NEWTON AS PHILOSOPHER

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Contents

Preface

This is a work in the history of philosophy. But it analyzes a figure considered first and foremost a mathematician and physicist. In recent years scholars have emphasized the importance of the complex interactions between philosophy and the natural sciences in the modern period. This study adopts a parallel perspective, attempting to shed new light on Isaac Newton by situating him within a rich philosophical milieu. I argue that this approach reflects Newton's own self-conception. He considered Descartes to be his most important predecessor among the myriad natural philosophers of the seventeenth century, and his principal contemporary interlocutors include many prominent philosophical figures, for instance Robert Boyle, Samuel Clarke, Roger Cotes, and John Locke in England, and Christiaan Huygens and Gottfried Wilhelm Leibniz on the Continent. For his supporters and detractors alike Newton single-handedly placed crucial topics on the philosophical agenda of the eighteenth century. It is hoped that this book will illuminate the philosophical aspects of Newton's work, and also bring a fresh perspective to key themes in the development of early modern philosophy.

I did not set out to write a book on Newton. Originally I was working on Kant's theoretical philosophy with Michael Friedman. When I first came to his office about a decade ago, Michael suggested that we read the Leibniz–Clarke correspondence together in preparation for my work on Kant's conception of space. This immediately sparked my interest in all things Newtonian. I eventually wrote a dissertation on what I called Kant's Newtonianism under Michael's direction – its chapter on Newton was my first attempt to understand the issues discussed in this book. Perhaps more than anything else, Michael has shaped my conception of what philosophy is – he taught me that any philosophical progress is tentative, and that our understanding of a text can always be deeper.

My early work was greatly advanced by a history of science seminar on Newton taught by Nico Bertoloni Meli: with his significant help, my paper

in his seminar eventually became my first article, on Newton's atomism and conception of divisibility. As a graduate student at Indiana I also had the pleasure of working closely with Fred Beiser and Paul Franks. It was Fred who encouraged me to study German more intensely in Berlin, and his astonishing range of historical and philosophical knowledge served as an inspiration to me. I first met Paul Franks while I was a graduate student at Michigan – his philosophical depth and originality immediately sparked my interest in Kant, and I was blessed to continue working with him after we both moved to Indiana. I owe my original interest in Kant not only to Paul, but also to the incomparable David Hills, whose knowledge will never be plumbed. Both Fred and Paul have publicly acknowledged the extraordinary constellation of faculty and graduate students working on Kantian topics in Bloomington in the late 1990s – I benefited greatly from participating in this group. The Kant reading group in Bloomington, run by Graciela De Pierris, was very important for my work. Among many other interlocutors I would especially like to thank Hess Chung and Christian Johnson, the two most insightful and knowledgeable graduate students I have ever known – I learned immensely from our almost nightly discussions over mediocre Chinese food and endless lukewarm tea at the famous Dragon restaurant. David Finkelstein, Karen Hanson, and Hindy Najman were also sources of philosophical wisdom in Bloomington. While I held a graduate fellowship at Tel Aviv University I learned much about Kant from Susan Neiman, who was a generous host during my year in Israel. I gave my very first public lecture at Tel Aviv, on Kant and Newton (of course). Once my graduate work was over, I was fortunate to receive a postdoctoral fellowship at the Dibner Institute at MIT while George Smith was its acting director. No one who knows George will be surprised to learn that he often took two or three hours out of his busy schedule to discuss Newton with me. There is no better interlocutor anywhere for discussing Newton. While at the Dibner I learned a great deal from the history of mechanics reading group, which included Moti Feingold, Al Martinez, Jim Voelkel, George, and Nico.

My colleagues at Duke have been extremely supportive – because of their open-mindedness, I was able to bracket my research on Kant and write this book. Among my many helpful Duke colleagues I would especially like to thank Robert Brandon, Fred Dretske, Tim Lenoir, Alex Rosenberg, David Sanford, Laurie Shannon, Barbara Herrnstein Smith, and Susan Sterrett for their comments on my work. For his official mentorship, and constant fruitful advice, I thank Tad Schmaltz; whenever I have a perplexing question, I simply walk next door.

