Michael Friedman’s Kant and the Exact Sciences (1992) refocused scholarly attention on Kant’s status as a philosopher of the sciences, especially (but not exclusively) of the broadly Newtonian science of the eighteenth century. The last few years have seen a plethora of articles and monographs concerned with characterizing that status. This recent scholarship illuminates Kant’s views on a diverse group of topics: science and its relation to metaphysics; dynamics and the theory of matter; causation and Hume’s critique of it; and, the limits of mechanism and of mechanical intelligibility. I argue that recent interpretations of Kant’s views on these topics should influence our understanding of his principal metaphysical and epistemological arguments and positions.

1. Introduction

Since Sir Peter Strawson helped to reinvigorate Anglo-American philosophical treatments of Kant nearly forty years ago, Kantian studies in English have taken the metaphysical and epistemological views of the Critique of Pure Reason as their principal focus. Despite their significance for prominent twentieth century neo-Kantians such as Ernst Cassirer, Kant’s views in the philosophy of science have generally not received equal attention in Anglo-American scholarship. Strawson himself famously dis-
missed the import of Kant’s philosophical reflections on science for achieving an understanding of the Critique (Strawson 1966, p. 23). With the appearance of Michael Friedman’s Kant and the Exact Sciences a decade ago, matters changed considerably. Friedman refocused scholarly attention on Kant’s status as a philosopher of the exact sciences, especially (but not exclusively) of the broadly Newtonian science of the eighteenth century.2 The last few years have seen a plethora of articles and monographs concerned with illuminating Kant’s status as a philosopher of science; some of this recent work also encompasses the post-Kantian thinkers who developed Naturphilosophie in the early nineteenth century.3 Some of Kant’s interpreters are now prepared to suggest that his classic work in metaphysics and epistemology must undergo a reinterpretation specifically in relation to Kant’s status as a theorist of science (cf. Butts [1988]; Watkins [2001a], p. 125). I will return to that theme in the conclusion.

The recent literature on Kant’s philosophy of science has had a number of general and significant effects, helping to engender a broad reassessment of several significant themes in Kantian studies. Most generally expressed, there is now a tendency to reconsider our previous understanding of the following two issues: (1) who we should count as Kant’s significant philosophical predecessors and interlocutors; and (2), how we should characterize, and indeed whether we should ultimately accept, the supposed intellectual discontinuity of Kant’s philosophical work. As for (1), the proper interpretation of any philosophical figure will of course involve a determination as to which predecessors and interlocutors to emphasize, and which to downplay or simply to ignore, and these are obviously contentious issues. The second issue, however, is specific to Kant and involves the proper interpretation of Kant’s so-called pre-critical work, that is, of his writings that appeared before the shift in his thinking that began

For Cassirer’s interpretation, see especially Cassirer (1910/1923) and Cassirer (1922); the latter, considered a masterpiece by many, has unfortunately never been fully translated into English. The Anglo-American literature has lagged behind the literature on the Continent in this regard: see, for instance, Plaass (1965) and Gloy (1976).

2. Friedman cites Gerd Buchdahl’s classic (1969) as one of his primary inspirations for connecting work on Kant and the philosophy of science. Unfortunately, a discussion of Buchdahl’s ground-breaking work on Kant lies beyond the scope of this essay. In addition to his (1969) volume, see also Buchdahl (1992) for a collection of many of his most important essays on Kant. However, in 2003, Studies in History and Philosophy of Science published a special issue devoted to themes from Buchdahl’s work, and so I discuss some of those essays in what follows.

3. For recent discussions of Naturphilosophie that also concern issues in Kant’s philosophy of science see, inter alia, Beiser (2003) and Friedman (2003b) and the literature cited therein.
sometime after 1770, when he was finally chosen for a professorship in philosophy at the University of Königsberg (see Kuehn 2001a).

The question of who should be counted an influential predecessor or interlocutor of Kant’s relates closely to the question of which opposing philosophical positions we should read Kant as attempting to mediate between. As is often emphasized in the scholarship under consideration here, in his very first published work, the essay on living forces of 1747, Kant prefigured a significant aspect of his mature philosophical attitude by attempting to split the difference between the opposed Cartesian and Leibnizian conceptions of force. Even more remarkably, in that text he presciently wrote:

In the treatise that Bülfinger submitted to the Petersburg Academy, I find an insight that I have always used as a rule for the investigation of truths. If men of good sense, who either do not deserve the suspicion of ulterior motives at all, or who deserve it equally, hold entirely opposed opinions, then it accords with the logic of probabilities to direct one’s attention on a certain and intermediate claim that agrees to an extent with both parties (Academy 1: 32).4

This passage encapsulates what many commentators identify as Kant’s characteristic orientation toward pre-existing philosophical conflicts (Beck 1967). And of course he has often been read as specifically splitting the difference between a broadly rationalist and a broadly empiricist conception of knowledge.

Although contemporary scholars remain interested in Kant’s attempts at philosophical mediation, if their focus is Kant’s philosophy of science, they often question whether we should continue to emphasize Kant’s relationship with his rationalist and empiricist predecessors. Indeed, what emerges from the work considered here is that the tendency to interpret the Critique vis-à-vis the canonical distinction between rationalism and empiricism may hinder our effort to comprehend some of Kant’s significant theses. Consider, for instance, his view that substances should be conceived of as forming a “community” of entities in thoroughgoing and reciprocal causal interaction, a theme in much of the recent literature (Edwards 2000 and Friedman 2000). No such conception can be found in Kant’s Leibnizian predecessors, who famously denied substantial interac-

4. All citations to Kant’s work are to volume and page numbers of the so-called Academy Edition of his oeuvre, with the exception of the first Critique, which I cite by the standard A/B numbers corresponding to its first and second editions, respectively. All translations are my own unless otherwise noted.
tion, nor in his empiricist predecessors such as Hume, who largely ignored the questions concerning substantial interaction that preoccupied their counterparts on the Continent. Such a conception, however, can certainly be gleaned from the broadly Newtonian conception of the world that Kant explicitly rendered part of his philosophical inheritance (Friedman 2001a, pp. 66–8; cf. Longuenesse 2002).

