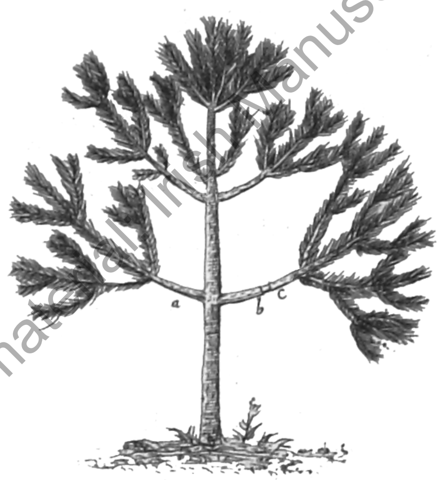
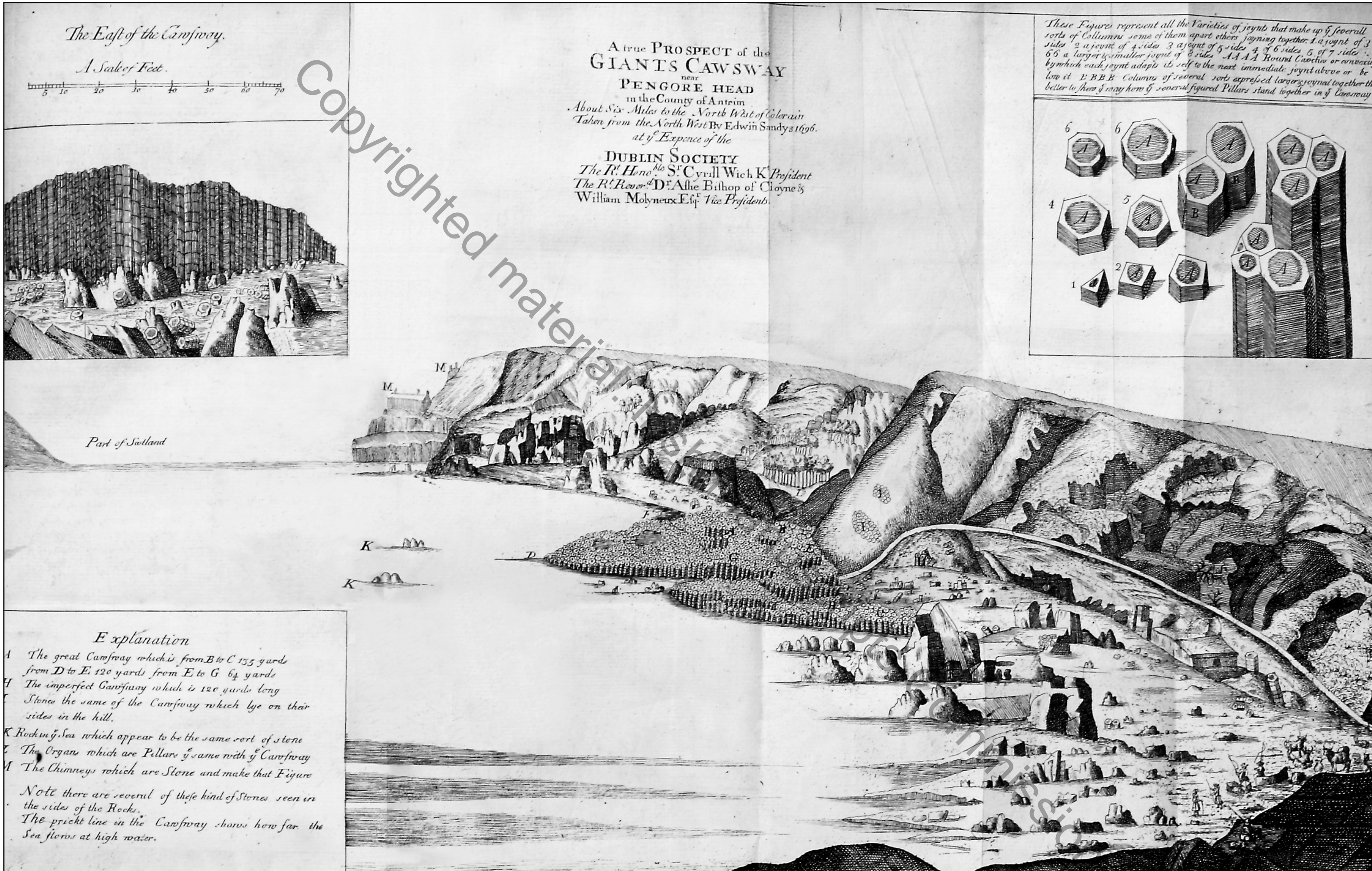
PAPERS OF THE

Dublin Philosophical Society





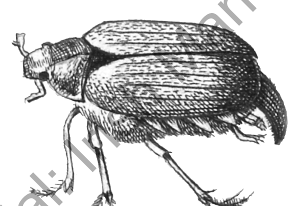
The Giant's Causeway. Reproduced from *Philosophical Transactions of the Royal Society*, xx, no. 241 (1698). See item 160.

PAPERS OF THE

Dublin Philosophical Society

1683–1709

VOLUME I



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SERIES CONTENTS

VOLUME I

VOLUME II

CONTENTS

VOLUME I

LIST OF ILLUSTRATIONS

The Roman numerals refer to the plate number of the illustration in this edition. The Arabic numerals in parenthesis refer to the item to which a particular illustration belongs.

In addition, very small sketches, redrawn from the manuscript originals, and not numbered, are to be found with items 23, 56, and 444 in this edition.

GENERAL INTRODUCTION

The intellectual world of late seventeenth-century Ireland was closely interwoven into the wider social and political situation of that country, and its preoccupations and biases thus reflected the divisions within Irish society. Those who responded most readily to the complex intellectual currents then flowing through much of western Europe, currents bearing with them new ways of looking at the natural world and at man himself, came largely from a small social caste made up of those who had settled or whose ancestors had settled in Ireland during the sixteenth and seventeenth centuries. These men looked first to England or Scotland for the source of their ideas and prejudices. They belonged to a wider British community and their situation in Ireland was essentially a colonial one. Their cultural dynamic, in both the broad sense of communal behaviour and outlook and the narrow sense of conscious intellectual articulation, was driven by a complicated engine made up of memories, contacts with relatives and friends across the Irish Sea, a feeling of separation from both the native Gaelic and the old English elements in Irish society (brought about by cultural as well as simply religious considerations), and a distinct sense of superiority and efficiency. This group produced the most positive response in Restoration Ireland to contemporary advances in learning. From it came most of the men who were in touch with international scholarship.

It was natural philosophy that provided perhaps the most dynamic element within the late seventeenth-century world of learning. Basing themselves on a variety of traditions, its practitioners were offering new and exciting ways of regarding nature and its operations. The work of the sixteenth-century astronomers and mathematicians, which was extended by Galileo and Descartes, was imposing a more mechanical and less 'organic' framework upon the universe, while the researches and teaching of those scientists influenced by the neoplatonism of the later renaissance and by the revival of Hermeticism in the hands of physicians and chemists such as Paracelsus and Helmont helped to diffuse the notion of man as controller of nature and as unraveller of its secret workings and operations. Both of these traditions (which often merged and were rarely entirely separated from one another) proved vital propellants of learning throughout the seventeenth century. The world of natural phenomena and of mathematics was becoming increasingly well defined and historians have found it possible to speak of 'science' and 'scientists' when discussing this period.[1]

One of the distinctive features of the scientific scene in seventeenth century Europe is the formation of societies devoted to the pursuit of natural learning. There had of course been literary academies before this time, but the foundation at Rome in 1601 of the Accademia dei Lincei, of which Galileo was proud to be a member, marks an important stage in the institutional development of modern science. Groups of a similar nature soon sprang up in France, Germany, and England. In the 1640s and 1650s regular meetings of natural philosophers were taking place at London and Oxford. In France men such as the Minim friar Marin Mersenne (1588–1648) maintained an immense network of international correspondence and acted virtually as one-man societies or clearing-houses for ideas and research. In various German towns associations of physicians and scholars met to study and disseminate information.[2]

These groups varied greatly in composition and ethos. Some were little more than social clubs in which conversation ranged widely. Others had a more definite and rigorous approach, and of these the most important was the Accademia del Cimento, which flourished at Florence between 1657 and 1667.[3] By this time however scientific leadership was moving northwards to France and England. The meetings of scholars at Oxford and London during the Commonwealth period led in 1660 to the first gatherings of what was to become the Royal Society of London for Improving Natural Knowledge.[4] Six years later the rather different Academie des Sciences was established at Paris under the patronage of Colbert.[5]

In 1665 the secretary of the Royal Society, Henry Oldenburg, founded the monthly *Philosophical transactions,* in which were printed communications received from scholars all over Europe. Oldenburg also maintained a vast correspondence and his abilities as a communicator of scientific information were vital to the society's early success.[6] Between 1663 and 1687 no less than 425 men were elected fellows of the society. They can be classified as follows.[7]

1 For an illuminating examination of 'the emergence of the scientific role', see J. Ben-David, *The scientist's role in society* (Englewood Cliffs, 1971), chapters 4 and 5 (pp 45–87).

