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978-0-521-29436-2 - Unpublished Scientific Papers of Isaac Newton: A Selection from the  
Portsmouth Collection in the University Library, Cambridge

Edited by A. Rupert Hall and Marie Boas Hall

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UNPUBLISHED  
SCIENTIFIC PAPERS OF  
ISAAC NEWTON

Cambridge University Press

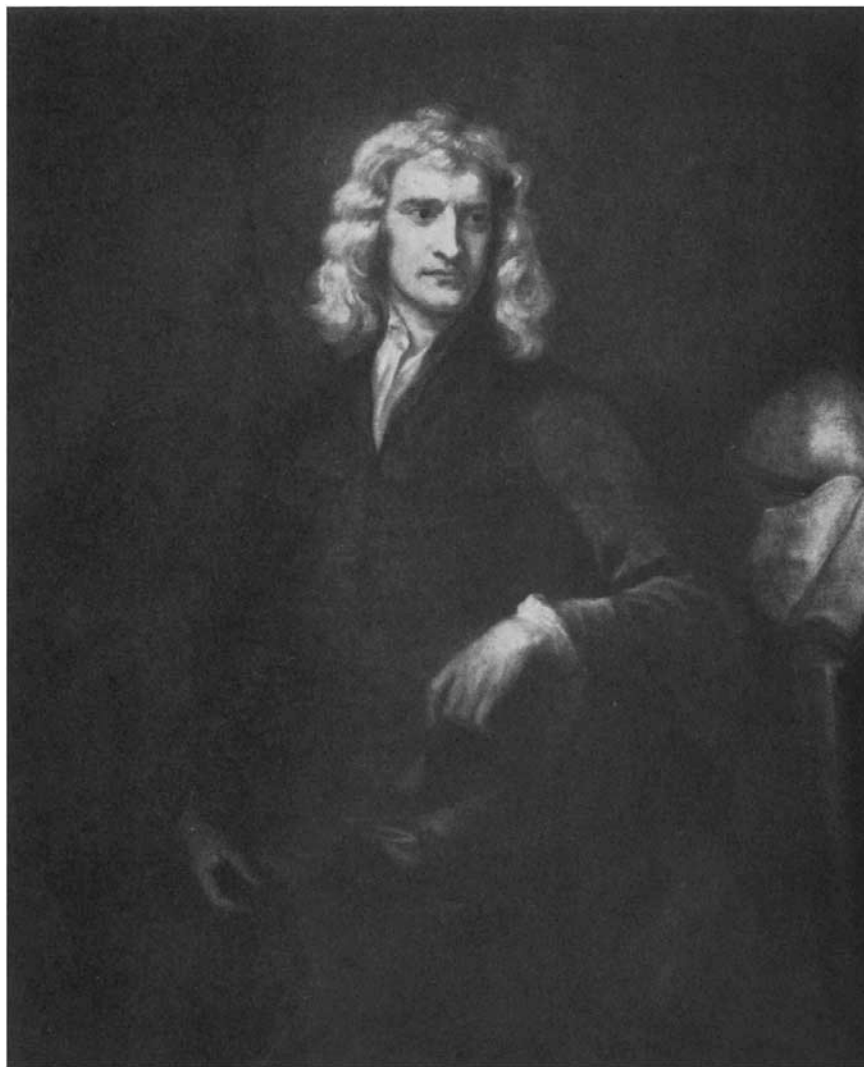
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PLATE I



Portrait of Isaac Newton about 1690, wearing his own hair.  
By (or after) Sir Godfrey Kneller.

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SCIENTIFIC PAPERS  
OF  
ISAAC NEWTON

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CHOSEN, EDITED AND TRANSLATED BY

A. RUPERT HALL

AND

MARIE BOAS HALL

*History of Science and Technology Department,  
Imperial College, University of London*

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## FOREWORD

The renaissance of Newtonian studies was only just beginning in 1959 when, following earlier forays into the Portsmouth Collection, we began to prepare material for the first issue of this book. The edition of Newton's *Correspondence*, now completed,<sup>1</sup> had not yet appeared in print and the first volume of D. T. Whiteside's magisterial edition of Newton's mathematical papers was still in its early stages.<sup>2</sup> At the end of that year I. Bernard Cohen, whose distinguished career in these studies was then opening, in offering to the History of Science Society at Chicago an account of Newton's manuscripts and of the then state of Newtonian scholarship, justly remarked that 'What is especially astonishing about the huge number of Newtonian articles and books is the general failure of the authors to consult the manuscript collections'.<sup>3</sup> Cohen was able to show that there was then a fresh interest in all aspects of Newton's life and writings, indicated by re-issues and translations of his works and a scattering of articles, and to indicate a number of projects in being, including his own splendid edition (with Alexandre Koyré) of the *Principia*, which happily came to fruition in 1972. But the vast legacy of Newton's papers was still largely unread, and when (in the first issue of this book) we tried to furnish a guide to studies based on Newton's manuscripts the result, incomplete indeed, was extremely modest.

