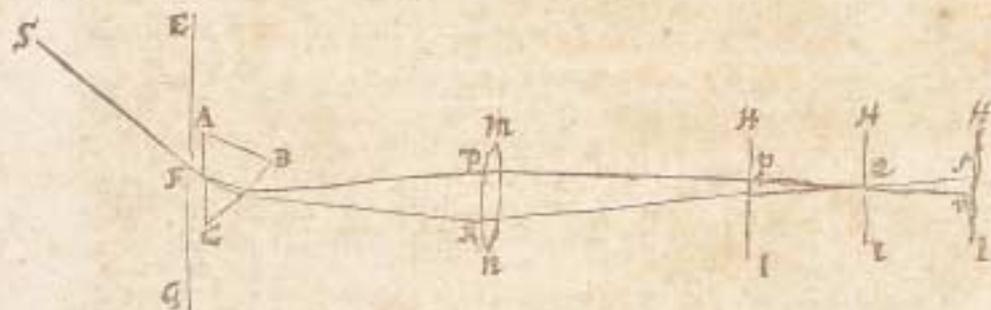


about three foot radius (suppose a broad Object-glass of a three foot Telescope,) at the distance of about four or five foot from thence, through which all those colours may at once be transmitted, and made by its Refraction to convene at a further distance of about ten or twelve feet. If at that distance you intercept this light with a sheet of white paper, you will see the colours converted into whiteness again by being mingled. But it is requisite, that the *Prisme* and *Lens* be placed steady, and that the paper, on which the colours are cast, be moved to and fro; for, by such motion, you will not only find, at what distance the whiteness is most perfect, but also see, how the colours gradually convene, and vanish into whiteness, and afterwards having crossed one another in that place where they compound Whiteness, are again dissipated, and severed, and in an inverted order retain the same colours, which they had before they entered the composition. You may also see, that, if any of the Colours at the *Lens* be intercepted, the Whiteness will be changed into the other colours. And therefore, that the composition of whiteness be perfect, care must be taken, that none of the colours fall besides the *Lens*.

In the annexed design of this Experiment, ABC expresseth the *Prisme* set endwise to light, close by the hole F of the window



EG. Its vertical Angle ACB may conveniently be about 60 degrees: MN designeth the *Lens*. Its breadth  $2\frac{1}{2}$  or 3 inches. SF one of the straight lines, in which difform Rays may be conceived to flow successively from the Sun. FP, and FR two of those Rays unequally refracted, which the *Lens* makes to convene towards Q, and after decussation to diverge again. And HI the paper, at divers distances, on which the colours are projected: which in Q constitute *Whiteness*, but are *Red* and *Yellow* in R, r, and t, and *Bl.* and *Purple* in P, p, and v.

# work by hand and brain

figure 14  
The prism  
experiment from  
Newton's first  
published paper on  
light and colours,  
University Library,  
T.340.1 b.85.6,  
pp. 3086-7.

Newton claimed that he had discovered the theory of light and colours in the early months of 1666. He demonstrated his idea that white light could be split into a spectrum of seven differently coloured and differently refrangible rays through a series of experiments with prisms. Although Newton described his optical theories in the first series of his Lucasian lectures, it seems likely that he had few hearers. His ideas reached a larger audience as a consequence of his design for a reflecting telescope. Isaac Barrow helped to communicate this to the Royal Society in 1671 and Newton then submitted a paper on light and colours to the Society's *Philosophical Transactions*. He became a fellow of the Royal Society in 1672 and was a frequent contributor to the *Philosophical Transactions*. John Collins, who assisted with the affairs of the Society, preserved many of Newton's letters from this time, and they later entered the Macclesfield Collection with the rest of Collins' papers. Newton was often anxious about both the costs of fellowship and the dangers of publicity, and withdrew from communication with the Society for several years after 1676. He also abandoned his plans to publish a complete account of his optical theories. These were resurrected by the success of the *Principia*. Newton's *Opticks* appeared in 1704 and a Latin translation with additional material was published in 1706. Newton incorporated those additions in the second, corrected edition of 1717.