2 See M. Ornstein, *The role of scientific societies in the seventeenth century* (Chicago, 1928) and H. Brown, *Scientific organizations in seventeenth-century France* (Baltimore, 1934).

3 See W.E. Knowles Middleton, *The experimenters: a study of the Accademia del Cimento* (Baltimore, 1971).

4 See M. Hunter, *Establishing the new science: the experience of the early Royal Society* (Woodbridge Suffolk, 1989); also C. Webster, *The Great Instauration: Science, medicine and reform, 1626–1660* (London, 1975).

5 See R. Hahn, *The anatomy of a scientific institution; the Paris Academy of Sciences* (Berkeley, 1971).

6 This is fully printed in A.R. and M.B. Hall (eds), *The correspondence of Henry Oldenburg* (13 vols, Madison, 1965–1986).

7 The table is taken from A.R. Hall's introduction to the reprint of Thomas Birch's *History of the Royal Society* of 1756–7 (Johnson Reprint Corporation, New York, 1968), p. xix. It can be compared with the similar classification of members of the Dublin Philosophical Society given in this introduction. See also M. Hunter, *The Royal Society and its Fellows 1660–1700* (Chalfont St Giles, 1985).

Noblemen (including baronets)	57
Gentlemen and politicians	65
Clergymen	29
Lawyers	17
Physicians and surgeons	60
Army and navy officers, civil servants	25
Merchants etc. of the city of London	12
Scholars and writers	32
Foreigners (mainly honorary)	32
Men of science	74
Unclassified	22

Immediately one of the characteristic features of the society becomes apparent: the wide range of interests from which it recruited its membership. The classification 'Men of science' is necessarily vague and includes (in addition to the physicians and surgeons) almost all those with any persistent interest in natural philosophy. These were then a small minority. But the importance of the society lies not only in its directly scientific work, and here the contributions to its proceedings made by men such as Boyle, Hooke, and Newton, are by any account of major significance, but also, and perhaps more importantly, in its function as the filter through which many of the great conceptual and practical problems of contemporary science were passed into a wider cultural community.

As a result of the stimulus produced by the weekly meetings of the Royal Society; by the printed reports published in the *Philosophical transactions;* by the influence and contacts of its members; similar groups were established in 1683 in both Oxford[8] and Dublin[9]. By then the London group had passed its first vigorous youth and the quality of its work had perhaps declined. But as a social institution and catalyst it still had a powerful influence and presented a potent example to others.

Thus it was that the small 'colonial' group in Ireland responded to the model of learning and research presented by the Royal Society, in itself part of a larger European movement. Based on the urban environment of Dublin—then a growing

8 On the Oxford Philosophical Society, which flourished 1683–90, see its minutes and correspondence published in R.T. Gunther, *Early science in Oxford* (14 vols, Oxford, 1923–45), vols iv and xii. No analytical study of this group exists.

In 1683 a philosophical society was also established at Boston under the influence of Increase Mather. See O.T. Beall, 'Cotton Mather's early "Curiosa Americana" and the Boston Philosophical Society of 1683', *William and Mary quarterly,* 3rd series, xviii (1961), 360–72.

9 On the Dublin Philosophical Society, see K.T. Hoppen, 'The Dublin Philosophical Society and the new learning in Ireland', *Irish Historical Studies,* xiv, no. 54 (1964), 99–118; K.T. Hoppen, 'The Royal Society and Ireland', *Notes and Records of the Royal Society,* xviii (1963), 125–35 and xx (1965), 78–99; K.T. Hoppen, introduction to 'Samuel Molyneux's tour of Kerry 1709', *Journal of the Kerry Archaeological and Historical Society,* no. 3 (1970), 59–80. I have presented a synthetic study of the society in *The common scientist in the seventeenth century: a study of the Dublin Philosophical Society 1683–1708* (London and Charlottesville, 1970), which contains an extensive bibliography and which (I hope) will in many ways complement this edition. The present introduction is not however merely a summary of the earlier book.

city[10] and the centre of English influence—this group reinforced its cultural distinctiveness by educating its youth at Trinity College Dublin founded in Queen Elizabeth's reign along the lines of the colleges of Oxford and Cambridge. Here student numbers rose after the Restoration as a result of the desire of many parvenu Cromwellian planter landowners to obtain a gentlemanly education for their sons.[11] The college taught its students an essentially conservative and scholastic syllabus, although some at least of the younger fellows had wider intellectual horizons and showed an interest in the works of writers like Gassendi, Descartes, Hobbes, and Cudworth.[12] And it was men such as St George Ashe, Samuel Foley, William King, and Edward Smyth, who were among the earliest members of the Philosophical Society established in 1683. Although the foundation of the society marked an important and novel development in the intellectual world of seventeenth century Ireland, it must not be seen as entirely unconnected with earlier developments in that country. The direct inspiration certainly came from England, but there had been some scientific activity in Ireland during the Interregnum period.[13] A circle of virtuosi was active in the 1650s, some of whose members worked in government service as surveyors, soldiers, or engineers. They included William Petty (later president of the Dublin Society), Benjamin Worsley, Robert Wood, Anthony Morgan, and Miles Symner. They were in close touch with that persistent educational reformer, the Puritan Samuel Hartlib, and Petty and Symner were already firm adherents of new ways in science and were conscious followers of the teachings (or what were thought to be the teachings) of Francis Bacon. By the mid-century Bacon's influence as a philosopher of scientific progress, as an opponent of Aristotelian scholasticism, as the great proponent of the inductive method in the study of natural phenomena, had deeply and widely pervaded English intellectual life.[14] Indeed his 'philosophy' had become all things to all men and acted as a respectable cloak behind which lurked a strange variety of contradictory beliefs. But Bacon's stress on fact-gathering and his opposition to Aristotelian traditionalism proved for

10 See J.G. Simms, 'Dublin in 1685', *Irish Historical Studies,* xiv, no. 55 (1965), 212–26; also R.A. Butlin, 'The population of Dublin in the late seventeenth century', *Irish Geography,* v (1965) 51–66.

11 That the pursuit of a 'gentlemanly' education could be unhelpful to scientific studies is argued in P.M. Rattansi, 'The social interpretation of science in the seventeenth century' in P. Mathias (ed.), *Science and society 1600–1900* (Cambridge, 1972), pp 28–9.

12 See H. Kearney, *Scholars and gentlemen: universities and society in pre-industrial Britain 1500–1700* (London, 1970), pp 152–3. For a more detailed account of Trinity at this period, see K.T. Hoppen, *The common scientist,* chapter 3, 'The society and Dublin University', pp 53–72, which includes a social analysis of the student body.

13 See T.C. Barnard, 'Miles Symner and the new learning in seventeenth-century Ireland', *Journal of the Royal Society of Antiquaries of Ireland*, cii (1972), 129–42; idem, 'The Hartlib Circle and the Origins of the Dublin Philosophical Society', *Irish Historical Studies*, xix, no. 73 (1974), 56–71 (with comment by K.T. Hoppen, *ibid*., xx, no. 77 (1976), 40–48); idem, 'The Hartlib Circle and the Cult and Culture of Improvement in Ireland' in M. Greengrass, M. Leslie and T. Raylor (eds), *Samuel Hartlib and Universal Reformation* (Cambridge, 1994), pp 381–97.

