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Never at Rest

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A Vulgar Mechanick can practice what he has been taught or seen done, but if he is in an error he knows not how to find it out and correct it, and if you put him out of his road, he is at a stand; Whereas he that is able to reason nimbly and judiciously about figure, force and motion, is never at rest till he gets over every rub.

Isaac Newton to Nathaniel Hawes

25 May 1694

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NEVER AT REST

A Biography of Isaac Newton

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Preface to the paperback edition

NOT a great deal of time has passed since I wrote a preface for the first printing of this book, and with that preface brought more than twenty years of work to a conclusion. After such a period I was, I confess, ready to move on to other matters, and with the exception of one Newtonian topic, I have done so. As a result I am not now prepared or inclined to revise the work in any fundamental way. Beyond correcting a few typographical and factual errors, I confine myself to indicating here some passages that reviews and recent publications have convinced me ought to be altered, and to mentioning the one topic on which my own research since completing the biography has led me to a deeper understanding.

In Chapter 2, pp. 57–58, I assert that Newton's secondary education did not include any significant mathematics. Recently, D. T. Whiteside has uncovered in Grantham a pocketbook dated 1654 that contains extensive "Notes for the Mathematicks." [See "Newton the Mathematician," in Z. Bechler, ed., *Contemporary Newtonian Research* (Dordrecht, 1982), pp. 110–11.] It appears to Whiteside to have been written in the hand of Henry Stokes, master of the grammar school of Grantham, which Newton began to attend during the year following the notes. Although most of the passage is devoted to elementary calculations, such as rules for determining the areas of fields, that a country gentleman might have found useful, not all of it remains at this level. Sixty-five pages on "The Measureing of Triangles [&] Circles" include instructions on how to calculate a table of sines (a task that Newton undertook, albeit briefly, at Cambridge), and a method for inscribing an equilateral septuagon in a circle (another topic that Newton encountered anew in his reading at Cambridge). Stokes even included the limits that Archimedes established for the value of pi, more than $3^{10/71}$ and less than $3^{1/7}$. As Whiteside does not fail to remark, this passage of the "Notes" inevitably reminds one of the geometric figures incised in the plaster at Woolsthorpe. The pocketbook strongly implies that my words on Newton's grammar school education need basic revision. It is highly probable that he was far from a novice in mathematics when he arrived at Cambridge, and the sudden immersion in mathematical study that began sometime during his undergraduate years as well as the burst of creativity that accompanied it, though not rendered

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one whit less stunning by this new information, do become considerably more comprehensible.

In his review of this book and in private communications with me, Whiteside has argued that in Chapter 4, the major discussion of Newton's mathematics (and I would add, in pp. 23–38 of Chapter 1, the discussion of seventeenth-century mathematics before Newton), I have neglected the distinction between indivisibles and infinitesimals, and that, as a result, the clarity of my exposition and some of the conclusions I draw suffer. I do not consider myself to be an historian of mathematics, and I am not now ready to plunge back into the demanding world of seventeenth-century mathematics in order to more fully clarify the matter in my own mind. Consequently, I am not able here to offer the revisions that are probably in order. Suffice it to say that in my experience, when Whiteside speaks on seventeenth-century mathematics, the wise attend. Hence I caution readers that in those passages, where something of importance to them involves indivisibles or infinitesimals, they would do well to consult the work of others, such as Whiteside's edition of the *Mathematical Papers*, his other writings, or the books I cite in the footnotes and bibliography.