It is particularly noteworthy that Kant tackles the issue of substantial interaction in the so-called Third Analogy of Experience, a section of the Critique that has often been ignored, even in otherwise comprehensive commentaries on the text. The traditional emphasis on Kant’s relation to Hume has coincided with a particularly strong emphasis on the Second Analogy, in which Kant deals explicitly with causation. The renewed emphasis on Kant’s philosophy of science, however, has led to a reinterpretation of the Third Analogy as an equally important section of the Critique (Edwards 2000, pp. 23–47, 147–166). And this section presumably cannot be understood without emphasizing Kant’s defense of a broadly Newtonian conception of substantial interaction.

The example of substantial interaction also indicates that one of the primary developments to arise from the recent work in Kant’s philosophy of science is the new emphasis, long overdue in Anglo-American commentary, on the ways in which Kant’s thought is intended to bring the Leibnizian metaphysics he inherited into fruitful conversation with Newtonian natural philosophy. Despite Newton’s well-known influence on the development of British empiricism, this distinction obviously cannot be reduced to that between rationalism and empiricism. Kant’s attempt to mediate between the Leibnizians and the Newtonians is, of course, one of the primary emphases of Friedman’s Kant and the Exact Sciences, but it also informs much of the recent scholarship (see Schönfeld 2000, Warren 2001a, and Watkins 2001a), including some not focused directly on issues in the history and philosophy of science.5

Another widely shared goal is to emphasize the remarkable philosophical continuity of Kant’s intellectual work, helping to revise the standard picture—fomented by Kant himself—according to which the so-called pre-critical writings are best left ignored (Edwards 2000, Schönfeld 2000, Warren 2001a, Watkins 2003).6 For his part, Schönfeld (2000) has writ-

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5. See, for instance, Franks (forthcoming), which is not primarily concerned with issues in the philosophy of science. I single out the Anglo-American literature in particular here because this emphasis has long been a staple in the French and German scholarship. For one of the most influential accounts, see the outstanding discussion in Cassirer (1922); one of the (massive) sections in the latter work is entitled “Von Newton zu Kant.” See also the important early contribution of Vuillemin (1955).

6. Important earlier work in this area was done by Laywine (1993) and by Shell (1996).
ten what is perhaps the most detailed reassessment of Kant’s pre-critical oeuvre. The pre-critical period is typically taken to end in February of 1772, when Kant famously wrote to his former student, the physician Marcus Herz, to express his newly found philosophical problem concerning a priori concepts, one whose solution eluded Kant at least until he wrote the Transcendental Deduction of the Categories in the first edition of the Critique in 1781. Schönfeld persuasively emphasizes the philosophical importance of Kant’s pre-critical discussions of themes familiar from the critical period; these include his treatment of arguments for the existence of God, his articulation of the distinction between real and logical opposition, and his defense of the thesis—put in modern form—that existence is not a predicate. All are relevant for understanding Kant’s later articulations of his views in the critical period, and the distinction between real and logical opposition is especially pertinent for Kant’s philosophy of science, as Warren helpfully emphasizes (2001a).

But Schönfeld is equally persuasive in arguing that Kant’s more narrowly scientific preoccupations in his first two decades of writing and teaching must also be given their scholarly due (cf. the classic account in Adickes 1924). In addition to discussing the well-known work on the origins of the solar system’s structure—which was labeled the “Kant-Laplace hypothesis” in the early nineteenth century—Schönfeld provides an engaging reconstruction of Kant’s treatment of various pressing issues in eighteenth century science (Schönfeld 2000, pp. 73–127). These include the proper explanation of earthquakes after the tragedy in Lisbon mid-century; various meteorological questions such as the cause of the trade winds; questions raised by a proper understanding of fire; and so on. As Schönfeld helpfully notes, Kant also lectured on cosmology, geography, meteorology, and on a wide range of other scientific topics. It may therefore not be a stretch to suggest that although Kant was one of the influential modern figures to insist on a distinction between science and philosophy, he also contributed, both in his research and in his pedagogy, to the development of each, albeit of one much more than the other (cf. Kuehn 2001b).

The recent literature has also been particularly persuasive in suggesting that Kant’s post-critical work—especially his last surviving manuscript, later published as the Opus Postumum—should not, as previously thought, be attributed to Kant’s senility, but should be taken seriously in its own right. In particular, it is now read as Kant’s last attempt to tackle many of the issues concerning the relation between physics and metaphysics that
he grappled with in texts like the Metaphysical Foundations of Natural Science of 1786. Eckart Förster has done more than anyone over the past decade to foment scholarly interest in the Opus Postumum, arguing especially that the project of the manuscript, which Kant himself describes as an attempt to forge a "transition" from the Metaphysical Foundations of Natural Science to physics, must be properly understood if we are to appreciate Kant’s considered interpretation of science and even of the success of the Critique of Pure Reason itself (Förster 2000; cf. Edwards 2000, pp. 147–166).