Various aspects of this book have been presented at the following venues: the joint meeting of the History of Science Society and the Philosophy of Science Association in Vancouver; the fifth and sixth international congresses of the History of Philosophy of Science Group (HOPOS) in San Francisco and in Paris; the Cartesian circle at Irvine; early modern philosophy workshops at the University of Pennsylvania and Mansfield College, Oxford; Newton conferences at Leiden University and at the Van Leer Institute in Jerusalem; and the philosophy departments at Toronto and Tufts. Numerous colleagues and friends have given me helpful criticism and feedback over the years – in addition to those mentioned above, I would like to thank Donald Ainslie, Lanier Anderson, Liz Anderson, Jeffrey Barrett, Zvi Biener, Katherine Brading, Justin Broackes, Janet Broughton, Anjan Chakravartty, Graciela De Pierris, Karen Detlefsen, Rob DiSalle, Mary Domski, Lisa Downing, Katherine Dunlop, Mordechai Feingold, Alan Gabbey, Daniel Garber, Don Garrett, Niccolo Guicciardini, Bill Harper, Sally Haslanger, Gary Hatfield, Barbara Herman, Nick Huggett, Rob Iliffe, Andrew Jainchill, Dana Jalobeanu, Lynn Joy, Sukjae Lee, Martin Lin, Paul Lodge, Jeff McDonough, Ernan McMullin, Scott Mandelbrote, Mohan Matten, Sy Mauskopf, Christia Mercer, Alan Nelson, Bill Newman, Eric Schliesser, Alison Simmons, Ed Slowik, Chris Smeenk, Kyle Stanford, Howard Stein, Friedrich Steinle, Daniel Sutherland, Jackie Taylor, Karin Verelst, Daniel Warren, Jessica Wilson, and John Young.

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When I published a collection of Newton's philosophical writings for Cambridge University Press, Hilary Gaskin was a wonderful editor; she has been once again with this volume. I am very grateful for her support of my work. I would also like to thank two anonymous referees who read the manuscript for Cambridge and made many fruitful suggestions. Many thanks to my research assistants, Shame Chikoro and James Abordo Ong.

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Lastly and most importantly: I dedicate this book to Rebecca Luna Stein, my partner, and to Isaac Janiak Stein, our son. Rebecca's intellectual courage inspires me; she is a constant source of insight and also of love. Without her I would have lacked the courage to write this book. True to his name, Isaac brings great laughter to our lives each day. Raising him with Rebecca has been the most philosophically potent experience of my life.

I

Newton as philosopher, the very idea

What does it mean to treat Newton as a philosopher?[1] We cannot identify any overarching philosophical position with Newton, as we identify dualism with Descartes, monism with Spinoza, or even classical empiricism with Locke. Newton never wrote a systematic philosophical treatise of the order of the *Meditations*, the *Ethics*, or the *Essay*. This was a significant choice, for he was perfectly familiar with such treatises, having already analyzed some in his youth. Even in his voluminous correspondence, and in his most important unpublished manuscripts, we do not find a systematic engagement with metaphysical issues akin to Descartes's. Newton positioned himself as a strong critic of Cartesianism, but his response to Descartes is significant as much for its lacunae as for its central claims. Thus these canonical philosophical figures, with their canonical texts, cannot serve as a model here.

To treat Newton as a philosopher might simply be to avoid an anachronistic characterization of his intellectual milieu. As scholars of the early modern period regularly note, the intellectual categories and disciplines of Newton's day – which ranges, roughly, from 1660 until 1730 – differ radically from our own. What we would consider to be separate fields of study – for instance, aspects of what we categorize as philosophy, especially metaphysics and epistemology, the physical sciences, and even theology – were interwoven into one overarching field called natural philosophy.[2]

[1] In a recent essay Calvin Normore raises this issue in passing, writing: "One of the most annoying philosophical questions is 'What is Philosophy?' Of course Philosophy is what Philosophers (*qua Philosophers*) do but who are the Philosophers? There is always Socrates but what about Isocrates? Leibniz, clearly, but what of Newton?" – Normore, "What is to be Done in the History of Philosophy," 75. See also the helpful discussion in Gabbey, "Newton, Active Powers and the Mechanical Philosophy," 329–31; Gabbey and I essentially agree on the best way to characterize Newton's status as a "philosopher."