The situation is very different today, and so we have removed those out-of-date pages from this reissue, which is otherwise identical with our original book. The contemporary student has available for his consultation the recent and very ample bibliography by Peter and Ruth Wallis, whose pages record the large and important scholarly output of recent decades as well as the work of earlier years.<sup>4</sup> Although some of the desiderata noted by Cohen in 1959 are still lacking,

<sup>1</sup> H. W. Turnbull, J. F. Scott, A. Rupert Hall and Laura Tilling, *The Correspondence of Isaac Newton*, Cambridge, 1959–77.

<sup>2</sup> D. T. Whiteside, *The Mathematical Papers of Isaac Newton*, Cambridge, 1967 – (seven volumes of eight now published).

<sup>3</sup> I. Bernard Cohen, 'Newton and Recent Scholarship', *Isis*, 51, 1960, 496.

<sup>4</sup> P. and R. Wallis, *Newton and Newtoniana, 1672–1975: A Bibliography*, Folkestone, 1977.

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such as a worthy biography of Newton to replace those of Sir David Brewster (1855) or L. T. More (1934) and an edition of Conduitt's papers, no serious student of Newton now fails to pursue his thought into the manuscript arcana. Besides the *Correspondence* and the great editions of Cohen and of Whiteside (the latter, too, now almost finished) we have available John Herivel's study of the development of Newton's ideas in mechanics, along with which Cohen's *Introduction* to the *Principia* should be noted;<sup>1</sup> in optics the many articles by Zev Bechler, Henry Guerlac, J. A. Lohne, A. E. Shapiro, R. S. Westfall and others have likewise explored in numerous different ways the rich implications of the manuscripts, while other scholars including B. J. T. Dobbs, K. Figala, J. E. McGuire and P. M. Rattansi have delved into the deepest and most obscure recesses of Newton's preoccupation with alchemical and other esoteric learning, which would be almost unknown to us had Newton's private papers not survived in such vast quantity.

In making even so partial and summary a note of scholarly achievement since the first publication of this book, we cannot omit mention of two scholars both living in 1962 and now dead: Joseph Hofmann and Alexandre Koyré. The former was naturally led from Leibniz's manuscripts to Newton's; the recent English version of one of his principal books (first printed, in fact, in 1949) must always be at the elbow of any historian of the calculus dispute.<sup>2</sup> Posthumously, Hofmann has given a definite edition of Leibniz's early scientific and mathematical correspondence (1672–76) which is inevitably of deep interest to students of Newton.<sup>3</sup> Koyré's later years were almost wholly given to Newtonian researches and especially to the manuscripts, for he was one of the first to appreciate how the development of Newton's ideas could be traced through them. His collection of essays on Newtonian topics is an essential starting-point for understanding Newton's contribution to the

<sup>1</sup> John Herivel, *The Background to Newton's 'Principia'*, Oxford, 1965. I. Bernard Cohen, *Introduction to Newton's 'Principia'*, Cambridge, 1971. See also R. S. Westfall, *Force in Newton's Physics: The Science of Dynamics in the Seventeenth Century*, London and New York, 1971.

<sup>2</sup> Joseph E. Hofmann, *Leibniz in Paris, 1672–1676*, Cambridge, 1974, a revised version of *Die Entwicklungsgeschichte der Leibnizschen Mathematik während des Aufenthalts in Paris (1672–76)*, Munich, 1949.

<sup>3</sup> G. W. Leibniz, *Sämtliche Schriften und Briefe, herausgeben von der Akademie der Wissenschaften der DDR, dritte Reihe, erster Band*, Berlin, 1976.

