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# THE CONSIDERATIONS OF THE CURIOUS: NATURAL PHILOSOPHY IN EARLY MODERN DUBLIN

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by

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A thesis submitted to the School of English

University of Dublin, Trinity College

in fulfilment of the requirements for the degree of Doctor of Philosophy

Supervisor: Professor Aileen Douglas

2019



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DECLARATION

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Susan Hemmens



## SUMMARY

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This thesis offers a re-evaluation of the activities and mindset of a community of natural philosophers who described themselves as curious: the members of the Dublin Philosophical Society (1683–1709) (DPS) and their circle in Ireland and further afield. Although they sometimes perceived themselves as being on the periphery of the learned world, members of the DPS engaged self-consciously and with reflection in that world. The thesis argues that the DPS, along with like-minded individuals in Ireland and abroad, participated in the making of knowledge in ways that they regarded as new. By way of a series of case studies, the thesis delineates the influences on the DPS, details the workings of the society, and discusses the reception of its outputs by peers.

Until recent decades, history of science has tended to exclude those topics which seemed to have little to contribute to the story of triumphant progress towards modern science. The interpretation of biblical accounts of cosmogony, and the connected study of chronology, have only recently begun to be included, following a more extensive re-integration of alchemy into chymistry. This thesis argues that inclusion of these less prominent topics in the narrative, as well as less prominent individuals and groups such as the DPS, permits a more nuanced description of the processes of intellectual change.

By attention to the formation and attitudes of individuals, and to their confessional, political and social contexts, the case studies presented in this thesis support this more complex view of philosophical activity, showing how and why such a community could listen with apparently equal interest to an account of the nature of acid and alkali, and to a commentary on the authenticity of the biblical texts of the Old Testament. Evidence presented in case studies of topics in natural history, in cosmology, and in laboratory investigations shows the intersection of the views of the DPS with the concepts developed by more prominent figures and groups in the learned world. Support is offered for the proposal that a search for reproducibility and a pattern of self-correction characterised the philosophical community as a whole, contributing to the process of intellectual change over time.

## ACKNOWLEDGEMENTS

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My principal thanks are due to my supervisor, Professor Aileen Douglas, for her expertise, patience, and encouragement during the writing of this thesis. I also wish to thank Professor Crawford Gribben, Professor Brendan Dooley and Professor Susan Schreibmann for their teaching in the structured modules of what began as a thesis in the ‘Texts, Contexts, Cultures’ programme. I am grateful to my internal and external examiners for stimulating and helpful discussions and comments.

I wish to acknowledge the generosity of Professor K. Theodore Hoppen, and his publishers, the Irish Manuscript Commission, whose 2008 edition of the papers of the Dublin Philosophical Society was made available electronically for the purposes of this thesis by the kind offices of the Administrator of the Irish Manuscripts Commission, Dr Cathy Hayes.

The cheerful assistance of library and archive colleagues in Trinity College Dublin, the Royal Irish Academy, the Representative Church Body Library, and the Bodleian Library, Oxford, is gratefully acknowledged.

Chapter 5 of this thesis is based substantially on a paper initially given at a seminar on Robert Boyle in the Worth Library, Dublin, in November 2011, and subsequently published in a special issue of *Intellectual History Review*, edited by Professor Michael Hunter and Dr Elizabethanne Boran.\* I am grateful to them for helpful discussions, and for encouragement in further research.

I am grateful to the Governors and Guardians of Marsh’s Library for their initial permission to undertake this thesis. My thanks are also due to my colleagues in Marsh’s Library, and in particular to the Director, Dr Jason McElligott, for their encouragement and practical support.

I wish to thank my family and friends, and particularly my husband, for bearing with my anxieties and occasional obsessions, and my brothers for critical proofreading. Finally, I recall with gratitude my late parents, who both encouraged me on my adventures in modern science, and would, I hope, have been pleased to see me undertake this further adventure in the seventeenth century.

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<sup>\*\*</sup> Susan Hemmens, ‘Crow’s Nest and beyond: Chymistry in the Dublin Philosophical Society, 1683–1709’, *Intellectual History Review* 25:1 (2015). 59-80.