[2] To my knowledge Edward Grant has written the only history of natural philosophy (see n. 4 below). On the very idea of natural philosophy, see Stein, "On Philosophy and Natural Philosophy in the Seventeenth Century," section 2 of Hatfield, "Was the Scientific Revolution a Revolution in Science?", Shapiro, *Fits, Passions and Paroxysms*, 26–40, and the incomparable treatment in Funkenstein, *Theology and the Scientific Imagination*. For an influential pre-Newtonian conception,

Hence to treat Newton as a philosopher in a historically accurate way might be to treat him as a natural philosopher, rather than more narrowly as a scientist, physicist, or mathematician.[3] Since Newton's *magnum opus* is called *The Mathematical Principles of Natural Philosophy*, there is little doubt that this attitude reflects his own self-conception.[4]

Yet this is only the beginning of the story. Newton certainly conceived of himself as a natural philosopher, among other things, but a brief glance at his *Principia* – including its full title – reveals the fundamental importance

see the Cartesian treatise by Rohault, *System of natural philosophy*, vol. I: 20–1. Rohault is especially concerned to indicate that natural philosophy analyzes objects within their natural state, where the contrast class is not the quasi-Aristotelian "violent" state of a thing, but rather some state that God creates against the ordinary course of nature. Hence Rohault explicitly brackets miracles, and what he calls "the mysteries of faith."

[3] As is well known, the word "scientist" was coined in 1833 by William Whewell when reviewing Mary Somerville's work (see Danielson, "Scientist's Birthright"); thus Somerville was likely the first person ever to be called a scientist. However, the term "science" was often used in the early modern period – see n. 4.

[4] In *A History of Natural Philosophy* Grant argues that we should not be "misled" by Newton's title, for he "might have used either of two medieval and early modern synonyms for natural philosophy, namely, 'natural science' (*scientia naturalis*) or 'physics' (*physica*)," to produce, respectively, the titles "Mathematical Principles of Natural Science" and "Mathematical Principles of Physics" (314). Grant contends that Newton kept his famous title – rather than the title *De Motu Corporum libri duo* – because it would help Halley, who saw the *Principia* through the press, to sell more books. On 20 June 1686, Newton wrote to Halley as follows:

I designed the whole to consist of three books . . . The third I now design to suppress. Philosophy is such an impertinently litigious lady that a man had as good be engaged in law suits as have to do with her. I found it so formerly [he presumably means the 1670s optics disputes] & now I no sooner come near her again but she gives me warning. The two first books without the third will not so well bear the title of *Philosophiae naturalis Principia Mathematica* & therefore I had altered it to this *De Motu corporum libri duo*: but upon second thoughts I retain the former title. Twill help the sale of the book which I ought not to diminish now tis yours. (*Correspondence*, vol. II: 437)

This was written in response to Halley, who had written to Newton two weeks earlier that he ought to include book III because "the application of this mathematical part, to the system of the world; is what will render it acceptable to all naturalists, as well as mathematicians, and much advance the sale of the book" (*Correspondence*, vol. II: 434). For his part, Grant concludes: "the argument that Newton did not believe he was doing natural philosophy in the *Principia* gains credibility from Newton himself" (*A History of Natural Philosophy*, 315). But this is misleading. Newton ultimately included the third book of the *Principia*, and his substantive point in his letter – which coheres with Halley's substantive point in his letter – is plain: without the third book, in which Newton discusses what he calls "the system of the world," the first two books of the *Principia* could not very accurately be called natural philosophy; rather, they would be better described as two books on the motion of bodies. For Newton as for Halley, natural philosophy was not principally concerned with just any motion of bodies that was tractable through mathematical analysis; rather, it was concerned with the mathematical analysis of the motions of the bodies within our solar system – within nature as we perceive it in our vicinity of the universe. And that, of course, is part of a long tradition in natural philosophy. Newton's innovation is to provide a mathematical analysis of the motions of these bodies. On Halley's role in printing the *Principia* see Cohen, *Introduction to Newton's "Principia,"* 130–42; for Halley's relation to Newton, see the materials reprinted and discussed in Cohen and Schofield, *Isaac Newton's Papers and Letters*, 397–424, which includes Halley's review of the first edition of the *Principia* in the *Philosophical Transactions of the Royal Society*.