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## FOREWORD

revolution in scientific and philosophic ideas of the seventeenth century.<sup>1</sup>

The present reissue is an exact facsimile of the original, apart from the one omission already noted. Newtonian scholarship has advanced so greatly in almost twenty years that, if we were to try to improve our texts and historical comments, it would be necessary to make a new book, which is not possible. We therefore ask the indulgent reader to accept it 'warts and all' as it was in 1962, conscious as we are of many mistakes in it and things we would now express differently. Yet we are also pleased to find that many opinions we expressed—even on such points as Newton's non-use of fluxions in preparing the *Principia*—have stood the test of time. The prudent reader will know that he may find an ampler context and richer annotation in the *Mathematical Papers* of Whiteside, and the books of Herivel and Koyré, besides many specialist papers dealing *inter alia* with documents first printed in this book.

Of the documents included in this volume the most important subsequent re-editions (not always from the identical manuscript, however) are as follows:

- I, 1 To resolve problems by motion. Whiteside, *Mathematical Papers of Isaac Newton* I, 400–48.
- II, 2 The Lawes of motion. Herivel, *Background to Newton's 'Principia'*, 208–15.
- II, 4 Gravia in trochoide descendentia. Herivel, 199–203; Whiteside, II, 420–31.
- IV, 1 Early drafts of propositions in mechanics. Herivel, 257–74; Whiteside, VI, 30–91.
- IV, 2 On motion in ellipses. Herivel, pp. 246–54; Whiteside, VI, 553–6.
- VI Comments on Hooke's *Micrographia*. Sir Geoffrey Keynes, *A Bibliography of Dr. Robert Hooke*, Oxford, 1960, 97–108.

Keynes' book was published before ours, but after our manuscript was complete and in the Press. It should also have been noted in the original issue that V, 1 'Of educating youth in the Universities' was first printed by W. W. Rouse Ball in his *Cambridge Papers*, Cambridge, 1918.

<sup>1</sup> Alexandre Koyré, *Newtonian Studies*, Cambridge, Massachusetts, 1965.

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What are the prospects for further extensive editions of Newton's vast legacy? Two obvious areas of his work suggest themselves: optics and chemistry. In optics, many early papers and drafts have indeed been published wholly or in part,<sup>1</sup> but there would be value in a convenient, thoroughly annotated collection of the whole mass including early drafts of the main *Opticks* itself and of the *Queries*. Far less has been printed of the sheets, covered with Newton's writing, devoted to chemical experiment and to alchemy, largely because most of these latter are transcripts from books, not original compositions. A competent scholar could, however, make an interesting selection from that part of this material which seems more directly related to Newton's own thought and experimentation. For the rest, it seems certain that the preponderance of Newtoniana still unedited is likely to remain so, though no longer wholly ignored by scholars as it was during the earlier part of this century.

A. RUPERT HALL  
MARIE BOAS HALL

IMPERIAL COLLEGE, LONDON

*April 1978*

<sup>1</sup> Beginning with A. R. Hall, 'Sir Isaac Newton's Notebook', *Cambridge Historical Journal*, 9, 1948, 239–50, through *Correspondence*, Vol. 1, 1959 to the recent facsimile of the *Unpublished first version of Isaac Newton's Cambridge Lectures on Optics, 1670–72*, with an introduction by D. T. Whiteside, Cambridge, The University Library, 1973, and many documents in the same editor's *Mathematical Papers*.



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## PREFACE

This is the first attempt to add to the published collection of Newton's scientific writings since 1838, when S. P. Rigaud printed a document that he entitled 'Propositiones de Motu'. Editorial neglect is much to be lamented: while the *Philosophia Naturalis Principia Mathematica* (1687) and the *Opticks* (1704) have been reissued (in English) more than once during the present century, the standard edition of Newton's writings is still the *Opera Omnia* collected by Samuel Horsley and published between 1779 and 1785. As for the immense mass of manuscript material that remained after Newton's death, although the most important part of it has been accessible in the Cambridge University Library for many years it has been little explored by scholars, even by the biographers of Newton.

Now, at last, Newton's correspondence is being collected and published for the first time in full. But there is still slight promise that England will honour the memory of its finest intellect in the way that Italy has honoured Galileo, France Descartes, Holland Huygens, or America Franklin. No complete publication of his writings is contemplated. As a very small step towards such a monument, and in the hope of encouraging others by making the Portsmouth Collection in the Cambridge University Library better known, we have selected for this volume a few documents from the great, still imperfectly sorted, number that it contains.