20 *Philosophical Transactions*, number 80 (19 february 1672)

(figure 14)

4°: 4g-4i<sup>4</sup>

19.5 × 12 cm

Cambridge University Library, t.340.1 b.85.6

The first contact that Newton had with the wider world of natural philosophers outside Cambridge came at the instigation of Isaac

Barrow, who initiated a mathematical correspondence between Newton and John Collins (see catalogue number 38) in summer 1669. In November 1669, Newton visited London and met Collins for the first time. Collins soon learned something of Newton's latest invention, the reflecting telescope (see catalogue numbers 22–4), and it was probably through him that the Royal Society heard of the discovery at the end of 1671. Barrow again acted as an intermediary, bringing one of Newton's telescopes to London for the Society to inspect. Seth Ward, Bishop of Salisbury and formerly Savilian Professor of Astronomy at Oxford, immediately proposed Newton as a candidate for fellowship of the Society. He was elected a fellow of the Royal Society on 11 January 1672 and, on 18 January, promised the Society's secretary, Henry Oldenburg (1615–77), that he would send him 'an accompt of a Philosophicall discovery [which] induced mee to the making of the said Telescope' (see catalogue 24). This he did on 6 February, submitting the paper on light and colours that Oldenburg published on behalf of the Royal Society in his journal, the *Philosophical Transactions*, on 19 February 1672.

Newton had been involved with the publication of other men's works from the late 1660s, when he began helping Barrow with an edition of his lectures (see catalogue 32). This was, however, Newton's own first step into the harsh and competitive world of the communication of scientific discoveries. His experiences on this occasion perhaps helped to generate the suspicion with which he later regarded the printed word. Newton was at first eager to submit his work to the scrutiny of others. He welcomed Oldenburg's communication of his work to Christiaan Huygens, the pre-eminent natural philosopher of the age, then living in Paris. Yet, as praise for his work began to be tempered by questions about the theories that lay behind it, Newton began to realise some of the dangers of publicity. Correspondence with Oldenburg, and publication in the *Philosophical Transactions*, drew from Newton some of his most important optical discoveries and speculations, but it also put him increasingly on edge (see catalogue number 27).

The discoveries that Newton communicated in 1672 were not new to him, but were a summary of some of the main conclusions of his optical studies during the second half of the 1660s. In particular, his paper on light and colours contained an account (pp. 3086–7, on display) of his experiments with a prism to show that white light was composed of

differently refrangible rays of coloured light, forming a spectrum from purple to red. Yet the confidence and familiarity with which Newton presented his results may have been one of the reasons for the scepticism that greeted many of his findings. Several prominent natural philosophers, in particular Huygens, Robert Hooke, and Ignace Gaston Pardies, soon engaged Newton in a wide-ranging correspondence, mediated through Oldenburg, that questioned both the conclusions and the methods of Newton's optical experiments.

H. W. Turnbull, J.F. Scott, A.R. Hall and Laura Tilling (eds), *The Correspondence of Isaac Newton*, 7 vols (Cambridge, 1959–77), vol. 1, especially pp. 74–107. Richard S. Westfall, *Never at Rest. A Biography of Isaac Newton* (Cambridge, 1980), pp. 231–80; I. Bernard Cohen (ed.), *Isaac Newton's Papers & Letters on Natural Philosophy* (Cambridge, 1958), pp. 47–59 (which reprints Newton's paper).

## 21 whipple museum, cambridge, accession number 1254 60° glass prism

One of the causes of the hostile reaction to Newton's theory of light and colours was the manner of Newton's account of his experiments with prisms. This gave the impression of being a simple, historical narrative of actions, beginning early in 1666, that were both easy to perform and straightforward to repeat. But Newton was being disingenuous both in terms of historical detail and with reference to the ease with which another might see what he had seen. Accounts in one of Newton's notebooks (see catalogue number 3) show that he bought lenses and grinding tools in April 1667 and three prisms in spring 1668. Experiments recorded in Newton's other notebooks (see catalogue numbers 9 and 11) suggest that he had begun using prisms some time before this as a means of exploring the optical theories of Descartes and others. It seems likely that Newton's initial discoveries can be dated to autumn 1665. But the path that Newton took was nevertheless slower and more complicated than he later suggested. Many of Newton's contemporaries had looked through prisms. His discovery depended on the experiment in which he allowed a sunbeam to traverse the prism, casting the spectrum onto the opposite wall of his room. In addition to this, his argument about the composition of light turned on an 'experimentum crucis' in which a second prism was used to demonstrate that the differently coloured rays that made up white light were independent of the angle at which the light had initially struck the first prism.