of the fact that his principles are "mathematical."[5] Newton titled his work to establish a replacement for Descartes's *Principles of Philosophy*, first published in Amsterdam in 1644, a text that Newton read carefully and kept in his personal library.[6] The differences between the two works are stark: whereas Descartes's text is familiar to historians of modern philosophy, with its focus on broadly conceived epistemic and metaphysical issues, Newton's text is a highly technical mathematical work that apparently ignores such issues altogether. Whereas Descartes's *Principia* attempts to account for an immense range of phenomena – tackling everything from global skepticism about human knowledge to God's immutability to the nature of heat, light, weight, and so on – Newton's text focuses specifically on the mathematical analysis of motion and the forces that cause it. The audiences of the two works differed accordingly: Descartes was comprehensible to anyone with a decent education in the codified Aristotelian corpus, or late Scholastic natural philosophy. In contrast, Newton's *Principia* was comprehensible only to the most sophisticated mathematicians. Descartes thought that metaphysics and physics could follow the same humanistic

[5] This is, of course, signaled in the very title of the *Principia*, but it characterizes his pre-*Principia* work as well. Newton had insisted on the importance of mathematics within natural philosophy already in his early optical research. Consider, for instance, this remarkable passage from his *Lectiones Opticae* of 1670, delivered as his inaugural Lucasian Professor lectures:

> the generation of colors includes so much geometry, and the understanding of colors is supported by so much evidence, that for their sake I can thus attempt to extend the bounds of mathematics somewhat, just as astronomy, geography, navigation, optics, and mechanics are truly considered mathematical sciences even if they deal with physical things: the heavens, earth, seas, light, and local motion. Thus although colors may belong to physics [*ad Physicam pertineant*], the science of them must nevertheless be considered mathematical, insofar as they are treated by mathematical reasoning. Indeed, since an exact science [*accurata scientia*] of them seems to be one of the most difficult that philosophy is in need of, I hope to show – as it were, by my example – how valuable mathematics is in natural philosophy. I therefore urge geometers to investigate nature more rigorously, and those devoted to natural science to learn geometry first. (*Optical Papers*, vol. I: 86–7; Shapiro trans.)

Isaac Barrow preceded Newton as the Lucasian Professor at Cambridge; for a helpful discussion of his influence on Newton's conception of the role of mathematics within natural philosophy, see Shapiro, *Fits, Passions and Paroxysms*, 30–40. For a brief discussion of the teaching of mathematics to Cambridge undergraduates in Barrow's and Newton's day, see Costello, *The Scholastic Curriculum at Early Seventeenth-Century Cambridge*, 102–4.

[6] When Newton wrote to Hooke in a famous letter, "If I have seen further it is by standing on the shoulders of giants," he included Descartes among them (*Correspondence*, vol. I: 416). Remarkably, Newton sometimes referred to the *Principia* as *his* "*Principia Philosophiae*" – for instance, in his (anonymous) "An Account," 180 and 198; cf. the notes of Cohen and Whitman as editors at *Principia*, 11. For discussion see especially the extensive chapter on Descartes and Newton in Koyré, *Newtonian Studies*, and also Cohen, "Newton and Descartes"; cf. Stein, "Newtonian Space–Time," and "Newton's Metaphysics." In *Elements of Early Modern Physics*, Heilbron writes that as of the mid-seventeenth century "Descartes then replaced Aristotle as the foil against which British physics tested its metal" (30).

methods, but for Newton physics was essentially mathematical.[7] Although both works belong to the seventeenth-century canon in natural philosophy, then, they represent two fundamentally distinct traditions.[8]

Newton eschews many of the issues that Cartesians placed at the center of natural philosophy, but not all of them. There is a danger of his overwhelming influence on physics in the eighteenth century blinding us to his own conception of how a mathematical investigation of natural phenomena might intersect with broader metaphysical concerns, such as God's relation to the physical world. Of course, one of the primary aspects of the *Principia*'s intellectual impact in the eighteenth century was the separation it effected between technical physics on the one hand, and philosophy on the other. In the hands of figures like Laplace and Lagrange, Newton's work led to the progressive development of Newtonian mechanics, and its practitioners embraced a conception of their discipline in which philosophical matters played little role. Yet these facts obscure Newton's own conception of his work. As he said repeatedly throughout his career, investigating the first cause is a proper part of natural philosophy.[9] Thus

[7] Newton and Descartes may also have differed in their understanding of mathematics, especially regarding geometry and geometric construction – see Domski, "The Constructible and the Intelligible." In this paper Domski helpfully indicates why Newton's famous discussion of geometry and mechanics in the author's preface to the first edition of his text (*Principia*, 381–2) may be misleading (1120–3).

