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978-0-521-19839-4 - Kant's Construction of Nature: A Reading of the Metaphysical Foundations of Natural Science

Michael Friedman

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KANT'S CONSTRUCTION OF NATURE

Kant's *Metaphysical Foundations of Natural Science* is one of the most difficult but also most important of Kant's works. Published in 1786 between the first (1781) and second (1787) editions of the *Critique of Pure Reason*, the *Metaphysical Foundations* occupies a central place in the development of Kant's philosophy, but has so far attracted relatively little attention compared with other works of Kant's critical period. This book develops a new and complete reading of the work, and reconstructs Kant's main argument clearly and in great detail, explaining its relationship to both Newton's *Principia* and eighteenth-century scientific thinkers such as Euler and Lambert. By situating Kant's text relative to his pre-critical writings on metaphysics and natural philosophy, and, in particular, to the changes Kant made in the second edition of the *Critique*, Michael Friedman articulates a radically new perspective on the meaning and development of the critical philosophy as a whole.

MICHAEL FRIEDMAN is Frederick P. Rhemus Family Professor of Humanities, Director of the Patrick Suppes Center for the History and Philosophy of Science, and Professor of Philosophy at Stanford University. His recent publications include *Reconsidering Logical Positivism* (Cambridge 1999), *A Parting of the Ways: Carnap, Cassirer, and Heidegger* (2000), and *Dynamics of Reason: The 1999 Kant Lectures at Stanford University* (2001). He is the editor and translator of *Immanuel Kant: Metaphysical Foundations of Natural Science* (Cambridge 2004).

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*A Reading of the Metaphysical Foundations
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*To the memory of
Robert E. Butts (1928–1997)
in gratitude for his support, encouragement, and friendship*

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Preface and acknowledgments

This book represents the culmination of an intellectual journey of more than thirty years, beginning in 1980 with my reading of Gerd Buchdahl's *Metaphysics and the Philosophy of Science*, published in 1969. To be sure, I had harbored a long-standing serious interest in Kant's philosophy since my days as an undergraduate. I had been gripped by the *Critique of Pure Reason* and excited by the rebirth of interest in Kant within the Anglo-American tradition sparked by the publication of P. F. Strawson's *The Bounds of Sense* in 1966. This rebirth, however, did not include a corresponding serious interest in Kant's philosophy of science. On the contrary, in Strawson, as in much of traditional Kant scholarship, Kant's engagement with the largely Newtonian science of his time tended to be downplayed or dismissed as involving an unjustified a priori commitment to principles that we now know to have been superseded by the later progress of science, and the hope was to preserve what was still viable in Kant's philosophy independently of this commitment. My own interest in Kant, before reading Buchdahl, ran squarely along such traditional lines.

Meanwhile, however, also during my years as an undergraduate, I began working in contemporary philosophy of science, especially the philosophy of physics. I continued this work as a graduate student, resulting in a dissertation (which later appeared in print, much expanded and revised, in 1983) on space-time physics in both its Newtonian and Einsteinian versions. Reading Buchdahl's book against this background appeared to me as a revelation, for I then saw a way to combine my long-standing interest in Kant with my newer interest in the philosophy of space-time physics from Newton to Einstein. Kant – *of course!* – was centrally concerned with our representations of space and time, which serve for him (together with the categories) as an a priori framework underlying what virtually everyone during the eighteenth-century Enlightenment took to be our best example of rational and objective knowledge of the natural world,

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namely Newton's *Principia*. More generally, as Buchdahl himself had argued, the *Critique of Pure Reason* could be read in the context of the development of the modern philosophical and scientific tradition from Galileo and Descartes through the eighteenth-century Enlightenment, as philosophers and natural scientists together (often combined in the same person) struggled to adjust our conceptions of both nature and humanity to the profound intellectual and spiritual upheavals of the scientific revolution and its aftermath.