Despite Newton's account, the circumstances of his experiments remain unclear and they certainly puzzled his contemporaries. Most puzzling of all was Newton's description of the spectrum itself. He initially suggested that it contained five distinct colours, later modifying this number to seven. Yet the distinction between these colours was understandably obscure to Newton's readers. Since Newton was himself uncertain about the causes of the behaviour of light that he had observed, it is not surprising that many of his contemporaries should have been sceptical about both his findings and the explanations that he offered for them.

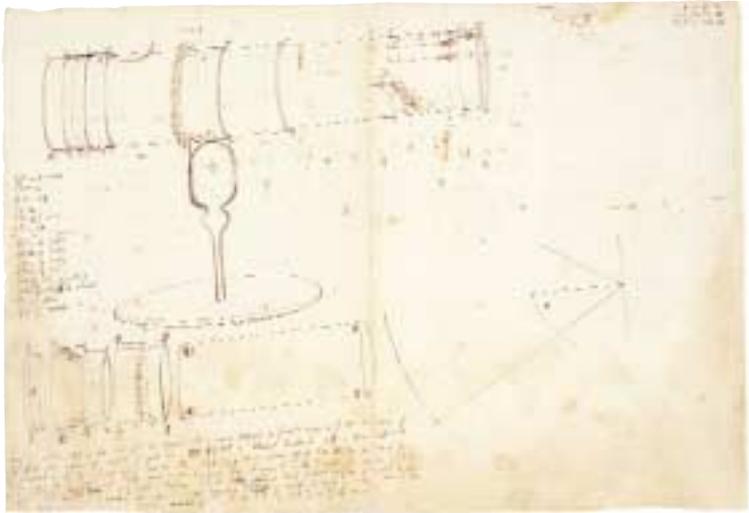
As a result of doubts about the conduct of his experiments, Newton described the prisms that he used in some detail, particularly in later correspondence. They were all triangular prisms each of whose angles was close to 60°. A number of candidates have been proposed as surviving examples of Newton's prisms. These include the prism on display. However, none of these prisms in fact match the exact dimensions that Newton specified. Indeed, it seems likely that they are all of much later manufacture, and that the prism on display is one that was presented to the Cavendish Laboratory in 1876 from the collection of W.H. Wollaston.

A.A. Mills, 'Newton's Prisms and his Experiments on the Spectrum', *Notes and Records of the Royal Society of London*, 36 (1981–2), 13–36; Simon Schaffer, 'Glass Works: Newton's Prisms and the Uses of Experiment', in David Gooding, Trevor Pinch and Simon Schaffer (eds), *The Uses of Experiment* (Cambridge, 1989), pp. 67–104; J.A. Lohne, 'Isaac Newton: The Rise of a Scientist 1661–1671', *Notes and Records of the Royal Society of London*, 20 (1965), 125–39.

22 cambridge university library, ms. add. 3970, ff. 591r- 592v  
(figures 15 & 16)  
24.4 × 37 cm

The telescopes which were responsible for the remarkable discoveries of Galileo and other seventeenth-century astronomers all depended on the ability of lenses to bring objects closer to the observer through the refraction of light. They suffered from a number of limitations that contemporaries hoped might be alleviated through new discoveries. Newton's essay 'Of Refractions' (see catalogue number 9) considered solutions to one of these limitations, spherical aberration, through the grinding of non-spherical lenses. His work on light, however, suggested

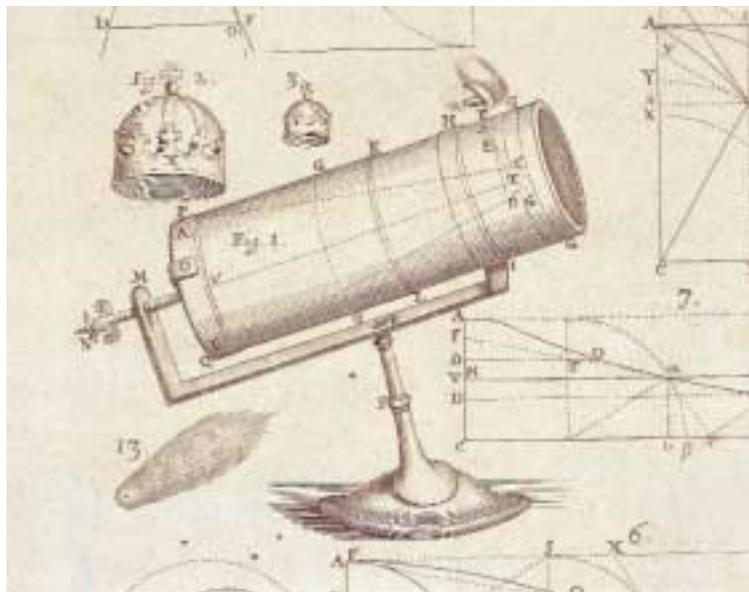
figure 15  
 Drawing by  
 Newton of his  
 reflecting telescope  
 and its parts,  
 University Library,  
 Ms. Add. 3970, ff.  
 591r–592v.