Chapter 9 contains a discussion (pp. 351–6) of a theological work, *Theologiae gentilis origines philosophicae*, which Newton began to compose in the 1680s. The more I thought about it and about the fact that Newton continued to refer to it the rest of his life, the more important it seemed to me. About the time this biography first appeared, I became convinced that I had not sufficiently understood this manuscript; it constitutes the one Newtonian topic that I have explored further since publication of the book. The study confirmed my growing belief that it was the most important theological treatise Newton ever composed, even though he never put it in a finished form. One must not be misled by the earnest narratives, which ring so quaintly in our twentieth-century ears, of the lives of Noah and his offspring. These were the familiar scholarly themes of the day, and Newton could no more leap out of his own age than any of us can. He could, however, bend this accepted material to radical new purposes. It appears to me that the *Origines* can be adequately described only as the first of the deist tracts. I have discussed it at length and compared it to superficially similar works upon which he drew in an essay—"Isaac Newton's *Theologiae Gentilis Origines Philosophicae*," in W. W. Wagar, ed., *The Secular Mind* (New York, 1982), pp. 15–34. To the best of my knowledge, this essay is the only discussion in print, beyond the brief passage in the present biography, of this important Newtonian manuscript, and I urge anyone interested in Newton's theological views to consult my essay.

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I devote pp. 740–4 of Chapter 14 to the correction of the error in Proposition X, Book II, for the second edition of the *Principia*, remarking at one point that “One would like to know more about the circumstances.” Volume 8 of Whiteside’s edition of the *Mathematical Papers* has appeared since I wrote that line, and, as a result, we do know more about the circumstances. The treatment of that matter (pp. 312–424) is one of the *tours de force* of Whiteside’s final volume. He assembles the papers on which Newton initially confirmed the validity of Bernoulli’s objection, and he identifies, as Bernoulli was not able to do, the precise nature of the error. There follow the manuscripts of six successive attacks on the problem, together with seven other draft passages, leading up to Newton’s successful location of the error and his correction of it. Indeed, as the manuscripts reveal, Newton even proceeded to an alternative demonstration of the correct result. Most interesting of all, Whiteside argues persuasively that only a computational error prevented Newton from realizing that he could have corrected the proposition within the framework of the original demonstration. Bernoulli seized on the radically amended proposition – for which he claimed credit, as the newly printed pages made its last-minute insertion clear – as evidence that Newton had not understood second derivatives when he composed the first edition of the *Principia*. That charge, endlessly repeated, figured prominently, much to Newton’s embarrassment, in the priority dispute. This brief paragraph cannot begin to do justice to the richness of Whiteside’s presentation, to which I refer readers wishing to know more about the incident.

In his review of the present work in the *American Historical Review*, 87 (1982), 1353, I. Bernard Cohen points out that the interpretations in the book are mine and are not necessarily shared by other Newtonian scholars. I never intended it otherwise. When I signed my name to the book, I understood that I was taking sole responsibility for its content, and I rather assumed that readers would understand the same. I have no privileged access to final truth, of course, and Professor Cohen may prove to be right about the interpretations he challenges in his review. Suffice it to say that I remain unrepentant as of this moment, and aside from the four passages above, the book continues to represent my view of Isaac Newton.

Preface

THE utility of biography, Dr. Johnson argued, rests on the fact that we can enter by sympathy into situations in which others have found themselves. Parallel circumstances to which we can conform our minds shape every life. Even the great are not removed from the factors common to all: “We are all prompted by the same motives, all deceived by the same fallacies, all animated by hope, obstructed by danger, entangled by desire, and seduced by pleasure.” I must confess that twenty years devoted to the biography of Newton have not in my case confirmed Dr. Johnson’s dictum. The more I have studied him, the more Newton has receded from me. It has been my privilege at various times to know a number of brilliant men, men whom I acknowledge without hesitation to be my intellectual superiors. I have never, however, met one against whom I was unwilling to measure myself, so that it seemed reasonable to say that I was half as able as the person in question, or a third or a fourth, but in every case a finite fraction. The end result of my study of Newton has served to convince me that with him there is no measure. He has become for me wholly other, one of the tiny handful of supreme geniuses who have shaped the categories of the human intellect, a man not finally reducible to the criteria by which we comprehend our fellow beings, those parallel circumstances of Dr. Johnson.