Nevertheless, although Buchdahl, unlike Strawson, gives a very significant role to Kant's philosophy of science, he still agrees with Strawson (and most traditional interpreters) in seeking sharply to separate the *Critique of Pure Reason* in particular from the Newtonian science of Kant's time. Buchdahl insists, more specifically, on a sharp distinction between ordinary and scientific experience, and, accordingly, he conceives the nature in general considered in the transcendental analytic of the *Critique* as a world of common-sense particulars constituted independently of scientific laws. He then conceives the world as it is described by modern scientific theories such as Newton's as a product of the regulative use of reason discussed in the transcendental dialectic, and it is only here, for Buchdahl, that properly scientific laws of nature come into play. Thus, while he of course acknowledges the importance of the *Metaphysical Foundations of Natural Science*, Buchdahl sees a significant "looseness of fit" between its project and that of the *Critique*. The specific scientific laws figuring prominently in the former work (such as Kant's three mechanical laws of motion) are merely *modeled* on the corresponding pure principles of the understanding articulated in the transcendental analytic (in this case the three analogies of experience), and such properly scientific laws of nature are in no sense intended to *follow* from the transcendental principles.

Buchdahl's sharp separation between ordinary and scientific experience is motivated, among other things, by a desire to make room for the later development of twentieth-century physics – and therefore for Kuhnian scientific revolutions – within the more general framework of the first *Critique*. The approach I began to develop after reading Buchdahl, by contrast, aimed to turn this perspective on its head. Against the background of my earlier work on the foundations of space-time physics from Newton to Einstein, I was forcibly struck, above all, by how deep Kant's insights into the presuppositions of Newtonian mathematical physics really were. It appeared to me that such depth of insight into the conceptual structure of the best available science of the time was an astonishing philosophical achievement all by itself, entirely independent of its relationship to the

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more modern scientific developments that were yet to come. Moreover, if one does want seriously to inquire into this relationship, I believe that the best way to proceed consists in carefully tracing out the way in which our modern (Einsteinian) conception of space, time, and motion (along with its corresponding philosophical motivations) is the result of a deep conceptual transformation that began with Kant's scientific situation at the end of the eighteenth century and concluded with the revolutionary new (Einsteinian) space-time theories characteristic of the early years of the twentieth.

My project here, however, concerns the interpretation of Kant in the intellectual context of his own time. And what is most distinctive of my approach is the central place I give to the *Metaphysical Foundations of Natural Science* within the philosophy of Kant's mature or "critical" period. I am convinced, in particular, that it is not possible adequately to comprehend this critical philosophy without paying very detailed and intensive attention to Kant's engagement with Newtonian science. Nevertheless, I do not wish to claim that the standpoint of the *Critique* is simply identical with that of the *Metaphysical Foundations*. On the contrary, the relationship between the former and the latter is mediated by what Kant himself calls the *empirical* concept of matter – a concept which, as such, belongs among neither the categories or pure concepts of the understanding nor the pure sensible concepts (e.g., geometrical concepts) employed in mathematics. Consequently, the propositions of what he calls pure natural science that Kant attempts to "prove" in the *Metaphysical Foundations* – on the basis of transcendental principles of the understanding, to which, in some cases, he explicitly appeals as premises – require for their derivation an additional specifically empirical element not found in the first *Critique*. The standpoint of the first *Critique*, on Kant's own account, is therefore significantly more abstract and general than that of the *Metaphysical Foundations*.

The precise relationship between the first *Critique* and the *Metaphysical Foundations*, and the precise sense of Kant's assertion that the concept of matter he develops in the latter work is an empirical concept, involve complex and subtle issues that can only be explored in detail in what follows. For now, however, I simply note that my approach to finding a central place for the *Metaphysical Foundations* within the critical philosophy proceeds by "triangulating" this work within a threefold philosophical and scientific context: (i) that created by the great turn of the century debate with Newton recorded in Leibniz's correspondence with Clarke, whose aftermath, from Kant's point of view, centrally involved the work of both

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Leonhard Euler and Johann Heinrich Lambert; (ii) Kant's own intellectual development from the earlier (and more Leibnizean) metaphysics and natural philosophy of his "pre-critical" period; (iii) Kant's further development in the critical period from the first edition of the *Critique*, through both the *Prolegomena* and the *Metaphysical Foundations*, to the second edition. We thereby see, in much more detail and with much more precision than is possible otherwise, exactly how Kant's life-long struggle delicately to situate himself at the intersection of Leibnizean metaphysics and Newtonian physics is finally brought to a successful – and deeply revolutionary – conclusion in the critical period.