that another problem, the distortion in colour and clarity of a distant object viewed through several lenses (chromatic aberration), might be more difficult to solve.

One way to overcome this problem was to use a mirror instead of a lens to gather light into the telescope. The construction of a reflecting telescope had the additional advantage of avoiding the problems of focussing an image resulting from spherical aberration. By 1668, Newton already possessed suitable tools and experience in working metal and glass to manufacture a reflecting telescope. He gave an account of his invention in his first surviving letter (a copy of which was later made by John Collins and is now in the Macclesfield Collection) in February 1669. Soon afterwards, Newton discussed his telescope with instrument makers in London and with Collins. Following his election to the Royal Society, Newton composed a paper about his telescope for the *Philosophical Transactions* (number 81, 25 March 1672, 4004–10, see figure 16). This described the instrument's construction, which Newton had already committed to paper in the drawing on display. The telescope's tube was made of pasteboard and was lengthened and shortened for focussing by means of metal screws. There were two highly polished mirrors of copper: one concave at the closed end of the telescope to reflect an object, the other small and flat, placed at the opposite end of the telescope to direct the reflected rays of light towards a tiny glass lens

figure 16  
 Newton's reflecting telescope, which doubled the size of a crown from a weather-cock on a neighbouring tower when compared with observations using a standard refracting telescope, University Library, T.340.1 b.85.7, table 1.



near the opening of the tube, where the enlarged image could be viewed by an observer.

Like his other optical discoveries, Newton's telescope generated controversy. It was clear that it could achieve a remarkable level of magnification compared with refracting telescopes of a similar size. Despite this, Huygens rightly wondered about the difficulty of manufacturing mirrors of suitable smoothness for the instrument and preventing them from tarnishing. Others, including Hooke, claimed that they had already described similar telescopes themselves and that therefore Newton deserved little credit for his work. It was certainly the case that James Gregory had already published another, more manageable, design of reflecting telescope, and that this model later became the standard for manufacture. Newton himself did not abandon the hope of improving refracting telescopes, which in fact remained the principal tools for late seventeenth-century astronomy. He nevertheless continued to develop his reflecting telescope in response to his critics. In March 1672, he suggested the replacement of the secondary, plane mirror with a prism. Although he did not ever build a telescope with this improvement, he did make a drawing of one, which is displayed here. This was also the design that Newton later described in the *Opticks* (1704).

H. W. Turnbull, J.F. Scott, A.R. Hall and Laura Tilling (eds), *The Correspondence of Isaac Newton*, 7 vols (Cambridge, 1959–77), vol. 1, 3–9, 72–7, 126–30; I. Bernard Cohen, 'Newton's Description of the Reflecting Telescope', *Notes and Records of the Royal Society of London*, 47 (1993), 1–9; A. Rupert Hall, 'John Collins on Newton's Telescope', *Notes and Records of the Royal Society of London*, 49 (1995), 71–8.

Presented to Cambridge University Library by the fifth Earl of Portsmouth. See *A Catalogue of the Portsmouth Collection of Books and Papers written by or belonging to Sir Isaac Newton* (Cambridge, 1888), pp. 9–10.

### 23 whipple museum, cambridge, accession number 2662

Replica of Newton's reflecting telescope

This is a replica made in 1953 of a reflecting telescope in the possession of the Royal Society. Newton had deposited one of his telescopes with the Royal Society at the end of 1671. This was placed in the Society's Repository, or museum, where it remained until at least 1718, although the Society had changed its address several times in the intervening years. When the Repository was catalogued in 1731, however, only the two mirrors remained. These had also disappeared by 1827. The replica on display is based on a telescope given to the Royal Society in 1766 by the London instrument makers, Thomas Heath and Tycho Wing. This telescope bears signs of restoration during the eighteenth century but was probably made by Newton in 1671. Newton constructed two telescopes in that year. One he sent to the Royal Society, the other he built with his friend John Wickens, who shared his rooms in Trinity. Newton kept this second telescope until at least the 1690s.