In making this selection we have been chiefly interested in tracing the development of Newton's ideas on the nature of matter; this was the starting-point from which the volume grew. In reading Newton's thoughts on this subject one penetrates as profoundly as may be into his comprehension of the ultimate structure of the physical universe, into the shadowy realm where physics, metaphysics and theology overlap in Newton's mind. We make no apology, however, for venturing beyond this theme in order to include some papers on mathematics and other topics. Far more remains untouched: we have printed nothing from the several working notebooks extant, nothing of Newton's chemistry, nor of his optics,

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nothing from his drafts on the controversies in which he was involved, nor from his personal papers. In particular we should draw attention to the volumes of mathematical papers, and those concerned with the writing and revision of the *Principia*; these eminently deserve further study, and at least partial publication.

Possibly it would be futile to print the whole of the Portsmouth Collection because, in spite of rumours reported by Newton's biographers, nearly all his papers have been preserved, and he kept so much. (The scattering of documents that occurred as a result of the Lymington sale in 1936 has been much less significant than many people imagine.) One finds, for instance, a copy of the following satirical advertisement of a pamphlet, naturally covered with Newton's indefatigable handwriting on the back:

A philosophical Essay upon Actions on distant substances, clearly explicating according to the Principles of the new Philosophy & Sr Isaac Newton's Laws of Motion all to actions [*sic*] usually attributed to Sympathy & Antipathy; as Taliacoli's nose in Hudibras, how it happened to fall off from the Gentleman's Face at Brussels when the Porter that owned it died 500 miles off at Boulogne? How Mothers mark their infants? with a receipt for to prevent Hare lips. Why when one person yawnes others do the same? Whence comes the aversion in many persons to Eat cheese &c? Why dogs bark at beggars, why whistling makes horses stale? Why corns shoot against change of weather. With an explication of the Loadstone, Amber, Jet, Glass and other Electric bodies, sympathetic powder, Amulets, Cramp rings, &c. Dedicated to ye Royal Society Tis given gratis at the Milliners shop right against the three Tuns in Cary-street, facing Lincoln's Inn fields Play-house Gate.

There is much else of trivial significance—pages of laborious computation whose purpose is indiscernible, detached sentences noting the opinion of some early Father on a doctrinal question, drafts in four or five different versions of passages in Newton's printed works—affording the searcher no excitement of discovery. But there is much else that does, and that deserves to be printed. In this volume we offer no more than a sample.

Newton's papers are not always easy to read, nor in perfect condition, nor complete. In our selection we have had to

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leave many lacunae, and fit some passages together without entire coherence. We have endeavoured to reproduce the documents as accurately as possible except that, for the most part, we have silently omitted words, sentences and occasionally whole paragraphs that were struck out by Newton and rewritten. In a few cases where a cancelled draft included matter of interest we have reproduced it. Contracted forms commonly used in Latin have been expanded without comment in the transcriptions, and we have not endeavoured to correct errors in Newton's Latin. Square brackets have been used occasionally where the sense seemed to require a different word from that written. Of course, no reproduction of a document other than a facsimile can be perfect: apart from the inevitable errors in transcription that have escaped our care, any printed version must appear considerably more neat and uniform than Newton's hurried script.

The translations of papers in Latin are our own, aided here and there by reference to Andrew Motte's English rendering of the *Principia*. Motte is a good guide to the seventeenth-century meaning of a Latin word not used in its classical sense, or not occurring in classical Latin. In some cases we have translated such a word by assuming that Newton had in mind the sense of the English one derived from it. We have preferred to use phrases that Newton either did use elsewhere, or that he might have used had he written in English rather than in Latin. In the translations we have aimed rather at literalness than elegance; to make a truly readable modern English version of Newton's heavy Latin prose, if that were at all possible, would involve so rewriting his sentences that all the spirit of the original would be lost. Newton thought in Latin as easily as in English, not infrequently slipping from one language to the other in the same note (see Plate II); hence the form of his argument and of his thinking was to some extent shaped by the structure of Latin prose. It would be frivolous to modify this more than need be.

The frontispiece is reproduced by gracious permission of Her Majesty the Queen from the portrait in Kensington Palace. We are grateful to the Syndics of the Cambridge University Press for undertaking publication of this complex book, and to the Press which has produced it so excellently.

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Our thanks are also due to Mr J. B. Hall, of St John's College, for his care in checking both the transcription and the translation of the Latin manuscripts, which has saved us many mistakes.