I proceed by what I have called a *reading* of Kant's text, which, as I understand it, is distinct from both a fully contextualized intellectual history and a more traditional line-by-line commentary. Thus, for example, while the first element of my triangulation begins with the stage-setting debate between Newton and Leibniz at the turn of the eighteenth century, I do not proceed by analyzing this debate in its own right and then tracing its influence throughout the century up to Kant. Nor do I comment upon each "explication" and "proposition" of the *Metaphysical Foundations* in turn, providing intellectual context and analysis as needed. Instead, I attempt to reconstruct what I understand to be Kant's main argument as it develops through all of its manifold twists and turns, where the evidence for my reconstruction is provided primarily by Kant's words themselves. I then introduce the first element of intellectual context in my triangulation (beginning with Newton and Leibniz, and continuing with such later figures as Euler and Lambert) when, in the course of my reconstruction, I find good reason to take Kant to be responding to or engaged with the work of one or another of these authors at some particular point in the argument – to have such works open on his desk, as it were, or at least in his mind. Indeed, the works that I list in Part II of my Bibliography (as primary sources other than Kant's own works) are limited to precisely these.

Similarly, while one might well take it to be the task of a traditional commentary to situate the author's analyses against the background of as much relevant secondary literature as possible, I have by no means attempted to do so here. Instead, I engage with secondary literature only to the extent that I have found it necessary and fruitful in order to clarify and develop various specific points in my reconstruction of Kant's argument. Thus, while I have learned much about Kant's philosophy of natural science from many more authors than those cited here, most of whom are cited in my earlier book on *Kant and the Exact Sciences*, published in

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1992, the secondary literature with which I now explicitly engage comprises precisely those works (in addition to the primary sources) that I have had open on my desk (or at least in my mind) while writing this book. Accordingly, the works that I list in Part III of my Bibliography (as secondary sources) are limited to these.

My reconstruction of Kant's argument has resulted in a long and in some respects rather complicated book. This reflects the fact that Kant's treatise is extremely compressed, and my attempt to comprehend it involves the extended procedure of triangulation described above. I hope that reading the *Metaphysical Foundations* together with those elements of the surrounding context, which, in my reconstruction, I find beneath the surface, will greatly enhance our understanding of this text. Its structure and organization add a further layer of complexity. For, although Kant does present a continuous linear argument, earlier parts of the argument typically point towards later parts for their completion and full articulation. In this sense, the text is more "dialectical" than linear, in that the meaning and point of what Kant is saying at any given stage only becomes fully articulated at a later stage. My reading, which also unfolds in a linear sequence following the four principal chapters of Kant's text, thereby inherits this dialectical character; and I find it necessary, accordingly, to go back and forth repeatedly (mostly in footnotes and cross references) in considering earlier and later passages together.

However, there is one especially important part of the *Metaphysical Foundations* that I do not subject to a more or less linear reconstruction: the Preface or *Vorrede*. Here Kant discusses what he is doing from a much more general point of view, and he explicitly considers the relationship between the project of the *Metaphysical Foundations* (which he here calls the special metaphysics of corporeal nature) and that of the first *Critique* (which he here calls general metaphysics or transcendental philosophy). So the Preface, in this sense, stands outside of the main line of argument developed in the four succeeding chapters. Because of this, and because of the great importance of the question of the precise character of the relationship between Kant's special metaphysical foundations of natural science and the general metaphysics of the *Critique*, I consider central themes and passages from the Preface in two distinct steps that frame my reconstruction of the main argument – prospectively in my Introduction and retrospectively in the Conclusion.