As Förster describes in detail, Kant insists in the Opus Postumum that to establish the “objective reality” of the categories—the fundamental concepts articulated in the Critique—we ultimately require the representational resources not just of intuition, but especially of outer intuition. That is, we require the perception of objects in space. Hence the Schematism chapter of the Critique, which attempts to indicate how one might infuse the categories with temporal content, may not be sufficient for this task because it fails to deal with spatial content. As Förster sees matters, the transition between the Metaphysical Foundations and physics that Kant envisions in the Opus Postumum involves infusing the categories of the Critique with sense and meaning by articulating their relation to outer intuition and therefore to spatial objects given in perception (Förster 2000, pp. 73–4; cf. Academy 4: 474–6, note). Whether Förster’s interpretation is correct, and whether Kant succeeds in the task Förster articulates for him, remain open questions, but it is to Förster’s credit that these questions are now the focus of scholarly attention (Friedman 2003c). At this stage, Förster has certainly convinced us that the Opus Postumum, like the critical and indeed the pre-critical writings, must be taken seriously, both in its own right and also because of the way in which it illuminates certain doctrines in the first Critique (cf. Guyer 2001). These are surely positive developments for Kantian studies.

Alas, the remarkable and wide ranging agreement on these matters must come to an end somewhere. As one would expect, against this background of agreement there are many substantive differences of emphasis. I discuss some of these, and some broader themes, in what follows.

2. Science and Metaphysics
One respect in which the intellectual continuity of Kant’s work noted above is especially evident concerns Kant’s general attitude toward the relation between science and metaphysics. Early on in his career, Kant was deeply influenced by Euler’s famous 1748 argument—expressed in his “Réflexions sur L’Espace et le Temps”—that metaphysics ought to presup-
pose the established results of science and mathematics, especially of mechanics and of geometry, avoiding any conflict with those results and with propositions that logically follow from them (Schönfeld 2000, pp. 209–28). Euler’s largely Newtonian point of view was controversial in this period precisely because it sat in tension with the Leibnizian philosophical perspective prevalent in Prussia. Kant’s acceptance of Euler’s attitude of the relation between science and metaphysics represents a decisive philosophical break with his Leibnizian predecessors and interlocutors. In the critical period, of course, Kant does not simply argue that metaphysics ought to presuppose prevailing scientific results, but that the task of metaphysics should, at least in part, be seen as explicating how those results, at least at a high level of abstraction, are possible. This is particularly evident in the Prolegomena of 1783 and in the second edition of the Critique, published in 1787 (see Friedman 2003a).

Kant’s contention that we should follow Euler in presupposing basic scientific results when engaging in metaphysical reflection raises an immediate question. As science progresses, its formerly accepted results are overturned, and perhaps directly contradicted. Does that entail that metaphysics itself must undergo a corresponding transformation with each new, and newly accepted, scientific theory? From Kant’s point of view, the new science of the late seventeenth century should be understood as thoroughly and permanently replacing the old, late Scholastic, conception of science, along with its set of scientific practices. Kant did not share the view—inspired by Kuhn—that scientific history is marked by a series of revolutions whereby one prevailing “paradigm” replaces another; rather, he thought that science followed what he took to be the model of mathematics: the Greeks set mathematics on the “secure path” of a science, a path from which it essentially never deviated in two millennia. Similarly, natural science, or at any rate certainly physics and astronomy, were set on that same type of secure path by figures like Galileo and Newton, and the task they bequeath future generations is simply one of continuing refinement. The process may be as unending as that envisioned by Kuhn, but with no future disruptions to the basic set of principles, conceptions and practices that the founders of the science establish. This is significant not least because if we accept Kant’s view, we are likely to attribute little philosophical import to the study of science’s history, a view that many philosophers and historians would obviously now dispute.

Kant’s understanding of the history of metaphysics mirrors his under-

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7. See Euler ([1748]1911–); for Kant’s early discussion of that paper, see Academy 2: 168.
standing of scientific history. Just as he thinks that a permanent “revolution” set physics on a “secure path” once and for all, leaving future generations to clarify and deepen previously established results, he characterizes his task as setting metaphysics itself on the “secure path of a science,” leaving the task of clarification to future generations of philosophers (Kuehn 2001a, p. 86). The lack of consensus, not to say outright chaos, reigning in metaphysics throughout the history of philosophy, from Kant’s point of view, can be overcome once the task of metaphysics and its proper methods are clarified in the critical philosophy. But to set metaphysics on such a path, Kant argues, does not involve making metaphysics itself “scientific” in the sense defended by some of Kant’s rationalist interlocutors; it does not mean that metaphysics ought to follow the mathematical methods of the new sciences (cf. Ameriks 2001, p. 38). That, from Kant’s point of view, is a hopeless dead-end for philosophy, one wrongly followed for instance by Spinoza in his Ethics (cf. Academy 4: 478).

Instead of contending that metaphysics ought to become “scientific” by following the mathematical methods of the sciences, Kant intends it to follow a kind of broad epistemic suggestion from the new science. Kant fundamentally disagreed with his empiricist predecessors concerning the proper interpretation of the epistemic achievements of Newtonian physics (a topic I discuss below). But he did contend that there is a sense in which metaphysics ought to follow a suggestion for how to proceed from the new (although not necessarily Newtonian) science. What could Kant possibly have had in mind?