14 See C. Hill, *Intellectual origins of the English revolution* (Oxford, 1965), especially chapter 3 (pp 85–130).

THE MINUTES

SECTION A

MINUTES 1683–7,
APRIL/MAY 1693, JULY 1695

1

15 October 1683

After some previous meetings in tendency to the better regulation, settlement, and method of future transactions, discoursed Mr Wm. Molyneux *de apparente magnitudine solis humilis et sublimis,*[1] wherein, declaring the matter of fact and propounding the certain ways of trying it, he descended to the solutions thereof given by several great authors, particularly Monsieur Des Cartes, Hobbs, Gassendus, and an abbot in the *Journal des sçavans*.[2] And all these he found fault with, demonstrating their solutions to be dissatisfactory and erroneous. The bishop of Ferns [Narcissus Marsh] discoursed the *radiis reflexis et refractis*, wherein he showed after a succinct manner the common appearances of refracting and reflecting concaves and convexes, as their magnifying and diminishing an object, their inversion and erection of the species; also that the reflected and refracted rays together make a cylinder, if the glass be plain; but if concave or convex (*ex parte corpori luminoso observa*), that then they make a cone (only allowing for the refraction made within the glasses), yet with this difference, that when concave, the cone's vertex is towards the luminous body, and the basis avers, but when convex, 'tis quite contrary; and that whereas, if these 2 last are made use of as *specula* or *perspicilla*, their affections are quite opposite one to th'other. But if one be a *speculum* and th'other a *perspicillum*, they are altogether agreeing. And this was shown in 3 plain and easy figures.[3] Mr

Note: R.S. Early Letters H.3.72. The minutes from here until 10 December 1683 were not entered in the minute book (B.L. Add. MS 4811), but a copy was sent to the R.S., from which the present text is taken.

1 See W. Molyneux's paper of 1687 'Concerning the apparent magnitude of the sun and moon, or the apparent distance of two stars, when nigh the horizon, or when higher elevated', no. 180.

2 See René Descartes (1596–1650), *La dioptrique* – originally published with *Discours de la méthode* (Leyden, 1637) – chapter six, in V. Cousin (ed.), *Oeuvres de Descartes* (11 vols, Paris, 1824–6), v, 54–71 '*De la vision*', especially p. 68; also Thomas Hobbes (1588–1679), *Elementorum philosophiae*, section II 'De homine' (London, 1658), chapter seven 'De loco apparente objecti visi per refractionum unicam', part seven 'Quare astra prope horizontem majora apparent quam culminantia', in W. Molesworth (ed.), *Thomae Hobbes Malmesburiensis opera philosophica quae Latine scripsit* (5 vols, London, 1839–45), II, 62–3; also Pierre Gassendi (1592–1655), *De apparente magnitudine solis humilis et sublimis* (Paris, 1642), a work containing four 'epistles'; also the appendix to *Journal des sçavans* (Amsterdam ed.) for 1672 (published 1673) with separate pagination and title as *Recoeuil des memoires et conferences sur les arts et les sciences presentées à Monseigneur le Dauphin pendant l'année MDCLXXII par Jean Baptiste Denis*, third conference, 15 August 1672, pp 254–61 'Extrait d'une letter ecrite par Monsieur l'abbé B… et envoyée au Sieur Denis pour estre leuë dans son asemblée, touchant la grandeur apparante de la lune auprés de l'orizon', and fourth conference, 1 October 1672, pp 274–81 'Extrait d'une seconde lettre de Monsieur l'Abbé B … touchant la grandeur apparante de la lune auprés de l'horison [sic], pour répondre à quelques remarques que le R.P. Pardies a faites sur la lettre inserée dans la troisième conference'. Molyneux confuses the French 'abbé' with the English 'abbot'.

3 Now Lost

Foley explained Dr Briggs's theory of vision,[4] and confirmed it with some observations from anatomy; and Mr Ash gave an account of part of Des Chales's book of motion.[5]

[4] William Briggs (1642–1704) physician and oculist; fellow of Corpus Christi College Cambridge (1668); studied at Montpellier under Vieusssens; M.D. (Cambridge) 1677; published the first part of his *Theory of Vision* in Robert Hooke's *Philosophical collections* – a continuation of the temporarily lapsed *P.T.* – no. 6 (1682), 167–78, and the second part in *P.T.,* XIII (1683), 171–82.

[5] Claude François Millet de Challes (1621–78) French Jesuit mathematician. On his return from missionary work among the Turks, he was appointed professor of hydrography at Marseille, and later of mathematics at his society's college in Lyons. His most famous work is *Cursus seu mundus mathematicus*, 3 vols (Lyons, 1674). Ashe refers to his *Traitté du mouvement local et du ressort* (Lyons, 1682).

2

22 October 1683

Mr Molyneux proceeded in his discourse for confutation of the forementioned authors in the abovementioned appearance. And then Mr Wm. King offered to bring in a satisfactory solution thereof at the next meeting. Dr Loftus discoursed concerning Pére Simon's *Histoire critique*;[1] Dr Molin *de alkali et acido*; and Mr Walkington concerning Tacquet's way of demonstrating Archimedes,[2] with which he found fault.

Note: R.S. Early Letters H.3.72

[1] Richard Simon (1638–1712) French Oratorian theologian and critic. The scandal caused by the liberalism of his *Histoire critique de vieux testament* (Paris, 1687) led to his retiring to Belleville as curate. His *Histoire* was suppressed as a result of pressure from Bossuet and others, but was reprinted at Amsterdam in 1680. It was translated as *A critical history of the old testament… translated into English by a person of quality* [Henry Dickinson] (London, 1682). Loftus's paper is lost.

[2] André Tacquet (1611–60) Flemish Jesuit mathematician; professor at Antwerp. Among his works are *Cylindricorum et annularium libri IV* (Antwerp, 1651), *liber V* (Antwerp, 1659); *Elementa geometricae planae ac solidae, quibus selecta ex Archimede theoremata* (Antwerp, 1654); and *Arithmeticae theoria et praxis accurate demonstrata* (Louvain, 1655).

3

31 October 1683

Mr King produced his solution of the phenomenon of the different bigness of the horizontal and meridional sun, and yet its subtending the same angle. But his account was not judged satisfactory. Mr Acton began his animadversions on Hobs's *De cive*.[1] Mr Walkington proceeded with his former animadversions and also took an occasion therefrom to discourse on the algebraical way of proceeding in demonstrations mathematical removing the 3 grand objections that Hobbs makes against it.[2] But one thing not being very clear, he was desired to reassume it at the next meeting. The thing was, how negative quantities multiplied on each other as –A on –B should produce +AB, and likewise how the roots A-B and B-A (though different magnitudes) have the same powers.

Note: R.S. Early Letters H.3.72

1 Thomas Hobbes, *Elementorum philosophiae sectio tertia de cive* (Paris, 1642), translated as *Philosophical rudiments concerning government and society* (London, 1651). Acton's paper is lost.

2 This is obscure. Hobbes's views on algebra are however well-known. See for example, *Principia et problemata* (London, 1674), chapter 3 'De operationibus algebricis', where he writes 'Nam ut hac methodo quaestionibus geometricae satisfiat, impossibile est. Est enim algebra una ex regulis arithmeticae, ad cujus theoriam perdiscendem opus est biduo aut triduo, ut plurimum'. W. Molesworth (ed.), *Thomae Hobbes Malmesburiensis opera philosophica* (5 vols, London, 1839–45), V, 167–8.

4

12 November 1683

The Lord bishop of Ferns [Marsh] produced a discourse concerning sounds and hearing[1] and comparing them in many respects to images and seeing, he offered many curious proposals for advancing one, as th'other is advanced by optic glasses. Mr Walkington gave the company full satisfaction in the business last left upon him. But Mr Tolet raised an objection against the algebraical mathematics drawn

Note: R.S. Early Letters H.3.72

1 Narcissus Marsh, 'An essay on sounds', No. 148.

from the 27th Quest. of the 16th Chap. of Kersey's 1st Book of algebra, p. 117[2], which Mr Walkington was desired to answer at his leisure.

[2] John Kersey the Elder (1616–?90) mathematician received no university training; gained his living as a teacher in London. He wrote the standard *The elements of that mathematical art commonly called algebra expounded in four books* (2 vols, London, 1673–4). The 27th question reads: ' A certain footman A departeth from London towards Lincoln, and at the same time another footman B departeth from Lincoln towards London, each keeping the same road. When they meet, A saith to B, I find that I have traveled 20 (or c) miles more than you, and have gone as many miles in 6 $^2/_3$ (or d) days, as you have gone miles in all hitherto. 'Tis true saith B, I am not so good a footman as you, but I find that at the end of 15 (or f) days hence, I shall be at London, if I travel as many miles in every one of these 15 days, as I have done many miles in every day hitherto. The question is to find how many miles those two cities are distant from one another, and how many miles each footman had travelled when they met each other.'

5

19 November 1683

Mr Molyneux explained the volution of concentric circles after Tacquet's method.[1] Dr Molin explained the fabric of the ear and the bones belonging thereto[2]. Mr Walkington discoursed of the objections against algebra raised by Mr Tolet.