[8] The treatment that the two works receive within modern scholarship reflects this fact: whereas Descartes's work is read almost exclusively by historians of philosophy, Newton's work is read almost exclusively by historians of science. This parallel masks a further point, however, for Newton's influence on modern mathematical physics is also reflected in part by the fact that historians of science, but not physicists, approach his work as a canonical text. For it is partly in virtue of Newton's success in founding the modern discipline of physics that contemporary physicists evince little interest in canonical texts, or in historical reconstructions. Newton himself already prefigured this perspective in the *Principia*, when he incorrectly attributed the first two laws of motion to Galileo, who certainly never articulated them in their Newtonian form (*Principia*, 424). But textual accuracy, and historical understanding, is presumably not Newton's aim in this passage; rather, Newton sees himself working within the same tradition as Galileo, and he attempts to further Galileo's work, for instance by providing a new understanding of why all bodies in free fall exhibit the same acceleration. On Galileo, see Bertoloni Meli, *Thinking with Objects*, 145–6.

[9] This represents Newton's consistent view, expressed in both published and unpublished materials, throughout his mature intellectual life. Among his published works see the General Scholium, which Newton added to the end of his text (*Principia*, 943) and the queries (*Opticks*, 369, 405). Among his unpublished works, see his first letter to Richard Bentley in 1692 (*Philosophical Writings*, 95–6), and his draft of the first edition preface to the *Opticks*, in which he writes: "One principle in Philosophy is the being of a God or Spirit infinite eternal omniscient omnipotent, & the best argument for such a being is the frame of nature & chiefly the contrivance of the bodies of living creatures" (McGuire, "Newton's 'Principles of Philosophy,'"183). Newton then proceeds to recount a design argument, one that appears elsewhere in his published works (e.g. in the General Scholium). The very next principle is the impenetrability of matter, followed by a third principle, which is expressed by the law of universal gravitation.

the key to treating Newton as a philosopher lies in discovering how the mathematical treatment of force and motion forms part of the same enterprise as an investigation of seemingly separate metaphysical issues, such as God's relation to the world.[10]

Yet even this characterization remains too narrow: Newton tackled numerous "metaphysical" topics separate from an analysis of the divine being. He did so, perhaps, as a matter of necessity. The astonishing success of Newtonian mechanics in the eighteenth century – a fact confronted by most of the major philosophers of that period – should not mislead us into thinking that Newton's work was immediately accepted by those in a position to assess it. On the contrary, the theory of gravity in the *Principia*, which first appeared in 1687, was not merely challenged on narrow mathematical or empirical grounds, but fundamentally rejected for its violation of the norms established by adherents of the mechanical philosophy, such as Leibniz and Huygens.[11] Thus in his correspondence after 1687, in the queries to the *Opticks*, and especially in the second edition of the *Principia* (1713), Newton was forced to defend his mathematical treatment of force and motion on fundamental metaphysical grounds.[12] These elements of Newton's work are crucial to the account in this book.

[10] For a significantly distinct perspective on these issues, see Cohen and Smith's introduction to their volume, *The Cambridge Companion to Newton*. See also the illuminating discussions in Hatfield, "Metaphysics and the New Science," 144–6, and in Friedman, "Metaphysical Foundations of Natural Science," 239.