Why then, one might ask, am I attempting to write Newton’s biography? My second prefatory confession is that increasingly I have asked the same question myself. Had I known, when in youthful self-confidence I committed myself to the task, that I would end up in similar self-doubt, surely I would never have set out. I did perceive that it would be a long and arduous task, though I was willing to undertake the labor. I thought at the time it would take ten years, not far short of eternity at that point in my life, though now, in its brevity, an indication of the chasm between expectation and reality. Perhaps even the prospect of twenty years would not have turned me back, but the other chasm, the unexpected gulf opening between me and my subject, would have been another matter. As I face the situation now, not in prospect but in retrospect, the lingering influence of the Puritan ethic makes the prospect of discarding the fruits of so much earnest toil abhorrent. For that matter, could any other potential biographer of Newton escape the same dilemma? Only another Newton could hope fully to enter

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into his being, and the economy of the human enterprise is such that a second Newton would not devote himself to the biography of the first. If history has a function—and my doubts have never extended to questioning that it has—perforce it must deal with the Newtons. Everyone who is informed agrees on the need for a new biography to replace Sir David Brewster's masterpiece, which is now one hundred and twenty-five years old. Others have aspired. It is not for me to decide whether I have succeeded where they failed. With all of the hesitations the paragraph above implies, I place the result of long years on the altar of history with the hope that it may add its bit to the understanding of the past to which the modern age has already contributed so much.

In writing Newton's biography, I have attempted, in accordance with my understanding of biography as a literary form, to avoid composing an essay on Newtonian science. At the same time I have sought to make Newton the scientist the central character of my drama. While he devoted himself extensively to other activities which a biography cannot ignore, from theology on one hand to administration of the Mint on the other, Newton holds our attention only because he was a scientist of transcendent importance. Hence I tend to think of my work as a scientific biography, that is, a biography in which Newton's scientific career furnishes the central theme. My goal has been to present his science, not as the finished product which has done so much to shape the whole of the modern intellect, but as the developing endeavor of a living man confronting it as problems still to be solved. Scientists and philosophers can probe the finished product. My interest in this biography centers exactly on what was not yet complete, the object of Newton's own activity, the substance of a life devoted to probing the unknown. I have tried to present his scientific endeavors in the context of his life, first in Woolsthorpe and Grantham, then in Cambridge, and finally in London. To an extent few others have equaled, however, Newton was a man of learning. Never fully at ease with others, he held his distance and lived largely in the setting of his own study. His books furnished the context of his life more than Cambridge or London did. A biographer ignores this truth about Newton at his own peril. I have done my best to keep it in mind and to present a picture of Newton in which the pursuit of truth, most importantly though not exclusively scientific truth, formed the essence of his life. To the extent that I have succeeded in this, the biography as a whole will also succeed.

The first volume of the Royal Society's edition of Newton's *Correspondence* appeared about the time I began serious work on the biography. Now all seven volumes are in print, and the footnotes in my book bear testimony to their indispensable aid. They are only

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part of the flood of Newtonian publications during the last two decades, on all of which my own work rests directly, to all of which I want to acknowledge a debt which is in fact beyond acknowledgment. The *Correspondence* has been necessary, as has the Whiteside edition of the *Mathematical Papers*, the final volume of which (to my loss I am sure) has yet to be published as I write this Preface. One of the features of my biography, which sets it apart from earlier ones, is the chronological account of Newton's mathematical activity. The account is my own, and I take full responsibility for it. It would have been impossible, however, without Whiteside's monument of scholarship.

Beyond these general publications are a number of others more restricted to single aspects of Newton's life: I. Bernard Cohen's *Papers & Letters* plus his edition of the *Principia* with variant readings undertaken jointly with the late Alexandre Koyré; A. R. and M. B. Hall's *Unpublished Scientific Papers*; John Herivel's *Background to Newton's 'Principia'*; and (though it differs from the above in being formally a monograph) B. J. T. Dobbs's *Foundations of Newton's Alchemy*. The publication of these works has significantly expanded the opportunities of Newtonian scholarship. I am not the first to benefit from them, nor will I be the last. I regret that my work is done too soon to derive further benefit from the publication of optical papers that Alan Shapiro has undertaken.