Note: R.S. Early Letters H.3.72

[1] A. Tacquet, *Opera mathematica* (Antwerp, 1669) 'De circulorum volutionibus'. This covers pp 145–68 of 'Cylindrica et annularia'. No details of Molyneux's explanation survive.

[2] On this subject, see Mullen's later paper, no. 187.

6

3 December 1683

Upon occasion of some former discourse, Mr Archdeacon Baynard proved at large that monarchy is the most natural government. Also, Mr Ashe gave an account of part of Des Chales's book of motion.[1]

Note: R.S. Early Letters H.3.72

[1] See no. 1, note 5.

7

10 December 1683

Mr Molyneux explained the phenomenon of double vision,[1] viz. placing suppose 2 candles directly before you, one a foot, th'other 3 foot distance from you, and looking steadfastly at the nighest, the furthest seems double. Also, looking steadfastly at the furthest, the nighest seems double. Then winking alternately with one and th'other eye, in the first case the image correspondent to the shut eye vanishes, that is, to the left eye shut the left image of the further duplicated object vanishes, and to the right eye the right image, viz. when looking at the further object, the nigher is duplicated, the image contrary to the shut eye vanishes, i.e. to the left eye shut the right image of the nigher duplicated object vanishes, and to the right eye shut the left image vanishes.

Dr Molin prosecuted his account of the structure of the ear. Mr Foley discoursed of the contagious communication of a strong imagination, to explain and improve a notion of Monsr. Malebranch's in his *la recherché de la vérité*, L. 2, part 3.[2] The same gentleman has upon the loom a very fine piece which he calls Computatio universalis, or logica rerum,[3] being an essay attempting in a geometrical method to demonstrate a universal standard whereby to judge of the intrinsic value of everything in the world. But of this, and Sir Wm. Petty's new invention, when they shall think fit to communicate them. Only let me take notice to you of one lately found out by a gentleman in Ireland, viz. to hang a coach so that notwithstanding the wheels of one side be never so high, or quite overturn, yet shall the body still hang *in aequilibrio*, and that the persons that are therein sit upright still and be free from harm.[4]

Note: R.S. early Letters H.3.72

1 W. Molyneux, 'An optic problem', no. 164.

2 Nicolas de Malebranche (1638–1715) French Oratorian metaphysician. In his most famous work, *De la recherche de la vérité*, 2 vols (Paris, 1674), he put forward the doctrine that the mind cannot have knowledge of anything external to itself, save through its relation to God. Foley, whose paper has been lost, refers to the third part of the second book, which is entitled 'De la communication contagieuse des imaginations fortes'. See the edition by G. Lewis (2 vols, Paris, 1945), I, 174–211.

3 See S. Foley, 'Computatio universalis', no. 135.

4 See R. Bulkeley, 'On a new fashioned … calash', no. 128, and W. Petty, 'Experiments…relating to land carriage', no. 192; also Bulkeley to Ashe, 11 July 1685, no. 296. The 'gentleman' is probably the Mr Clignet mentioned in W. Molyneux to Aston, 22 April 1684, no. 226.

8

28 January 1683–4

Having passed the three meetings since Christmas holidays in settling some rules for our society, this day we met for the subscribing to the obligation and electing of officers to continue till first day of next November, being All Saints' Day.[1] Dr Charles Willoughby was chosen director of the society, and Mr Wm. Molyneux was chosen secretary and treasurer. Likewise the obligation was subscribed by these following: Narcissus [Marsh, bishop of] Ferns and Laghlin, Sir Wm. Petty, Dr Rob. Huntington, provost of the college, Dr Charles Willughby, Rich. Bulkly Esq., Francis Cuff Esq., Mr Sam. Foley, Mr John Baynard, Mr St George Ashe, Dr Al. Mullin, Mr George Tolet, Mr Mark Baggot, Mr John Keogh; signed by proxy W.M., Mr Wm Molyneux. At the same meeting Sir Wm. Petty produced an instrument of wood contrived by himself for explaining the difficulty about the volution of concentric circles, or wheels, on which he promised to discourse at the next meeting

Note: B.L. Add. MS 4811, f. 160; Draft, T.C.D. MS I.4.18, f. 44.

[1] These rules, together with the obligation, are printed as no. 525 below. The minutes for the three meetings mentioned have been lost, but the meetings themselves are referred to in Dudley Loftus's 'Letter to a person concerning the society', no. 529 below.

9

4 February 1683–4

Sir Wm Petty discoursed on the instrument he produced the last meeting. Mr Ashe gave an account of several experiments he had made during the hard frosty weather in freezing various liquors, eggs, apples, etc.[1] to which experiments the bishop of Ferns made some additions of his own trial. Mr Foley made a discourse about the sailing of ships with oblique winds,[2] on which occasion Sir Wm. Petty gave us some of his thoughts on the same subject. The experiment of burning camphire mixed

Note: B.L. Add. MS 4811, f. 160; Draft, T.C.D. MS I.4.18, f. 44.

[1] St G. Ashe, 'Experiments of freezing', no. 119. The Winter of 1683–4 was severe: see William to Thomas Molyneux, 8 January 1683–4 in *D.U.M.,* p. 476 'We have had a most extraordinary hard Winter, for the Liffey has been frozen over so as to admit thousands of people to pass over for those six weeks'.

[2] S. Foley, 'Of the sailing of ships with oblique winds', no. 133.

with snow was tried and succeeded. Mr Molyneux produced a letter from Dr Plot, secretary to the R[oyal] S[ociety], which contained the minutes of the Oxford Society, wherein some passages were required to be further explained by the gentlemen at Oxford, particularly on what account Dr Smith asserts that a great part of the Mediterranean Sea is discharged by an undercurrent at the strait mouth.[3] Also, in the experiments that Dr Plot and Mr Musgrave made for the sweetening brine,[4] to what end did they distil it from salt of tartar, ashes, lime, chalk, etc., when 'tis well known (as Dr Mullen asserted) that plain distillation of salt water will sweeten it. Mr Archdeacon Baynard promised to give us at several times and in divers discourses the method for instructing of youth from the beginning of their learning languages to their entrance into the university. Mr Francis Herne began to write for us, February 11, 1683–4.[5]

3 This letter has been lost. See Oxford Minutes, 21 December 1683 (Gunther, IV, 28) 'as for the vast quantity of water, which runs into the Mediterranean, he [Smith] conjectures that a great part of it may run out again, by an under-current at the straits mouth'. See T. Smith, 'A conjecture about an under-current at the streights mouth', *P.T.* XIV (1684), 564–6, a MS copy of which was sent to Dublin (see no. 224, especially note 4).

Thomas Smith (1638–1710) non-juring divine; fellow of Magdalen College Oxford 1667. In 1668 he went to Constantinople as chaplain to the English ambassador. Refusal to swear the oath to William and Mary, lost him his fellowship in 1692. He then became keeper of the Cottonian Library. He wrote a life of Robert Huntington – a member of the Dublin Society – as part of *Admodum reverendi R.H. epistolae: et veterum mathematicorum. Graecorum, Latinorum, et Arabum synopsis, collectore E. Bernardo. Praemittuntur Huntingtoni et Bernardi vitae* (London, 1704).

4 See Oxford Minutes, 11 January 1683–4, Gunther, IV, 30.

Robert Plot (1640–96) antiquary; B.A. Magdalen Hall Oxford 1661, M.A. 1664, B.C.L. and D.C.L. 1671; moved to University College 1676. He was especially interested in natural history, and in 1674 published a sheet of queries 'to be propounded … in my travels through England and Wales'. His *Natural history of Oxfordshire* (Oxford, 1676; another edn 1677) greatly added to his reputation, and in 1682 he became secretary to the Royal Society. He edited the *P.T.* from no. 143 to no. 166. He was appointed first custos of the Ashmolean Museum and professor of chemistry at Oxford in 1684. His *Natural history of Stafford-shire* (Oxford, 1686), while certainly overcredulous, deserved its contemporary reputation. He was the first president of the Oxford Philosophical Society.

William Musgrave (?1655–1721) physician and antiquary; fellow of New College Oxford 1677–92; studied at Leyden 1680; elected F.R.S. 1684 and F.R.C.P. 1692. He settled in Exeter in 1691 and practised medicine there until his death. He succeded Plot as secretary to the Royal Society, and also acted as secretary to the Oxford Society. His publications include *De arthritide symptomatica dissertatio* (Exeter, 1703) and *Antiquitates Britanno-Belgicae* (4 vols, Exeter, 1711–20).