In the preface to the second edition of the Critique, Kant provides a brief, but highly suggestive, account of the experimental side of the new science, arguing that thinkers like Galileo and Torricelli engaged in a novel type of experimentation, thereby setting physics, or “natural science,” on a secure path. Kant takes this episode in scientific history seriously enough to contend that metaphysics may be able to divine from it a clue as to how it can proceed in the future such that it can finally quell its endless disputes. He first characterizes the relevant aspect of the new experimental methods as follows:

When Galileo rolled balls of a weight chosen by himself down an inclined plane, or when Torricelli made the air bear a weight that he had previously thought to be equal to that of a known column of water, or when in a later time Stahl changed metals into calx and then changed the latter back into metal by first removing something and then putting it back again, a light dawned on all scien-
Kant wants a similar light to dawn on philosophy. He contends that this type of experimental method, which he seems to think of as essentially novel when it appears in the seventeenth century, not only marks a new episode in the history of science, but provides a kind of model or analogy for philosophy. As he writes:

I should think that the examples of mathematics and natural science, which have become what they are now through a one-time revolution, would be remarkable enough that we might reflect on the essential element in the alteration of the type of thinking that has been so advantageous to them, and at least as a trial [Versuch], imitate it insofar as their analogy with metaphysics, as rational cognition, might allow (Bxv-xvi).

The clue Kant finds in the experimental method of Galileo and Torricelli ultimately leads him to what he famously characterizes as his “Copernican” revolution in philosophy. The latter is characterized by the overarching view that we can achieve a priori knowledge in metaphysics by thinking of objects as conforming to our cognition [Erkenntnis] of them, rather than by thinking that knowledge can be achieved only if our cognition conforms to objects.8

These interrelated concerns obviously raise a broader issue: what criteria did Kant envision for some discipline or enterprise to be properly called “scientific?” Was this even of concern to Kant? Of course, one must take care with such a question in part because anachronism is a danger here, but also in part because the German Wissenschaft has various uses that the English science lacks. Wissenschaft can of course mean simply a systematic epistemic enquiry, a broader meaning, perhaps, than we tend to attribute to science. But Kant also used Wissenschaft in a more restricted and technical sense. He perhaps infamously remarked in the Preface to the

8. For the details of the “Copernican” revolution in philosophy, see also the note to Bxii. There are other respects in which Kant thought of the new science as providing a kind of “clue” for philosophers. For instance, in the Critique of Practical Reason, Kant notes that the form of physical laws—what he takes to be their universality and necessity—provides moral philosophy with, as it were, a suggestion as to the proper form of the moral law (see Academy 5: 67–71).
Metaphysical Foundations that chemistry, though perhaps a "systematic art," could not properly be called a science because it lacked a priori principles (Academy 4: 468). To his credit, Kant later revised this assessment in the face of the chemical revolution wrought by figures like Lavoisier (see especially Friedman 1992a). Recent work has also focused on Kant's understanding of the human sciences, especially history and anthropology, and on his view of whether these sciences can be considered explanatory in any significant sense (Makreel 2001; Sturm 2001; Zammito 2002; Jacobs and Kain 2003). This is likely to be of continuing interest in the future.

3. Dynamics and the Theory of Matter
A significant portion of the recent literature attempts to clarify Kant's dynamical views and, relatedly, his theory of matter (Edwards 2000, Warren 2001b). Eric Watkins—who has done as much as any commentator to clarify Kant's understanding of force—notes that at the most basic level, a force for Kant is "a causal activity of a substance that explains a change of state" (2001a, p. 124). To avoid difficult epistemic issues concerning explanation, one might amend this definition in a friendly fashion by claiming that for Kant, a force is a cause of a substance's change of state. This may in fact be an aspect of Leibniz's conception of force, as Watkins contends, but it might be added that it bears a striking resemblance to Newton's understanding as expressed in the Definitions in the Principia.

One result of the renewed emphasis on what we might call Kant's Newtonianism, and on his attempt to mediate between Leibnizian metaphysics and Newtonian natural philosophy, is a new pressure on Kant scholars to develop sophisticated readings of Leibniz and Newton's philosophically salient work. Perhaps because he is not—at least at the present moment—considered a member of the early modern philosophical canon, Newton in particular presents a problem for Kant's interpreters. Several of the authors considered here present a reading of Newton's Principia according to which it refrains, or attempts to refrain, from discussing causes (Schönfeld 2000, pp. 67, 90; Watkins 1997, p. 316). There is some reason to question such a reading. In the Definitions that precede Book I, Newton conceives of gravity as a type of centripetal force, and defines centripetal force to be a "source" of impressed force, where the latter, in turn, is defined as "the action exerted on a body to change its state either of resting or of moving uniformly straight forward" (Newton 1999, p. 405). The causal language here is explicit: Newton defines gravity as a kind of cause, as something that alters states of motion of bodies. As Arthur Pap puts it in his early treatment of Kant's philosophy of physics, for Newton accelerations have "veras causas, viz. forces" (1946, p. 70). Given that the rest of
the *Principia* proceeds to present a theory of gravity—culminating in the identification of the force of gravity as that force which is responsible for the weight of bodies on earth and for the planetary orbits—it cannot quite be said that Newton’s theory avoids all causal talk, or the investigation of causes *per se.* This is salient not least because Kant makes precisely this point in his lectures on physics for 1785, the so-called Danziger Physik (Academy 29: 115). How such claims will eventually alter our understanding of the relevant aspects of Kant’s views remains to be seen, but it can already be noted that recent scholarly trends rightly reemphasize their broad import.

As a number of commentators have noted, Kant’s conception of force pictures them as “fundamental” in several significant respects. At the most general level, he thought that certain types of force can be considered “fundamental” in the sense that some dynamic types cannot be reduced to the action of any other force (Academy 4: 513). That view, of course, is a familiar one. It might be added that Kant’s conception is not only thoroughly familiar but, and perhaps *ipso facto,* fundamentally Newtonian.