During the time I have been at work on Newton, I have received assistance of many kinds from many sources. Grants from the National Science Foundation, the George A. and Eliza Gardner Howard Foundation, the American Council of Learned Societies, and the National Endowment for the Humanities; and sabbatical leaves from Indiana University have provided most of the time for study and writing, much of it in England, where the great bulk of Newton's papers exist. One of those years I had the privilege and advantage to be a Visiting Fellow of Clare Hall, Cambridge. The National Science Foundation and Indiana University have also helped to finance the acquisition of photocopies of Newton's papers. The staffs of many libraries have outdone themselves in kind assistance, most prominently (in proportion to my demands) the Cambridge University Library, the Trinity College Library, the Widener Library at Harvard, the Babson College Library, the Indiana University Library, and the Public Record Office. Most of the typing I owe to a succession of secretaries over the years in the Department of History and Philosophy of Science at Indiana University, but among them especially Karen Blaisdell. The help of Anita Guerrini in proofreading has been invaluable. I cannot sufficiently express my gratitude to those I have mentioned and to many others who have helped in less central ways. I can at least try to express it, and I do.

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Nor can any author omit his family. By the time my children reached consciousness, I had embarked on the biography. Now I finish it as they complete their educations and set out on their own. The whole of their intimate experience of me has been flavored by the additional presence of Newton. I do not know if I would have been a more satisfactory father without the biography. Suffice it for them to realize that what they put up with over the years did in the end achieve some sort of conclusion, incarnation as a book. My wife of course endured more, and I thank her for enduring it with grace and understanding. In the end she discovered the only adequate defense—she is writing a book herself and may, if I improve, acknowledge my encouragement and support in her own preface.

R.S.W.

Acknowledgments

I WISH to acknowledge permission granted me by the Babson College Library to reproduce an alchemical diagram, a plan of the Jewish temple, and a scheme of the twelve gods of the ancient peoples, all found among the Grace K. Babson Collection; by the Trustees of the British Museum to reproduce a picture of the ivory bust by Le Marchand; by the University of California Press to reproduce six diagrams from their edition of the English translation of the *Principia*; by the Syndics of Cambridge University Library to reproduce eleven sketches and passages from the Portsmouth Papers; by Cambridge University Press to reproduce the picture of Croker's medal of Newton from John Craig, *The Mint* (Cambridge, 1953); by the Joseph Halle Schaffner Collection, University of Chicago Library, to reproduce a drawing of chemical furnaces; by Columbia University to reproduce an engraving of the Richter miniature and a lithograph of the Gandy portrait from the David Eugene Smith Collection, Rare Book and Manuscript Library; by the President and Fellows of Corpus Christi College, Oxford, to reproduce a drawing of the comet of 1680–1; by Lord Egremont and the Petworth Estate to reproduce the Kneller portrait of 1720; by the Bibliothèque Publique et Universitaire de Genève to reproduce the portrait of Nicolas Fatio de Duillier; by W. Heffer & Sons Ltd. of Cambridge, England, to reproduce the portrait of Newton in their possession; by the Jewish National and University Library

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to reproduce a scheme of the Revelation of St. John the Divine from the Yahuda Papers; by the Provost and Fellows of King's College, Cambridge, to reproduce a set of alchemical symbols from the Keynes Collection and an ivory plaque by Le Marchand; by the Trustees of the National Portrait Gallery to reproduce the Kneller portrait of 1702 and a portrait, artist unknown, of 1726; by Neale Watson Academic Publications, Inc., to reproduce four diagrams from Richard S. Westfall, *Force in Newton's Physics* (London, 1971); by the Warden and Fellows of New College, Oxford, to reproduce a drawing of Woolsthorpe, a picture of the house on St. Martin's Street, a drawing of the *experimentum crucis*, and a scheme of chronology from the New College MSS; by Lord Portsmouth and the Trustees of the Portsmouth Estates to reproduce two Kneller portraits as well as the Thornhill portrait of 1710; by the Royal Society to reproduce their drawing of the reflecting telescope, the sketch by Stukeley, an ivory plaque by Le Marchand, the Jervas portrait of 1703, the Vanderbank portrait of 1725, and the Vanderbank portrait of 1726; by Sotheby Parke Bernet & Co. to reproduce pictures of a bust and a plaque sculpted by Le Marchand; by the University of Texas to reproduce the Newton family tree; by the Master and Fellows of Trinity College, Cambridge, to reproduce the Thornhill portrait of 1710, the Murray portrait of 1718, the Vanderbank portrait of 1725, and the Seeman portrait of 1726; and by the Yale Medical Library to reproduce the drawing of Jupiter enthroned from their alchemical paper.

