remote, we are yet more ignorant not knowing so much as their very outward Shapes or the sensible and grosser parts of their Constitutions. (*Essay* IV, III, 26)

In sum, Locke's skepticism about the possibility of a genuine "Science" of nature depends on central tenets of the mechanical philosophy, and his view of what experimental inquiry can achieve (mere "Judgment" and "Opinion") is a consequence of his demonstrative ideal of "Knowledge" and "Certainty."[29]

We thereby finally arrive at a fifth important difference between Locke and Newton: unlike Newton's conception of his own inductive method, probable opinion in Locke can never result in a truly universal exceptionless law. Locke does not anticipate an experimental method leading to the formulation of inductively established, exceptionless universal laws of the kind envisioned in Newton's Rules III and IV; and he does not arrive, in particular, at the idea that such an inductive method can replace the demonstrative ideal of the mechanical philosophy with an alternative ideal of scientific knowledge. In Locke, experience is merely a source for the modification and revision of what we provisionally regard as nominal essences, but there is no way, as we have seen, that we could ever know whether such nominal essences correspond to—or even approximate—the truly necessary connections determined by the real essences. In devising conventional nominal essences of particular substances, we rank things by using general names in order to class individuals together into species or kinds in accordance with our observations and experiments. However, we could never attain either certainty or necessity or knowable exceptionless universality in this way. For example, the regularities we have observed in making general claims about gold—we have observed that gold, unlike iron, has always been malleable—have no knowable connection with the truly exceptionless universality we could obtain only by a knowledge of gold's real essence. Thus, even if we interpret Locke's nominal essences as generalizations resulting from induction (since the formulation of nominal essences depends on repeated observations), these generalizations could never amount to what Newton calls inductive or experimental "proofs" of truly universal exceptionless laws of nature. Genuine exceptionless universality, for Locke, could only result from certain and demonstrative knowledge, which, in the case of bodies, is for us unattainable.

For Locke, therefore, corresponding to the unbridgeable skeptical gap between primary and secondary qualities, real and nominal essences, there is a parallel unbridgeable gap between the regularities we actually observe and the truly universal, absolutely certain laws which must demonstratively flow from the real essences:

> The more, indeed, of these co-existing Qualities we unite into one complex *Idea*, under one name, the more precise and determinate we make the signification of that Word; But yet never make it thereby more capable of *universal Certainty*, in respect of other Qualities, not contained in our complex *Idea*; since we perceive not their connexion, or dependence one on another; being ignorant both of that real Constitution in which they are all founded; and also how they flow from it. . . . Could any one discover a necessary connexion between *Malleableness*, and the *Colour* or *Weight* of *Gold*, or any other part of the complex *Idea* signified by that Name, he might make a *certain* universal Proposition concerning *Gold* in this respect; and the real Truth of this Proposition, That *all Gold is malleable*, would be as *certain* as of this, *The three Angles of all right-lined Triangles, are equal to two right ones*. (*Essay* IV, VI, 10)[30]

Thus, Locke identifies truly universal laws of nature with absolutely necessary and demonstratively certain laws, grounded in the (forever unknowable) real constitution or essence of bodies. Because of this conception of the universality and necessity of the laws of nature, his empirical scientific methodology is left with an exclusive emphasis on probable opinion concerning the differences among particular substances, such as the observable differences in the sensible qualities of gold and iron. Locke nowhere envisions the third category of inductive or experimental "proofs" in Newton's sense.

As we have seen, Newton's Rule III explicitly warns against the danger of allowing mechanical hypotheses to interfere with what he takes to be an inductively established universal law—the law of universal gravitation—and Rule IV goes on to emphasize that restrictions in the accuracy or scope of such laws can only be grounded in further inductive evidence. Proceeding in this way, we can successively correct for any exceptions that may inductively be found, so as eventually to approximate closer and closer to a truly universal and exceptionless inductive generalization. Generalizations grounded by this method have the "highest evidence that a proposition can have in this [experimental] philosophy," with which no corpuscularean hypothesis or conjecture can possibly compete. Newton's conception of experimental philosophy, unlike Locke's, is fashioned in explicit opposition to the demonstrative ideal of the mechanical philosophy, and his conception of inductive generalization, in particular, is intended to replace this ideal with a contrary purely inductive ideal. This is precisely the crucial step that Locke never takes and which, as we shall see, is taken by Hume.

II. Hume and Locke on Causation and Necessity

Newtonian inductivism inspires Hume's own positive account of causation and conception of scientific methodology—both in opposition to the mechanical philosophy of nature which Hume has inherited. As we have seen, in the received view of causation, shared by both Descartes and Locke, nature or reality has an ultimate or intrinsic constitution of primary qualities which underlies the causal relations we can observe—this view of causation is thus intimately related to a view of the necessity in nature. For Locke, in particular, a material necessity independent of both our minds and our available empirical methods explains causal connections and resides in the intrinsic causal powers of bodies—powers with which the primary qualities of substances are endowed. Locke shares the mechanical philosophy's understanding of how a microstructure of primary qualities in one body can necessitate effects in another: the motions of the microscopic parts of one body are communicated by impact to the microscopic parts of another.

Descartes, who, together with Galileo, can be regarded as one of the fathers of the mechanical philosophy, makes it very clear that, in his conception, the efficient cause *intrinsically and necessarily contains* everything that can be found in the effect. For example, in the *Third Meditation* (paragraph 14), Descartes famously writes: "[I]t is manifest by the natural light that there must be at least as much <reality> in the efficient and total cause as in the effect of that cause. For where, I ask, could the effect get its reality from, if not from the cause? . . . For if we suppose that an idea contains something which was not in its cause, it must have got this from nothing."[31] This is in accordance with Descartes's *general* conception of efficient causation, whether mental or material, and involving both finite creatures and God. With respect to physical or material nature, in particular, pure mathematics, as the study of pure extension, lies at the foundation of physics.[32] The general principles of physical nature can be *deduced* from mathematical principles concerning the shape, size, position, and motion of particles of matter (together with the laws of motion resulting from God's creation).[33] The causes of all natural effects or changes are conceived in terms of the motions of the minute parts of matter, and the only intelligible idea of communication of motion is by impact or impulse. To know all the details of the particular configuration of the hidden microstructure of a body would be tantamount to possessing absolutely a priori knowledge of the effects that necessarily follow from such a configuration, since the effects are contained a priori within it —and therefore follow with geometrical necessity from it.

This view of causation would explain the causal nexus in a *single case*—if we could penetrate into the intrinsic hidden microstructure of the bodies involved. In my view, Hume's argument against the very notion of singular causation is the first instance where we can appreciate his moves against the mechanical philosopher's conception of efficient causation. Indeed, it is precisely in the context of arguing against singular causation that he famously argues against the demonstrative derivation of effects from causes, and this argument is also explicitly directed against the received view that we have grounds for claiming that there really is, independently of our observation of causes and effects, a necessary connection between them. In advancing objections to taking a singular observation of a relation between objects as causal, Hume is not merely preparing the ground to claim, following the model of Newtonian induction, that the central ingredient in our idea of causation is constant conjunction, that is, uniform experience of like causes followed by like effects.[34] He does not merely argue that the observation, for the first time, of a phenomenon followed by another in a single case does not give rise to the belief in causation. He raises, in addition, several interconnected skeptical doubts regarding the mechanical philosophy's model of causal explanation: the containment of the effect within the cause, the ideal of demonstrative knowledge of causation, and the reality of a necessary connection between cause and effect—all dependent on the postulation of a hidden configuration of primary properties.

Contrary to the mechanical philosopher's conception of the containment of the effect in the cause, Hume argues that the ideas of cause and effect are *distinct* ideas, entirely separable and thus independent from one another: "[A]ll distinct ideas are separable from each other, and as the ideas of cause and effect are evidently distinct, 'twill be easy for us to conceive [to form the idea of] any object to be non-existent this moment, and existent the next, without conjoining to it the distinct idea of a cause or productive principle" (T 1.3.3.3; SBN 79).[35] He also makes it explicit that his rejection of the conception of the containment of the effect in the cause goes hand in hand with his rejection of an a priori, demonstrative model of causal explanation:

> 'Tis easy to observe, that in tracing this relation, the inference we draw from cause and effect, is not deriv'd merely from a survey of these particular objects, and from such a penetration into their essences as may discover the dependence of the one upon the other. There is no object, which implies the existence of any other if we consider these objects in themselves, and never look back beyond the ideas which we form of them. Such an inference wou'd amount to [demonstrative] knowledge, and wou'd imply the absolute contradiction and impossibility of conceiving any thing different. But as all distinct ideas are separable, 'tis evident there can be no impossibility of that kind. When we pass from a present impression to the idea of any object, we might possibly have separated the idea from the impression, and have substituted any other idea in its room. (T 1.3.6.1; SBN 86–7)

To "consider these objects in themselves" is to consider only the meager evidence of impressions of sensation or objects before the mind. Any further ideas that we take to have been inferred from these direct presentations might have been erroneously inferred, for there is no intrinsic connection in terms of the content of distinct presentations before the mind such as those we regard as a cause and an effect. It follows from this that it is intelligible to regard anything as the cause of anything else—as Hume puts it at T 1.3.15.1 (SBN 173): "Any thing may produce any thing." The reference to the postulation of an essence, in particular, makes it clear that Hume is here targeting the mechanical philosophers, including Locke.

Thus, at the first stage of his skeptical argument, Hume immediately raises doubts about the very model of causation and necessity of the mechanical philosophy:

> Having thus discover'd or suppos'd the two relations of *contiguity* and *succession* to be essential to causes and effects, I find I am stopt short, and can proceed no farther in considering any single instance of cause and effect. Motion in one body is regarded upon impulse as the cause of motion in another. When we consider these objects with the utmost attention, we find only that the one body approaches the other, and that the motion of it precedes that of the other, but without any sensible interval. 'Tis in vain to rack ourselves with *farther* thought and reflection upon this

> subject. We can go no *farther* in considering this particular instance. (T 1.3.2.9; SBN 76–7)

Notice that he writes that he has discovered or *supposed* the relations of contiguity and succession, thus suggesting that they are not always observed, and thus that they might be merely hypothetical assumptions.

However, as it will turn out, these two relations are less hypothetical than the idea of a necessary connection between the single events we call cause and effect. For, at the macroscopic level, we often have impressions of sensation of contiguity and succession, but never of necessity. More importantly, this passage does not merely point out the limited inferences we can make from the observation of contiguity and succession in one single case, but it also explicitly states, against the mechanical philosophy, that in the paradigmatic case of causation of motion by impact (whether macroscopic or microscopic), we only observe two entirely separate and distinct events. In a single observed case of what is taken to be motion by impact, the mechanical philosophy makes a causal claim on the basis of the assumption that the second body moves, in a precise way, as a necessary, quasi-geometrical consequence of the precise motion of the first body. Hume's implicit claim at T 1.3.2.9 is that, given that the mechanical philosophy's paradigmatic case of causal explanation of motion by impact does not work at the macroscopic level, it follows that the notion of a microstructural necessary connection based on motion by impact of the corpuscles does not work either ("'tis in vain to rack ourselves with *farther* thought and reflection upon this subject").

It is very revealing that in the first *Enquiry* (at the parallel first stage of his skeptical argument) Hume also uses the example of the change effected by the impact or impulse of one *macroscopic* observed object on another: "The mind can never possibly find the effect in the supposed cause, by the most accurate scrutiny and examination. For the effect is totally different from the cause, and consequently can never be discovered in it. Motion in the second Billiard-ball is a quite distinct event from motion in the first; nor is there anything in the one to suggest the smallest hint of the other" (EHU 4.9; SBN 29). That motion by impact is the paradigm of an intelligible and necessary causal connection according to the mechanical philosophy allows Hume to turn his general criticism of this philosophy against Locke's and other empiricist versions. For, the motion of a billiard ball following the impact with another is an observable phenomenon, and, in the causal explanation of such a motion, the empiricist mechanical philosopher can concentrate on *manifest* primary qualities of the bodies involved. Such a philosopher, from Hume's point of view, has been carried away by the macroscopic observation of the manifest primary qualities in question, and has then transferred the model of the motion of billiard balls to an assumed unobservable microstructural level.