5 This last sentence is to be found only in the draft minutes. Nothing further is known of this Herne. He, and the other scribes, Samuel Davis (Minutes, 17 March 1683–6, no. 15), and Charles Whittingham (Minutes, 25 January 1685–6, no. 82) and the 'operator' Nicholas Hudson (Minutes, 3 March 1683–4, no. 13), seem to have constituted the entire - and possibly rather temporary – staff of the society.

SECTION B

PAPERS

1683–1701

INTRODUCTION

In this section are printed all the extant papers read to the Dublin Philosophical Society during its first two periods of activity (1683–7 and 1693–?7/8), or written by members during the times when meetings were in abeyance, save for those sent to Dublin from either the Royal or Oxford Societies, and which, though copies of them sometimes survive among the Dublin Society's manuscripts, belong properly to the transactions of the two English groups.[1] A full list of all the papers printed in this section can be found after the list of 'lost papers' at the end of this Introduction. The survival of a full set of minutes for the period 1683–7 makes it possible to date the papers then produced with entire precision. It will however be readily noticed that many papers read to the society in these years no longer survive and are known only as a result of being mentioned (usually briefly, sometimes at greater length) in the minutes. A list of such 'lost papers' is to be found at the end of this Introduction.

The lack of surviving minutes for all but a few meetings after 1687 makes the dating of later papers more difficult. However, the best available date is given in each case. Now, it might be argued that only papers certainly known to have been delivered at formal meetings should be included here. After careful reflection, I have however rejected this view on two grounds: in the first place such a course would exclude some papers for which there is very strong (if not entirely conclusive) circumstantial evidence to suggest that they were presented at meetings of the society in the 1690s; in the second place it would lead to the sacrifice of an important unity to an arbitrary logic. As a result, it was decided to include all extant papers written by members both during the otherwise ill-documented revival of the society in the 1690s and during the two intervals before and after that revival.[2]

As the brief revival of the society by Samuel Molyneux in the years 1707 and 1708 forms a distinct area of activity which to a large extent lies apart from that of the years before, *all* the surviving material for that period has been included in

1 References to such papers (many of which were in fact printed in the *P.T.*) are however given in the notes to the Dublin Society's minutes in Section A. A few of the papers here printed, and known to have been read to the society, were the work of non-members (nos 118, 132, 190, 197), but of course *their* provenance is quite different from that of those which originated in London or Oxford.

2 Of course papers written by members *before* joining the society which were clearly produced under circumstances entirely unconnected with its affairs, and which were subsequently never (or are not known to have been) read to the society, have not been included here. For three papers by Francis Robartes, which fall into this category, see no. 200 (introductory note).

a single section, Section D. The terminal date of the present section – 1701 – is dictated by the simple fact that no member seems to have produced any relevant papers between then and 1706.

In a few cases a difficulty arises as to how best to distinguish between a 'paper' and a 'letter'. Thus, some pieces, which were clearly read to the Dublin Society as papers, survive only in the form of a letter written by their authors or by the society's secretary to the Royal or Oxford Societies, or in some other formally epistolary state. As no precise or exclusive rule seems helpful here, I have used my judgement in such cases. The reader will however find, appended to the introduction to Section C (Letters 1683–1706), a list of such 'letters' that have been included in the present section.

The papers are arranged by author (themselves alphabetically listed), and in cases where more than one paper by a single author is printed these are arranged chronologically amongst each other.

List of papers now lost which are known to have been read at meetings of the Dublin Philosophical Society

In drawing up this list, an attempt has been made to exclude items which should more properly be classified as impromptu discussions or demonstrations, as also those obviously very brief contributions fully preserved in the minutes themselves. As the minutes are the only source in this matter, discrimination has not proved easy. When in doubt I have included the item in question in the present list. In many cases further information regarding the items here listed is provided in the annotation to the minutes in Section A. It can readily be seen, if one compares the present list with that of surviving papers read to the society, that a much higher proportion of some members' papers have survived than of others. The fact that so many of William Molyneux's papers are still extant is largely explained by the survival of a collection of his manuscripts at Trinity College, Dublin. On the other hand, none of Mullen's personal manuscripts have survived, and this no doubt partly explains the high proportion of 'lost' papers noted under his name. Yet their unusually large number may also be the result of his having often spoken impromptu or from brief notes, and having then subsequently failed to write these up into the style of a formal paper or address.

RICHARD ACTON

Animadversions on Hobbes's *De cive* (31 October 1683)

Of the *macreuse* or scoter (27 July 1685)

ST GEORGE ASHE

On de Challes's book of motion (3 December 1683)
Account of the wind, weather, and height of mercury for the last months (4 May 1685)[3]
Of a man who suckled his child (22 June 1685)
Account of the wind, weather, and height of the mercury for June 1685 (6 July 1685)
Account of the wind, weather, and height of the mercury for July 1685 (3 August 1685)
Account of the wind, weather, and height of the mercury for September 1685 (19 October 1685)
Account of the wind, weather, and height of the mercury for December 1685 (18 January 1685–6)
Of the success of mixing coal-dust with clay in order to make fuel (18 January 1685–6)
Concerning trees (18 January 1685–6)
Account of the wind, weather, and height of the mercury for January 1685–6 (1 February 1685–6)
Account of the wind, weather, and height of the mercury for February 1685–6 (8 March 1685–6)
Account of the wind, weather, and height of the mercury for March 1685–6 (12 April 1686)
Account of the wind, weather, and height of the mercury for April 1686 (3 May 1686)

JOHN BAYNARD

Monarchy the most natural government (3 December 1683)
Concerning the instruction of youth for the university (18 February1683–4)

SIR RICHARD BULKELEY

Experiments on venal and arterial blood (25 February 1683–4)
Observations on a dissected dog (25 February 1683-4)
Of the luctation of divers alkalis and acids (5 May 1684)

[3] All of Ashe's 'Accounts of the wind etc.' have been lost. They were presumably drawn up along the same lines as that of W. Molyneux for May 1684, reproduced as Plate XLIX in this edition. It seems likely that Ashe also drew up 'accounts' for those months omitted from the above series, but that these are, for some reason, not mentioned in the minutes.

THE PAPERS

118

Jonathan Aland

A demonstration for finding the true meridian distance of places

(a) That by which I find the true Meridian distance of places is the moon's departure from, or application to, the sun, the planets, or any of the fixed stars, having a table of their longitudes and latitudes, and by the moon's course and the planet's in twenty-four hours, I can easily find their places and distances at any time of the day or night that I make my observation. And by comparing my observation with the distance the ephemeris gives me, I find the difference by subtracting the lesser from the greater. But because the latitude of the planets may cause an error in the observation and make it more or less distance than the ephemeris does, which only shows you their places upon the ecliptic, it is necessary I should say something to that, how we may be certain what to subtract for so much latitude according to so much distance as I may have by my observations. As for that I answer, I can make a scale, shall set that off to less than a minute; but an easier way I have by placing a sight-vane higher or lower, according as the latitude of the planet is, which shall at once reduce that and give you the exact distance of the planets upon the ecliptic, but with directions how to observe in that method. And if you observe the distance of the moon from any planet or star that should have contrary latitude to her, it is but adding those two together, and place the sight-vane so much higher or lower as shall be directed. But if they have both the same latitude (that is to say) both north or both south, it is but subtracting the less from the greater, as suppose the moon to have 5 degrees north, and Jupiter two degrees north, you must subtract two from five, and the remainder is 3 degrees, which you must fix your vane to. But if they should happen to have just as much latitude as one another, and both north or south, they will answer the same distance upon the zodiac as if they were both upon the ecliptic without any latitude. Therefore, in that case your vane is not to be placed higher nor lower, but upon a straight line you are to observe. Having thus far laid down the grounds on which I work, it will be necessary to show you how by this the meridian of places may be found.