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## ABBREVIATIONS

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- Bacon, *Works* *The Works of Francis Bacon*. Edited and translated by James Spedding, Robert Leslie Ellis and Douglas Denon Heath. London, 1811–97.
- Birch, *History of the RS* Birch, Thomas. *The History of the Royal Society of London for Improving of Natural Knowledge from Its First Rise, in which the Most Considerable of Those Papers Communicated to the Society, which Have Hitherto Not Been Published, are Inserted as a Supplement to the Philosophical Transactions*. London, 1756–7.
- Boyle, *Correspondence* Boyle, Robert. *The Correspondence of Robert Boyle, 1636–1691*. Edited by Michael Hunter, Antonio Clericuzio, and Lawrence Principe. 6 vols. London: Pickering & Chatto, 2001.
- Boyle, *Works* Boyle, Robert. *The Works of Robert Boyle*. Edited by Michael Hunter and Edward B. Davis. 14 vols. London: Pickering & Chatto, 1999–2000.
- Cohen, *Modern Science* Cohen, H. F. *How Modern Science Came into the World: Four Civilizations, One 17th-Century Breakthrough*. Amsterdam: Amsterdam University Press, 2010.
- DPS Dublin Philosophical Society
- DPS Papers* Hoppen, K. Theodore, ed. *Papers of the Dublin Philosophical Society 1683–1709*. 2 vols. Dublin: Irish Manuscripts Commission, 2008.
- DUM Wilde, William. ‘Molyneux, Sir Thomas, Bart., M.D., F.R.S.: Gallery of Illustrious Irish men—No. XIII’. *The Dublin University Magazine: A Literary and Political Journal*. Dublin, 1841.
- EMLO Early Modern Letters Online, Cultures of Knowledge, <http://emlo.bodleian.ox.ac.uk>. Accessed 20 September 2018.
- ESTC The English Short Title Catalogue. <http://estc.bl.uk>. Accessed 20 September 2018.
- Levitin, *Ancient Wisdom* Levitin, Dmitri. *Ancient Wisdom in the Age of the New Science: Histories of Philosophy in England, c. 1640–1700*. Cambridge: Cambridge University Press, 2015.
- Locke, *Correspondence* Locke, John. *The Correspondence of John Locke*. Edited by E. S. de Beer. The Clarendon Edition of the Works of John Locke. Oxford: Oxford University Press, first published 1976–9; reissued 2010.
- Marsh, *Diary* Marsh, Narcissus. *Scholar Bishop: The Recollections and Diary of Narcissus Marsh 1638–96*. Edited by Raymond Gillespie, Cork: Cork University Press, 2002.
- Molyneux, *Dioptrica* Molyneux, William. *Dioptrica Nova. A treatise of dioptricks in two parts: wherein the various effects and appearances of*

- spherick glasses, both convex and concave, single and combined, in telescopes and microscopes, together with their usefulness in many concerns of humane life, are explained.* London, 1692.
- Molyneux, *Life*
- Molyneux, Capel. *An Account of the Family and Descendants of Sir T. Molyneux, Kt, Chancellor of the Exchequer in Ireland. With a Memorial of the Life of W. Molyneux; an Autobiography.* Edited by Sir T. Phillipps, Bart. Dublin, 1820.
- Molyneux, *Sciothericum*
- Molyneux, William. *Sciothericum Telescopicum Or, a New Contrivance of Adapting a Telescope to an Horizontal Dial for Observing the Movement of Time.* Dublin, 1686.
- ODNB
- Oxford Dictionary of National Biography. Edited by Brian Harrison, Lawrence Goldman and David Cannadine. Oxford: Oxford University Press, 2004-. <http://oxforddnb.com>. Accessed 20 September 2018.
- Poole, *World Makers*
- Poole, William. *The World Makers: Scientists of the Restoration and the Search for the Origins of the Earth.* Oxford: Oxford University Press, 2010.
- SDFB
- Six Degrees of Francis Bacon. Christopher Warren, Daniel Shore, Jessica Otis, Scott Weingart and John Ladd. <http://www.sixdegreesoffrancisbacon.com/about>. Accessed 20 September 2018.