A. R. H.

M. B. H.

UNIVERSITY OF CALIFORNIA

LOS ANGELES

*August 1960*

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## A NOTE ON THE HISTORY OF NEWTON'S MANUSCRIPTS

Newton's niece, Catherine Barton, married (1717) John Conduitt, who succeeded Newton as Master of the Mint. Their only child, also named Catherine, married (1740) the Hon. John Wallop who became Lord Lymington when his father was created Earl of Portsmouth. Conduitt had the custody of Newton's papers after the latter's death in 1727, and collected many memorials of his predecessor. These papers all remained in the possession of Conduitt's descendants as a single collection for over 150 years. They were explored by Samuel Horsley when he prepared his edition of the works of Newton (1779–85) and were again made available to Sir David Brewster when writing his *Memoirs* (1855).

In 1872 the then Earl of Portsmouth entrusted the whole collection to the University of Cambridge, where its contents were arranged and catalogued by a committee consisting of H. R. Luard, Sir George Stokes, John Couch Adams, and G. D. Liveing. Their catalogue of the Portsmouth Collection, published in 1888, divides the materials into fifteen sections:

- I Mathematics (MSS. Add. 3958–72)<sup>1</sup>
- II Chemistry (MSS. Add. 3973–5)
- III Chronology
- IV History
- V Miscellaneous, chiefly theological
- VI Correspondence (MSS. Add. 3976–86; copies in Add. 4007)
- VII Books (MSS. Add. 3987–4004)
- VIII Miscellaneous Papers (MSS. Add. 4005)
- IX Papers concerning Flamsteed (MSS. Add. 4006)
- X Correspondence concerning Fontenelle's *Eloge*
- XI Conduitt's drafts for a Life of Newton
- XII Papers relating to Newton, after his death
- XIII Papers concerning Newton's family, and the Mint
- XIV Books and Papers not by Newton
- XV Complimentary Letters

<sup>1</sup> The numbers in brackets are the present shelf-marks of the Newton papers in the Cambridge University Library.



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#### HISTORY OF NEWTON'S MANUSCRIPTS

When the work of the committee was done, the Earl of Portsmouth presented the scientific part of the collection to the University of Cambridge, that is, the papers catalogued in Sections I and II, and VI to IX above: they remain in the University Library. The remainder of the Collection was returned to Lord Portsmouth, including a considerable number of original letters of which, however, copies had been made.

It was this latter portion of the Collection that was offered for sale by Messrs Sotheby's of London in 1936, on the instructions of Viscount Lymington. It was composed largely of Newton's annotations from alchemical authors, of his theological extracts and writings, and of the Conduitt and other personal papers. There was also a mass of material on Newton's administration at the Royal Mint, which was presented to the Mint by Viscount Wakefield. Lord Keynes was the principal buyer at this sale; his acquisitions (apart from some gifts he made to Trinity College) are now in the Library of King's College, Cambridge. Thanks to his energetic and generous actions the complete dispersion of Newton's papers was prevented, and although many were scattered, a large part of the original Portsmouth Collection can now be consulted in Cambridge, at the University Library and King's College.

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## ABBREVIATIONS

**BIRCH, Boyle.** Thomas Birch, *The Life and Works of the Honourable Robert Boyle* (two editions: London, 1744, 1772).

**BIRCH, History.** Thomas Birch, *History of the Royal Society*. London, 1756–7.

**BREWSTER.** Sir David Brewster, *Memoirs of the Life, Writings and Discoveries of Sir Isaac Newton*. Edinburgh, 1855.

**CAJORI.** *Sir Isaac Newton's Mathematical Principles of Natural Philosophy and his System of the World. Translated into English by Andrew Motte in 1729. The translation revised... by Florian Cajori.* Berkeley, 1946.

**EDLESTON.** Joseph Edleston, *Correspondence of Sir Isaac Newton and Professor Cotes*. London, 1850.

*Opticks.* Sir Isaac Newton, *Opticks*. (Fifth edition), London, 1931.

*Papers & Letters.* I. Bernard Cohen (ed.). *Isaac Newton's Papers & Letters on Natural Philosophy*. Cambridge, Mass., 1958.

*Portsmouth Catalogue.* *A Catalogue of the Portsmouth Collection of Books and Papers written by or belonging to Sir Isaac Newton*. Cambridge, 1888.

*Principia.* Is. Newton, *Philosophiae Naturalis Principia Mathematica*. London, 1687. (Facsimile reprint issued by William Dawson & Sons Ltd, London, n.d.) All references, unless otherwise stated, are to this edition.