Moreover, the mechanical philosopher uses the same hypothetical causal explanation for the burning effect of fire on another body, the suffocating effect of water on non-aquatic creatures, the nourishing effect of bread in the human body, and so on. In all cases the causal explanation should reduce to motions by impact within a microstructure of primary qualities of corpuscles with certain shapes and sizes. In all cases effects allegedly follow with necessity from (and are contained in) causes because of the hypothesis of the existence, at the microstructural level, of powers that necessitate effects.

By emphasizing that all we observe are distinct, separable events, Hume implies that the only clue to any legitimate postulation at the microscopic level is provided by the macroscopic observation of separate events. Any connection that we would find at the microscopic level, if we were to advance by means of observation to it, would thus be an inductively derived connection, not an intelligible necessary connection of the intrinsic content of the (ideas of) cause and effect. Hume is not precluding the attempt to advance by the inductive method into the microscopic level. Yet, because our only guide is what we observe, we can only inductively generalize from the observed to the unobserved, and thus claim that if we could penetrate into the microscopic level, we would still only observe separate, distinct events, just as we do at the macroscopic level. The postulation of a hidden microstructure prior to what we can observe not only interferes with the inductive method, but it is also entirely idle, since claims about the unobserved microscopic level can only be inductively inferred from regular and constant experience at the macroscopic level. In particular, the most we can claim concerning laws of impact is that the same inductively inferred laws holding at the macroscopic level between distinct and separable events hold for the not yet observed microscopic level as well.

In driving his argument to the conclusion that the ideal of demonstrative knowledge of nature should thus be *replaced* by the inductive method, Hume shows that all the data we have concerning anything we might ever observe about causes and effects (whether we do or do not have "microscopical eyes") are observations of separate events. The point is that there is no legitimate postulation or hypothesis, such that, if we were to advance by means of observations to the microscopic level, we must then observe a structure of primary qualities and powers that demonstratively necessitate their effects. For, the only clue we are afforded by observations at the macroscopic level is that the impression or idea of a cause and the impression or idea of an effect are entirely distinguishable and thus separable events. This regressive move from the macrolevel to what we can legitimately claim at the microlevel mimics Hume's (and Berkeley's) argument against the mechanical philosophy's claim that secondary qualities are only in the mind, whereas perceived primary qualities exist also in the objects themselves.[36] Even in the best possible case for the mechanical philosophy—the macroscopic observation of the impact of billiard balls—we cannot reason a priori. Hume can thus put together his criticisms of single case causation, of the a priori model of causal explanation of the mechanical philosophy (with its attendant notion of necessity), and of Locke's empiricist version of this model.

In Hume's critical discussion of the received views of necessity there is also a first stage, which parallels the skeptical argument concerning a priori knowledge of causation and singular causation. In the first *Enquiry*, section 7, part 1, he targets again the mechanical philosophy's model of causal explanation and necessity, more specifically, Locke's version involving the notion of power. As we have seen, a Lockean power—which Hume equates with the notion of necessary connection he is criticizing—is responsible for the effects following with necessity from substances, and itself flows from or reduces to the configuration of primary properties of the substance. Hume here explicitly attributes to Locke, in a footnote, the view he criticizes:

> In reality, there is no part of matter, that does ever, by its sensible qualities, discover any power or energy, or give us ground to imagine, that it could produce any thing, or be followed by any other object, which we could denominate its effect. Solidity, extension, motion; these qualities are all complete in themselves, and never point out any other event which may result from them. The scenes of the universe are continually shifting, and one object follows another in an uninterrupted succession; but the power or force, which actuates the whole machine, is entirely concealed from us, and never discovers itself in any of the sensible qualities of bodies. We know, that, in fact, heat is a constant attendant of flame; but what is the connexion between them, we have no room so much as to conjecture or imagine. It is impossible, therefore, that the idea of power can be derived from the contemplation of bodies, in single instances of their operations; because no bodies ever discover any power, which can be the original of this idea.[1] (EHU 7.8; SBN 63–4)

And the footnote then explains:

> Mr. Locke, in his chapter on power, says, that, finding from experience, that there are several new productions in matter, and concluding that there must somewhere be a power capable of producing them, we arrive at last by this reasoning at the idea of power. But no reasoning can ever give us a new, original, simple idea; as this philosopher himself confesses. This, therefore, can never be the origin of that idea. (EHU 7.8 n12; SBN 64 n1)

If he had not added the footnote, a superficial reading might suggest that here Hume is in agreement with Locke, since Hume claims that we never observe the power that necessitates the effects of the machine of nature (and in this section 7 of the first *Enquiry* he is discussing the technical philosophical sense of "power," not the loose and popular sense he has employed in section 4). However, Hume says that we have room neither to conjecture nor to imagine the hidden microstructure postulated by the mechanical philosophy—the hidden "machine" in nature. He notes that, as impressions of sensation, solidity, extension, and motion are complete in themselves, in the sense that they do not point beyond what we observe, and thus do not suggest that they might potentially necessitate any effects. As I suggested above, the macroscopic case of impact of billiard balls has particular force against Locke; for, on Locke's empiricist version of the mechanical philosophy, it might appear that we could form the "new" idea of an unobserved power operating at the microscopic level, by hypothetical regressive reasoning from observable macroscopic cases of motion by impact (Hume suggests this interpretation of Locke in the footnote to EHU 7.8). We could then transfer this idea of power to all other cases of causal connection among bodies by appeal to the hidden microstructure. Hume is here denying that such hypothetical reasoning is legitimate.[37]

Hume is not simply saying, as Locke would, that we cannot know the parts of the hidden "machine." Hume is making a polemical claim that the model of motion by impulse or impact of the microscopic parts in a body—as yielding an intrinsic necessary connection between cause and effect—relies on a notion of power or necessary connection that is simply unintelligible, for it is a new idea that does not have a corresponding simple impression in the alleged case of single causation. This follows from what he says about the case of impact in general in the *Treatise* and the macroscopic case of impact in particular in the first *Enquiry*.

This reading is confirmed by a passage in the first *Enquiry*, section 6, where he places the laws of impact and gravitation (and common-sense generalizations) on an entirely equal footing with respect to their legitimacy and intelligibility—which, in all cases, are based on the inductive method and thus the observation of constant conjunction. Unlike Locke, in the *Essay*, who explicitly claims that the only intelligible explanation of motion is by impulse and suggests that Newton's *Principia* is a work in pure mathematics,[38] Hume unreservedly accepts universal gravitation as a law of nature, and takes Newton's theory to articulate a fundamental law of nature on a par with all other inductively established laws: "There are some causes, which are entirely uniform and constant in producing a particular effect; and no instance has ever yet been found of any failure or irregularity in their operation. Fire has always burned, and water suffocated every human creature: The production of motion by impulse and gravity is an universal law, which has hitherto admitted of no exception" (EHU 6.4; SBN 57). (Notice the qualification, in accordance with Newton's Rule IV, that these laws have *hitherto* been observed to be exceptionless, thus the suggestion that they are open to revision by experience).

Recall that the mechanical philosophy has called into question the intelligibility of Newton's law of universal gravitation precisely because of a commitment to the idea that the only intelligible action among bodies is by contact. Thus, the fact that, in the *Treatise*, he regards contiguity as one of the central ingredients in our idea of causation might suggest that Hume retains the mechanical philosophy's model of intelligibility.[39] However, as the last quoted passage from EHU 6.4 reveals, contrary to the mechanical philosophy, there is for Hume absolutely no asymmetry between the law of universal gravitation and the laws of impact. Similarly, in a closely related passage, Hume takes the law of gravitation to be on a par with the inductively arrived at general principles of elasticity, cohesion of parts, and communication of motion by impulse: "Elasticity, gravity, cohesion of parts, communication of motion by impulse, these are probably the ultimate causes and principles which we shall ever discover in nature; and we may esteem ourselves sufficiently happy, if by accurate enquiry and reasoning, we can trace up the particular phenomena to, or near to, these general principles" (EHU 4.12; SBN 30–1).

Hume calls all these forces "general principles." This is in keeping with Newton, who does not characterize such forces as flowing from the inner nature of things (as we have seen, Newton denies repeatedly that gravity is essential to matter) but claims that we know that these forces exist only if we know the laws that concern their operations—which laws have been discovered by induction from the phenomena. Thus Newton writes in the *Opticks, Query* 31 (401):

> It seems to me farther, that these Particles have not only a *Vis inertiae*, accompanied with such passive Laws of Motion as naturally result from that Force, but also that they are moved by certain active Principles, such as is that of Gravity, and that which causes Fermentation, and the Cohesion of Bodies. These Principles I consider, not as occult Qualities, supposed to result from the specifick Forms of Things, but as general Laws of Nature, by which the Things themselves are form'd; their Truth appearing to us by Phaenomena, though their Causes be not yet discover'd.

In the same vein, Hume takes the laws or principles of elasticity, gravity, cohesion of parts, communication of motion by impulse to be completely equivalent with respect to legitimacy and intelligibility, for, in all these cases, we have inductively discovered laws of nature arising from the observation of constant conjunction. And again, the power or necessary connection, which hypothetically might be taken to be involved in action by contact, is as unintelligible as gravitational action at a distance: “We surely comprehend as little the operations of one [the Supreme Being] as of the other [the grossest matter]. Is it more difficult to conceive, that motion may arise from impulse, than that it may arise from volition? All we know is our profound ignorance in both cases” (EHU 7.25; SBN 73). In the immediately preceding paragraphs, he has argued against occasionalism, and, before addressing occasionalism, Hume has also argued, as I have pointed out (see note 37), against Locke’s view that we acquire the idea of power from the actions of the mind. A footnote to the last quoted words then stresses the equal unintelligibility attending the idea of a power that allegedly operates in inertia, motion by impact and gravitational action at a distance: we have to limit our claims to “facts,” that is, to observed constant conjunctions and the inductively inferred conclusions from such observations. As Newton’s Rule III prescribes, all we can rely on are observations, and if the observations are sufficient in number, uniform and constant, we can generalize by induction to unobserved cases of the same kind:

> I need not examine at length the *vis inertia* which is so much talked of in the new philosophy, and which is ascribed to matter. We find by experience, that a body at rest or in motion continues for ever in its present state, till put from it by some new cause; and that a body impelled takes as much motion from the impelling body as it acquires itself. These are facts. When we call this a *vis inertia*, we only mark these facts, without pretending to have any idea of the inert power; in the same manner as, when we talk of gravity, we mean certain effects, without comprehending that active power. (EHU 7.25 n16; SBN 73 n1)

As we have seen, by claiming that he feigns no hypotheses Newton means that he accepts the law of gravitation as an exceptionless universal mathematical law, independently of whether or not a hidden structure of particles of ether interacting by impact (or in any other way) can be found to explain the law. Hume understands that Newton’s law of gravitation appears to involve an action across arbitrarily large spatial distances, and he is equally aware, at the same time, that Newton himself tries to overcome this difficulty by the hypothesis of an ethereal medium. Indeed, the passage from the footnote just quoted continues as follows:

> It was never the meaning of Sir ISAAC NEWTON to rob second causes [natural causes as distinct from the primary cause, which is God] of all force or energy; though some of his followers have endeavoured to establish that theory upon his authority. On the contrary, that great philosopher had recourse to an etherial active fluid to explain his universal attraction; though he was so cautious and modest as to allow, that it was

a mere hypothesis, not to be insisted on, without more experiments. (EHU 7.25 n16; SBN 73 n1)

Hume is here referring to Query 21 of the *Opticks*, where Newton speculates that the action of gravitation might be explained by the pressure exerted by an interplanetary ether. Similarly, in "A Letter from a Gentleman to his Friend in Edinburgh" to John Coutts, around 1745, Hume writes: "Sir *Isaac Newton* . . . plainly rejects it [Descartes's and Malebranche's hypothesis of occasional causes], by substituting the Hypothesis of an Aetherial Fluid, not the immediate Volition of the Deity, as the Cause of Attraction."[40] And this might show to Hume that the idea of spatial contiguity is a central ingredient in even *Newton's* conception of causation. But Newton's appeal to an ether in Query 21 does not involve the mechanical philosopher's model of intelligibility, based on the collisions or impacts of minute parts of matter, for the pressure exerted by Newton's ether is generated by short-range repulsive forces acting at very small distances. Hume is also well aware that Newton takes his ethereal conjecture to be merely hypothetical (as is made explicit in both of the last two quotations), not as proved by induction. Newton's attempt to find an explanation of gravitational attraction in terms of an ether is thus not inconsistent with the Newtonian ideal of inductive method, and it is not inconsistent, in particular, with the rejection by both Hume and Newton of the mechanical philosophy's claim that only motion by contact is intelligible, together with their demonstrative ideal of a science of bodies. That, in the *Treatise*, Hume takes spatial contiguity to be an ingredient of the notion of causation—to the extent that he does—certainly does not, therefore, align him more closely with the mechanical philosophy than with Newton.