I wish further to acknowledge the permission and courtesy given me by the American Philosophical Society; Babson College (for the Grace K. Babson Collection); the Bodleian Library; the Syndics of the Cambridge University Library (for the Portsmouth Papers and other MSS); the University of Chicago Library (for the Joseph Halle Schaffner Collection); the William Andrews Clark Memorial Library (of UCLA, Los Angeles, California); the Rare Book and Manuscript Library of Columbia University (for the David Eugene Smith Collection); the Francis A. Countway Library of Medicine (Boston, Massachusetts); the Edinburgh University Library; the Emmanuel College, Cambridge, Library; the Syndics of the Fitzwilliam Museum, Cambridge; the Huntington Library (San Marino, California); the Jewish National and University Library (for the Yahuda MSS); the Provost and Fellows of King's College, Cambridge (for the Keynes MSS); the Pierpont Morgan Library; the Warden and Fellows of New College, Oxford; the Royal Society; the Smithsonian Institution Libraries (for the Dibner Collection); the Department of Special Collections of the Green Library, Stanford University (for the Newton Collection); the Controller of H.M. Stationery Office (for Crown-copyright records in the Public

Acknowledgments

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Record Office); the University of Texas (for manuscripts in the Humanities Research Center, Austin); and the Master and Fellows of Trinity College, Cambridge, to cite manuscripts.

The University of California Press has allowed me to quote from the Cajori edition of Newton's *Principia*: Cambridge University Press to quote from I. Bernard Cohen and Alexandre Koyré, eds., *Isaac Newton's Philosophiæ Naturalis Principia Mathematica*; from B. J. T. Dobbs, *The Foundations of Newton's Alchemy*; from A. R. and M. B. Hall, eds., *Unpublished Scientific Papers of Isaac Newton*; from H. W. Turnbull et al., eds., *The Correspondence of Isaac Newton*; and from D. T. Whiteside, ed., *The Mathematical Papers of Isaac Newton*: Dover Publications, Inc., to quote from their edition of Newton's *Opticks*: A. E. Gunther to quote from R. W. T. Gunther, *Early Science in Oxford*: Harvard University Press to quote from I. Bernard Cohen, ed., *Isaac Newton's Papers & Letters on Natural Philosophy: History of Science* to quote from Karen Figala, "Newton as Alchemist": Oxford University Press to quote from Mark Curtis, *Oxford and Cambridge in Transition*; from John Herivel, *The Background to Newton's 'Principia'*; and from Frank Manuel, *The Religion of Isaac Newton: The Notes and Records of the Royal Society* to quote from J. E. McGuire and P. M. Rattansi, "Newton and the 'Pipes of Pan'" and from R. S. Westfall, "Short-writing and the State of Newton's Conscience, 1662": and Yale University Press to quote from Marjorie Hope Nicolson, *Conway Letters*. I gratefully acknowledge all of their kindnesses.