[11] For his part Leibniz conceived of Newton as a metaphysician, although he contended that he had "little success in metaphysics" in a letter to J. Bernoulli in March of 1715 (*Correspondence*, vol. VI: 212–13). He responded to the *Principia* in his *Tentamen* of 1689 (discussed in ch. 2), in a significant 1693 letter to Newton (*Philosophical Writings*, 106–7, also discussed below), and in much of his correspondence late in life, especially the famous series of exchanges with Clarke in 1715 and 1716. Leibniz's criticisms of Newton are well known, but Huygens's may not be. He wrote to Leibniz in November of 1690 as follows: "Concerning the cause of the tides given by M. Newton, I am by no means satisfied, nor by all the other theories that he builds upon his principle of attraction, which seems to me absurd, as I have already mentioned in the addition to the *Discourse on Gravity*" (*Œuvres complètes*, vol. IX: 538). I first learned of this important letter from George Smith. Huygens maintained his adherence to the mechanical philosophy in the face of Newton's deviation from its norms in his theory of gravity – see especially his *Discours sur la cause de la Pesanteur* in *Œuvres complètes*, vol. XXI: 129–30, 159–60 (this is the original pagination, given marginally in the text). Newton was present when Huygens introduced his *Discours* to the Royal Society in 1689 (Westfall, *Never at Rest*, 488). Huygens and Leibniz each received a copy of the *Principia* from Newton himself – see *Never at Rest*, 472. It should be noted that Huygens also uncovered empirical reasons for doubting Newton's conclusion in book III of the *Principia* that gravity acts universally on all bodies: see the helpful account in Schliesser and Smith, "Huygens's 1688 Report," 5–7.

[12] Ironically, Newton's early optical work, published in the Royal Society's *Philosophical Transactions* in the 1670s, was similarly greeted with fundamental objections and, from Newton's point of view at least, with fundamental misinterpretations. This episode also spawned a series of responses from Newton regarding, among other things, the proper methods in optical research and theorizing.

The extensive debate about Newton's methods – which spawned the famous correspondence between Leibniz and Clarke in the early eighteenth century – suggests that there were two revolutionary developments in seventeenth-century natural philosophy. One involved a shift from neo-Aristotelian or "Scholastic" natural philosophy to Cartesianism, and the other a shift from mechanistic to Newtonian natural philosophy. This second shift raised philosophical problems as profound as those accompanying the first. The first revolutionary development involved significant conceptual continuity. Although the Aristotelians in the late sixteenth and early seventeenth centuries resisted the idea that everything in nature could be explained mechanically – arguing that some phenomena must be explained through a combination of matter and form – they would certainly have found that idea intelligible. The neo-Aristotelians had a mechanics that, although not foundational like Cartesian mechanics, and although not part of an overarching "mechanical philosophy," did involve the explanation of some processes in terms of matter and motion, where matter is characterized solely by the size and shape of its parts. Descartes then made the widespread intelligibility of his mechanical explanations a hallmark of his work.[13]

With the revolutionary shift from mechanistic to Newtonian natural philosophy after 1687, however, we find a fundamental lack of conceptual continuity. Just as the mechanists pronounced Scholastic explanations employing matter and form to be unintelligible, they treated Newton's explanation of various gravitational phenomena as equally incoherent. The criticisms mirrored one another in a significant way: Leibniz maintained for years that Newton had revived precisely the incoherent Scholastic talk of occult qualities that the mechanists had attempted to expunge permanently

Although I discuss some of these issues briefly in ch. 2, largely to underscore the parallels between the debates in optics and those in physics, this book focuses especially on the latter. For further details, see Harper and Smith, "Newton's New Way of Inquiry."

13 See especially the discussion in Garber, "Descartes, Mechanics, and the Mechanical Philosophy." When reflecting on the character of his own work, Descartes writes in section 200 of *Principia Philosophiae*: "I have used no principles in this treatise which are not accepted by everyone; this philosophy is not new but is very old and very common." He then elaborates:

> I have considered the shapes, motions and sizes of bodies and examined the necessary results of their mutual interaction in accordance with the laws of mechanics, which are confirmed by reliable everyday experience. And who has ever doubted that bodies move, have various sizes and shapes, and various different motions corresponding to these differences in size and shape; or who doubts that when bodies collide bigger bodies are divided into many smaller ones and change their shapes? (*Principia Philosophiae*, vol. VIII-1: 323)

from natural philosophy.[14] Newton always embraced the familiar view that God represents a fundamental component of our understanding of nature, expressing that view even in the *Principia*'s first edition.[15] But with the mechanistic charges of unintelligibility, he was pressed into more extensive debates concerning the metaphysical presuppositions and implications of his mathematical treatment of force and motion. In the course of these discussions Newton consistently articulated a compelling and overarching conception of the relation between mathematical physics on the one hand, and more clearly metaphysical concerns on the other. These lie at the center of this book.