In the *Dialogues concerning Natural Religion*,[41] Hume endorses a crucial result in Newton's *Opticks*, but he does not use the word "hypothesis." In part 1, paragraph 11 of this work, Philo argues that when we speculate "into the creation and formation of the universe; the existence and properties of spirits; the powers and operations of one universal Spirit" and so on, "we have here got quite beyond the reach of our faculties," and we cannot, therefore, appeal to common sense and experience. Cleanthes objects that Philo's argument would lead us to reject one of Newton's results: "In reality, would not a man be ridiculous, who pretended to reject *Newton's* explication of the wonderful phenomenon of the rainbow, because that explication gives a minute anatomy of the rays of light; a subject, forsooth, too refined for human comprehension?" (DNR 1.13; 136). Cleanthes continues: "Light is in reality anatomized: The true system of the heavenly bodies is discovered and ascertained. But the nourishment of bodies by food is still an inexplicable mystery: The cohesion of the parts of matter is still incomprehensible" (DNR 1.14; 136–7). Hume is here referring to Newton's crucial experiment with the prism, which decomposes white light into different colored rays of light. But Newton's explanation of the "wonderful phenomenon of the rainbow" does not postulate corpuscles. The discussion of this result is placed in the *Opticks*, but earlier than the conjectural Queries; and Newton explicitly regards it as inductively proved from the phenomena.[42] Moreover, it is clear that Hume is aware that Newton takes this "anatomization" of light (and thus Hume himself so takes it) as having an inductive proof on a par with the explanation of "the true system of the heavenly bodies."

A passage from *The Natural History of Religion*, chapter 3, might plausibly be taken to show that Hume endorses corpuscularianism without qualifications: "Could men anatomize nature, according to the most probable, at least the most intelligible philosophy, they would find, that these causes are nothing but the particular fabric and structure of the minute parts of their own bodies and of external objects; and that, by a regular and constant machinery, all the events are produced, about which they are so much concerned."[43] Thus Hume views corpuscularianism with sympathy, following Locke, Boyle, Newton, and virtually all natural philosophers of the period. Nonetheless, as this very passage shows, he regards it, as Newton does, only as "most probable," that is, as hypothetical and thus not as inductively proved. To view with sympathy the hypothesis of atomism or corpuscularianism does not commit Newton or Hume to the mechanical philosopher's postulation of an intrinsic hidden structure defined by a fixed set of primary qualities, in advance of what our inductive method allows us to discover of that part of nature that is not yet manifest. The right method of inquiry for Newton starts from manifest regular phenomena and advances to universal but revisable laws, leaving open what the microstructural constitution of objects might eventually be found to be. What we can claim as existing in nature is determined by what has been discovered so far by the inductive method, rather than by a postulation in advance of a specific type of hidden structure or essence which is, so to speak, "waiting" to be discovered.

John P. Wright, one of the first proponents of the Lockean, skeptical realist interpretation of Hume's views on causation and necessity, considers the following sentence in the *Treatise* as evidence that Hume postulates the reality of a hidden microstructure, in the corpuscularian tradition, with the added Lockean proviso that we might never fully know it: "We must certainly allow, that the cohesion of the parts of matter arises from natural and necessary principles, whatever difficulty we may find in explaining them" (T 2.3.1.8; SBN 401).[44] In my view, on the contrary, if we go on to read the whole passage and its wider context, what emerges again is that Hume takes corpuscularianism as merely hypothetical in Newton's sense. Thus, immediately after the above sentence, Hume adds:

> And for a like reason we must allow, that human society is founded on like principles [natural and necessary principles]; and our reason in the

> latter case is better than even that in the former; because we not only observe that men *always* seek society, but can also explain the principles, on which this universal propensity is founded. For is it more certain, that two flat pieces of marble will unite together, than that two young savages of different sexes will copulate? Do the children arise from this copulation more uniformly, than does the parents care for their safety and preservation? (T 2.3.1.8; SBN 401–2)

Hume's claim is that we have a better case of (an approximation to) an inductive proof of the natural and necessary principles governing human nature than of the cohesion of the parts of matter, even when we have evidence for the latter in an observable phenomenon. Moreover, in the text surrounding this passage, he suggests that he is guided by the desideratum that the proper causal explanation of the phenomena we observe consists in inductively arriving at general and necessary principles (exceptionless universal laws), on the basis of uniform experience.

Indeed, this passage belongs to Book 2, part 3, section 1 of the *Treatise*, entitled "Of liberty and necessity" (paragraph 8), and it is preceded, in paragraph 3, by a statement of the deterministic character of what we take to be necessary laws of matter. In paragraph 4, Hume criticizes the mechanical philosopher's (including Locke's) idea of the necessity of nature (in almost the same words as we saw above in the first *Enquiry*, section 7, part 1). This same paragraph 4 then summarizes his positive account of the idea of necessity as a projection arising from inductive inference. The comparison, in paragraph 8, of the different degrees of certainty concerning the laws of matter, on the one hand, and the laws of human nature, on the other, suggests that there are different degrees of approximation to an inductive proof from the observation of more or less uniform experience. However, the desideratum is to seek additional evidence in order to turn conclusions for which we might have different degrees of positive experience, but not yet *completely* uniform positive experience, into conclusions for which there is an inductive proof on the basis of completely uniform experience. (I return to this desideratum in section III below.)

Hume often talks of the limits on how far we can advance in the discovery of the "ultimate secrets" and "ultimate causes and principles" of nature (for example, in the above quoted passage from section 4 of the first *Enquiry* referring to elasticity, gravity, and so on). Such language and similar references to our ignorance of "secret powers" suggest to defenders of the skeptical realist interpretation that Hume, like Locke, believes that, whereas the mechanical philosophy has the correct idea of intelligibility and of causal explanation in terms of a material necessity residing in the real essence of individual substances, we cannot in fact penetrate into the hidden microstructural mechanisms it postulates. An important example of Hume's reference to the secrets or powers of nature occurs at EHU 4.16 (SBN 33):

> It must certainly be allowed that nature has kept us at a great distance from all her secrets, and has afforded us only the knowledge of a few superficial qualities of objects; while she conceals from us those powers and principles, on which the influence of these objects entirely depends. Our senses inform us of the colour, weight, and consistency of bread; but neither sense nor reason can ever inform us of those qualities, which fit it for the nourishment and support of a human body. Sight or feeling conveys an idea of the actual motion of bodies; but as to that wonderful force or power, which would carry on a moving body for ever in a continued change of place, and which bodies never lose but by communicating it to others; of this we cannot form the most distant conception. But notwithstanding this ignorance of natural powers[1] and principles, we always presume, when we see like sensible qualities, that they have like secret powers, and expect, that effects, similar to those, which we have experienced, will follow from them. . . . It is allowed on all hands, that there is no known connexion between the sensible qualities and the secret powers, and consequently, that the mind is not led to form such a conclusion concerning their constant and regular conjunction, by anything which is known of their nature.

However, in the footnote to the word "powers," Hume explains the sense in which he here uses this word: "The word, *power*, is here used in a loose and popular sense. The more accurate explication of it would give additional evidence to this argument. See section 7" (EHU 4.16 n7; SBN 33 n1). And section 7, which is dedicated to the idea of necessary connection, provides an accurate explication of the notion of power in the technical sense used by philosophers, including Locke. As we have seen, the conclusion of that explication is that the notion of power or necessary intrinsic connection among events is unintelligible.

The following passage from the *History of England* might also be taken (mistakenly) to show that Hume agrees with Locke's reasons for being skeptical about the knowledge of nature: "While Newton seemed to draw off the veil from some of the mysteries of nature, he shewed at the same time the imperfections of the mechanical philosophy; and thereby restored her ultimate secrets to that obscurity, in which they ever did and ever will remain" (6:542). In the immediately preceding sentence, however, Hume gives a long laudatory list of Newton's many virtues. The very first item in this list, and the one most relevant to the point at issue, describes Newton as "[c]autious in admitting no principles but such as were founded on experiment; but resolute to adopt every such principle, however new or unusual." In my view, contrary to a Lockean interpretation, this shows that Hume is on Newton's side precisely with regard to Newton's criticisms of the mechanical philosophy's purely hypothetical explanations and their claim of intelligibility. In the above description of Newton's method, Hume points out that the only "principles" one can "resolutely" admit, according to the "cautious" inductive method, are general conclusions inductively derived from observations or phenomena, including such surprising and "unusual" conclusions as the law of gravitation. This Newtonian prescription stands in contrast to the a priori assumed "principles" or hypotheses of the mechanical philosophy, and their claim of exclusive intelligibility. That the contrast here is between Newton's inductive method and the hypotheses of the mechanical philosophy is confirmed by the sentence about the imperfections of the mechanical philosophy; and, putting these two adjacent passages together, Hume implies that the hypotheses of the mechanical philosophy are not "founded on experiment," that is, they go against the Newtonian inductive method.

Hume's references to "ultimate secrets," "secret powers," and the like do not commit him to Locke's view that we know that there exists a hidden constitution of primary qualities endowed with powers, but we cannot know its exact configuration, or to the (unattainable) ideal in Locke's *Essay* of a demonstrative knowledge of nature. As Hume's critical discussion of the received idea of power or necessary connection reveals, "secret powers" in the Lockean or mechanical philosopher's sense cannot be comprehended: they are simply unintelligible, and no more intelligible, in particular, than universal gravitation. A commitment in advance to the existence of such presumed ultimate sources of causal intelligibility—even if we admit that they will remain forever hidden from us—is therefore entirely idle, and, as Newton himself has argued, it can then actually obstruct the advancement of the inductive method.

III. Hume's Newtonian Ideal of Inductive Proof

There is a second stage in Hume's skeptical argument concerning causation which makes it even more different from Locke's skeptical realism. This crucial stage focuses, paradoxically, on Newton's and Hume's own inductive method. Hume makes a transition from the discussion of alleged singular causation to a discussion of the inductive inference as licensed by the principle of the uniformity of nature.[45] Along the way, he ends up offering a revolutionary new conception of causation in terms of a universalizing inductive inference modeled on Newton's inductive method—the best possible methodology for the study of nature. The skeptical argument at *Treatise* 1.3.6 (also in the first *Enquiry*, section 4, part 2) focuses precisely on the possibility of grounding his own version of Newton's guiding general principle of the inductive method.

At *Treatise* 1.3.6, in the course of answering the second question he has posed at T 1.3.2.15 (SBN 78) ("Why we conclude, that such particular causes must *necessarily* have such particular effects; and what is the nature of that *inference* we draw from the one to the other, and of the *belief* we repose in it?"), Hume adds as an essential ingredient of the notion of causation the observation of constant conjunction—that like objects have been always placed in like relations. This experience amounts to the observation of uniformities of the kind Newton illustrates, as we have seen, in the explanation of Rule III. But how and why can we generalize from what we have hitherto uniformly observed to the unobserved? Hume asks: "[W]hether we are determin'd by reason to make the transition [from the experience of the constant conjunction of events of a first kind with events of a second kind to unobserved events of either kind, or to universal laws of nature] or by a certain association and relation of perceptions" (T 1.3.6.4; SBN 88–9). In view of the previous contrasts he has drawn between natural and philosophical relations (at *Treatise* 1.1.4–5), and between knowledge and probability (at *Treatise* 1.3.1–2), Hume's question here can be taken to be whether we are determined to draw an inference by natural principles of association of the mind (by natural relations), or, instead, we base the causal inference on philosophical relations (on "reason," that is reasoning)—where philosophical relations, in my view, involve reflective comparisons that yield legitimizing reasons.[46] He then proceeds to claim that "If reason determin'd us, it wou'd proceed upon that principle, *that instances, of which we have had no experience, must resemble those, of which we have had experience, and that the course of nature continues always uniformly the same*" (T 1.3.6.4; SBN 89).

