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(*b*. London, England, October 1630; *d*. London, 4 May 1677)

geometry, optics.

Barrow's father, Thomas, was a prosperous linendraper with court connections; his mother, Anne, died when Isaac was an infant. A rebel as a dayboy at Charterhouse, Barrow came later, at Felsted, to accept the scholastic disciplining in Greek, Latin, logic, and rhetoric imposed by his headmaster, Martin Holbeach. In 1643, already as firm a supporter of the king as his father was, he entered Trinity College, Cambridge, as pensioner. There he survived increasingly antiroyalist pressure for twelve years, graduating B.A. in 1648, being elected a college fellow (1649), and receiving his M.A. (1652), the academic passport to his final position as college lecturer and university examiner. In 1655, ousted by Cromwellian mandate from certain selection as Regius professor of Greek (in succession to his former tutor, James Duport), he sold his books and set out on an adventurous four-year tour of the Continent. On his return, coincident with the restoration of Charles II to the throne in 1660, he took holy orders and was promptly rewarded with the chair previously denied him. In 1662 he trebled his slender income by concurrently accepting the Gresham professorship of geometry in London and acting as locum for a fellow astronomy professor; he was relieved of this excessive teaching load when, in 1663, he was made first Lucasian professor of mathematics at Cambridge.

During the next six years, forbidden by professorial statute to hold any other university position, Barrow devoted himself to preparing the three series of *Lectiones* on which his scientific fame rests. In 1669, however, increasingly dissatisfied with this bar to advancing himself within his college, he resigned his chair (to Newton) to become royal chaplain in London. Four years later he returned as king's choice for the vacant mastership of Trinity, becoming university vice-chancellor in 1675. Barrow never married and, indeed, erased from his master's patent the clause permitting him to do so. Small and wiry in build, by conventional account he enjoyed excellent health, his early death apparently being the result of an overdose of drugs. he was remembered by his contemporaries for the bluntness and clarity of his theological sermons (published posthumously by Tillotson in 1683–1689), although these were too literary and long-winded to make him a popular preacher. His deep classical knowledge resulted in no specialized philological or textual studies. Although he was one of the first fellows of the Royal Society after its incorporation in 1662, he never took an active part in its meetings.

As an undergraduate, Barrow, like Newton a decade later, endured a traditional scholastic course, centered on Aristotle and his Renaissance commentators, which was inculcated by lecture and examined by disputation: but from the first he showed great interest in the current Gassendist revival of atomism and Descartes's systematization of natural philosophy. (His 1652 M.A. thesis, *Cartesiana hypothesis de materia et mote haud satisfacit praecipuis naturae phaenomenis*, is based on a careful study of Descartes and Regius.) That, also like Newton, he mastered Descartes's *Géométrie* unaided is unlikely. The elementary portion of Euclid's *Elements* was part of Barrow's college syllabus, but some time before 1652 he went on to read not only Euclidean commentaries by Tacquet, Hérigone, and Oughtred, but also more advanced Greek works by Archimedes and possibly Apollonius and Ptolemy. His first published work, his epitomized *Euclidis Elementorum libri XV* (probably written by early 1654), is designed as a quadrivium undergraduate text, with emphasis on its deductive structure rather than on its geometrical content, its sole concessions to contemporary mathematical idiom being its systematic use of Oughtred's symbolism and a list "ex P. Herigono" of numerical constants relating to inscribed polyhedra. To its reedition in 1657, Barrow added a similar epitome of Euclid's *Data*, and in his 1666 Lucasian lectures expounded a likewise recast version of Archimedes' method in the *Sphere and Cylinder;* a full edition, in the same style, of the known corpus of Archimedes' works, the first four books of Apollonius' *Conics*, and the three books of Theodosius' *Spherics* appeared in 1675. Overloaded with marginal references, virtually bare of editorial amplification, and fussy in their symbolism, these texts can hardly have been easier to read than their Latin originals, and only the conveniently pocketsized *Euclid* reached a wide public. Barrow himself commented that his Apollonius had in it "nothing considerable but its brevity." His early attempt at a modern approach to Greek mathematics was a short, posthumously edited *Lectio* in which he analyzed the Archimedean quadrature method in terms of indivisibles on the style of Wallis' *Arithmetica infinitorum*.