Forces are “fundamental” for Kant in another significant sense. He takes repulsive and attractive force to be constitutive of matter *per se,* and therefore thinks that understanding these basic types of force is indispensable to understanding matter itself. Carrier provides an especially clear and useful account of this aspect of Kant’s theory of matter (Carrier 2001a, 2001b). Carrier notes, for instance, that on this view all differences between objects—or between substances in space and time—can be traced back to, or should be conceived of as resulting from, differences in force combinations within the material objects or substances themselves. This is a rejection of the view that there are different types of matter, or different types of substance. One way to characterize Kant’s interpretation of a Leibnizian conception of substance is to note that Leibniz thought of each

9. Some commentators also question whether Newton took forces to be “real” in any significant sense (see, for instance, Watkins 1998, pp. 123–4 and Zammito 2003, p. 85). This issue is related to the question of whether Newton refrains from treating causes of phenomena in the *Principia,* indeed, Newton himself links the two in the General Scholium. To defend the contention that Newton did not consider forces to be “real,” or the view that Newtonian mechanics need not commit its adherents to the “reality of force,” one must, in the least, provide an interpretation of the famous comment in the General Scholium in which Newton reflects on what the *Principia’s* theory of gravity has accomplished. After noting that he does not assign a “cause to gravity,” and that he refrains from feigning any hypotheses about such a cause, Newton insists nonetheless that “it is enough that gravity really exists [satis est quod gravitas revera existat], acts according to the laws that we have set forth, and is sufficient to explain all the motions of the heavenly bodies and of our sea” (Newton 1972, p. 764).
substance as the sole member of its own type, each with its own complete concept expressing its essence. The principle of the identity of indiscernibles rules out the possibility that there could be two numerically distinct tokens of one of these types, for then they would be qualitatively identical, yet numerically distinct. Of course, Kant characterizes the Leibnizian view in this way precisely to reject it (see A260/B316–A292/B349).

Förster helpfully reminds us that Kant already held a dynamical conception of matter in 1756, and struggled with its details in the late work of the *Opus Postumum*. That is to say, Kant struggled with and defended a dynamical conception of matter throughout nearly his entire intellectual career. This indicates in a rather striking fashion the remarkable continuity of Kant’s philosophical work, both in terms of its themes, and in this case in terms of its particular details (Förster 2000, pp. 38, 66ff; cf. also Pollok 2002). The Kantian dynamical conception of matter proved to be influential in the late-eighteenth and early-nineteenth century, both in philosophy and in the sciences. For instance, it apparently aided Øersted in his discovery of the electromagnetic force, a significant case of crossover between science and philosophy (Friedman 2003b).

The concept of force, of course, is both a physical and a metaphysical concept, or at any rate it has both physical and metaphysical connotations. As I just suggested, the conception of force in Kant’s metaphysics ought to be understood as a basic competitor to the Leibnizian metaphysical view—certainly well-known to Kant—according to which a force should be conceived of as an internal principle of change of an individual substance (Edwards 2000, pp. 63–73). The notion that there are various types of force is therefore quite foreign to Leibniz’s metaphysics, for it conceives of each substance as bearing its own force, just as each substance has its own so-called complete concept, a notion from which all of its states can in principle be derived. For two substances to bear the same force, therefore, is precisely analogous to their having the same “complete concept,” and in the latter case, the (supposedly) two substances would *ipso facto* be the same substance. The Newtonian view that there are basic types of force, however, is precisely the view that Kant articulates and defends.

4. Causal Laws and “Hume’s Problem”

The Anglo-American tradition of reading Kant as responding to Hume’s critique of metaphysics, though not without obvious and considerable merits, has tended to obscure the continuity of Kant’s work, and especially the similarities of the work written before and after Hume awoke Kant from his “dogmatic slumber.” In particular, viewing Kant’s first *Critique* as primarily expressing his response to Humean skepticism of one variety or
another tends to obscure the many Newtonian concepts that Kant employs in that text. Explicating these concepts is an important step in articulating the significant differences in the philosophical responses to Newtonian science found in Hume and in Kant, but it may be less significant as a way of understanding Kant’s response to what he eventually understood as “Hume’s problem,” which Kant saw as fundamental to metaphysics and epistemology.

Any discussion of Kant’s conception of causation must, of course, include a consideration of his attempted solution of, or at any rate his response to, “Hume’s problem.” It is generally agreed that from Kant’s point of view, the Humean problem, which originates with Hume’s critique of the origin of the concept cause in the Treatise and the Enquiry, must be understood as a general problem in metaphysics, one that touches any concept that purports, in Kantian language, to be a priori. Since Kant, like some of his rationalist predecessors, took all of the principal concepts of metaphysics to be a priori, “Hume’s problem” is then interpreted to be a systematic and general challenge to all previous metaphysics.

The issues just enumerated are, of course, well known. A perusal of the recent commentarial literature, however, indicates a distinct emphasis, viz. on the ways in which the Humean and Kantian conceptions and critiques of causation can be reinterpreted as distinct responses to the overwhelming success of Newtonian science in the eighteenth century. Whereas Hume took himself to be introducing the “experimental method”—i.e. the “method” Newton purportedly follows in his Principia mathematica and Opticks—into moral subjects by refraining from employing the concept of cause except to refer to certain regularities in our experience, Kant took himself to be responding to Newton’s success in general, and to the derivation of the law of universal gravitation in particular, by emphasizing that there must be a priori principles grounding the types of epistemic claim made in the new science (see B17–18, the note to B21, and B128). For as Kant emphasized repeatedly, Newtonian physics—and we can take the Newtonian theory of gravitation as our example here—involves claims to knowledge that hold not only of all bodies within the reach of our senses, but of all bodies with mass within the entire universe, and any naïve empiricist epistemology would at least appear to be in tension with claims of such scope.

Kant discusses the theme of the epistemic scope of Newtonian science

10. For some relevant discussions of such views, and of Hume’s more general interpretation of Newtonian science, see Hume (1854, Volume 5: 374) and Hume (1966, pp. 73, note and 204).