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# CHAPTER 1

## INTRODUCTION

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### Prologue: Contexts and Cultures

*...Experiment is matter of Fact, and strikes the senses so forcibly,  
that there is no opposing it.<sup>2</sup>*

*O Lord grant that in studying thy works we may also study to  
promote thy Glory (w<sup>ch</sup> is the true end of all our studies).<sup>3</sup>*

In April 1686, the Irish natural philosopher William Molyneux (1656–98), writing a preface to his account of a newly-designed instrument, described the knowledge produced by experiment as acting so powerfully upon the senses that the ‘matter of Fact’ could not be denied. In April 1693, Narcissus Marsh (1638–1713), scholar and Anglican bishop, added a devout prayer to his diary, drawing the study of the creator’s works into the context of his religious duty. Both Molyneux and Marsh were founding members of the Dublin Philosophical Society (DPS), which was established in 1683 and continued, with some interruptions, until 1700, with a brief revival under William Molyneux’s son Samuel between 1707 and 1709.<sup>4</sup> This thesis seeks to investigate the context and significance of their community of natural philosophers in early modern Dublin and further afield in Ireland, and their place and connections in the wider world of the learned, with a focus on the earlier part of the society’s activities. Although perceiving themselves as placed on the periphery of that world, both Marsh and Molyneux contributed in private and in public to the investigation of the created universe under their God, who had ‘made all things in number, measure and weight’.<sup>5</sup>

<sup>2</sup> William Molyneux, *Sciothericum telescopicum* (Dublin, 1686), preface. Hereafter Molyneux, *Sciothericum*.

<sup>3</sup> Narcissus Marsh (Raymond Gillespie, ed.), *Scholar Bishop: The Recollections and Diary of Narcissus Marsh; 1638–1696* (Cork, 2003), 50. This prayer, which is similar to other devotional utterances in Marsh’s diary, is additionally relevant to this thesis in that it follows a record of ‘the renewal of our Philosophical meeting’. Hereafter Marsh, *Diary*.

<sup>4</sup> K. Theodore Hoppen, ed. *Papers of the Dublin Philosophical Society 1683–1709* (Dublin: 2008). Hereafter *DPS Papers*. First set of minutes, DPS Papers no. 1.

<sup>5</sup> ‘... and as God has made all things in number, measure, and weight, that Learning which teaches us the affections of number and measure, as being the Foundation on which true Philosophy is to be

The formal establishment of the society, as defined by the first set of minutes of 15 October 1683, was preceded by an earlier, sociable meeting of like-minded individuals to discuss topics in natural philosophy. Narcissus Marsh had described a 'Club' meeting for a very similar purpose in 1682, in Trinity College, predating the formal structure.<sup>6</sup> At its inception, the DPS sought strong links with its avowed model, the Royal Society in London, and with a sister society in Oxford, which saw exchanges of information between the secretaries of the societies. As will emerge in Chapter 2, and in the accounts of exchanges on particular topics elaborated in the subsequent chapters, personal links between individual members of the societies were also of importance in the transmission of ideas and information. Inter-generational transmission and influences on the organisational structure of the DPS are also discussed, with the polymath William Petty (1623–87) setting out rules for the Dublin society along the lines of the reforming rules for the Royal Society which he had promoted.<sup>7</sup> As also discussed later in this chapter, the colonial context of Ireland was reflected in the membership of the society, and in those assuming office. As with the Royal Society, the ties to the political establishment were firm, which was also reflected in the confessional allegiances of the membership to the established church.

The papers of the DPS, published in the last decade in a comprehensive edition by K. Theodore Hoppen, form a rich source for a deeper analysis of the reading, experimentation and thinking of this intellectual circle in Dublin and further afield in Ireland. The records of the society as presented in Hoppen's edition are complemented by the correspondence and other activities of particular members, such as Narcissus Marsh and William Molyneux, in contexts broader than that of the society.

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superstructed, is chiefly to be respected.' Molyneux, *Sciothericum*, Preface (unnumbered). The scriptural reference is to the biblical book of Wisdom 11:20.

<sup>6</sup> See further discussion in the third section of this chapter, 'Accounts of the Dublin Philosophical Society'.

<sup>7</sup> Petty had decided opinions on method and process, which he brought to the reform of the Royal Society in the 1670s and to the organisation of the DPS about a decade later. William Petty, *The advice of W.P. to Mr. Samuel Hartlib. For the advancement of some particular parts of learning* (London, 1648); Birch, *History of the Royal Society*, 4 vols. (London, 1756-7), vol. 3, 136. The rules drawn up for the Dublin society may be found at no. 525 in the *DPS Papers*.