Suppose I am at sea at any day, which must be expressed, and that the hour and minute suppose at one a clock *post merid.*, I make my observation by the sun and moon, and find their distance to be with latitude *reduct.* 2s. 11d. 30m. I look in the ephemeris made for the meridian of London and see what distance the sun and moon had with them at their 12 a clock and reduce their places to one a clock the

Note: B.L. Add. MS 4811, ff 88–9; another copy, R.S. Classified Papers VIII (1), 50. Read to the society on 25 May 1685, no. 60 (see note 1 there).

same day, and see what distance then they had, suppose 2s. 10d. 5m., then must be subtracted so much from the distance you made by observation, and the remainder is 0s. 01d. 25m., which must be brought into [f. 88v] time, which is done thus: look in the ephemeris, and see how much the sun run the last 24 hours and also the moon and see what she runs the next 24 hours also, and by that you will have the motion she made those last minutes you had by observation, as suppose the moon to have run the last 24 hours 12d. 55m. and the next 24 hours 13d. 5m., the mean motion is 13 degrees. Then subtract the sun's course out of that, suppose 60 minutes, and the remainder is 12 degrees. Then I say if 12 degrees gives 24 hours, what doth 01d. 25m. give? I find it gives 170 minutes or 2 hours 50 minutes, which is so much to the east or west of that place for which the ephemeris is calculated after the equation of time is considered, as I shall show you. Now, if you would know whether it be to the eastward or westward of that place, you must consider whether the moon were to the east or west of the sun or star you took her distance from. If to the eastward, then you are to the westward, because you had more distance by your observation at that time than the planet's places had in London by the ephemeris, for the moon making her departure from the sun every minute creeps further from him, so by consequence those to the westward, whose meridians are later, must by that time have more distance. But if the moon be to the westward of the sun or planet, conclude the contrary.

(b) There is one thing which I must not forget, and that is the equation of time, because all ephemeris are calculated by equal time, and there is often difference between that and apparent time, but for that you have an equation table, that considering the sign and degree the sun is in, you may find what is to be added or subtracted, as suppose the sun be in Taurus 28 degrees, I find 9 minutes given for equation, and atop of the column writ 'add', which showeth that the planets were not really in those places laid down by the ephemeris until 9 minutes after. Wherefore it made my observation so much to the eastward more than I really was, because, if I had observed 9 minutes after, the moon would have gotten so much further distance from the sun, therefore I add 9 minutes to the minutes of time or meridian distance I made before, and it gives 179 minutes or 2 hours 59 minutes to the westward of the meridian of London

There is one thing to be considered, that is: suppose the ephemeris may be calculated too much to the eastward or westward of London, it must necessarily make your observation to err so much from the distance of that place, but if it errs not some time to the east, and another time to the west, it is no matter, for by one or two observations a man may easily find how much to allow, so that the demonstration is the same, and if you have no tables of the fixed stars that you can depend upon, I believe Mr Gadburie's ephemeris will pretty well answer the sun's, moon's, and planets' places, as I have by several observations found. [1] All which I leave to your consideration.

There are many other things I might add by way of direction, as the best stars and planets to observe the moon's distance from, also when it is best to observe by the sun, and when not; as also the exactness of the time in observing, as also the best method of instruments for this purpose, two sorts [f. 89] especially that I can readily demonstrate, and many other things which otherwise would leave the world in a doubt, besides many objections that may happen where I may not be to answer. I shall insert but one, and that is this: suppose one ephemeris gives the place of a fixed star some minutes or one or two degrees more or less longitude than another ephemeris does, how shall I know which to trust to, or know what to allow, if either or both false? As for that, I answer knowing the latitude and longitude of the moon by the ephemeris after two or 3 observations that I can depend upon, for the moon's place by her distance from other planets, I will find the true place of that star, knowing her latitude if she has any, for by my scale I reduce both the latitude of the moon and the star and find their true distances upon the ecliptic as it is laid down by the ephemeris or tables made for that purpose. But this must be observed in a place which I already know the meridian of, for by finding then the difference that that star with the moon gives me more or less than the true meridian distance of the place I am in by the observation of other stars or planets, it argues that star to have so much more or less longitude than the tables gives, and thus in short I have answered that I could enlarge as I said before, but intend not at this time to say any more, having a design, as this finds encouragement, to give many examples that will make the thing plain, with descriptions of the instruments and manner of observing, with what cautions are necessary; but I conclude, leaving it to your consideration. I am your servant, Jonathan Aland

[1] John Gadbury (1627–1704) astrologer; defended William Lilly and other practitioners in *Philastrogus* (London, 1652); wrote many astrological works. He was wrongfully imprisoned during the Popish plot and later received compensation. After the fall of James II he became a non-juror. Among his works are *De cometis* (London, 1665), *Vox solis* (London, 1667), and many ephemerides. See no. 360, note 4.

119

St George Ashe

Experiments of freezing

Upon occasion of the cold weather I made a few experiments of freezing which were hinted to me by Mr Boyl's book,[1] Dr Merrett's[2] and an Italian treatise of ice written by one Bartoli a Jesuit.[3]

I exposed on a very cold night in a north and east window these several liquors to be frozen: Patrick's Well water, pump water, water with about a 20th part salt dissolved in it which is above the proportion said to be in sea-water, ale, milk, claret, aniseed water, urine, and syrup if gillyflowers, and observed the following particulars. The spring water and pump water began to freeze exactly at the same time, viz. $^1/_2$ hour after they were exposed; the salt water an hour after; the ice of the spring water was most transparent and had a few bubbles in it; that of the salt water lost much of its saltness. They all were raised considerably above their first weight. The ale in a night's space froze an inch and $^1/_2$, its ice was flaky, consisting of many lamina laid together, with large vacuities between. It was not transparent but kept the colour and smell of the ale, but lost the taste, being almost insipid. The milk was wholly frozen into a soft ice most curiously figured, which kept both taste and colour. The claret froze $^1/_2$ inch into a flaky ice of little consistence containing a few bubbles. It was figured, insipid, and lost almost both smell and colour. The claret under the ice was (I thought) much more spiritous and strong. The aniseed water froze $^1/_6$ inch, its ice was full of bubbles, and lost very much of the smell, taste, and colour. The urine (though it abound with salt) froze almost as soon as ordinary water into an ice finely figured (for which see Mr Hooke),[4] but without any ill smell or taste. The syrup grew only clammy, and lost its fluidity, and became of the consistence of thick oil. At the same time I exposed eggs and apples to be frozen, the eggs were longest afreezing, and being cut, the white was found to be in a clear

Note: T.C.D. MS I.4.18, ff 123–4; another copy, B.L. Add. MS 4811, f. 1r–v. Read to the society on 4 February 1683–4, no. 9 (where see note 1).

1 R. Boyle, *New experiments and observations touching cold, or, an experimental history of cold* (London, 1665; 2nd edn 1683).

2 Christopher Merret (1614–95) physician; educated at Gloucester Hall and Oriel College Oxford; settled at London and elected F.R.C.P. in 1651, censor 1657–70, Gulstonian lecturer 1654; an original F.R.S. Among his works is *Pinax rerum naturalium Britannicarum* (London, 1667). His *An account of freezing made in December and January 1662* is appended to Boyle's *New experiments*—see note 1 above.

3 Daniello Bartoli (1608–85) was born at Ferrara, studied classics, and entered the Society of Jesus. He was a successful preacher. His most famous work is *Dell' historia della Compagnia di Giesù* (6 vols, Rome, 1653–73). Ashe refers to his *Del ghiaccio e della coagulatione* (Rome, 1681; another edition Bologna, 1682).

4 R. Hooke, *Micrographia* (London, 1665), pp 88–91: Observation XIV, part 1, 'Several observables in the six-branched figures formed on the surface of urine by freezing'.

transparent ice with a few bubbles, the yolk as hard as that of a boiled egg, much redder in the middle than toward the extremities, except one whitish speck just in the centre. The shell thereof was burst in many places. The frozen egg swam in water and when thawed, sunk, but this did not succeed in another trial, although the frozen eggs and apples were lighter than the same thawed. I thawed one of the frozen apples by the [time][5] [f. 123v] which in a few hours time began to rot. Another I thawed in water, which in 1/4 hours time gathered a thick coat of ice about it, but did not corrupt as the first. This appearance made a story I met with in a describer of Muscovy to seem probable, which before I thought romantic, viz. that one way of recovering frozen people is to immerge them in a large vessel of water, out of which they are then drawn in a little time, with an exact case or armour of ice about them.