11. Of course, Newton himself understood the import of precisely these issues and attempted, in his Rules for the Study of Natural Philosophy, to provide four basic principles

in a remarkable passage in the Dialectic to the *Critique*. In this particularly incisive passage, Kant mentions both Kepler’s laws—which he describes as “not fully corrected experience” or data—and Newton’s derivation of universal gravitation from those laws, using these issues as a way of introducing his interpretation of what might be called a Newtonian method in science more generally. He notes in particular that Newtonian science proceeds by seeking unification in its understanding of various phenomena under the rubric of a single force. And the latter, in turn, is intended to be seen as following a single law, where the paradigm case of such a law is of course the law of universal gravitation. In attempting to explain the various observed motions of the planets and the comets in the solar system, Kant writes that we search for

> unity in the cause of all the laws of this motion (gravitation); from there we extend our conquests, and seek to explain all variations and apparent deviations from those rules based on the same principle; finally we even add on more than experience can ever confirm, namely, in accord with the rules of affinity, we think of hyperbolic comet paths in which these bodies exit our solar system entirely and, going from sun to sun, unite in their path the more remote parts of what is for us an unbounded world system, but one that is connected through a single moving force (A663/B691).

This extremely rich passage expresses Kant’s decidedly anti-empiricist interpretation of Newtonian science, and the anti-empiricist lessons he draws from his understanding of the procedures of *Principia mathematica*. The passage also emphasizes Kant’s view that our understanding of the “world system” rests on our discovery that its various far-reaching constituents can be understood as causally connected through a single force governed by a single law.12

As Arthur Pap pointed out some time ago, Kant’s understanding of Newton pressed him into rejecting Hume’s contention that we can justify any given proposition only by one of two methods: induction or logical deduction (Pap 1946, p. 57). Although Kant accepted that this disjunction is *exclusive*, distinguishing carefully between propositions that can be justified by induction and those by deduction, he rejected Hume’s
claim that it should be considered exhaustive. Kant thinks, for instance, that Newton's law of universal gravitation is certainly justifiable, but not simply via one of these two methods bequeathed to science by Hume. For the scope of the law covers all bodies with mass in the universe, and therefore, from Kant's point of view, reaches beyond the epistemic limits of induction, and yet the law surely cannot be logically deduced from first principles. Instead of concluding, so much for the law, Kant concludes, so much for the Humean scheme.

And finally, to return to an earlier theme, Kant also appears to have rejected Hume's inference from his understanding of Newtonian science that epistemic progress can be made through careful empirical investigation while we refrain from employing the supposedly problematic concept of cause. In the passage discussed above, Kant seems to have been committed to the view that Newtonian science progresses precisely by identifying real—as opposed to merely relative—motions and determining what forces generate such motions. One then proceeds by attempting to discover laws that govern the forces. This interpretation certainly reflects some of Newton's more prominent characterizations of his own method and goals.13 Once again, reevaluating Kant’s response to Hume requires us to reconsider their divergent responses to Newtonian science.

5. Mechanism and its Limits

As with most other early modern philosophers concerned with the “new science,” Kant was preoccupied by questions about the nature of mechanism, and as with these other thinkers, some of Kant’s most prescient and revealing thoughts about mechanism arise in his discussions of the limits of the so-called mechanical philosophy and of “mechanical explanation.” In fact, there are at least two contrasts to keep in mind here. On the one hand, Kant’s views on “mechanism” involve the contrast between those phenomena and events that are mechanically explicable, and those that are not. On the other, Kant also contrasts what he calls the “mechanical” and the “dynamical” modes of explanation. One distinction is not necessarily reducible to, or identical with, the other. The former contrast arises especially in the context of Kant’s treatment of various questions in what we would call the philosophy of biology, especially questions concerning organisms (see Kreines 2003). The latter contrast arises, among other places, in Kant’s discussion of explanation in physics. I discuss these in turn.

Some of the very best recent work on mechanical inexplicability in

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13. For some relevant remarks in texts known to, and discussed by, Kant, see Newton (1952, p. 376) and Newton (1999, p. 793).
biology has been done by Hannah Ginsborg, who has tackled Kant’s views of various natural phenomena, such as organisms, that are said to be “inexplicable” vis-à-vis known mechanical laws. What precisely does it mean for a biological phenomenon, or event, or entity, to be “inexplicable” in accordance with known mechanical laws? Ginsborg notes that if certain initial conditions are explicated in a sufficiently robust fashion, Kant thinks that we may, at least in principle, be able to explain the development of an organism out of those conditions through known mechanical laws. For instance, if we have a sufficiently robust characterization of the initial attributes of an egg of a particular avian species, we may in principle be capable of explaining the growth of an individual bird of that particular species from that particular egg. Ginsborg likens this to the explanation of how a clock tells the time given a robust understanding of certain initial conditions—such as how the clock is “set” and how its various parts interact, etc. What we cannot do, from Kant’s perspective, is explain the development of a particular bird from unformed bits of matter. That is, we cannot understand how an “organized” biological entity such as a bird can have developed out of “unformed” or undifferentiated groups of matter (Ginsborg 2001, pp. 242–3). An egg, therefore, is taken to be an antecedently organized or “formed” material object, one whose development into a related “formed” object can be understood. I suppose that the implication here is that if all the constituent molecules of the egg were separated from one another and placed in a pile with some arbitrary structure, that would be an “unorganized” or “unformed” grouping, even if we are willing to treat the pile as a single entity. We cannot understand how such a pile could become an egg through known mechanical laws, and we therefore cannot understand how it could eventually become a bird.