A. Rupert Hall and A.D.C. Simpson, 'An Account of the Royal Society's Newton Telescope', *Notes and Records of the Royal Society of London*, 50 (1996), 1–11; A.D.C. Simpson, 'Newton's Telescope and the Cataloguing of the Royal Society's Repository', *Notes and Records of the Royal Society of London*, 38 (1983–4), 187–214; A.A. Mills and P.J. Turvey, 'Newton's Telescope. An Examination of the Reflecting Telescope attributed to Sir Isaac Newton in the Possession of the Royal Society', *Notes and Records of the Royal Society of London*, 33 (1978–9), 133–55.

### 24 cambridge university library, macclesfield collection,

box 3/4/13

20.4 × 15.7

This is the second letter that Newton wrote to Henry Oldenburg, and the first following his election to the Royal Society. In an earlier letter of 6 January (also in the Macclesfield Collection), he had thanked

Oldenburg for his care in securing Newton's priority for the invention of the reflecting telescope. In this letter, which Oldenburg received on 19 January, Newton considered possible improvements to the metal mirrors that he had used in the telescope. This discussion revealed the considerable understanding of how to work metal and make alloys that Newton had gained since the start of his alchemical experiments in the late 1660s. Newton concluded his letter by asking about the duties of a Fellow of the Royal Society and for information about the Society's meetings. In formulating these queries, he promised to send the Society an account of his theory of light and colours, which had prompted him to construct his telescope and '[which] I doubt not but will prove much more gratefull then the communication of that instrument, being in my Judgment the oddest if not the most considerable detection [which] hath hitherto beene made in the operations of Nature' (see catalogue number 20).

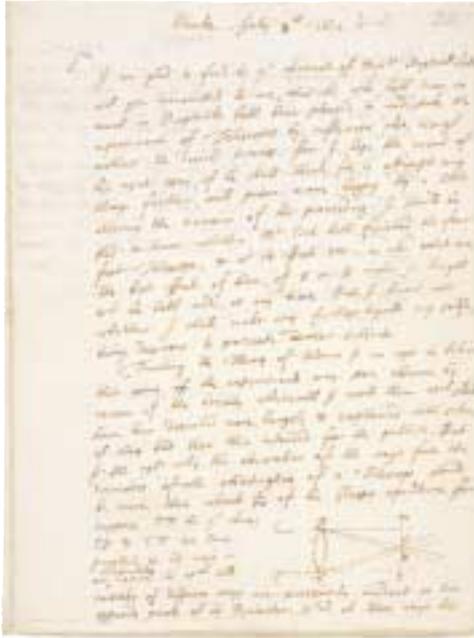
H. W. Turnbull, J.F. Scott, A.R. Hall and Laura Tilling (eds), *The Correspondence of Isaac Newton*, 7 vols (Cambridge, 1959–77), vol. 1, 82–3 (which prints this letter).

Purchased from the Macclesfield family by Cambridge University Library, August 2000.

25 cambridge university library, macclesfield collection,  
 box 3/4/22  
 (figure 17)  
 20.7 × 15.6 cm

This is one of numerous letters exchanged between Newton and Oldenburg in the aftermath of Newton's first publications in the *Philosophical Transactions*. Oldenburg had written to Newton on 2 July 1672, passing on encouragement and criticism from a letter that Huygens had sent on 21 June. Newton's reply was composed at Stoke on 8 July. He acknowledged Huygens' remarks and asked about the progress of Christopher Cock, a London instrument maker, who was building a four-foot reflecting telescope with metal mirrors and also making trials of much shorter telescopes, such as Newton's own prototype. The Royal Society had asked Cock to make a larger version of Newton's telescope on 14 March. Despite his confidence that it would be completed within two weeks, Cock had been forced to report a month later that he was having trouble burnishing the large steel mirror

figure 17  
A letter from  
Oldenburg  
discussing reactions  
to Newton's papers  
on light and on the  
reflecting telescope,  
University Library,  
Macclesfield  
Collection, Box  
3/4/22.



that the telescope required. Newton was already becoming bored with the detailed investigation of his invention and its potential, which seemed to be generating more and more criticism of his design. As a result, he commented 'I know not whether I shall make any further tryalls my selfe, being desirous to prosecute some other subjects'. The letter concluded with a discussion of spherical aberration in telescopes, in which Newton tried to clarify parts of his theory of light and colours. On this topic, Newton was still willing to give ground to Huygens and other critics, admitting that 'I am apt to beleive that some of the experiments may seem obscure by reason of the brevity wherewith I writ them'. Nevertheless, he maintained that his measurements, which Huygens had doubted, were accurate.