As we have seen, in Rules III and IV Newton formulates the basic idea of his inductive scientific methodology, and the explanation of Rule III includes the guiding principle of the inductive method that nature is always consonant with itself. In my view, the principle in italics in the above sentence from T 1.3.6.4 (SBN 89) is Hume's own version of the Newtonian principle, which licenses the universalization of completely uniform experience into exceptionless laws. As Alexandre Koyré emphasizes, for Newton this methodological principle has a *justificatory* role, since it is precisely on its basis that we are licensed to go beyond the data of the senses and attribute to all bodies whatsoever—observed and unobserved—the qualities we have observed so far: "And it is just because nature is consonant to herself that we can generalize the data of experience and attribute to *all* bodies the properties that experience shows us in those which are within our reach" (267).

Although Hume does not explicitly refer to Newton's Rule III in his epistemological writings, he does refer to it in the second *Enquiry*, in support of his empirical generalization regarding how we are determined to approve of the social virtues. He suggests that because the principle of usefulness or utility has been found to have a great force or energy as the (sole) source of the moral approbation paid to the (more artificial) social virtue of justice, it must have a considerable force or energy in the case of such (more natural) social virtues as humanity, benevolence, and so on:

> The necessity of justice to the support of society is the SOLE foundation of that virtue; and since no moral excellence is more highly esteemed, we may conclude that this circumstance of usefulness has, in general, the strongest energy, and most entire command over our sentiments. It must, therefore, be the source of a considerable part of the merit ascribed to humanity, benevolence, friendship, public spirit, and other social virtues of that stamp. . . . It is entirely agreeable to the rules of philosophy, and even of common reason; where any principle has been found to have a great force and energy in one instance, to ascribe to it a like energy in all similar instances. This indeed is Newton's chief rule of philosophizing. (EPM 3.48; SBN 203–4)

To this last sentence he adds a footnote in which he explains: "Principia, Lib. III."

In order to understand the full import of this example, it is important to see that there are, both in Newton and in Hume, two ways of applying Newton's methodological principle that nature is consonant with itself. In the first place, this principle licenses the inductive inferences from particular constant conjunctions of the same type to unobserved cases of, or universal generalization over, these same types. The formulation of Newton's Rule III articulates this kind of straightforward induction, and, in the explanation of this Rule, Newton mentions the principle that nature is consonant with itself as guiding such inferences. He illustrates how such a principle guides the inferences from the experience that particular bodies or parts of bodies are extended to the generalization that all bodies are extended, from the experience that particular bodies are impenetrable to the generalization that all are impenetrable, and the same inductive procedure is followed to conclude that all bodies are movable and endowed with the power of inertia.

However, in his most important application of Rule III, Newton shows that induction and its justificatory principle of the uniformity of nature have an even more far-reaching application. At a second stage, a higher level of generalization can proceed by the same methodological rule: different generalizations obtained by induction and the principle of the uniformity of nature in different realms can now be unified with one another under an even more comprehensive generalization. Precisely because of the uniformity of nature, we can now obtain a higher order generalization of lower level generalizations. Thus, in the explanation of Rule III, Newton illustrates this second type of application of induction and the principle of the uniformity of nature with his own inference to the law of universal gravitation. The law of gravitation holds in the realm of objects close to the earth; it holds in the different realm of the relation between the planets and the sun; it again holds in the different realm of the interaction between the moon and the sea, and so on. The law of universal gravitation is generalized to all bodies whatsoever starting from these more restricted lower level generalizations.

In this way, the principle of gravity, which initially has explanatory power in one realm (bodies close to the earth, for example) is shown also to have explanatory power in another realm (the motions of the planets, for example). Inductive generalization and the assumption of the uniformity of nature unify all these lower level generalizations under a higher level generalization. Similarly, in Hume, the principle of public interest and utility is inductively shown to have "sole" explanatory power concerning the (more artificial) social virtue of justice. Then, in a second stage, public interest and utility can be further generalized so as to explain a "considerable part" of the (more natural) social virtues of humanity, benevolence, and so on. The result is a higher level generalization that unifies all of the virtues under a single law of public interest and utility. This unification can be achieved precisely because of a second level assumption that human nature is uniform. Hume thus takes Newton's Rule III as a model for his own inductive investigation of human nature, and he thereby models the moral sciences on the Newtonian method in the natural sciences.

This general point is further substantiated by Hume's own "rules by which to judge of causes and effects" presented in *Treatise* 1.3.15 (SBN 173–6). The first three rules comprise the definition of cause in terms of constant conjunction (uniform experience). Rule four states that we can turn into a rule an operation that we naturally follow, namely, that when we have (inductively) discovered causes and effects on the basis of uniform experience, we usually extend our observation to every phenomenon of the same kind. The fifth rule also depends, as the previous ones, on the assumption that we establish causes and effects on the basis of uniform experience: when several different objects produce the same effect it must be by the same (more properly, by a resembling) quality present in all of the causes. And the sixth rule in turn depends on the fifth: the difference in the effects of two resembling causes must proceed from the particular qualities on which they differ: "For as like causes always produce like effects, when in any instance we find our expectation to be disappointed, we must conclude that this irregularity proceeds from some difference in the causes" (T 1.3.15.8; SBN 174). Rule six thereby registers *irregularities*, but prescribes what reasoning might lead us to refine them in the direction of perfect uniformity. It is precisely by assuming the uniformity of nature—that like causes produce like effects—that we can then undertake this process of refinement.

In rule seven, however, the crucial Newtonian background stands out even more clearly. At issue are compound causes of "compounded" effects:

> When any object encreases or diminishes with the encrease or diminution of its cause, 'tis to be regarded as a compounded effect, deriv'd from the

> union of the several different effects, which arise from several different parts of the cause. The absence or presence of one part of the cause is here suppos'd to be always attended with the absence or presence of a proportionable part of the effect. This constant conjunction sufficiently proves, that the one part is the cause of the other. (T 1.3.15.9; SBN 174)

Hume then proceeds to illustrate this rule with a (cautionary) example from the moral sciences: "A certain degree of heat gives pleasure; if you diminish that heat, the pleasure diminishes; but it does not follow, that if you augment it beyond a certain degree, the pleasure will likewise augment; for we find that it degenerates into pain" (ibid.).

Hume illustrates exactly what he has in mind in his earlier discussion of "the probability of causes":

> We may establish it as a certain maxim, that in all moral as well as natural phaenomena, wherever any cause consists of a number of parts, and the effect encreases or diminishes, according to the variation of that number, the effect, properly speaking, is a compounded one, and arises from the union of the several effects, that proceed from each part of the cause. Thus because the gravity of a body encreases or diminishes by the encrease or diminution of its parts, we conclude that each part contains this quality and contributes to the gravity of the whole. The absence or presence of a part of the cause is attended with that of a proportionable part of the effect. This connexion or constant conjunction sufficiently proves the one part to be the cause of the other. (T 1.3.12.16; SBN 136)

He here has in mind the conclusion—central to the law of universal gravitation—that each part of a gravitating body (like the earth) also gravitates (so that the gravity of the whole is the sum of the gravities of the individual parts), and he proceeds to apply this Newtonian model, once again, to an example from the moral sciences: "As the belief, which we have of any event, encreases or diminishes according to the number of chances and past experiments, 'tis to be consider'd as a compounded effect, of which each part arises from a proportionable number of chances and experiments" (ibid.).

Newton establishes the property of gravity in question in Propositions 6 and 7 of Book III of the *Principia*, which crucially depend on Rule III.[47] We first show, by experiment, that all bodies falling toward the earth are attracted by gravity in proportion to their quantity of matter. We then observe, by the equality of action and reaction, that all these bodies must attract the earth as well, and we conclude, by Rule III, that the latter attraction (for which we do not yet have experiments) must also take place in proportion to the earth's quantity of matter. Therefore, the earth's gravity arises from, and is compounded out of, the individual gravitational attractions of its parts. Cotes's summary in his Preface to the second edition explains this point:

> The attractive forces of bodies, at equal distances, are as the quantities of matter in these bodies. For, since bodies gravitate toward the earth, and the earth in turn gravitates toward each body, with equal moments, the weight of the earth toward each body, or the force by which the body attracts the earth, will be equal to the weight of the body toward the earth. But, as mentioned above, this weight is as the quantity of matter in the body, and so the force by which each body attracts the earth, or the absolute force of the body, will be as its quantity of matter.
>
> Therefore the attractive force of entire bodies arises and is compounded from the attractive force of the parts, since (as has been shown), when the amount of matter is increased or diminished, its force is proportionally increased or diminished. Therefore the action of the earth must result from the combined actions of its parts; hence all terrestrial bodies must attract one another by absolute forces that are proportional to the attracting matter. (*Principia*, 387)

It therefore appears overwhelmingly likely that Hume not only has Newton's argument for universal gravitation clearly in mind in the *Treatise*, but he also takes Newton's Rule III as the fundamental guide for his own inductive investigations of the moral sciences there—just as he does so later in the second *Enquiry*.[48]

Yet Hume's own positive notion of causation modelled on Newton's inductive method is not limited to the justificatory role of the principle of the uniformity of nature in inductive inference. That we must not assume anything before (or beyond) experience, that the premises of our causal inductive inferences consist of uniform experience, and the universalizing character of the laws resulting from such inferences to the unobserved are also essential ingredients of Newton's inductive method. As I have shown, Locke did not anticipate the import of Newton's Rules III and IV, and he certainly did not envision replacing the ideal of demonstrative knowledge of nature by the Newtonian inductive method. In Locke there is no serious consideration of the merits or limits of a principle of induction to ground genuinely universal laws—a principle which legitimizes the formulation of universal exceptionless causal laws concerning all corporeal substances, or even all corporeal substances of a particular kind, beyond the narrow scope of our experiments. What might be taken to be inductive generalizations in the formulation of nominal essences of substances need not correspond with the ultimate metaphysical explanation of causal relations involving these substances, which lies at the level of their hidden microstructure.

According to Hume, as we have seen, the mechanical philosophy's a priori model of the causal relation in terms of the intrinsic necessary structure of substances is not a correct but unattainable ideal model; rather, it provides a completely misguided model of the causal relation. This ideal is entirely misplaced when applied to matters of fact, not because there is an unknowable inner microstructure of necessary connections that explains the regularities we observe, but rather because the very idea of necessary connection as an intrinsic quasi-geometrical containment is itself completely incorrect. As Hume's characterization of causation (as a philosophical relation) at *Treatise* 1.1.4–5 revealingly puts it, causation does not concern relations that we can ascertain by merely inspecting the intrinsic features of presentations before the mind. Instead, causation concerns *extrinsic* relations among separate, distinct presentations before the mind (most notably, the relation of constant conjunction), so that there can be no relation of containment between the two distinct events we call cause and effect.[49]

However, from his radical skeptical standpoint, at the last stage of his skeptical argument concerning causation, necessity and induction (in both the *Treatise* and the first *Enquiry*), Hume argues against the possibility of grounding his own positive notion of causation in terms of constant conjunction and inductive inference. He focuses on the very principle of the uniformity of nature presupposed by such inferences and argues, in particular, that there is neither an a priori nor an inductive justification of the general principle guiding Newton's inductive method. Therefore, from Hume's radical skeptical standpoint, the Newtonian inductive leap from what we have hitherto observed to an exceptionless generalization including the unobserved is also ultimately ungrounded. This inquiry into the justification of the guiding methodological principle of Newtonian induction shows, in my view, that, at T 1.3.6 and EHU 4.2, Hume targets what he himself takes to be the best possible form of causal inference. Nevertheless, the confident use of this method within the natural standpoint of science and common life is not affected by his own unsustainable radical skeptical argument. That his skepticism about the best possible inductive method is directed at his own Newtonian model of scientific inference sharply brings out the mutual autonomy of Hume's two standpoints.[50]

There is, therefore, a fundamental asymmetry between Hume's skepticism concerning the a priori model of causal explanation of the mechanical philosophy and his skepticism concerning Newton's (and his own) inductive method. Within the naturalistic standpoint of science and common life, Hume emphatically endorses the inductive method but not the a priori model of causal explanation. Inductive inference, for Hume, even before it is refined into the ideal Newtonian inductive method by a reflection compatible with common life and science, follows natural principles of association of the mind and relies only on experience. But the a priori reasoning of the mechanical philosophers, involving the postulation of a hidden configuration of primary qualities and powers demonstratively necessitating its effects, does not follow such natural operations. This asymmetry also reveals itself in the character of Hume's positive notion of necessity, within the standpoint of common life and science. He explains (but does not ultimately justify) such a positive notion of necessity as a projection from our inductive inferences,[51] whereas the necessity of hidden powers postulated by the mechanical philosophy has no analogue, for Hume, in any natural operations of the mind. This inherited notion of necessity is simply rejected once and for all—from *both* standpoints.