Why exactly does Kant defend this view? To explain something mechanically, according to Ginsborg’s interpretation, is to explain it via the powers of matter per se in accordance with the laws of nature. This definition, however, masks the fact that there are two types of mechanical explicableability and inexplicableability, according to Ginsborg’s interpretation (Ginsborg 2004). The first type of mechanical inexplicableability is as follows. Kant seems to think that both organisms and artifacts are mechanically inexplicable according to the definition above if we construe the “something” in the definition in a particular fashion. We cannot explain the existence of a watch through the powers of matter per se; we must make

14. Incidentally, Leibniz may have held a similar view, as indicated by a passage in the New Essays: “I attribute to mechanism everything which takes place in the bodies of plants and animals except their initial formation” (Leibniz 1890, II.ix.11). It might be noted in this context that the publication of the New Essays in mid-century afforded Kant his first glimpse of Leibniz’s own thought.
reference to human activity to do so, and perhaps this is part of what we mean by the term “artifact.” However, we can, as we have seen, explain the functioning of a watch through matter’s bare powers by reference to the laws of nature (given certain initial conditions).

Kant also thinks, second of all, that organisms are mechanically inexplicable in a way that watches and other machines are not: in the case of a watch, we can understand its functioning by considering the ways in which its various parts interact with one another. The idea seems to be that we can, at least in principle, understand a watch’s functioning by considering the interactions among its various parts, down to the molecular, or even the atomic, level. In the case of organisms, however, we are in principle blocked from achieving this type of understanding. Kant apparently thinks that the behavior or functioning of an organism cannot be understood by considering the interactions among its various inorganic parts at the microscopic level. The idea is that it cannot be understood by articulating the various structures and interactions among its molecular or atomic constituents.

Ginsborg persuasively argues, however, that the Kantian view of organisms should not be understood to entail the further view that the development, growth and characteristics of organisms are, as it were, lawless. On the contrary, Kant takes organisms to be “purposes,” or akin to them, and by this he apparently means that he takes organisms to be subject to various universal normative constraints. That is, organisms and their various organs ought to develop and behave in a particular fashion. This highlights one component of Kant’s more general understanding of biology and its difference from physics: unlike physical laws, biological generalizations do not concern what always happens, or what is probable; they concern what ought to happen. An organism’s, or an organ’s, deviation from the relevant norm is then taken to be a reason for considering it to be malfunctioning, or ill, or in need of some type of repair (Ginsborg 2001, pp. 250–2).

Kant points to what may be a relevant distinction when, in the first Critique, he contrasts what he calls two types of necessity (cf. A547/B575). With respect to the first type, an event might be “necessary” in that it could not fail to happen given certain initial conditions. But with regard to the second type of necessity, an event would be “necessary” in the sense that it ought to happen, even if it does not happen, or indeed never has.

The first type of necessity, from Kant’s point of view, characterizes principles such as the laws of physics. The second type, in contrast, characterizes what Kant regards as the principles or “laws” of morality. As Ginsborg usefully notes, Kant thinks that the second type of necessity also characterizes biological generalizations, broadly conceived.

The second Kantian contrast noted above, that between what he calls
the “mechanical” and the “dynamical” modes of explanation, has also received significant attention in the recent commentarial literature (see especially Warren 2001a, 2001b; cf. Pollok 2002). From the point of view of recent history of science, one of Kant’s more significant contributions to eighteenth century physics and chemistry is his view, expressed in various works throughout his career, that matter should be understood as composed of two fundamental, and opposing, forces (cf. Pollok 2001). This view is closely related to a number of themes in Kant’s mature work.

Warren has provided an especially helpful articulation of Kant’s discomfort with certain aspects of the mechanical philosophy, particularly as it relates to Kant’s conception of dynamics (Warren 2001a, 2001b). Warren focuses his attention on the property of impenetrability, arguing that Kant rejected what he took to be the account of the impenetrability of objects available in the mechanical philosophy for what turn out to be philosophically salient reasons. Chief among them is this: on what Kant calls the “mechanistic” conception, impenetrability is conceived of as a primitive intrinsic property in the sense that it is not taken to result from, or to be reducible to the action of, any force borne by the body in question. One reason for the mechanists to hold this conception, in turn, is that they think of force in such a way that a body will bear a force only if it is in motion. Bodies lack forces if they lack motion altogether. And impenetrability is not conceived of, according to the mechanist view, as a property that bodies bear only when in motion; on the contrary, a body at rest will certainly be impenetrable to other bodies. So in rejecting the mechanistic account of impenetrability, Kant is accepting the view that bodies do in fact bear forces independently of their states of motion. Warren notes that Kant’s acceptance of this view is a nod to his Newtonian predecessors (Warren 2001, p. 100). In particular, Kant claims that bodies bear repulsive and attractive force independently of their motion, and the impenetrability of a body is due specifically to its repulsive force.

More generally speaking, the renewed focus on Kant’s relation to what we can broadly call the “mechanical philosophy,” a theme Kant himself emphasized in texts like the *Metaphysical Foundations of Natural Science*, is a welcome development, not least because it underscores the importance of one of the issues with which we began, namely Kant’s attempt to mediate between Leibnizian metaphysics and Newtonian natural philosophy. Kant certainly accepted the general Leibnizian claim that the “mechanists” threw the baby out with the late-Scholastic bath water, but in a way that indicates his dissatisfaction with certain aspects of the broadly Leibnizian attitude intended to enrich the mechanist conceptions prevalent in the period. And that dissatisfaction, as we have briefly seen, was in part due to
Kant’s trumpeting of a broadly Newtonian dynamics. Kant’s dynamics, in turn, is obviously quite closely connected to his understanding of many other concepts and issues, including causation, explanation, matter and motion; we have seen a few of the relevant connections above. We can certainly look forward to further discussion of the details of these aspects of Kant’s thought, and of his understanding of his relation to his predecessors and interlocutors, in the future.