Barrow's Gresham inaugural, still preserved, tells little of the content of his lost London lectures; perhaps they were similar to works of his on "Perspective, Projections, Elem^{ts} of Plaine Geometry" mentioned by Collins. The first of his Lucasian series, the *Lectiones mathematicae* (given in sequence from 1664 to 1666), discourse on the foundations of mathematics from an essentially Greek standpoint, with interpolations from such contemporaries as Tacquet, Wallis, and Hobbes (usually cited only to be refuted). Such topics as the ontological status of mathematical entities, the nature of axiomatic deduction, the continuous and the discrete, spatial magnitude and numerical quantity, infinity and the infinitesimal, and proportionality and incommensurability are examined at length. Barrow's conservatism reveals itself in his artificial preservation of the dichotomy between arithmetic and geometry by classifying algebra as merely a useful logical (analytical) tool which is not a field of mathematical study in itself. The *Lectiones geometricae* were, no doubt, initially intended as the technical study of higher geometry for which the preceding course had paved the way, and the earlier lectures may indeed have been delivered as such.

About 1664, having heard (as he told Collins) that “Mersennus & Torricellius doe mencõn a generall method of finding y^e^ tangents of curve lines by composition of motions; but doe not tell it us,” he found out “such a one” for himself, elaborating an approach to plane geometry in which the elements were suitably compounded rotating and translating lines. In his first five geometrical lectures he took some trouble to define the uniformly “fluent” variable of time which is the measure of all motion, and then went on to consider the properties of curves generated by combinations of moving points and lines, evolving a simple Robervallian construction for tangents. Later lectures (6–12), evidently thrown together in some haste, are in large part a systematic generalization of tangent, quadrature, and rectification procedures gathered by Barrow from his reading of Torricelli, Descartes, Schooten, Hudde, Wallis, Wren, Fermat, Huygens, Pascal, and, above all, James Gregory; while the final *Lectio*, 13, is an unconnected account of the geometrical construction of equations. We should (despite Child) be careful not to overemphasize the originality of these lectures; the “fundamental theorem of the calculus,” for example, and the *compendium pro tangetibus determinandis in Lectio* 10 are, respectively, restylings, by way of propositions 6 and 7 of Gregory’s *Geometriae pars universalis* (1668), of William Neil’s rectification method (in Walls’ *De cycloide*, 1659) and of the tangent algorithm thrashed out by Descartes and Fermat in their 1638 correspondence (published by Clerselier in 1667). In theory, as Jakob Bernoulli argued in 1691, Barrow’s geometrical formulations could well have been the basis on which systematized algorithmic calculus structures were subsequently erected; but in historical fact the *Lectiones geometricae* were little read even by the few (Sluse, Gregory, Newton, Leibniz) qualified to appreciate them, and their impact was small. Perhaps only John Craige (1685) based a calculus method on a Barrovian precedent, and then only in a single instance (*Lectio 11*, 1).

Barrow’s optical lectures, highly praised on their first publication by Sluse and James Gregory, had an equally short-lived heyday, being at once rendered obsolete by the Newtonian *Lectiones opticae*, which both in methodology and in subject matter, they inspired. In his introduction he lays down the scarcely novel mechanical hypothesis of a lucid body (a “congeries corpusculorum ultra pene quam cogitari potest minutorum” or “collection of particles minute almost beyond conceivability”) as the propagating source of rectilinear light rays. his hypothesis of color (in *Lectio 12*) as a dilution in “thickness” and swiftness, of white light through red, green and blue to black, is no less shadowy than the Cartesian explanation to which it is preferred. Structurally, the technical portion of the *Lectiones* is developed purely mathematically from six axiomatic “Hypotheses opticae primariae et fundamentales [seu] leges... ab experientiâ confirmatae,” notably the Euclidean law of reflection and the sine law of refraction, and presents a reasonably complete discussion of the elementary catoptrics and dioptrics of white light. Not unexpectedly, the organization and mathematical detail are barrow’s, but his topics are mostly taken from Alhazen, Kepler, Scheiner, Descartes, and others: thus, his improvement of the Cartesian theory of the rainbow (*Lectio 12*, 14) derives from Huygens by way of Sluse. The most original contributions of the work are his method for finding the point of refraction at a plane interface (*Lectio 5*, 12) and his point construction of the diacaustic of a spherical interface (*Lectio 13*, 24); both were at once subsumed by Newton into his own geometrical optics, and the latter (in ignorance) was triumphantly rediscovered by Jakob Bernoulli in 1693.