H. W. Turnbull, J.F. Scott, A.R. Hall and Laura Tilling (eds), *The Correspondence of Isaac Newton*, 7 vols (Cambridge, 1959–77), vol. 1, 212–13 (which prints this letter); A. Rupert and Marie Boas Hall (eds), *The Correspondence of Henry Oldenburg*, 13 vols (Madison and London, 1965–86), vol. 9, 116–25, 150–1; Thomas Birch (ed.), *The History of the Royal Society of London*, 4 vols (London, 1756–7), vol. 3, pp. 19, 43.

Purchased from the Macclesfield family by Cambridge University Library, August 2000.

## 26 cambridge university library, ms. add. 3970 f. 501r

*(figure 18)*

31.3 × 20 cm

The debate over Newton's theory of light and colours continued throughout the early 1670s, encouraged partly by Oldenburg's indefatigable pursuit of communications for the Royal Society. On 7 December 1675, Newton sent Oldenburg the most complete answer that he had yet composed to his critics, in the form of two documents, 'An Hypothesis explaining the Properties of Light discoursed of in my severall papers' and the 'Discourse of Observations'. Both papers were based partly on drafts that Newton had composed in 1672. They were read aloud at the weekly meetings of the Royal Society held between 9 December 1675 and 10 February 1676, and constituted the majority of the business on those occasions. The purpose of Newton's 'Hypothesis' (see catalogue number 28) was to try to expand on the theory of light and colours in order to explain the causes of the behaviour that Newton had described. It was a direct response to Robert Hooke and others who

figure 18

Newton's observation of coloured rings produced by light passing through a thin film of air between two glass plates, University Library, Ms. Add. 3970, f. 501r.



supported the theory that colour was produced by the modification of light as it fell on particular bodies. Despite the rejection of this position that his theory entailed, Newton was still drawn to many aspects of a mechanical explanation for light. He struggled to find a cause for the changes of state that light appeared to undergo as it was transmitted across the boundaries between different media. In the end, he argued for the existence of a pervasive form of subtle matter, or aether, that might produce these effects both mechanically and through some form of spiritual action, perhaps implanted by God. This argument married Newton's continuing respect for Cartesian natural philosophy with his growing conviction, nurtured by alchemical study, that organic as well as mechanical explanations were necessary for an understanding of growth and change in nature.

In both the 'Hypothesis' and the 'Discourse of Observations', Newton drew on the optical and anatomical experiments that he had carried out in the mid-1660s (see catalogue number 11). The 'Discourse of Observations', of which the manuscript on display is a fair copy in Newton's hand, was concerned primarily with the behaviour of light as it passed through thin films of air or water between two glass plates. It consisted of twenty-four observations, with careful measurements, that helped to establish that the transmission of light was periodic in character. Inconveniently, this was exactly what Hooke had argued. Newton's experiments had been greatly influenced by Hooke's work on colour in *Micrographia* (1665) but his own theory involved a rejection of many of Hooke's ideas. Rather than regarding his findings as exceptional, however, Newton used them as the cornerstone of his new ideas of the transmission of light. They provided a firm, empirical case for what was otherwise a largely speculative argument.

In January 1676, Newton changed his mind about allowing Oldenburg to publish his most recent thoughts about light. Perhaps defeated by the difficulty of propounding a coherent theory, Newton abandoned his optical writing for over a decade. Yet there were also other reasons for his silence. The awkwardness of his personal circumstances (see catalogue number 5) encouraged him to avoid controversy. He was also beginning to have doubts about Oldenburg's reliability as a mediator between author and critics. When he did start to draft the text of the *Opticks* in 1687–8, Newton incorporated the 'Discourse of Observations' almost without change into Book II. As he struggled to

complete the work in the early 1690s, however, he returned to the hypotheses that he had first introduced in 1672 and had developed extensively in 1675. By the mid-1690s, he had extended his theory of the transmission of light to cover thick plates as well as thin films. Nevertheless, an adequate physical explanation for the behaviour of light continued to elude him even in the composition of the *Queries* for the *Opticks* in the final years before the book's publication in 1704.