Newton's response to the intellectual controversy generated by the *Principia*, in turn, helps to illuminate the narrowness of his metaphysical ruminations. Newton lacks a metaphysical system that addresses the major topics raised by his most important predecessor, Descartes, or his most insistent critic, Leibniz. His discussions are largely limited to questions about the ontology of space and time, the laws of motion and the forces that cause motion, our knowledge of matter within physics, and God's relation to the physical world.[16] This reflects Newton's famous reluctance to engage

[14] One of Leibniz's most colorful discussions occurs in a letter he wrote to Nicolas Hartsoeker, later published in English translation in the *Memoirs of Literature* in 1712:

> Thus the ancients and the moderns, who own that gravity is an *occult quality*, are in the right, if they mean by it that there is a certain mechanism unknown to them, whereby all bodies tend towards the center of the earth. But if they mean that the thing is performed without any mechanism by a simple *primitive quality*, or by a law of God, who produces that effect without using any intelligible means, it is an unreasonable occult quality, and so very occult, that it is impossible that it should ever be clear, though an angel, or God himself, should undertake to explain it. (*Philosophical Writings*, 112)

He makes a similar charge in his last letter to Clarke (L 5: 113, *Die philosophischen Schriften*, vol. VII: 417). I discuss this issue in depth in ch. 4.

[15] In corollary five to proposition 8 of book III, Newton discusses the density of the planets and their placement relative to the sun, arguing: "God therefore placed the planets at different distances from the Sun so that according to their degrees of density they may enjoy more or less of the Sun's heat" – see *Principia Mathematica*, vol. II: 583 note. The reference to God was removed in the second edition (*Principia Mathematica*, vol. II: 582–3; *Principia*, 814), but that edition included the new General Scholium, which contains the following remark: "This most elegant system of the sun, planets, and comets could not have arisen without the design and dominion of an intelligent and powerful being" (*Principia*, 940). Although Newton removed the original passage from the second edition, at least one of his confidants, Samuel Clarke, continued to cite it years later – see his Boyle Lectures for 1704, *A Demonstration of the being and attributes of God*, 82. For an excellent discussion of these issues, see Cohen, "Isaac Newton's *Principia*, the Scriptures, and the Divine Providence," 529ff.

[16] Intriguingly, *De Gravitatione* – an unpublished manuscript in which Newton presents numerous criticisms of Cartesian natural philosophy – is not an exception to this point, for although it was most probably written before 1687, it concerns the somewhat narrow range of issues that Newton tackles in later published texts and correspondence. Thus in *De Gravitatione* Newton discusses motion, the ontology of space and time, the nature of material bodies, mind–body dualism, and God, rejecting

in intellectual disputation – evident already in his earliest optical writings in the 1670s – and also his attempt to rebut mechanist criticisms, for Newton and the mechanists were engaged in a philosophical dispute regarding physics itself. Nonetheless, as we shall see, Newton inherits a series of fundamental concepts from the seventeenth-century metaphysical tradition represented by figures such as Descartes. He consistently articulates his most basic views by employing the concepts God, substance, and action.[17] Hence he does not typically employ novel concepts in his work within natural philosophy; the novelty of his views lies in part in his transformation of these concepts in sometimes controversial ways.

Despite his use of well-worn metaphysical concepts – such as God and substance – that are central to the Cartesian system, Newton's basic orientation toward philosophical issues differs fundamentally from that evinced by Descartes. Given Descartes's view of the relation between metaphysics and physics, responding to skepticism is as significant for the latter as it is for the former. Metaphysics serves as the foundation for physics – *Principia Philosophiae* presupposes basic metaphysical principles concerning (e.g.) the essence of body and the nature of God. These metaphysical principles, in turn, are firmly established by surviving a confrontation with a fundamental skepticism about our knowledge of nature; the defeat of this skepticism signals that we can be certain of our basic metaphysical knowledge. Since physics presupposes the first principles of metaphysics, and since metaphysics is characterized by a struggle to establish its own authority, our knowledge in physics hangs in the balance when we confront radical skepticism in the *Meditations*. For Newton, in contrast, global skepticism is irrelevant – he takes the possibility of our knowledge of nature for granted.[18] Instead, the primary epistemic questions confronting us are raised by

various Cartesian views along the way, but he ignores other issues in Cartesian metaphysics, such as the proofs for the existence of God, the proper response to skepticism, the question of innate ideas, etc. For a helpful suggestion about the dating of *De Gravitatione* see Feingold, *The Newtonian Moment*, 25–6. For an extensive discussion of *De Gravitatione*, see Steinle, *Newtons Entwurf "Über die Gravitation."*