**RIGAUD.** S. P. Rigaud, *An Historical Essay on the First Publication of Sir I. Newton's Principia*. Oxford, 1838.

**ROUSE BALL.** W. W. Rouse Ball, *An Essay on Newton's 'Principia'*. London, 1893.

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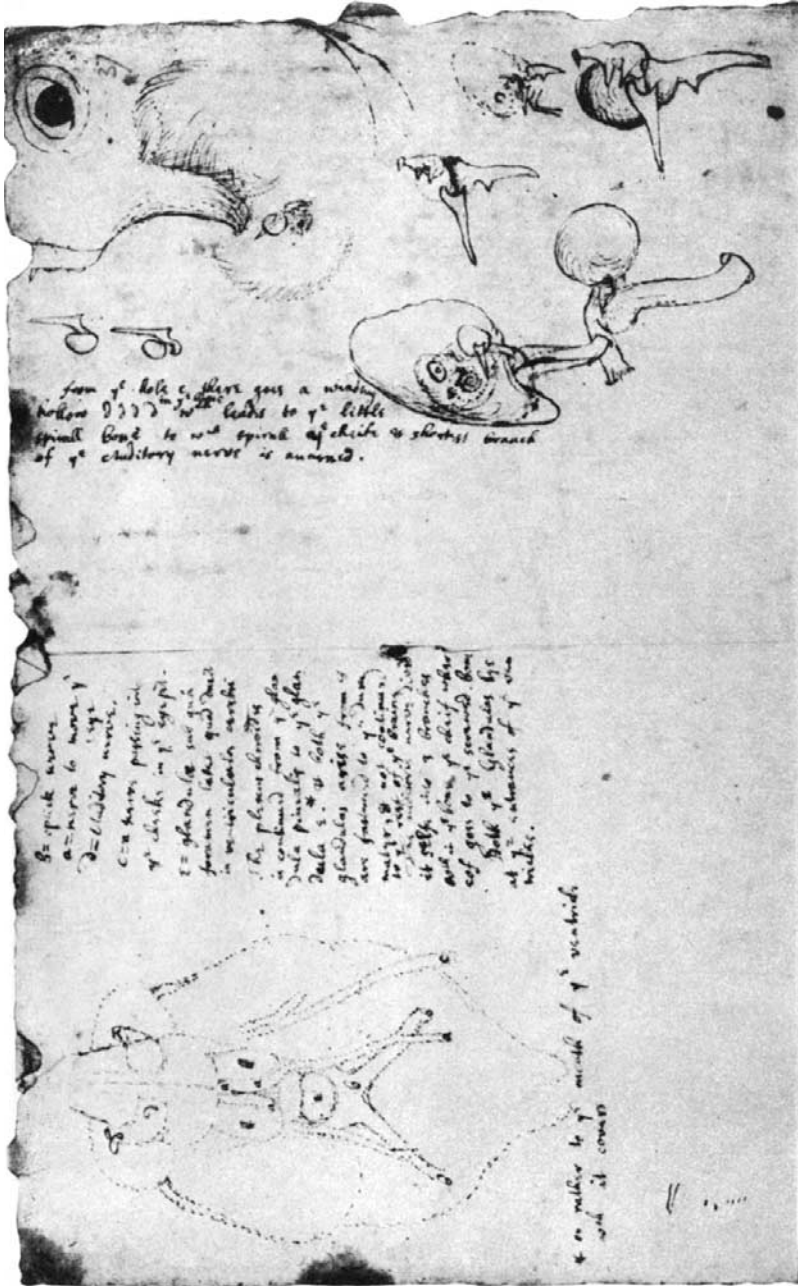
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PLATE II



nerve divides itself into 3 branches within the bone, the chief whereof goes to the screwed bone. Both the glandules lie at the entrances of the ventricles. Text, right: 'from the hole e there goes a winding hollow dddd in the bone which leads to the little spiral bone to which spirall the chief and shortest branch of the Auditory nerve is annexed.' On the same sheet is a draft receipt to be signed by Hannah Smith of Woolsthorpe (Newton's half-sister), dated 30 October 1665.

Anatomical drawings by Newton. Left: the brain, probably of a small rodent. Right: the eye of a bird, and the bones of the ear. Text, left: 'a, nerve to move the eye; b, optic nerve; c, a nerve passing into the cheek in the eye-pit; d, auditory nerve; e, glandule beneath which the foramen lies which leads into the ventricles of the brain. The plexus choroides is continued from the pineal glandule to the glandule e or rather to the mouth of the ventricle which it covers. Glandules arise from and are fastened to the dura mater. and are not continued to the rest of the brain. The auditory