6. Future Directions
It should hopefully be clear that the scholarship under review here has had significant effects in Kantian studies in general beyond the bounds of Kant’s philosophy of science in particular. Yet at least one significant question remains, a question that has been implicit in some of the remarks above, and one that was only very briefly raised at the outset. Will the recent scholarly trends eventually lead to a reevaluation not just of Kant’s pre-critical and critical writings in the philosophy of science, including the *Opus Postumum*; and not just of the overall philosophical continuity of Kant’s work and of his mediation between pre-existing philosophical views; but also to a broader reinterpretation of the holy grail in Kantian studies, the *Critique of Pure Reason*? The *Critique* remains, of course, the canonical Kantian text, the volume about which no Kant scholar can remain agnostic. There can be little doubt that scholars now feel compelled to consider the relation between the *Critique* and the *Opus Postumum*, or between it and the pre-critical writings, and this is surely a positive development. But we do not yet know whether the trends outlined briefly in this essay will engender a reinterpretation of the main doctrines of the *Critique* itself, or perhaps even of what we should consider its main doctrines to be. Some scholars have recently made suggestive forays in precisely that direction (see Friedman 2003a), so it may be fitting to conclude by speculating about the paths future research might follow.

Although much work remains to be done, it is clear from the current scholarship that future debate about the *Critique* will likely address at least one concern that is already felt to be pressing by some of Kant’s interpreters. If the *Critique* does, in some to be articulated sense, provide a “theory of science,” or a theory of what is sometimes called “scientific experience,” does this fact entail that it cannot, or simply fails to, provide a theory of “ordinary” perceptual experience? To use a turn of phrase popularized by Wilfrid Sellars that is often invoked in these discussions, does the *Critique* attempt to engage with both the “scientific image” and the “manifest image” of the world, or simply the former (cf. Sellars 1963)? Under what construal could it engage with both of them? This type of
question has already served as the focal point of several discussions in the literature, including debates concerning Kant's conception of causation and the implications of his understanding of substantial interaction (Friedman 1992b and Allison 1996; Watkins 1998b, p. 593; Friedman 2000 and Longuenesse 2002; cf. Ameriks 2001).

Future discussion will hopefully succeed in avoiding an anachronistic conception of the distinction between the “scientific” and the “manifest” images. Since Eddington first articulated his influential conception of the “two tables” in the early part of the twentieth century, our understanding of the relation between the two images Sells made famous has been marked by the distinction between quantum mechanical and classical objects and processes, where the “ordinary” objects of everyday experience are understood as following the classical laws, even while their atomic constituents are not. As Friedman has noted, this distinction cannot be grafted onto Kant’s understanding of science: for Kant, the objects of everyday experience just are the objects modeled in the latest science. That is the case not just because the science in question treats the constituents of ordinary objects, but also because its laws and principles treat ordinary objects and their constituents in precisely the same fashion.15 Newtonian science concerns itself in the first instance with objects and processes no more exotic than the rising of the tides, the falling of a rock, and the setting of the sun. The scientific image of the “world system” is therefore entirely continuous with its manifest image, from Kant’s point of view. For his part, Ameriks (2001) persuasively argues that one aspect of Kant’s project in the Critique in particular, and in the critical philosophy in general, is to explain the coherence of science and “ordinary knowledge.” Ameriks makes his case in part by noting that the fundamental concepts articulated in the Critique, with cause chief among them, serve to ground both our ordinary and our scientific knowledge. This point of view is extremely suggestive and certainly deserves further consideration.16

In writing a tribute to Gerd Buchdahl’s influence on Anglo-American

15. That Newtonian science treats macroscopic objects and their microscopic constituents in precisely the same fashion can easily be seen from the third of the Rules for the Study of Natural Philosophy in Book III of the Principia (Newton 1999, pp. 795–6). In his discussion of the third rule Newton notes, among other things, that the primary properties of macroscopic objects—including their extension, impenetrability and mobility—arise from the very same properties of their constituents. Mandelbaum (1964) discusses this rule, and its philosophical implications, at some length and very persuasively.

16. In a radically different context, Quine raises several similar issues at the end of “Two Dogmas of Empiricism,” particularly when he writes that science is “a continuation of common sense” (Quine 1963, p. 45). Of course, for Quine this is due in part to the fact that in ordinary experience we “posit” such entities as tables and chairs, and in something like the way in which the physicist “posits” atoms and electrons. It is important to keep
Kant scholarship—an article that very rightly highlights Buchdahl’s revival of the neo-Kantian tradition of viewing Kant’s first Critique as a work in what we call the philosophy of science—Robert Butts presciently writes of the Critique and the Metaphysical Foundations:

If the link between these two works is understood as Kant intended, then the Critique itself must be read as providing a theory of science, and the major emphasis of that work is now seen as a philosophical attempt to find the right assessment of Newton’s achievement against the background of Kant’s continuing acceptance of certain features of Leibniz’s metaphysics. If we read the great Critique in this way every important ingredient of that work requires a new understanding (Butts 1988, p. 13).

Of course, this is a particularly strong claim, one that may be considered hyperbolic by some. It seems to me that we are not yet in a position to judge Butts’s contention adequately. Yet at this stage of development we can perhaps conclude that it is precisely this type of challenge that now demands our attention.

References

Quine’s view in mind, however, because it surely lies in the background to current interpretations of these issues in Kant, just as Sellars’s views lie in the background (and for some, in the foreground).


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