A note about dates

BECAUSE England had not yet adopted the Gregorian calendar (which it treated as a piece of popish superstition), it was ten days out of phase with the Continent before 1700, which England observed as a leap year, and eleven days out of phase after 28 February 1700. That is, 1 March in England was 11 March on the Continent before 1700 and 12 March beginning with 1700. I have not seen any advantage to this work in adopting the cumbersome notation 1/11 March, etc. Everywhere I have given dates as they were to the people involved, that is, English dates for Englishmen in England and Continental dates for men on the Continent, without any attempt to reduce the ones to the others. In the small number of cases where confusion might arise, I have included in parentheses O.S. (Old Style) for the Julian calendar and N.S. (New Style) for the Gregorian.

In England the new year began legally on 25 March. Some men adhered faithfully to legal practice; many wrote double years (e.g., 1671/2) during the period from 1 January to 25 March. Everywhere, except in quotations, I have given the year as though the new year began on 1 January.

Abbreviations used in footnotes

<i>Add MS</i>	Additional MS in the Cambridge University Library (for this book, that part of the Additional MSS constituting the Portsmouth Papers)
<i>Babson MS</i>	Newton manuscript in the library of Babson College, Babson Park, Mass.
<i>Baily</i>	Francis Baily, <i>An Account of the Rev^d John Flamsteed, the First Astronomer Royal</i> (London, 1835–7)
<i>Burndy MS</i>	Newton manuscript in the Dibner Collection, Smithsonian Institution Libraries
<i>CM</i>	Council Minutes of the Royal Society
<i>Cohen</i>	<i>Isaac Newton's Papers & Letters on Natural Philosophy</i> , ed. I. Bernard Cohen (Cambridge, Mass., 1958)
<i>Comm epist</i>	<i>Commercium epistolicum D. Johannis Collins, et aliorum de analysi promota</i> (London, 1713)
<i>Corres</i>	<i>The Correspondence of Isaac Newton</i> , ed. H. W. Turnbull, J. F. Scott, A. R. Hall, and Laura Tilling, 7 vols. (Cambridge, 1959–77)
<i>CSPD</i>	Calendar of State Papers Domestic
<i>CTB</i>	Calendar of Treasury Books
<i>CTP</i>	Calendar of Treasury Papers
<i>Edleston</i>	<i>Correspondence of Sir Isaac Newton and Professor Cotes</i> , ed. J. Edleston (London, 1850)
<i>Halls</i>	<i>Unpublished Scientific Papers of Isaac Newton</i> , ed. A. R. and Marie Boas Hall (Cambridge, 1962)
<i>Herivel</i>	J. W. Herivel, <i>The Background to Newton's 'Principia'</i> (Oxford, 1965)
<i>Hiscock</i>	W. G. Hiscock, ed., <i>David Gregory, Isaac Newton and Their Circle</i> (Oxford, 1937)
<i>JB</i>	Journal Book of the Royal Society
<i>JBC</i>	Journal Book (Copy) of the Royal Society
<i>Keynes MS</i>	Newton manuscript in the Keynes Collection in the library of King's College, Cambridge

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Abbreviations used in footnotes

<i>Math</i>	<i>The Mathematical Papers of Isaac Newton</i> , ed. D. T. Whiteside, 8 vols. (Cambridge, 1967–80)
<i>Mint</i>	Mint Papers in the Public Record Office
<i>Opticks</i>	<i>Opticks</i> , based on the 4th ed. (New York, 1952)
<i>Prin</i>	<i>Mathematical Principles of Natural Philosophy</i> , trans. Andrew Motte, rev. Florian Cajori (Berkeley, 1934)
<i>Stukeley</i>	William Stukeley, <i>Memoirs of Sir Isaac Newton's Life</i> , ed. A. Hastings White (London, 1936)
<i>Var Prin</i>	<i>Isaac Newton's Philosophiæ Naturalis Principia Mathematica</i> , 3rd ed. with variant readings, 2 vols., eds. Alexandre Koyré and I. Bernard Cohen (Cambridge, 1972)
<i>Villamil</i>	Richard de Villamil, <i>Newton: The Man</i> (London, 1931)
<i>Yahuda MS</i>	Newton manuscript in <i>Yahuda MS Var. 1</i> in the Jewish National and University Library, Jerusalem