The organization of my book into four main chapters preceded by an introduction and followed by a conclusion follows the structure of my reading. The four main chapters correspond to the four principal

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chapters of Kant's text – which themselves correspond, in turn, to the four main headings of the table of categories in the *Critique*. The consecutively numbered sections, however, reflect the structure of the continuous linear argument (cumulatively extending from chapter to chapter) that I find in the text. I thereby develop my reconstruction of this argument within the framework of Kant's architectonic – where, in particular, the final section in each of my four chapters concerns the relationship between this part of the argument and the corresponding categories.

My reading of Kant's treatise is Newtonian, in so far as I place Newton's *Principia* at the very center of Kant's argument. This much is signaled in the text of the *Metaphysical Foundations* by the circumstance that the name of Newton occurs far more often than that of any other author – and most of these references, in fact, are to the *Principia*. For this reason, among others, the idea that Newton's *Principia* is paradigmatic of the natural science for which Kant attempts to provide a metaphysical foundation has often been simply taken for granted – by both Buchdahl and myself, for example. More recent authors, however, have begun to challenge this idea and, in particular, have brought to light previously under-emphasized connections between Kant's argument in the *Metaphysical Foundations* and the Leibnizean tradition in which he received his philosophical education. This development, I believe, has been a healthy one, and there is one important issue on which I have accordingly changed my views significantly. Whereas I (along with many others) had assumed that the three mechanical laws of motion Kant articulates in his third chapter or Mechanics correspond closely to Newton's three Laws of Motion, I have now been convinced by the work of Erik Watkins and Marius Stan that this was a mistake. I shall discuss the issue substantively in what follows, but here I want to insist that this recent work has not compromised my overriding emphasis on Newton's *Principia* in the slightest. On the contrary, the very close and detailed reading I now give of Kant's fourth chapter or Phenomenology is intended, among other things, to establish the depth and centrality of Kant's engagement with Book 3 of Newton's masterpiece beyond any reasonable doubt.

The first fruits of my study of the *Metaphysical Foundations of Natural Science* were presented in a series of seminars at the University of Western Ontario in the Spring of 1984, when I held a Canada Council Visiting Foreign Scholars Fellowship. I am grateful to William Demopoulos for nominating me for this Fellowship, and to the participants in these

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seminars – which were initiated by Demopoulos and Robert E. Butts – for very valuable discussions and feedback. The result was my first publication on this topic, entitled “The Metaphysical Foundations of Newtonian Science,” in a volume edited by Butts appearing in 1986 commemorating the bicentennial anniversary of the publication of the *Metaphysical Foundations*. I am very much indebted to both Butts and Demopoulos for providing me with this first opportunity to develop my ideas and for encouraging me in their further development thereafter. I continued to return to Western Ontario in subsequent years and to receive significant encouragement and feedback from a number of others there as well, including, especially, Richard Arthur, Robert DiSalle, William Harper, and Itamar Pitowsky.

In coming to terms with Kant's relation to Newton's *Principia* I have had the great good fortune of receiving invaluable help from perhaps the two leading philosophical Newton scholars of our time: Howard Stein and George E. Smith. Indeed, I moved to Chicago in 1982 largely to take advantage of Stein's deep knowledge of Newton, and I was not disappointed. Building on multiple readings of Stein's classic discussion of “Newtonian space-time,” I was then able to interact with Stein himself and, for example, to attend his year-long course on the conceptual development of physics from Ancient astronomy through Einstein. Stein's work, more generally, provided the basis for my understanding of the conceptual framework for describing space, time, and motion that Newton had created – and, therefore, the basis for my understanding of Kant's treatment of space, time, and motion in the *Metaphysical Foundations*. I would not have been able even to get started in developing my reading of Kant's treatise without Stein's help and example.