Snow and ice will freeze, not only when mingled with ordinary salt, but also with any chemical salt or with sugar, or almost any other substance which speedily melts the snow or ice. To try the expansive force of freezing, I filled a vial with water and tied the cork down to it with a strong packthread, and having buried it for some time in snow and salt, the cork was violently thrust out, and the ice continued beyond the bottle. Sack will without much difficulty freeze (and I suppose brandy also, though I did not try it), if you first burn it, and so draw out and consume the spirituous part. In a frozen sheep's eye, the 3 humours were hard and not diaphanous, the crystalline was very white. What Aristotle says in his *Meteors*, that warm water will freeze sooner than cold,[6] is manifestly false, as will appear to anyone upon trial; that the various figures of ice upon glass window in hard weather proceeds from the shootings of divers salts in the air is manifested by a pretty experiment, viz. put into a glass some snow and salt, and when they begin to melt, apply to the outside thereof liquors impregnated with various salts, and you will see them shoot in many curious figures and flowers upon the glass, which presently vanish and disappear. By variating the degrees of cold in water I made the same body sink and swim therein. I filled a bottle with snow and salt, and having stopped it, I hung it in the air, where it soon congealed the moist vapours thereof into a thin hoary ice, though much more plentifully about the bottom than the sides or top, whence we may infer that the sphere of activity of cold tends most downwards, as that of heat upwards. From some such hint some Italians have thought it possible to make an artificial fountain in the midst of summer, viz. by putting a quantity of snow or ice into a funnel and thereby condensing the ambient air into a dew which shall constantly trickle [f. 124] down. I tried a way of making artificial snow,

5 The word in square brackets occurs only in the minute book version, where it is inserted over a caret mark. It might just possibly read 'fire'.

6 The famous doctrine of 'antiperistasis'. For Aristotle's view of freezing, see his *Meteoroligica*, Book IV, especially chapters 5–7.

viz. by beating the whites of eggs or any other substance into a froth, which, exposed to the cold air, will soon turn into flakes of snow not to be distinguished from the natural. The refraction of glass and ice is near the same, and a triangular prism of ice cut exactly will show a pretty variety of colours like that of glass. I could not find it to be true what is generally said, that ice when it swims keeps $^1/_7$ of its superficies above the liquor, for sometimes it had $^1/_9$ part above, and often less. Kercher [*recte* Kircher] mentions 2 ways of freezing quicksilver, which Mr Boyle says could never perform.[7] Quare, whether amber or the loadstone lose ought of their attractive powers by being frozen?

7 See T. Birch (ed.), *The works of the Honourable Robert Boyle* (5 vols, London, 1744), ii, 264 (*New experiments*). I have been unable to trace the reference to Athanasius Kircher.

120

St George Ashe

Of mathematics and a new method of demonstration

(a) The preeminence of mathematical knowledge, and the certainty of its way of reasoning, are manifest from the few or no controversies between the professors thereof (especially in pure unmixed mathematics), and from the easy discovery of paralogisms. Some of the reasons of which certitude may be these: because quantity, the object about which it is conversant, is a sensible obvious thing, and consequently the ideas we form thereof are clear and distinct and daily represented to us in most familiar instances; because it makes use of terms which are proper, adequate, and unchangeable; its axioms and postulata also are very few and rational; it assigns such causes and generations of magnitudes as are easily apprehended and readily admitted; it rejects all trifling in words and rhetorical schemes, all conjectures, authority, prejudices, and passion; lastly, so exquisite an order and method in demonstrating is observed, that no proposition is pretended to be proved, which does not plainly follow from what was before demonstrated, as is manifest in Euclid's *Elements*. Now, as a further instance of the evidence of mathematical theorems, I believe it were not difficult to demonstrate any one of Euclid's independently from the rest, without any precedent lemmas or propositions. As an essay of which I will here subjoin some of the most useful, and upon which the solution of most problems, especially algebraical ones, do depend, and those also in the most various and different parts of geometry, viz. concerning the properties of angles, circles,

Note: T.C.D. MS I.4.18. ff 86–9; another copy B.L. Add. MS 4811, ff 21v–3; printed in *P.T.*, XIV (1684), 672–6. Read to the society on 14 April 1684, no. 18. See Plate II.

triangles, squares, proportionals, and solids. The propositions which I will endeavour to demonstrate thus independently shall be these: the 32nd and 47th of the 1st book, most of the 2nd and 5th books, the 1st and 16th of the 6th, with their corollaries.[1] [f.86v]

In order to demonstrate the 32nd, I suppose it known what is meant by an angle, triangle, circle, external angle, parallels, and that the measure of an angle is the arc of a circle intercepted between its sides, that a right angle is measured by a quadrant, and 2 right angles by a semicircle. I say then (in Fig. 1)[2] that in the triangle ABC the external angle BCE is equal to the 2 opposite internal ones ABC, BAC; for let a circle be drawn, C being the centre and BC the radius, and let CD be drawn parallel to AB, those 2 lines being always equidistant will both have the same inclination to any 3rd line falling upon them, that is (by the definition of an angle) they will make equal angles with it; for if any part of CD (for instance) did incline more to BC than did AB, upon that very account they would not be parallel. It follows therefore that the angles ABC, BCD are equal, also BAC = DCE, because AE falls upon 2 parallels, but the external angle BCE = BCD + DCE, which were before proved to be equal to ABC, BAC. Q.E.D. Hence may be inferred as a corollary, that the 3 angles of every triangle are equal to 2 right ones, for the angles ACB + BCE are measured by a semicircle, and therefore equal to 2 right angles. Corollaries also from hence are the 20th, 22nd, and 31st of the 3rd book,[3] which

1 Book I, 32: 'In any triangle, if one of the sides be produced, the exterior angle is equal to the two interior and opposite angles, and the three interior angles of the triangle are equal to two right angles.'

Book I, 47: 'In right-angled triangles the square on the side subtending the right angle is equal to the squares on the sides containing the right angle' (Pythagorean theorem).

Book II is concerned mainly with a discussion of the methods of geometrical algebra. In it, propositions 9–14 are proved by means of Book I, 47.

Book V contains a discussion of the theory of proportions, with particular reference to magnitudes in general.

Book VI, 1: 'Triangles and parallelograms which are under the same height are to one another as their bases.'

Book VI, 16: 'If four straight lines be proportional, the rectangle contained by the extremes is equal to the rectangle contained by the means; and, if the rectangle contained by the extremes be equal to the rectangle contained by the means, the four straight lines will be proportional.'

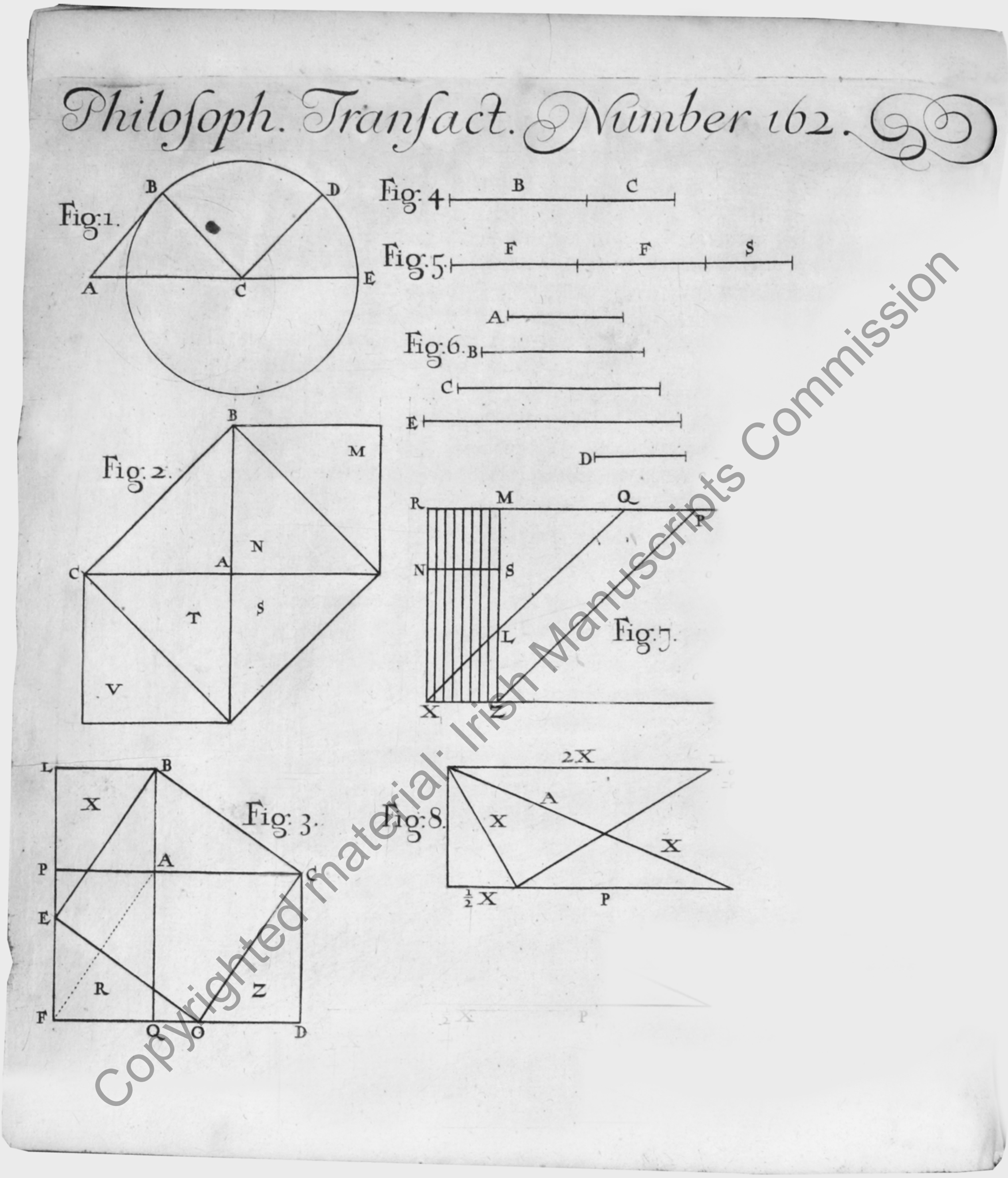
It is not possible to identify the edition of Euclid used by Ashe or the other members of the society. They may have consulted Isaac Barrow's compressed Latin ed. of the thirteen genuine and two apocryphal books (Cambridge, 1655; English trans., 1660). De Challes's simplified ed. of the first eight books (Lyons, 1674; English trans., London, 1685) also achieved great popularity. The quotations given throughout the present work are from the edition by T.L. Heath (3 vols, 2nd edn, Cambridge, 1926). Each proposition etc. is given in full on first citation, which can be traced by means of the index.