H. W. Turnbull, J.F. Scott, A.R. Hall and Laura Tilling (eds), *The Correspondence of Isaac Newton*, 7 vols (Cambridge, 1959–77), vol. 1, 110–16, 360–92; Cambridge University Library, Ms. Add. 3970, ff. 519r–28v; Thomas Birch (ed.), *The History of the Royal Society of London*, 4 vols (London, 1756–7), vol. 3, 247–305; I. Bernard Cohen (ed.), *Isaac Newton's Papers and Letters on Natural Philosophy* (Cambridge, 1958), pp. 177–235 (which reprints the text of the 'Hypothesis' and the 'Discourse of Observations' from Birch); Alan E. Shapiro, *Fits, Passions, and Paroxysms* (Cambridge, 1993), pp. 49–97, 138–50.

Presented to Cambridge University Library by the fifth Earl of Portsmouth. See *A Catalogue of the Portsmouth Collection of Books and Papers written by or belonging to Sir Isaac Newton* (Cambridge, 1888), pp. 9–10.

27 cambridge university library, macclesfield collection,  
box 3/4/18  
31 × 20.5 cm

This is a letter that Newton sent to John Collins (see catalogue number 38) on 25 May 1672. It replied to a typical letter that Collins had written on 30 April (also in the Macclesfield Collection), which contained extensive news of books that were printing in London and overseas. In the first flush of his fame, Newton had had ambitious plans for publications. He now informed Collins that the edition that he had prepared of the *Geographia universalis* of Bernhard Varenius was ready for the press, as were the additions that he had written for Nicolaus Mercator's edition of Gerard Kinckhuysen's *Algebra*. Newton's edition of Varenius was indeed published in 1672, but Collins was less successful in coaxing any of Newton's mathematical work into the world. Already Newton had decided not to prepare an edition of his optical lectures (see catalogue number 6) for publication: 'finding... by the little use I have made of the Presse, that I shall not enjoy my former serene liberty till I have done with it'. The reaction to his paper on light and colours, particularly from Hooke and other natural philosophers that he had admired when he had known them only through their books, had convinced Newton of the

dangers of publicity. He worried about the treatment of his ideas in the *Philosophical Transactions*. Although he was given the opportunity to reply several times to his critics, he told Collins that he was ‘a little troubled to find my selfe cut short of that fredome of communication [which] I hoped to enjoy, but cannot any longer without giving offence to some persons whome I have ever respected’. In March 1673, Oldenburg had to talk Newton out of resigning from the Royal Society. Newton chafed continually against the fees that he had to pay. The lengthy trial by correspondence, which lasted until his withdrawal from the Royal Society in 1676, only served to confirm the disillusionment and insecurity that were already apparent in summer 1672.

H. W. Turnbull, J.F. Scott, A.R. Hall and Laura Tilling (eds), *The Correspondence of Isaac Newton*, 7 vols (Cambridge, 1959–77), vol. 1, 146–50, 161–2 (which prints this letter).

Purchased from the Earl of Macclesfield by Cambridge University Library, August 2000.

28 cambridge university library, ms. add. 3970, ff. 544r-545v  
(figure 19)  
29.9 × 18.6 cm

Newton composed ‘An Hypothesis explaining the Properties of Light discoursed of in my severall papers’ as an answer to Robert Hooke’s ‘Considerations’ on the new theory of light and colours (see catalogue number 26). He developed his initial reply of November 1672 into the more complete document that he sent to Henry Oldenburg in December 1675.

The pages on display provide evidence of Newton’s care in constructing optical experiments that would allow him to measure the phenomena that he observed. They illustrate his attempts to use quantification to support the conclusions of his theory of light and colours and assist in finding causes for the behaviour of light. Like Descartes, Newton argued that this behaviour was the result of interactions between corpuscles of light and the particles of the medium through which they travelled. He suggested that light itself might excite vibrations in an aetherial medium, and drew a comparison between effects of the colours of the spectrum and those of the divisions of a string necessary to sound the tones of a musical scale. This analogy had already led Newton to define seven colours in the spectrum, where he had earlier



figure 19  
Newton's attempt  
to calibrate light as  
a vibration in an  
aetherial medium,  
similar to the  
calibration of sound  
travelling through  
the air as repre-  
sented in a  
musical scale,  
University Library,  
Ms. Add. 3970, ff.  
544r-545v.