17 Many thanks to Michael Friedman for discussion of this point.

18 So if science is separated from philosophy in Newton's hands, it is not through the defeat of skepticism, but through its rejection as a fundamental problem confronting our knowledge of nature. This may be partially definitive of the modern distinction between science and philosophy. Whereas modern science continued to ignore skepticism, taking it for granted that we can achieve knowledge of nature, philosophy continued to be preoccupied by skepticism of various varieties, assuming that we must confront it in one way or another. Cf. Bloch, *La Philosophie de Newton*, 492. Thanks to Sean Greenberg for discussion of this point.

physical theory itself. Thus Newton eschews one of the animating features of the early modern philosophical debate.[19]

So we might say that Newton is systematic and philosophical without articulating a philosophical system.[20] He never embraces a global metaphysical position such as dualism or monism, and he never presents an overarching theory of knowledge or response to global skepticism. But he deals systematically with those elements of metaphysics that are intimately connected with his work in mathematical physics. In the course of defending his work from the mechanists he presents a novel conception of the relation between physics and metaphysics. This book aims to clarify that conception.

The rest of the book proceeds as follows. In ch. 2 I focus on three interpretations of Newton's conception of the relation between physics and metaphysics, each of which responds explicitly to the issues raised above. The chapter's dialectic can be expressed in this way: whereas the first interpretation, which originates in the eighteenth century, conceives of Newton as a kind of anti-metaphysician, the second attempts to account for his anti-metaphysical remarks by arguing that he transforms traditional metaphysical questions into empirical ones. The third interpretation, which I defend throughout this book, acknowledges the significance of Newton's transformation of certain metaphysical questions into empirical ones, but also discusses his commitment to an overarching metaphysical picture of God's relation to the physical world.

The following three chapters emphasize Newton's novel approach to traditional metaphysics, while highlighting his commitment to a metaphysical framework centering on God. That framework is minimalist, but involves a clear conception of God's relation to the world, the nature of action, and the ontology of space and time. In ch. 3 I argue that Newton can retain his traditionalist rejection of action at a distance while postulating that all material objects in the world interact gravitationally in accordance with the theory in the *Principia*. Thus Newton is able simultaneously to reject the

19 This difference is reflected in the Cartesian and Newtonian texts themselves. Descartes makes allowances for those who are not initiates in his project, beginning his *Meditations* from a universally accessible standpoint – the perspective of a knowing agent with ordinary sensory beliefs that can be called into question through universally accessible procedures, such as the contemplation of the possibility that one believes one is awake, but is actually dreaming. Newton, in contrast, makes no allowances for the lay reader, beginning his deductions in the *Principia* from a standpoint that is accessible only to mathematicians. This is also reflected in the point made in n. 18.

20 Maclaurin describes this aspect of Newton's achievement in a typically favorable – and generally accurate – way at the end of book I of *An Account*, 95–6. See also Gabbey, "Newton, Active Powers, and the Mechanical Philosophy," 335. Thanks to Eric Schliesser for discussion of this point.

mechanical philosophy, while avoiding a kind of physical action that he famously calls "inconceivable." I then argue in ch. 4 that Newton's rejection of mechanist principles runs even deeper – it is reflected in his conception of the essence of matter, and in his understanding of the knowledge of matter expressed in physical laws. This indicates the strength of Newton's commitment to a physical approach to metaphysical problems, for he transforms the metaphysical discussion of physical action and the nature of matter among the mechanists into an empirical investigation. Despite these revolutionary views, however, Newton maintains his allegiance to a fundamental metaphysical framework centered on his (often provocative) conception of God. This framework is evident especially in Newton's famous discussion of absolute space, the focal point of ch. 5. Finally, ch. 6 employs my interpretation of Newton's metaphysical framework to illuminate his refusal to embrace action at a distance, despite significant empirical pressure originating with the *Principia* itself. Throughout his mature intellectual life, I argue, Newton articulated a minimalist but significant conception of God's action within the spatiotemporal world of the natural philosopher. The depth of his commitment to this conception is underscored by the fact that he never wavered from it, even in the face of the substantial controversies that it generated over the years. Newton was, in that regard, an impressively consistent thinker.