2 The eight figures are here reproduced as Illustration II (from the *P.T.* version).

3 Book III, 20: 'In a circle the angle at the centre is double of the angle at the circumference, when the angles have the same circumference as base.'

Book III, 22: 'The opposite angles of quadrilaterals in circles are equal to two right angles.'

Book III, 31: 'In a circle the angle in the semicircle is right, that in a greater segment less than a right angle, and that in a less segment greater than a right angle; and further the angle of the greater segment is greater than a right angle, and the angle of the less segment less than a right angle.'



120 PLATE II

Eight geometrical figures.

Reproduced from *P.T.*, xiv, no. 162 (1684) contain the properties of circles, whose deduction from hence, being both natural and obvious, I omit.

In order to demonstrate the 47th, I suppose the meaning of the terms made use of to be known, and that 2 angles or superficies are equal when, one being put on the other, it neither exceeds nor is exceeded. This being allowed, I say [f. 87] the sides about the right angle are either equal or unequal. If equal (as in Fig. 2) let all the squares be described, the whole figure exceeds the square of the hypotenuse BC by the 2 triangles M, V, and exceeds also the squares of the other 2 sides AB, AC by the 2 triangles ABC and S, which excesses are equal, for M is equal to ABC, the 2 sides about the right angle being 2 sides of a square upon AB, by supposition equal to AC, and the 3rd side equal to BC. Therefore the whole triangles are equal. After the same manner S and V are proved to be equal. Therefore the square of CB is equal to the squares of the 2 other sides. Q.E.D.

But if the sides be unequal (as in Fig. 3rd), let the squares be described and the parallelogram LQ completed, the whole figure exceeds the square upon BC by 3 triangles X, R, Z, and exceeds also the squares LA, AD, by the triangle ABC and the parallelogram PQ. Which excesses I say are equal, for Z is equal to ABC, the side OC=BC, CD=AC, the angle D=A, and OCD=BCA, which is manifest by taking the common angle ACO out of the 2 right angles BCO, ACD. Therefore, by superimposition, the whole triangles are equal. In like manner X is proved equal to ABC, also R, and the parallelogram PQ to be double of the triangle ABC. Thus the excesses being proved equal, the remainders also will be equal, viz. the square of BC to the squares of AB, AC. Q.E.D. Manifest corollaries from hence are the 35th and 36th of the 3rd book, also the 12th and 13th of 2nd.[4] [And here I shall observe that by this method of proving the 47.1 Eucl. 'tis manifest that that proposition may be demonstrated otherwise than Euclide has done it, and yet without the help of proportions, which Peletarius denied as possible.][5]

4 Book III, 35: 'If in a circle two straight lines cut one another, the rectangle contained by the segments of the one is equal to the rectangle contained by the segments of the other.'

Book III, 36: 'If a point be taken outside a circle and from it there fall on the circle two straight lines and if one of them cut the circle and the other touch it, the rectangle contained by the whole of the straight line which cuts the circle and the straight line intercepted on it outside between the point and the convex circumference will be equal to the square on the tangent.'

Book II, 12: 'In obtuse-angled triangles the square on the side subtending the obtuse angle is greater than the squares on the sides containing the obtuse angle by twice the rectangle contained by one of the sides about the obtuse angle, namely that on which the perpendicular falls, and the straight line cut off outside by the perpendicular towards the obtuse angle.'

Book II, 13: 'In acute-angled triangles, the square on the side subtending the acute angle is less than the squares on the sides containing the acute angle by twice the rectangle contained by one of the sides about the acute angle, namely that on which the perpendicular falls, and the straight line cut off within by the perpendicular towards the acute angle.'

5 The passage in square brackets occurs only in the version printed in the *P.T.*, having presumably been taken from a (now lost) copy sent to the R.S.

Jacques Peletier (1517–82) French poet and mathematician and principal of the College of Bayeux. He also studied medicine, and became principal of the College of Mans in 1573. His mathematical works include *L'Algèbre* (Lyons, 1554). For his discussion of Euclid, I, 47, see *Jn. Euclidis elementa geometrica demonstrationum libri sex* (Lyons, 1557), pp 46–50.

(b) The first 10 propositions of the 2nd book are evidently demonstrated only by substituting species or letters instead of lines, and multiplying them according to the tenor of the proposition. Thus to instance in one or two: in Fig. 4, call the whole line A, and its [f. 87v] parts B and C, therefore A=B+C, and consequently AA=BB+CC+2BC, which is the very sense of the 4th of the 2nd book.[6] Thus also (in Fig. 5), let a line be cut into equal parts F, F, and let another line S be added thereto, 'tis manifest that 4FF+4SF+2SS=2FF+2FF+2SS+4SF, which is the 10th proposition of the same book.[7]

Almost the whole doctrine of proportionals, viz. permutation, inversion, conversion, composition, division of ratios, and proportion ex aequo, and consequently the most useful propositions of the 5th book, are clearly demonstrated by one definition, and that is, of similar or like parts which are said to be such as are after the same manner or equally contained in their wholes; thus (in Fig. 6), the antecedents A and C are either equal to their consequents, or greater, or less. If equal, the thing is manifest; if less, then (by the definition of proportionals) A and C are like parts of B and C. Therefore what proportion the wholes B and C have to one another, the same will A and C have, which is permutation. Likewise, E:C :: B:A, which is inversion; so also, if from proportionals you take like parts, the remainders will be proportional, whence conversion and division are demonstrated, and if to proportionals you add like parts, the wholes will still be proportional which is composition etc. If the antecedents be greater than the consequents, the consequents will be like parts of them, and the demonstration exactly the same with the former.

The first of the 6th book is proved by considering the generations of parallelograms, which are produced by drawing or multiplying the perpendicular upon the basis, that is, taking it so often as there are parts and divisions in the base. Therefore (in Fig. 7), the same proportion that RX single has to NX single, the same has RX multiplied by XZ, that is, repeated a certain number of times, to NS multiplied by XZ, that is, repeated the same number of times, which is as much as to say RX : NX :: par.RZ : par.NZ. Now that this proportion also is true in oblique-angled parallelograms is proved because they are equal to rectangled ones upon the same basis and between [f. 88] the same parallels, as does thus independently appear (in Fig. 7), the triangles RQX and MPZ are equal, for RX=MZ, QX=PZ, RM=QP; therefore, adding to both MQ, RQ=MP. If therefore from these equal triangles you take what is common. viz. MLQ, the remainders will be equal, RXLM=QLZP, to both which add XLZ, and the whole parallelograms will be equal, RZ=QZ. Q.E.D. That triangles also having a common basis are in the proportion

6 Book II, 4: 'If a straight line be cut at random, the square on the whole is equal to the squares on the segments and twice the rectangle contained by the segments.'

7 Book II, 10: 'If a straight line be bisected, and a straight line be added to it in a straight line, the square on the whole with the added straight line and the square on the added straight line both together are double of the square on the half and of the square described on the straight line made up of the half and the added straight line as on one straight line'.