If I could not have gotten started without Stein, I could not have finished without Smith. Smith's course on the *Principia* had become legendary, and I was therefore extremely pleased when we were able to bring him to Stanford as a Distinguished Visiting Professor in the Winter and Spring quarters of 2009. I learned more about the detailed internal workings of the *Principia* than I could have possibly imagined. Moreover, at the end of his visit Smith did me the inestimable service of reading the then current draft of my manuscript with extraordinary patience and care, and of discussing my treatment of the relationship between Kant and Newton with me over a period of several weeks. These discussions provided the indispensable basis, in connection with this issue, for my rewriting of the manuscript in the following years – as will be readily apparent to any attentive reader of the final result.

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I first became acquainted with Robert DiSalle during Stein's course on the development of physics mentioned above. I then got to know him much better at a conference on "Philosophical Perspectives on Newtonian Science" in 1987, where DiSalle commented on a paper of mine. This paper went on to become my second publication on the *Metaphysical Foundations* when it appeared, together with DiSalle's incisive comments, in a volume bearing the title of the conference in 1990. His comments, and our subsequent interactions, have been invaluable to me, as has the lasting philosophical friendship that we have enjoyed ever since. I was able to see much more of DiSalle after he subsequently moved to the University of Western Ontario, where, together with Demopoulos (one of my oldest philosophical friends), the three of us shared numerous profitable exchanges on the meaning and significance of conceptual foundations (and conceptual transformations) in the exact sciences from Newton and Kant to the present.

I have also enjoyed, for many years, lasting philosophical friendships with two leading scholars of Kant's scientific thought: Gordon Brittan and Erik Watkins. I have learned much from both of them and was particularly inspired at the beginning of my intellectual journey by Brittan's pioneering "analytical" approach to the subject in his 1978 book on *Kant's Philosophy of Science*. Watkins's later work on the Leibnizean background to the *Metaphysical Foundations* has left a significant imprint on the present book. In addition, both Brittan and Watkins read the penultimate version of my manuscript, and I am grateful to both for their supportive and helpful comments – which decisively influenced its final structure and content.

I was a Visiting Professor at the University of Konstanz in the Spring-Summer term of 1994, where I taught a course on *Kant's Philosophie der Physik* together with Martin Carrier. I had already become acquainted with Carrier through his own work on Kant's philosophy of physics, and I was then able to learn much more from him at Konstanz. His philosophical friendship has also been invaluable to me, and, more specifically, an exchange between the two of us concerning Kant's "mechanical estimation" of quantity of matter in the *Metaphysical Foundations* occupies a pivotal position in the reading that I develop here.

In the Fall of this same year I moved to the Department of History and Philosophy of Science at Indiana University, Bloomington, where I remained until finally moving to Stanford in 2002. During my years at Indiana I presented a seminar on the *Metaphysical Foundations* on a number of occasions, and to a number of gifted students with backgrounds

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in both philosophy and the history of science. Scott Tanona contributed an outstanding paper on Kant and Newton that has since appeared in *Philosophy of Science* and has significantly helped me in my further thinking. Mary Domski and Andrew Janiak are now well-known scholars of Newton and modern philosophy (including Kant) in their own right.

A particularly memorable year was 1998, when both Konstantin Pollok and Daniel Sutherland came to Bloomington as Visiting Scholars. Pollok was then in the process of completing his dissertation (later published as his *kritischer Kommentar* on the *Metaphysical Foundations*) at the University of Marburg, Sutherland in the process of completing his dissertation (on the role of Kant's concept of magnitude) at the University of California at Los Angeles. I formed lasting philosophical friendships with both of them, and the work of both figures prominently in my book.