Barrow’s relationship with Newton, although of considerable historical importance, has never been clarified. That newton was barrow’s pupil at Trinity is a myth, and Barrow’s name does not appear in the mass of Newton’s extant early papers; nor is there good evidence for supposing that any of Newton’s early mathematical or optical discoveries were in any way due to Barrow’s personal tutelage. In his old age, the furthest that Newton would go in admitting a mathematical debt to Barrow was that attendance at his lectures “might put me upon considering the generation of figures by motion, tho I not now remember it.” It may well be that Barrow came to know Newton intimately only after his election to senior college status in 1667. Certainly by late 1669 there was a brief working rapport between the two which, if it did not last long, at least resulted in Newton’s consciously choosing to continue the theme of his predecessor’s lectures in his own first Lucasian series.

BIBLIOGRAPHY

I. Original Works. The contents of barrow’s library at the time of his death are recorded in “A Catalogue of the Bookes of D^r^ Isaac Barrow Sent to S.S. by M^r^ Isaac Newton... July 14. 1677” (Bodleian, Oxford, Rawlinson D878,33^r^-59^r^). His *Euclidis Elementorum libri XV breviter demonstrati* appeared at Cambridge in 1655; to its 1657 reedition (reissued in 1659) was appended his edition of Euclid’s *Data*. Both reappeared in 1678, together with Barrow’s *Lectio... in qua theoremata Archimedis De sphaera & cylindro per methodum indivisibilium investigala exhihentur* (Royal Society, London, MS XIX). An English edition of the *Elements; the Whole Fifteen Books* (London, 1660) was reissued half a dozen times in the early eighteenth century, and an independent English version by Thomas Haselden of the *Elements, Data, and Lectio* together appeared there in 1732. The manuscript of Barrow’s *Archimedis opera: Apollonii Pergaei Conicorum libri IIII: Theodosii Sphaerica: Methodo novo illustrata, & succincte demonstrata* (London, 1675) is now in the Royal Society, London (MSS XVIII-XX): a proposed apendix epitomizing Apollonius’ *Conics, 5–7* (from Borelli’s 1661 edition) never appeared., His *Lectiones mathematicae XXIII; In quibus Principia Matheseôs generalia exponuntur: Habitae Cantabrigiae A.D. 1664, 1665, 1666* was published posthumousluy at London in 1683 (reissued 1684 and 1685); an English version by John Kirkby came out there in 1734. The rare 1669 edition of Barrow’s *Lectiones XVIII Canabrigiae in scholis publicis habitae; In Quoibus exponutur* was speedily followed (1670) by his *Lectiones geometricae: In quibus (praesertim) generalia curvarum linearum symptomata declarantur:* these were issued (both together and separately) at London in 1670, 1672, and 1674. Unpublished variant drafts of geometrical lectures 10, 11, and 13 are extant in private possession.

The optical lectures were reprinted, none too accurately, in C. Babbage and F. Maseres' *Scriptores optici* (London, 1823), and all three Lucasian series were collected, together with Barrow's inaugural, in W. Whewell's *The Mathematical Works of Isaac Barrow D.D.* (Cambridge, 1860). A mediocre English translation of the geometrical lectures by Edmund Stone (London, 1735) is more accurate than J. M. Child's distorted abridgment, *The Geometrical Lectures of Isaac Barrow* (Chicago-London, 1916). Alexander Napier's standard edition of Barrow's *Theological Works* (9 vols., Cambridge. 1859), based on original manuscripts in Trinity College, Cambridge, and otherwise restoring the text from Tillotson's "improvements," is scientifically valuable for the *Opuscula* contained in its final volume: here will be found the texts of barrow's early academic exercises and college orations, as well as of his professorial inaugurals. The extant portion of Barrow's correspondence with Collins has been published several times from the originals in possession of the Royal Society, London, and the Earl of Macclesfield, notably in Newton's *Commercium epistolicum D. Johannis Collins, et aliorum de analysi promota* (London, 1712) and in S. P. Rigaud's *Correspndence of Scientific Men of the Seventeenth Century*. II (Oxford, 1841), 32–76.

II. Secondary Literature. Existing sketches of Barrow's life (by Abraham Hill, John Aubrey, John Ward, and, more recently, J. H. Overton) are mostly collections of unsupported anecdote, both dreary and derivative. Percy H. Osmond's *Isaac Barrow, His Life and Times* (London, 1944) has few scientific insights but is otherwise a lively, semipopular account of Barrow's intellectual achievement. In "Newton, Barrow and the Hypothetical Physics," in *Centaurus*, **11** (1965), 46–56, and *Atomism in England From Hariot to Newton* (Oxford, 1966), p. 120, Robert H. Kargon argues that Barrow's scientific methodology, as expounded in the *Lectiones mathematicae*, physics rather than as Archimedean classicism, but he is uncritical in his acceptance of Barrow's early influence on Newton.

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