By contrast, the lack of a conception of causation as intimately connected with the inductive method prevents Locke from having Hume's positive notion of necessity. Locke's notion, as we have seen, is the mechanical philosopher's conception of a quasi-geometrical containment of effects in the microstructure of substances associated with the ideal of demonstrative knowledge of nature. From a Humean inductive perspective, within the natural standpoint, the notion of necessity associated with the laws of nature does not mean that we postulate hidden ontological structures which, it turns out, we cannot know. Rather, our natural belief in necessity is entirely dependent on inductive inferences themselves. The best of these inductive inferences, based on completely uniform experience, give rise to our belief in causal laws of nature, and laws so obtained are taken to be firmly established by our inductive method (there is an inductive "proof" for them), to be exceptionless, and to be in opposition to the miraculous. To believe that nature obeys these inductively established exceptionless causal laws is to believe that there is necessity in nature.[52]

Humean necessity is therefore merely a necessity projected onto nature from our uniform experience and the inductive inferences that such experience compels. Hume does not make a prior metaphysical assumption to the effect that there are necessary laws in nature waiting, so to speak, to be discovered, and there is no commitment on his part to the *reality* of laws independently of our inductive formulation and inductive confirmation of them. We must assume simply the *possibility* of inductively formulating laws on the basis of uniform experience and the principle of the uniformity of nature. As we saw above, in the discussion of his own "rules by which to judge of causes and effects," Hume suggests that we must strive to (although we might not always succeed in) attaining a *complete* inductive proof of universal exceptionless laws (following Newton's Rule III). This means that we must always search for uniform experiences supporting laws of nature, which we can *provisionally* take to be necessary but nonetheless revisable (according to Newton's Rule IV).

The discussion of miracles in section 10 of the first *Enquiry* further reveals these crucial methodological differences with Locke, especially concerning the notion of probability. Hume begins the discussion of miracles by pointing out that, although experience must be our only guide in reasoning concerning matters of fact, experience offers us different degrees of assurance. Only "infallible experience" provides the highest certainty and constitutes a "proof": "In such conclusions as are founded on an infallible experience, [the wise man] expects the event with the last degree of assurance, and regards his past experience as a full *proof* of the future existence of that event" (EHU 10.4; SBN 110). In this context, in which Hume is arguing from the point of view of natural science and common sense, full or entire "proof" is not understood as demonstrative a priori proof, but rather as the Newtonian inductive proof on which the laws of nature are grounded. In particular, Hume claims that laws of nature have been established on the basis of a "firm and unalterable experience."[53] In science and common life we can assume, using here the Newtonian standards, that well-established laws of nature have been "proved," thus we can expect with complete confidence the occurrence of future events predicted by such laws.

In the same introductory remarks, Hume draws a contrast between the "proofs" of natural laws afforded by uniform collective experience and the merely "probable" evidence provided by a collective experience that has not been *completely* uniform (I call the latter "mere probability"). When there have been both positive and contrary observations, we have merely probable evidence. In these cases:

> [A wise man] proceeds with more caution: He weighs the opposite experiments: He considers which side is supported by the greater number of experiments: to that side he inclines, with doubt and hesitation; and when at last he fixes his judgement, the evidence exceeds not what we properly call *probability*. All probability then supposes an opposition of experiments and observations, where the one side is found to overbalance the other, and to produce a degree of evidence, proportioned to the superiority. (EHU 10.4; SBN 111)[54]

These reflections concerning mere probabilities are squarely in the tradition of the "experimental philosophy" of Bacon, Boyle, and Locke.[55] However, as we shall see, Hume *subordinates* these mere probabilities to the desideratum of achieving (Newtonian) inductive "proofs" and thereby completely transforms the Baconian, Boylean, and Lockean notion of (mere) probability.

What Hume here calls "probability" is a species of the wider notion of probability prominent in *Treatise*, 1.3, sections 1–2, and section 6, and first *Enquiry*, section 4. In those earlier sections, "probable" characterizes *all* claims about "matters of fact and existence," *including* the laws of nature, which are firmly established by perfectly uniform experience and inductive proof. In those earlier sections, in my view, Hume takes these laws as the best or ideal representatives of matters of fact (probable) claims. Indeed, in the skeptical argument regarding induction, his radical skepticism concerns precisely our knowledge of the laws of nature, which are here (in the section on miracles) regarded as "established" by a "firm and unalterable experience"—that is, by complete inductive proofs.

In the section on miracles, especially part 2, it becomes clear that even the most reliable individual human testimony is always merely probable evidence (in the weaker sense)—we can always find both positive and contrary evidence in the process of evaluating witnesses. Thus, individual testimony can be always reasonably challenged in the context of science and common sense (just as witnesses can be challenged in the context of legal procedures in courts of common law), whereas it is almost always unreasonable to challenge firmly established laws of nature such as Newton's law of gravitation or the law that all people must sooner or later die. In order to resolve challenges to testimony, expertise and careful reflection on the evidence is required in weighing favorable and unfavorable cases. Nevertheless, no matter how wisely and carefully the experts may reflect on testimonial evidence that does not amount to completely uniform collective experience, the firmly established laws of nature—established by collective and uniform experience—*always* enjoy a superior warrant over individual or local testimony. Testimonial evidence must be compatible with the well-established laws of nature, and its credibility is thus completely subordinated to such laws.

The superiority of warrant accorded here to the inductively well-established laws of nature, regarded (at least provisionally) as universal and exceptionless, is a central difference between Hume's and Locke's understanding of the methodological principles of the "experimental philosophy" they both endorse. Hume's methodological principle famously expressed as "a wise man proportions his belief to the evidence"—concerning cases where there is both positive and negative evidence, that is, mere probability—can also be found in Locke. For example, at *Essay* IV, XV, 5, Locke writes: "Probability wanting that intuitive Evidence, which infallibly determines the Understanding, and produces certain Knowledge, *the Mind if it will proceed rationally, ought to examine all the grounds of Probability*, and see how they make more or less, *for or against* any probable Proposition, before it assents to or dissents from it, and upon a due ballancing the whole, reject, or receive it, with a more or less firm assent, proportionably to the preponderancy of the greater grounds of Probability on one side or the other." However, as we have seen, Locke's background assumption is the distinction between "Knowledge" (or "Science") and what I here call "mere probability" (for Locke: "Opinion," "Faith" or "Judgment"). There are for Locke only these two categories of cognition, and there is no special place, in particular, for what Hume and Newton call (complete) inductive "proofs." Thus, Locke defines "probability" as coinciding with mere probability:

> As Demonstration is the shewing the Agreement, or Disagreement of two *Ideas*, by the intervention of one or more Proofs, which have a constant,

> immutable, and visible connexion one with another: so *Probability* is nothing but the appearance of such an Agreement, or Disagreement, by the intervention of Proofs, whose connexion is not constant and immutable, or at least is not perceived to be so, but is, or appears for the most part to be so, and is enough to induce the Mind to *judge* to be true, or false, rather than the contrary. (Essay IV, XV, 1)

Locke also discusses different degrees of grounds of assent to probable propositions. In particular, some among those he calls (at *Essay* IV, XVI, 5–6) propositions about "particular Existence" or "*particular matter of fact*" are capable of very extensive human testimony, and thus enjoy the highest degree of probability. Our belief concerning these propositions rises to the level of "assurance" (in contrast to lesser degrees of assent such as mere "confidence"). Locke's description of this highest degree of probability might be taken to suggest that, after all, he does have the Newtonian and Humean notion of inductive proof, based on constant and completely uniform experience:

> The first therefore, and *highest degree of Probability*, is, when the general consent of all Men, in all Ages, as far as it can be known, concurs with a Man's constant and never-failing Experience in like cases, to confirm the Truth of any particular matter of fact attested by fair Witnesses: such are all the stated Constitutions and Properties of Bodies, and the regular proceedings of Causes and Effects in the ordinary course of Nature. This we call an Argument from the nature of Things themselves. For what our own and other Men's constant Observation has found always to be after the same manner, that we with reason conclude to be the Effects of steady and regular Causes, though they come not within the reach of our Knowledge. Thus, That Fire warmed a Man, made Lead fluid, and changed the colour or consistency in Wood or Charcoal: that Iron sunk in Water, and swam in Quicksilver: these and the like Propositions about particular facts, being agreeable to our constant Experience, as often as we have to do with these matters . . . we are put past doubt, that a relation affirming any such thing to have been, or any predication that it will happen again in the same manner, is very true. These *Probabilities* rise so near to *Certainty*, that they govern our Thoughts as absolutely, and influence all our Actions as fully, as the most evident demonstration: and in what concerns us, we make little or no difference between them and certain Knowledge: our Belief thus grounded, rises to *Assurance*. (*Essay* IV, XVI, 6)

Locke here comes very close to formulating the Newtonian and Humean conception of complete inductive proof. Nonetheless, there are still several crucial differences. First, Locke does not conceive the propositions with the highest degree of probability as universal and exceptionless *laws of nature*. Locke's examples are all about particular kinds of substances or particular events (another example Locke gives in the same section is the proposition, reported by all Englishmen who have had an occasion to mention it, that it froze in England during the previous winter). Second, Locke does not claim that when we inductively establish such propositions we have thereby established (necessary) causal connections. Finally, and most importantly, Locke does not view his highest degree of "assurance" as any kind of replacement for the demonstrative ideal of knowledge of nature: he does not see (in accordance with Newton's Rule III) that the demonstrative ideal may *conflict* with the inductive method, nor (in accordance with Rule IV) that we should therefore *substitute* the latter in place of the former. As we have seen, Locke is precluded from taking these further steps precisely because of his hypothesis that the metaphysical causal grounding of the regularities we observe—associated with nominal essences—resides in the real essential constitution of bodies but is forever hidden from us.[56]

Moreover, in Locke's examples of different degrees of assent to propositions with different degrees of probability, the different degrees in question are crucially tied to the testimony of witnesses. On this topic, Locke should be read as agreeing with Boyle that the evaluation of human testimony provides a model for the study of nature. The difference between reliable and unreliable evidence is determined by the difference in witnesses' number, integrity, skill, and so on, and the consideration of contrary testimony (*Essay* IV, XVI, 4). The competition is thus, as in courts of common law, among a variety of individual witnesses. Boyle explicitly draws analogies between the evaluation of the probabilities of the testimony of witnesses in courts of law and the evaluation of the probabilities of conclusions drawn from experiments in the study of nature.[57] And, for both Locke and Boyle, the probabilities of conclusions drawn from experiments and the observation of nature at most afford us—just as in human testimony and natural history more generally—something approaching knowledge of particular provinces of the vast incomprehensible universe, not scientific knowledge of truly universal laws of nature.

Hume agrees with Locke on the importance of testimony. However, Locke, unlike Hume, suggests that our assent to "well-attested" miracles has a high degree of probability.[58] Again unlike Hume, Locke never appeals to well-established universal laws of nature to nullify the probability of post-Scriptural reports of miracles. Truly universal laws of nature, for Locke, are in competition neither with well-attested nor with non-well-attested miracles, because, as we have seen, we can, in reality, establish no such laws: we can only make generalizations, concerning the nominal essences of particular kinds of substances, which amount merely to judgment or opinion.

For Locke, observation and experience is a guide, but only in the sense in which it is understood in the "experimental philosophy" of Bacon and Boyle: what is always at issue is the weighing of favorable and unfavorable cases. Hume agrees that observation and experience can be a guide in this Baconian, Boylean and Lockean sense and that such a guide affords us mere probability. Yet, in the same texts where he goes along with the tradition of Bacon, Boyle and Locke in assessing the different degrees of merit of testimonies, Hume argues that experience can also be a guide in a different and much stronger sense: experience can give us the superior assurance of "full proofs" such as the inductive derivation of truly universal and necessary laws of nature by Newton. Hume's overriding and unequivocal adherence to this Newtonian inductive methodology therefore represents a crucial point of departure from Locke.