seen only five. But, unlike Hooke, Newton was convinced that light was propagated as particles moving in straight lines and not as a wave. His experiments with thin films created difficulties for any explanation of the phenomena based simply on the velocity of light. In order to explain the rings that he had observed, Newton was tempted to argue that the vibrations set up as light passed through a medium exceeded the speed of light itself. As in the analogy with a musical scale, Newton suggested that it was the size of particles of light that determined the effects that were visible both as different colours and as patterns of interference. The observations that he presented in support of this analysis later formed the basis for the puzzling theory of 'fits of easy reflection and transmission' that Newton developed in the *Opticks*.

Penelope Gouk, *Music, Science and Natural Magic in Seventeenth-Century England* (New Haven, 1999), pp. 241–6.

Presented to Cambridge University Library by the fifth Earl of Portsmouth. See *A Catalogue of the Portsmouth Collection of Books and Papers written by or belonging to Sir Isaac Newton* (Cambridge, 1888), pp. 9–10.

29 isaac newton, *Opticks*

(London, 1704)

(figure 20)

4<sup>o</sup>: a<sup>4</sup>, b<sup>1-3</sup>; b<sup>3-4</sup>; c-s<sup>4</sup>; 2a-2s<sup>4</sup>; 2t<sup>1</sup>

Cambridge University Library, shelfmark Adv. b. 39.3

Newton took great care in the preparation of the *Opticks* for the press. This was partly a result of the anxiety that he continued to feel about some of his conclusions, which resulted in the suppression of the introduction that he had planned and the curtailment and redistribution of the fourth book of the text. The search for a cause of the behaviour of light continued to vex Newton. His last minute corrections are often apparent in the printers' copy of the first edition (Ms. Add. 3970(3)). Further revisions were made impossible by the publication of the book in 1704. However, Newton continued to work at the text. His additions to what appear to be proof sheets, for Books I and II and most of Book III, are displayed here. Drafts of these corrections also survive in the manuscript of the *Opticks* (Ms. Add. 3970(3), f. 240b, for example, incorporates the material that Newton added to Query 10 on page 134 of the proofs). Newton saw the need for a second edition of the book almost immediately and commissioned his friend and disciple, Samuel Clarke

figure 20  
Proofs of the first edition of the *Opticks*, showing the corrections that Newton made in preparing the second edition, University Library, shelfmark Adv. b. 39.3, pp. 134-5.



(1675–1729), to make a Latin translation that would include some of the new work.

Richard S. Westfall, *Never at Rest. A Biography of Isaac Newton* (Cambridge, 1980), pp. 643–8.

Presented to Cambridge University Library by the fifth Earl of Portsmouth. See *A Catalogue of the Portsmouth Collection of Books and Papers written by or belonging to Sir Isaac Newton* (Cambridge, 1888), p. 41.

### 30 isaac newton, *Optice*, trans. samuel clarke

(London, 1706)

4<sup>o</sup>: a<sup>4</sup>, b<sup>3</sup>, a-3s<sup>4</sup>, 3t<sup>2</sup>

19 × 12.5

Cambridge University Library, shelfmark Adv. b. 39.4

Clarke was paid £500 for translating the *Opticks* into Latin. Another young friend of Newton, the mathematical tutor Abraham De Moivre saw the book through the press. It included a number of changes, most importantly the addition of seven new queries at the end of Book III, explaining some of Newton's thoughts about the nature of matter and the action of light and gravity. Further queries were introduced into the second English edition of the *Opticks*, which appeared in 1717.

This copy of *Optice* belonged to Newton and includes a few corrections in his hand, especially to the list of errata (sig. b1r-3v). Newton also turned down the corners of some of its pages to mark passages that featured in later controversies concerning his work. The book is open to display illustrations based on Newton's earlier optical experiments.

John Harrison, *The Library of Isaac Newton* (Cambridge, 1978), p. 201.

Listed by the booksellers who appraised Newton's library for his executors; bought with the rest of the library by John Huggins in 1727. Bookplate of Charles Huggins. Bookplate of James Musgrave, with shelfmark E6–27. Presumed sold at Thame Park, 13–15 January 1920. Bought by C.W. Adams from Thomas Thorp, Guildford, for 16s. in July 1921. Presented by Adams to Cambridge University Library, 8 December 1928.