Marsh, Molyneux and their immediate circle of the founding members of the DPS lived through a period of change and instability. In 1611, the poet John Donne expressed the feelings of unease experienced by many when he wrote that 'a new philosophy calls all in doubt'.<sup>8</sup> Not only the authority of the scriptures, but the understanding of the natural order and its reflection in the political order was being questioned by new discoveries and new attitudes. The established curricula of the universities were being dismissed as irrelevant prosy quibblings, and the books themselves seemed ranged against one another in a quarrel of the old and new modes of thinking.<sup>9</sup> William Molyneux's equation of 'experiment' with 'matter of fact', proclaimed in the preface to his *Sciothericum Telescopicum*, formed one view of the new patterns of acquisition, recognition and definition of knowledge, a view which has been widely discussed in the literature of history and philosophy of science. A less well-known aspect is introduced by Narcissus Marsh's description of the 'true end' of his studies. Marsh's original fields of study – 'Old Philosophy, Mathematics and Oriental languages' – placed his observations of terrestrial and celestial forms, from caterpillars to comets, in the context of the relationship between philosopher and creator, and of the birth of the earth and the chronology of the scriptures. Such concepts figured largely in the seventeenth-century understanding of humankind's place in the universe and the proper ordering of human society. Due order, for Anglicans such as Marsh and Molyneux, was to be found in conformity with the religion 'as by law established', and under the monarch, as divinely appointed.

In recent decades, history of science has tended to concentrate on overviews of the activities and output of the larger groupings such as the influential Royal Society, and of major figures, such as the Irish chymist Robert Boyle (1627–91), the Royal Society's technical innovator Robert Hooke (1635–1703), and the discoverer of

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<sup>8</sup> This much-quoted phrase from Donne is taken from 'The First Anniversary: The Anatomy of the World', first published in 1611.

<sup>9</sup> Much later, Jonathan Swift's satirical presentation of the debate between the ancients and moderns is found in his prolegomena to *A Tale of a Tub*, published in 1704: for one of the many discussions of this work see Kenneth Craven, *Jonathan Swift and the Millennium of Madness: The Information Age in Swift's "A Tale of a Tub"* (Lincoln NE, 2006).

gravity, Isaac Newton (1643–1727), to name but three. In this thesis, I turn instead to a circle of the less prominent, assessing their contribution to the practice of natural philosophy. I argue that by involvement in exchange of information, observations and experiments, by repetition of earlier experiments, and by critical assessment of concepts promoted in the manuscript and printed communications of the self-proclaimed Republic of Letters, these philosophers joined a circle of witnesses to what they termed ‘matters of fact’, and that although they themselves had a sense of being somewhat remote from the learned world, their input was actively sought and valued beyond their immediate circle. This introductory chapter sets the DPS in its historical and historiographical context, reviewing some of the varying modern interpretations of the search for knowledge undertaken by early modern natural philosophers, and the nature of the matters of fact which they sought to document and understand.

It is not possible to approach a description of the context and culture in which the members of the DPS understood their own activities without pausing to reflect on a more general, and relatively recent, set of historiographical debates. One of the liveliest and longest lasting has been the dispute as to whether a ‘scientific revolution’ occurred in the seventeenth century, and if so, what its nature and genesis might have been. Unaware of what vigorous disagreements he was engendering, Alexander Koyré, seeking at the end of the 1930s to describe the origins of the modern sciences, used the term ‘Scientific Revolution’ for the first time.<sup>10</sup> Herbert Butterfield adopted the concept with enthusiasm. Declaring that ‘the so-called scientific revolution ... outshines everything since the rise of Christianity and reduces the Renaissance and the Reformation to mere episodes’, Butterfield established a trend in the

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<sup>10</sup> Alexandre Koyré’s concept was first published in French as *Études Galiléenes* (Paris, 1939) at the outbreak of World War II, and later in English: see Koyré, ‘Galileo and the Scientific Revolution of the Seventeenth Century’, *The Philosophical Review* 52:4 (1943). He originally confined the use of the term explicitly to the work of Galileo and Descartes, but extended it in a later publication to the span between Copernicus and Newton: see Koyré, *From the Closed World to the Infinite Universe* (New York, 1957). See also H.F. Cohen, *The Scientific Revolution: A Historiographical Inquiry* (Chicago, 1994), Chapter 2.