It was during these last years at Bloomington that I began the serious writing of what eventually became this book. One of the first new steps I took was to engage in detail with the second or Dynamics chapter of Kant's treatise, and I was immediately struck by the stark contrast between the atomism of discrete point-centers developed in his pre-critical version of a dynamical theory of matter and the new view of matter as a true continuum (substantially present in each part of the space that it occupies) developed in the *Metaphysical Foundations*. I had fruitful discussions about this with my old friend Mark Wilson, who, although no Kantian, is a devoted student of continuum mechanics. His help and advice on this topic was invaluable, and it led to a more extensive (and fruitful) engagement with Euler's early work on the subject than I had previously envisioned.

Since arriving at Stanford I have presented my seminar on the *Metaphysical Foundations* on several more occasions, while I continued to work on my manuscript. I have been fortunate to have been involved with the dissertations of a number of outstanding students with serious interests in Kant (and the *Metaphysical Foundations*) here as well, including Ludmila Guenova, Teru Miyake, Samuel Kahn, and Tal Glezer. Special thanks are due to Dustin King, who took my seminar while still an undergraduate and contributed an extraordinary paper on Kant's use of the mathematical method in the *Metaphysical Foundations* that is still influencing my thinking. Moreover, the seminar completed in the Winter quarter of 2011–2012 was particularly important, since I there distributed (almost) final versions of my chapters from week to week and thereby received valuable feedback. I am grateful, in this connection, to all those

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who participated; and I owe special thanks to two students – Greg Taylor and Paul Tulipana – who prepared the index.

The most important and substantial revisions of my manuscript were accomplished in the academic year 2010–11 at the Max Planck Institute for the History of Science in Berlin. I am indebted to the many scholars I encountered there, and particularly to the three Directors at the time, Hans-Jörg Rheinberger, Lorraine Daston, and Jürgen Renn, who kindly provided me with successive positions in their three Departments as a Visiting Scholar. I am especially indebted, however, to Vincenzo De Risi, who was leading a research group at the Institute and whom I had earlier met as an outside examiner of his dissertation at the University of Pisa. This dissertation, a deeply original study of Leibniz's geometry and monadology, was published (in English) in 2007 and has since (and justly) attracted considerable attention. I am indebted to it personally for a significantly improved understanding of the relationship between the Leibnizean–Wolffian philosophy of Kant's time and Leibniz himself. De Risi is now embarked on a study of later developments in the philosophy of space and geometry, including Kant's, and we had many extremely fruitful conversations during my year in Berlin. De Risi also provided me, during this same year, with very helpful comments on my manuscript.

Towards the end of my year in Berlin I met Marius Stan, who spent time in De Risi's research group on the history and philosophy of geometry and the concept of space. It was during this time that I read (and discussed with him) Stan's important paper on Kant's Third Law of Mechanics, which exerted a significant influence (as already suggested) on my current understanding of Kant's three laws. I was also stimulated by discussions with Stan concerning his work in progress on Kant's treatment of rotation in the *Phenomenology* to clarify my own views on this central but difficult topic.

The last – but by no means least – important experience during my year in Berlin involved becoming reacquainted with Daniel Warren. I had first become acquainted with him many years ago, when I taught at the University of Pennsylvania in the late 1970s and he was a medical student there. He attended my course on the first *Critique*, and I was immediately struck by his philosophical talent. He later obtained a doctorate in philosophy from Harvard, and I had the privilege of serving on his committee. Warren's dissertation, completed in 1994, has since appeared in the Routledge Outstanding Dissertations Series and has now become a classic study of Kant's Dynamics – its influence is also very clear and present in my book. But what was most inspirational for me during my year

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in Berlin were a number of intensive conversations I had with Warren concerning the crucial question of the precise relationship between the *Metaphysical Foundations* and the first *Critique*. The conception that I ultimately arrived at and developed (in my Conclusion) of the different yet complementary perspectives of the two works was stimulated by these memorable conversations.

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Note to the paperback edition. I have made several small but essential changes in this edition: on pp. xvii and 46, correcting two significant typos; on pp. 406–8 and 611, correcting citations of Leibniz's *New Essays*; and on p. 245, correcting a mistake in elucidating a chemical term pointed out by M. Bennett McNulty.