Hume's discussion of the eight "rules by which to judge of causes and effects" in the *Treatise* substantiates my claim that his desideratum is to subordinate the Baconian, Boylean, and Lockean conception of "experimental philosophy" to the Newtonian inductive method by seeking to turn mere probabilities into complete inductive proofs. As we have seen, rule six, in particular, registers the lack of complete uniformity, but prescribes what reasoning might lead us to refine our partial regularities in the direction of perfect uniformity. The guiding idea, I believe, is that when experience is not completely uniform (when we encounter contrary experiences to the supposition of a causal relation), we should assume that there are other causes at work which we have not yet discovered. Hume's desideratum, in such a case, is then always to seek the complete causes of the phenomenon so as to come closer and closer to perfect uniformly. In other words, we should always strive to turn mere probabilities into conclusions of inductive proofs based on uniform experience (even if we cannot always succeed).

In this spirit, Hume ends the section on the eight rules by declaring:

> All the rules of this nature [rules to direct our judgment in philosophy] are very easy in their invention, but extremely difficult in their application; and even experimental philosophy, which seems the most natural and simple of any, requires the utmost stretch of human judgment. There is no phenomenon in nature, but what is compounded and modify'd by so many different circumstances, that in order to arrive at the decisive point, we must carefully separate whatever is superfluous, and enquire by new experiments, if every particular circumstance of the first experiment was essential to it. These experiments are liable to a discussion of the same kind, so that the utmost constancy is requir'd to make us persevere in our enquiry, and the utmost sagacity to choose the right way among so many that present themselves. (T 1.3.15.11; SBN 175)

In sum, Hume's notion of "proof" as a species of probability represents the culmination of his methodological differences with Locke. Such a proof is an induction based on completely uniform experience that grounds the postulation of exceptionless (albeit revisable) laws of nature. Proofs about matters of fact in this Humean sense—that is, our best inductive methods, such as Newton's—do not correspond to either of the categories envisioned by Locke. The proof of laws of nature is neither an a priori demonstrative proof nor a mere probability that consists in weighing favorable and unfavorable evidence. Thus, Hume writes:

> Those philosophers, who have divided human reason into *knowledge and probability*, and have defin'd the first to be *that evidence, which arises from the comparison of ideas*, are oblig'd to comprehend all our arguments from causes or effects under the general term of probability. But tho' every one be free to use his terms in what sense he pleases; and accordingly in the precedent part of this discourse, I have follow'd this method of expression; 'tis however certain, that in common discourse we readily affirm, that many arguments from causation exceed probability, and may be receiv'd as a superior kind of evidence. One wou'd appear ridiculous, who wou'd say, that 'tis only probable the sun will rise to-morrow, or that all men must dye; tho' 'tis plain we have no further assurance of these facts, than what experience affords us. (T 1.3.11.2; SBN 124)

Precisely because he rejects the ideal of demonstrative knowledge of nature embraced by the mechanical philosophy, there is no room in Hume for Locke's category of "Knowledge" or "Science" in our understanding of nature. At the same time, however, since Hume, unlike Locke, takes Newtonian inductive proof as his ideal of scientific knowledge, our understanding of nature contains more than Locke's category of probable "Opinion." For Locke, the propositions with the highest degree of probability concern observable qualities of particular existences that are capable of human testimony, and, as I have emphasized, Locke nowhere envisions that a purely inductive ideal of knowledge of nature could replace the demonstrative ideal. For Hume, on the contrary, experience is a strong guide in our understanding of nature precisely because we do have, in some cases, completely uniform experience that affords inductive proof of exceptionless universal laws. If none of our experience were completely uniform, we could hope for very little in our attempts to understand nature. Moreover, although large portions of our experience are not (yet) so uniform, we must still endeavor to find the required uniformities by further inductive inquiry, in order to turn mere probabilities, as far as possible, into inductive proofs.

NOTES

This paper is developed and expanded from earlier versions presented at a number of venues over the past several years. I presented its first version at a symposium on Hume's remark: "A wise man, therefore, proportions his belief to the evidence" at the Twenty-eighth Annual Hume Society Conference, Victoria, Canada, 2001. I subsequently developed the parallel with Newton and the contrast with Locke in versions presented at the California Institute of Technology, April 2003; the Central Division Meetings of the American Philosophical Association, April 2004; the Thirty-first Annual Hume Society Conference, Tokyo, Japan, August 2004; and the Department of History and Philosophy of Science at Indiana University, October 2005. I am indebted to the audiences at all of these venues for helpful comments and discussion. I am also indebted to anonymous referees for *Hume Studies*, and especially to the editors Peter Millican and Peter Loptson, for a very helpful set of comments on an earlier draft. Finally, I am particularly indebted to discussions with Michael Friedman, especially concerning technical aspects of Newton's natural philosophy, and I am also indebted to Edwin McCann for very helpful discussions concerning Locke.

1 David Hume, *The History of England*, "Based on the Edition of 1778, with the Author's Last Corrections and Improvements," 6 vols. (Liberty Classics, 1983), 6: 542.

2 Mordechai Feingold, "Partnership in Glory: Newton and Locke Through the Enlightenment and Beyond," in *Newton's Scientific and Philosophical Legacy*, ed. P. B. Scheurer and G. Debrock (Dordrecht: Kluwer, 1988), 291–308. This article masterfully weaves together the circumstances surrounding the association of the two thinkers in both the expert and popular minds of the period.

3 G. A. J. Rogers, "Locke's *Essay* and Newton's *Principia*," *Journal of the History of Ideas* 39.2 (1978): 217–32, 229. (I thank Mary Domsky for bringing to my attention this particular passage as pointedly summarizing Rogers's overall view of a close kinship between Locke and Newton.) In this and other articles, Rogers argues extensively for a close connection between Locke's and Newton's scientific methodology and, in general, for what he takes to be the important influence of Locke on Newton. Other articles where G. A. J. Rogers develops the same view are, for example, "The Empiricism of Locke and Newton," in *Royal Institute of Philosophy Lectures*, vol. 12 (1977–1978): *Philosophers of the Enlightenment*, ed. S. C. Brown (Sussex and New Jersey: The Harvester Press and Humanities Press Inc., 1979), 1–30; and "The System of Locke and Newton," in *Contemporary Newtonian Research*, ed. Z. Bechler (D. Reidel Publishing Company, 1982), 215–38. In a similar vein, John Yolton, in a more cautious tone, writes, for example in "The Science of Nature," in *John Locke: Problems and Perspectives*, ed. J. Yolton (Cambridge: Cambridge University Press, 1969), 193: "In his admiration for Boyle, Newton, and Sydenham, Locke was praising these men for this method of carefully observing and recording the observed coexistence of qualities. In his own scientific interests Locke practiced this method also. Theory and hypothesis must find their place in the context of experience and history. The scientists of the day had been making new discoveries and advances by using the method praised by Locke."

4 All citations from *A Treatise of Human Nature* (abbreviated as "*Treatise*" or "T") are from the David Fate Norton and Mary J. Norton edition (New York: Oxford University

Press, 2000), and thus include the Book, part, section, and paragraph numbers. I also add the corresponding page number in the L. A. Selby-Bigge second edition, with text revised and notes by P. H. Nidditch (Oxford: Oxford University Press, 1978), abbreviated as "SBN" All citations of *An Enquiry concerning Human Understanding* (abbreviated as "first *Enquiry*" or "EHU") are from the Tom L. Beauchamp edition (New York: Oxford University Press, 1999), which includes section and paragraph numbers. All citations of *An Enquiry concerning the Principles of Morals* (abbreviated as "second *Enquiry*" or "EPM") are from the Tom L. Beauchamp edition (New York: Oxford University Press, 1998), which includes sections and paragraph numbers. For each of the *Enquiries*, I also add a reference to the page numbers in *Enquiries concerning Human Understanding and concerning the Principles of Morals*, L. A. Selby-Bigge, third edition, with text revised and notes by P. H. Nidditch (New York: Oxford University Press, 1975), abbreviated as "SBN."

5 At EHU 1.14–5 (SBN 14), Hume expresses the hope that his own science of human nature might meet with the same success as Newton's determination of the laws and forces that govern the motions of the planets. Here Newton is not mentioned explicitly by name, but it is obvious that Hume refers to Newton when he writes about "the philosopher" who established the laws and forces of planetary motions: "Astronomers had long contented themselves with proving from the phaenomena, the true motions, order, and magnitude of the heavenly bodies: Till a philosopher, at last arose, who seems, from the happiest reasoning, to have also determined the laws and forces, by which the revolutions of the planets are governed and directed." In the Introduction to the *Treatise*, Hume expresses the same aspiration of modeling his own science of human nature on Newton's method. This is evident in Hume's desideratum, explicitly stated at T Intro.8 (SBN xvii), of avoiding conjectures and hypothesis in explaining the most general and certain principles derived from experience. In the present paper I shall dwell on this desideratum, which I take to be central to Newton's and Hume's rejection of the methodological scientific ideal of the mechanical philosophy.

6 All citations from John Locke, *An Essay concerning Human Understanding* (abbreviated as "*Essay*") are from the Peter H. Nidditch edition (Oxford: Oxford University Press, Clarendon Edition, 1975), and include the Roman numeral numbers of the book and chapter, followed by the Arabic number of the section.

7 In particular, as I argue in my book manuscript, *Ideas, Evidence, and Method: Hume's Skepticism and Naturalism concerning Knowledge and Causation*, Hume adopts and radicalizes the Lockean perceptual and imagist model of apprehension of items before the mind, conceived as the standard of ultimate evidence.

8 Neither Hume nor Locke has the resources in their empiricist conception of mathematics and the relationship of mathematics to physics to incorporate the constitutive role of mathematics in Newton's physics. By contrast, precisely this constitutive role is emphasized in Kant's reading of Newton: see, for example, Michael Friedman, *Kant and the Exact Sciences* (Cambridge, Mass: Harvard University Press, 1992). I. Bernard Cohen, *The Newtonian Revolution* (Cambridge, UK: Cambridge University Press, 1980) emphasizes the methodological import of Newton's mathematization of nature; and this approach is further developed by George E. Smith, "The methodology of the *Principia*," in *The Cambridge Companion to Newton*, ed. I. Bernard Cohen and George E. Smith (Cambridge, UK: Cambridge University Press, 2002). According to Cohen and Smith, at the heart of Newton's method is a process of mathematical idealization and succes-

sive approximations by revision. There is no doubt that, in his adoption of Newton's inductive method, Hume ignores the role of mathematics and idealizations.

9 All citations from Isaac Newton, *The Principia: Mathematical Principles of Natural Philosophy* (abbreviated as "*Principia*") are from the new translation by I. Bernard Cohen and Anne Whitman, assisted by Julia Budenz, preceded by a guide to Newton's *Principia* by I. Bernard Cohen (Berkeley and Los Angeles: University of California Press, 1999).

10 In this brief presentation of the agreements and disagreements between Newton and the most distinguished rationalist proponents of the mechanical philosophy after Descartes, I follow the extremely lucid presentation of this issue by Howard Stein in "Newtonian Space-Time," *Texas Quarterly* 10.3 (1967): 174–200.

11 In "Newtonian Space-Time," 179, Howard Stein writes: "But since the second stage of [Newton's] argument has concluded that *all* the major bodies [of the solar system] are surrounded by inverse-square acceleration-fields, that is gravitational fields, which affect *all* the bodies about them, it would seem to *follow* that these bodies affect one another; that, for instance, the sun gravitates towards each planet, Jupiter and Saturn towards one another, and so forth. Huygens does not say how he is able to escape this conclusion; but there is really just one way he can, namely by refusing to extend the inverse square law arbitrarily far—i.e., by supposing the validity of that law restricted to some finite region, beyond which the gravitational field decays more rapidly and even goes to zero. There is reason to believe that this was Huygens's conscious supposition, made not just from skepticism of the reach of empirical generalization (for to *doubt the exactness* of such a generalization is very much less than to *believe an equally definite contrary statement*: here, for example, the statement that the acceleration of Saturn towards Jupiter is not what Newton thinks, but zero), but made on the basis of Huygens's own theory of the mechanical cause of gravity, which could hardly be reconciled with Newton's unrestricted linear superposition of gravitational fields. For Newton, on the other hand, it is a fundamental principle of method to press empirical generalizations as far and as exactly as possible, subject to empirical correction; and to do so without regard for theoretical considerations of a speculative kind." At the end of these words, Stein has a footnote referring to Newton's Rule IV, in *Principia*, Book III. I return to Rule IV below.

12 I. Bernard Cohen, in "A Guide to Newton's *Principia*" preceding his new translation of the *Principia*, 200, explains that the terms "intension" and "remission" go back to late-medieval doctrine referring to qualities that "undergo an intension or remission by degrees."

13 Alexandre Koyré, in *Newtonian Studies* (London: Chapman and Hall, 1968), chapter 6, argues that a comparison of the manuscripts showing the changes throughout the three editions of the *Principia* illustrates the polemical character of the Rules directed against the continental rationalists, especially Descartes and Leibniz. Koyré argues, in particular, that Rule IV was added to the third edition precisely because the defenders of the mechanical philosophy still persisted in rejecting universal gravitation after the second edition.

14 Thus, at the end of the exposition of this rule, Newton asks the reader to accept an immense leap: universal gravitation among every piece of matter in the universe. Alexandre Koyré, in *Newtonian Studies*, 268, referring to this last claim, exclaims: "This is an affirmation of an incalculable scope."

15 Letter to Cotes, March 1713, in *Newton. Philosophical Writings*, ed. Andrew Janiak (Cambridge, UK: Cambridge University Press, 2004), 118.

16 Letter to Boyle, February 1678–1679, in *Isaac Newton's Papers & Letters on Natural Philosophy*, ed. I. Bernard Cohen (Cambridge, Mass: Harvard University Press, 1978), 253.

17 Sir Isaac Newton, *Opticks* (New York: Dover Publications, Inc., 1979).

18 Letter to Oldenburg, June 1672, in Cohen, *Isaac Newton's Papers & Letters*, 118.

19 It is important to distinguish Newton's doctrine that light consists of differently refrangible *rays* (of different colors) from his corpuscularian hypothesis that these rays consist of different types of physical *corpuscles*. Newton takes himself to have established the first doctrine by the inductive "proofs" afforded by his famous prism experiments, beginning in the very first "Proposition" in the body of the *Opticks*. By contrast, the conjecture—"Are not the Rays of Light very small Bodies emitted from shining Substances?"—is only proposed much later, in Query 29, as a plausible or hypothetical explanation of these different degrees of refrangibility (among other things). See Howard Stein's discussion of Newton's crucial experiment of the prism in "On Locke, 'the Great Huygenius, and the incomparable Mr. Newton'," in *Philosophical Perspectives on Newtonian Science*, ed. Phillip Bricker and R. I. G. Hughes (Cambridge, Mass: MIT Press, 1990), 26–7, where Stein describes the results of such an experiment as having been "proved with what may be called 'experimental certainty,' and quite independently of any mechanical explanation of the nature of light," and as having been regarded as such by Newton. I return to these issues in relation to Hume in section III of this paper.

20 In the fourth edition (1700) of the *Essay* II, VIII, 11 and 12, Locke makes some limited changes in response to Newton's theory of gravitation. In Locke's reply to Stillingfleet's second letter—"Mr. Locke's Reply to the Right Reverend the Lord Bishop of Worcester's Answer to his Second Letter," in *The Works of John Locke, in Nine Volumes*, 12th edition (1698; repr. London: C. and J. Rivington et al., 1824), 3: 467–8—Locke has announced his intention to change those passages in the *Essay* which assert "that bodies operate by impulse, and nothing else." This is because he has been "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." However, in this letter Locke still claims that he can conceive the operations of bodies one upon another in no other way but by impulse—this conception derives from our idea of body and what we know of matter. Thus, the letter continues: "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 by what we know of matter, but also an unquestionable and every where visible instance, that he has done so." The change affecting *Essay* II, VIII, 11 in the fourth edition commits Locke solely to the view that the only way *we can conceive* bodies to operate is by impulse, and this is how bodies produce ideas in us—Locke now does not make any claim about the operation of bodies *themselves* upon one another. Similarly, the first sentence of *Essay* II, VIII, 12, which in the previous editions read: "If then Bodies cannot operate at a distance" (Nidditch edition, critical apparatus at the bottom of page 136), is simply eliminated. These changes are really very modest; in particular, the new sentences incorporated in *Essay* II, VIII, 11, are still consistent with the belief in the

superior intelligibility of motion by impulse or impact. In addition, there is no reference to Newton's theory of gravitation in the *Essay* in any of its editions. Besides the letter to Stillingfleet, other writings in which Locke makes similar favorable pronouncements concerning Newton's theory of gravitation are *Locke's Conduct of the Understanding*, ed. Thomas Fowler (Oxford: Clarendon Press, 1892) and *Some Thoughts Concerning Education*, ed. John Yolton and Jean Yolton (1693; repr. Oxford: Clarendon Press, 1989).

21 Thus, the famous "hypotheses non fingo" passage from the second edition General Scholium quoted above begins as follows: "Thus far I have explained the phenomena of the heavens and of our sea by the force of gravity, but I have not yet assigned a cause to gravity. Indeed, this force arises from some cause that penetrates as far as the centers of the sun and planets without any diminution of its power to act, and that acts not in proportion to the quantity of the *surfaces* of the particles on which it acts (as mechanical causes are wont to do) but in proportion to the quantity of *solid* matter, and whose action is extended everywhere to immense distances, always decreasing as the squares of these distances" (*Principia*, 943). Moreover, when Newton entertains the possibility of explaining the action of gravity by the pressure exerted by an interplanetary ether in Query 21 of the *Opticks*, this pressure is not due to motion by impact (as in the vortex theories of Descartes, Huygens, and Leibniz) but to short-range repulsive forces acting at very small distances.

22 Locke gives several overlapping lists of primary qualities; perhaps the most complete list appears at *Essay* II, VIII, 9: "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." Locke then often uses "Bulk" to comprise solidity and extension together, whereas "Texture" appears to refer to the way in which the various "insensible Corpuscles," with their individual sizes and figures, are situated with respect to one another (so as, for example, to reflect light of various colors).

23 G. A. J. Rogers, by contrast, consistently takes the primary-secondary quality distinction as a central point of agreement between Newton and Locke. See, for example, Rogers's "The System of Locke and Newton," 225.

24 See note 19 above: again, the observable rays referred to there should be sharply distinguished from the unobservable corpuscles, which according to Newton's conjectural Query 29 hypothetically constitute such rays.

25 Howard Stein, "On Locke, 'the Great Huygenius, and the incomparable Mr. Newton'." More generally, in my discussion of the methodological differences between Newton and Locke, I am very much indebted to this article. However, I especially emphasize the points that illuminate the closely related methodological differences between Locke and Hume.

26 Earlier, at *Essay* II, XXIII, 23–7, Locke has also pointed out another ground of our ignorance of bodies: our lack of understanding of their cohesion, that is, "how the solid parts of body are united or cohere together to make Extension" (*Essay* II, XXIII, 23).

27 For Locke's conventionalism about nominal essences of different kinds of substances, thus about natural kinds, see *Essay* III, VI.

28 The certain knowledge that for Locke we can in fact attain includes (necessary) intuitive knowledge, (necessary) demonstrative reasoning (as in Descartes, mathematics,

not logic, is the paradigm of both intuitive and demonstrative knowledge), knowledge of the existence of God, and sensitive knowledge of the real existence of things without the mind. However, it does not include the specific nature of existing physical things. See, for example, *Essay* Book IV, chapters II–IV, VI, and IX–XI.

29 Edwin McCann—for example, in "Lockean Mechanism," in *Philosophy, its History and Historiography*, ed. A. J. Holland (Dordrecht: Kluver, 1983)—has argued against the interpretation I follow in this paper, according to which Locke adopts a geometrical, deductive model of the powers and operations of bodies. On McCann's view, when Locke affirms, for example in passages such as *Essay* IV, III, 28, that the "mechanical affection" (primary qualities) of bodies have "no affinity at all" with the sensations of secondary qualities produced by them in our minds, and thus "we can have no distinct knowledge of such Operations beyond our Experience; and can reason no otherwise about them, than as effects produced by the appointment of an infinitely Wise Agent, which perfectly surpass our Comprehensions," he means that there are contingent, divinely established laws of nature, which do not follow with necessity from the mechanical nature of bodies. On this view, Locke is not a pure mechanist: the connection of observable qualities and powers with the microstructure or real essence of bodies is not strictly a priori, but contingently established by the arbitrary power of God. In order to have Knowledge of bodies, in addition to knowing their real essence (which we do not know), we need to know the contingent general connections ordained by God, which can only be cognized experimentally. Michael Ayers, in *Locke: Epistemology and Ontology*, 2 vols. (London and New York: Routledge, 1991), 2: chap. 12, argues against McCann's interpretation (and other more limited voluntarist interpretations, such as Leibniz's and Margaret Wilson's). In this controversy I side with Michael Ayers: not only do I take Locke to endorse the demonstrative ideal of the knowledge of nature, but I also agree with Ayers that Locke's pronouncements about unknown conjunctions possibly established by God are skeptical *epistemological* claims of possibility, not *ontological* claims regarding the contingent character of the laws of nature.

30 In a similar passage at *Essay* IV, III, 25, which I partially quoted before, Locke affirms again the impossibility of deriving truly universalizing conclusions from observations, and suggests that knowledge of universal laws (if *per impossibile* we could have it) would be demonstrative knowledge as in geometry: "If a great, nay far the greatest part of the several ranks of *Bodies* in the Universe, scape our notice by their remoteness, there are others that are no less concealed from us by their *Minuteness*. These insensible Corpuscles, being the active parts of Matter, and the great Instruments of Nature, on which depend not only all their secondary Qualities, but also most of their natural Operations, our want of precise distinct *Ideas* of their primary Qualities, keeps us in an uncurable Ignorance of what we desire to know about them. I doubt not but if we could discover the Figure, Size, Texture, and Motion of the minute Constituent parts of any two Bodies, we should know without Trial several of their Operations one upon another, as we do now the Properties of a Square, or a Triangle. . . . But whilst we are destitute of Senses acute enough, to discover the minute Particles of Bodies, and to give us *Ideas* of their mechanical Affections, we must be content to be ignorant of their properties and ways of Operation; nor can we be assured about them any further than some few Tryals we make, are able to reach. But whether they will succeed again another time, we cannot be certain. This hinders our certain Knowledge of universal

Truths concerning natural Bodies; and our Reason carries us herein very little beyond particular matter of Fact."

31 Here I follow the translations of René Descartes's texts in *The Philosophical Writings of Descartes*, ed. John Cottingham, Robert Stoothoff, and Dugald Murdoch, 2 vols. (Cambridge: Cambridge University Press, 1985).

32 See, for example, *Principles of Philosophy*, Part Two, article 64; Descartes's letter to Clerselier, as an appendix to the Replies to Gassendi's Fifth Set of Objections, and so on.

33 See, for example, *Principles of Philosophy*, Part Four, article 187.

34 Hume adds constant conjunction at T 1.3.6 and EHU 4, part 2, after he has argued in both works against singular causation.

35 See also T 1.3.6.1 (SBN 86–7), which I quote in the main text below; EHU 4.6 (SBN 27); and so on.

36 At EHU 12.15 (SBN 154), Hume writes: "It is universally allowed by modern enquirers, that all the sensible qualities of objects, such as hard, soft, hot, cold, white, black, etc. are merely secondary, and exist not in the objects themselves, but are perceptions of the mind, without any external archetype or model, which they represent. If this be allowed, with regard to secondary qualities, it must also follow, with regard to the supposed primary qualities of extension and solidity, nor can the latter be any more entitled to that denomination than the former. The idea of extension is entirely acquired from the senses of sight and feeling; and if all the qualities, perceived by the senses, be in the mind, not in the object, the same conclusion must reach the idea of extension, which is wholly dependent on the sensible ideas or the ideas of secondary qualities." Note that solidity is a primary quality for Locke, but not for Descartes, thus here Hume seems to have in mind Locke's version of the mechanical philosophy (together with that of other empiricists, like Boyle).

37 Thus, the footnote suggests that in Hume's reading of Locke this is one of the ways in which Locke accounts for the origin of the idea of power. However, as Edwin McCann has called to my attention, in the *Essay*'s chapter on power (Book II, chapter XXI), Locke suggests that our model of the idea of active power involved in causation is the active power of the mind. In transferring the idea of the latter to bodies, the idea of power becomes unclear. In any case, this Lockean account is also rejected by Hume. In the first *Enquiry*, section 7, part 1, Hume rejects the view that we obtain the idea of power or necessary causation from the actions of the mind, and it is likely that here Locke is again one of his targets. Hume argues that we are not conscious of the alleged active power of our minds either from the influence of volition on the body or from the capacity of the mind to manipulate and raise new ideas.

38 At *Essay* IV, VII, 3, Locke writes: "Mr. *Newton*, in his never enough to be admired Book, has demonstrated several Propositions, which are so many new Truths, before unknown to the World, and are farther Advances in Mathematical Knowledge."

39 Hume drops the requirement of contiguity in the first *Enquiry*'s characterization of causation. Moreover, as we have seen, after having introduced spatial contiguity and temporal succession, he writes at T 1.3.2.9 (SBN 76) that these ingredients have been

"discover'd or *supposed*" (my emphasis). This suggests that they are not always observed, and thus that they might be merely hypothetical assumptions. This suggestion should concern only contiguity, however, but not temporal priority. For, at T 1.3.2.7 (SBN 75–6), Hume provides an argument that causes cannot be but temporally prior to effects: "The consequence of this [simultaneous causation] wou'd be no less than the destruction of that succession of causes, which we observe in the world; and indeed, the utter annihilation of time." This follows from his view that our idea of time derives from our observation of change. In Newton, on the other hand, universal gravitation involves simultaneous causation. Nonetheless, this does not align Hume more closely to the mechanical philosophy than to Newton. The condition of temporal succession is not particularly associated with the mechanical philosophy's conception of efficient causation. Descartes, for example, declares (First Set of Replies, paragraph 9): "[T]he natural light does not establish that the concept of an efficient cause requires that it be prior in time to its effect. On the contrary, the concept of a cause is strictly speaking, applicable only for as long as the cause is producing its effect, and so it is not prior to it." (See also the Fourth Set of Replies, paragraphs 62–3.) Indeed, Descartes proposes the theory that "light can extend its rays [in a rectilinear motion] instantaneously from the sun to us" (*Optics*, Discourse One, paragraph 3). For another example of Descartes's endorsement of simultaneous causation—"a power . . . transmitted instantaneously"—which does not involve light, see, for example, *Regulae*, Rule Nine, paragraph 6.

40 David Hume, *An Enquiry concerning Human Understanding*, and *A Letter from a Gentleman to His Friend in Edinburgh*, ed. Eric Steinberg (Indianapolis: Hackett Publishing Company, 1977), 121.

41 David Hume, *Dialogues concerning Natural Religion*, ed. Norman Kemp Smith (Indianapolis: The Liberal Arts Press, Inc., 1947).

42 See notes 19 and 24 above and the corresponding discussion in the main text. In his comments to an earlier version of the present article, delivered at the Central Division Meetings of the American Philosophical Association, Chicago, April 2004, Michael Jacobides suggested that the above-quoted passage from the *Dialogues* might be taken as evidence that Hume endorses Newton's corpuscularian account of light. My reply on that occasion was the same as here: the anatomization of light to which Hume refers is not part of Newton's conjectural corpuscularian account of light. It is crucial to realize, on the one hand, that Newton accepts corpuscularianism only as a hypothesis or conjecture; on the other hand, the results of Newton's crucial experiment of the prism are taken by Newton, and also by Hume, as inductively proved from the phenomena. Nevertheless, I am here indebted to Jacobides for raising this question.

43 David Hume, *The Natural History of Religion*, in David Hume, *Writings on Religion*, ed. Antony Flew (Chicago: Open Court, 1992), 117. I thank James Dye for bringing this passage to my attention in his comments to my presentation of an earlier version of this paper at the Twenty-eighth Annual Hume Society Conference, Victoria, Canada, 2001.

44 John P. Wright, in *The Sceptical Realism of David Hume* (Manchester: Manchester University Press, 1983), 17, writes: "It is important to note that Hume holds that there is something there which is in principle discoverable and which, at the same time, we probably never will be able to discover. What is in question is not the existence of the hidden properties: 'We must certainly allow, that the cohesion of the parts of matter arises from natural and necessary principles, whatever difficulty we may find in

explaining them' (T. 401). What is in question is the exact nature of the ultimate causal principles and our degree of awareness of them." Galen Strawson, in *The Secret Connexion: Causation, Realism, and David Hume* (Oxford: Clarendon Press, 1989), also advances a skeptical realist interpretation of Hume's views on causation and necessity.

45 This transition includes in the *Treatise*, but not in the first *Enquiry*, a step which in a certain sense "reduces" the justification of "the maxim of the philosophers" that every event must have a cause to the justification of the causal inductive inference. I have discussed some aspects of this transition in my "Causation as a Philosophical Relation in Hume," *Philosophy and Phenomenological Research* 64.3 (2002): 499–545.

46 In "Causation as a Philosophical Relation in Hume," I discuss Hume's distinction between two kinds of philosophical relations at *Treatise* 1.3.1–2 (SBN 69–78)—those established either by intuitive and demonstrative reasons, or by perception and reasoning based on experience—and I render it in terms of two methods for justifying claims about relations: either solely on the basis of comparisons of intrinsic features of the relata, or on the basis of their extrinsic relations. I shall leave for another occasion my defense of the view that in asking whether we are determined by reasoning to draw causal inferences, Hume raises the question of whether we have legitimizing or justificatory reasons (either a priori or a posteriori) for causal inductive inferences to the unobserved. For the view that at T 1.3.6 (SBN 86–94) Hume does not raise skeptical doubts about induction see Don Garrett, *Cognition and Commitment in Hume's Philosophy* (Oxford: Oxford University Press, 1997), chap. 3.

47 I am especially indebted to Michael Friedman here.

48 Newton himself makes the essential role of Rule III perfectly explicit in the course of Propositions 6 and 7. According to Corollary 2 to Proposition 6, "All bodies universally that are on or near the earth are heavy [or gravitate] toward the earth, and the weights of all bodies that are equally distant from the center of the earth are as the quantities of matter in them. This is a quality of bodies on which experiments can be performed and therefore by rule 3 is to be affirmed of all bodies universally" (*Principia*, 809). Corollary 1 of Proposition 7 then concludes: "Therefore the gravity toward the whole planet arises from and is compounded of the gravity toward the individual parts" (*Principia*, 811). Compare also note 14 above, which I have appended to Newton's summary statement of the argument for universal gravitation in his explanation of Rule III.

49 See note 46 above. As I explain in the paper cited there, Hume's distinction between two types of philosophical relations (roughly, intrinsic and extrinsic) is essentially the same distinction he later makes in the first *Enquiry* between relations of ideas and matter of fact. From Hume's point of view, therefore, to conceive of causation in terms of quasi-geometrical containment goes against the very distinction between relations of ideas and matters of fact.

50 I have developed this theme of the mutual autonomy of Hume's two standpoints in detail in my "Hume's Pyrrhonian Skepticism and the Belief in Causal Laws," *Journal of the History of Philosophy* 39.3 (2001): 351–83, and also in "Causation as a Philosophical Relation in Hume." In the latter article I first argued, in particular, that Hume fully endorses, outside his radically skeptical standpoint, the normativity of inductive proof with its attendant principle of the uniformity of nature, which he models on Newton's Rule III. I also argued, in this way, against Annette Baier, who takes

Hume's negative conclusion concerning the ultimate justification of the principle of the uniformity of nature as an argument against rationalist, deductivist attempts at grounding the inductive inference. In my view, on the contrary, precisely because Hume argues at T 1.3.6.7 (SBN 89–90), and also very clearly at EHU 4.19 (SBN 35–6), that there is no inductive justification of the principle of induction, Hume raises radical skeptical doubts about his own Newtonian inductivist model of scientific inference. Nevertheless, according to Hume, within the natural standpoint (as opposed to the radically skeptical standpoint), our best inductive method (following Newton's Rule III) enables us to formulate "well-established" and exceptionless (albeit revisable) causal laws of nature.

51 Hume writes: "Tho' the several resembling instances, which give rise to the idea of power, have no influence on each other, and can never produce any new quality *in the object*, which can be the model of that idea, yet the *observation* of this resemblance produces a new impression *in the mind*, which is its real model. For after we have observed the resemblance in a sufficient number of instances, we immediately feel a determination of the mind to pass from one object to its usual attendant, and to conceive it in a stronger light upon account of that relation. . . . Necessity, then is the effect of this observation, and is nothing but an internal impression of the mind, or a determination to carry our thoughts from one object to another" (T 1.3.14.20; SBN 164–5).

52 In "Causation as a Philosophical Relation in Hume," I argue that Hume's notion of necessity does not reduce to brute regularity, as it might prima facie appear, and as it has been proposed by what I take to be an extreme version of the regularity or uniformity interpretation of Hume's notion of causation. In my view, the scientist formulates causal laws by careful inductive reflection on uniform evidence, and this methodical reflection adds normativity to the idea of necessity brought about by the basic natural process of the mind exposed to repeatedly observed regularities. And it is precisely the addition of normativity that turns the exceptionless universality of the causal laws into something more than mere brute regularity. In enabling us to formulate what we take to be necessary laws of nature, the inductive method thereby *delimits* the course of nature, in that it defines the distinction between the natural and the supernatural; and through this delimitation the normative force of our best inductive method is projected onto nature itself. Hume's definition of a miracle simply as a violation of the well-established laws of nature implies that the inductive method leading to the formulation of these laws constitutes our understanding of the natural as opposed to the supernatural. In a Lockean view, by contrast, nature has a real intrinsic structure independently of our knowledge of it. What is supernatural is what violates this structure, and the laws we inductively establish need not correspond to it. A Lockean view therefore employs an explicitly ontological notion of the necessity of nature. By contrast, precisely because it is our best inductive method that determines what the course of nature is, Hume's notion of necessity is an epistemological notion.

53 Hume makes this claim in order to support his further claim that there is a full proof against the occurrence of a miracle: "A miracle is a violation of the laws of nature; and as a firm and unalterable experience has established these laws, the proof against a miracle, from the very nature of the fact, is as entire as any argument from experience can possibly be imagined" (EHU 10.12; SBN 114).

54 The distinction between "proofs" afforded by uniform experience and the mere probability afforded by the balancing of opposite experiments was already developed in *Treatise* Book 1, part 3, sections 11, 12, 13, and 15, and in section 6 of the first *Enquiry*.

55 In particular, towards the end of the discussion of miracles (EHU 10.39; SBN 129), Hume quotes Bacon explicitly, although not exactly to enunciate methodological rules of experiments and observations, but in order to reinforce his own general conclusion that testimony concerning religious miracles has null authority.

56 In the same chapter XVI, of Book IV, where the above-quoted discussion of the highest degree of probability occurs, Locke reiterates the metaphysical hypothesis of a hidden real essence and the corpuscularian explanation of causes: "Concerning the manner of Operation in most parts of the Works of Nature: wherein though we see the sensible effects, yet their causes are unknown, and we perceive not the ways and manner how they are produced. These and the like Effects we see and know: but the causes that operate, and the manner they are produced in, we can only guess, and probably conjecture. For these and the like coming not within the scrutiny of humane Senses, cannot be examined by them, or be attested by any body, and therefore can appear more or less probable, only as they more or less agree to Truths that are established in our Minds, and as they hold proportion to other parts of our Knowledge and Observation. . . . Observing likewise that the different refractions of pellucid Bodies produce in our Eyes the different appearances of several Colours; and also that the different ranging and laying the superficial parts of several Bodies, as of Velvet, watered Silk, *etc*. does the like, we think it probable that the Colour and shining of Bodies, is in them nothing but the different Arrangement and Refraction of their minute and insensible parts" (*Essay* IV, XVI, 12).

57 For example, in Boyle's "The Reconcileableness of Reason and Religion," in *The Works of the Honourable Robert Boyle*, 6 vols., ed. Thomas Birch (1772; repr. Hildesheim: George Olms, 1965–1966), 4: sections 7–8. See Rose-Mary Sargent, *The Diffident Naturalist: Robert Boyle and the Philosophy of Experiment* (Chicago: The University of Chicago Press, 1995) for an excellent discussion of this and other aspects of Boyle's methodology and natural philosophy.

58 Well-attested miracles are those reported by Scripture, which Locke regards as the written word of God (see *Essay* IV, XVI, 13–4). At a presentation of an earlier version of this paper at the California Institute of Technology in April 2003, Mordechai Feingold pointed out that both Locke and Newton agree that the only miracles for which we have good evidence are those reported by Scripture.