interpretation of scientific change.<sup>11</sup> His statement of the importance of the changes in thinking and practice which sprang from the ‘revolution’ was popularised and perpetuated.<sup>12</sup> This assertion of the over-riding significance of the Scientific Revolution came to form one historiographical extreme. The opposite extreme was articulated in Steven Shapin’s provocative opening sentence to his widely acclaimed book, *The Scientific Revolution* (1996): ‘There was no such thing as the Scientific Revolution, and this is a book about it’.<sup>13</sup>

The historiography of the seventeenth-century developments has been surveyed repeatedly in the last twenty years, each survey taking a different approach to the nature and existence of the concept of the ‘Scientific Revolution’ – with or without capitalisation. Certainly, scientific thinking changed over time. A fundamental research problem in the history of science has been the attempt to describe and delineate the change, whether as revolution, which carries within it the concept of a sharp discontinuity, or as evolution, which (at least in its popular use) conveys the sense of a series of relatively smooth transitions. As will become apparent below, the discipline of history of science, which as Lawrence Principe has asserted is not yet entering a ‘grave old age’, has generated such debate surrounding the very concept of a Scientific Revolution that that one could ‘ask ten historians of science about its nature, duration and impact and get fifteen answers’.<sup>14</sup>

It must be acknowledged that it is difficult to resist the tendency to assume an inevitable set of positive progressions in scientific thinking and thus to write that history as a procession of triumphs. Despite the zeal of various reforming movements in historiography, many accounts of the history of science present the ‘pivotal’ findings, the more popular and simplified accounts referring to prominent figures as ‘fathers’ of this or that discipline. Marcus Hellyer’s description of a

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<sup>11</sup> This much-quoted phrase from Butterfield does not usually either include or emphasise his reference to the “so-called” scientific revolution, which also lacked its now customary capitalisation. See H. Butterfield, *The Origins of Modern Science* (London, 1949), viii.

<sup>12</sup> For example, by A. Rupert Hall in his once widely-used textbook *The Scientific Revolution, 1500-1800: The Formation of the Modern Scientific Attitude* (London, 1954).

<sup>13</sup> Steven Shapin, *The Scientific Revolution* (Chicago, 1996), 1.

<sup>14</sup> Lawrence Principe, *The Scientific Revolution: A Very Short Introduction* (Oxford, 2011), 2.

'cosmic relay race towards truth starting at Copernicus and ending at Newton' may, as he admits, risk parody of 'a tale well told by good scholars' but it does describe the sense of triumphant progress present in some accounts.<sup>15</sup>

Many more nuanced studies have sought to describe the nature and mechanism of the phenomenon named as the Scientific Revolution. A seminal work on the potential mechanism of such a revolution was *The Structure of Scientific Revolutions* by Thomas Kuhn, originally published in 1962 and running to many editions.<sup>16</sup> Kuhn proposed that scientific research proceeds by a process of paradigm shift, in which a new paradigm is generated as a result of an 'anomaly' observed in a long pattern of that conduct of 'normal science' which he characterised as 'puzzle-solving'. This proposal, and the detailed examples which Kuhn employed, resulted in a long and energetic debate with philosophers of science, the most prominent being Karl Popper.<sup>17</sup> Kuhn drew attention to the culturally and socially determined elements of scientific process but the unquestioned concept of revolution *per se* formed the basis for his proposal. That being so, his search was essentially for a central mechanism by which such revolution(s) might come about. His later reflections and those of his more recent evaluators have pinpointed the concept of incommensurability (the situation in which two systems completely fail to map to one another) as the most significant element in his explanation of the processes.<sup>18</sup> In contrast, Stephen Toulmin's *Human Understanding* (1972) set out to demonstrate that scientific change is an evolutionary process, in which the most useful concepts survive and give rise to greater numbers of intellectual offspring.<sup>19</sup> A further consideration of an

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<sup>15</sup> Marcus Hellyer, *The Scientific Revolution: The Essential Readings* (Oxford, 2003), 3. That this triumphant progress was Western and Eurocentric seemed at one time barely worthy of comment: this aspect has recently received attention from H.F. Cohen in *How Modern Science Came Into The World: Four Civilizations, One 17th-century Breakthrough* (Amsterdam, 2010). Hereafter Cohen, *Modern Science*.

<sup>16</sup> Thomas Kuhn, *The Structure of Scientific Revolutions*, third ed. (Chicago, 1996).

<sup>17</sup> Steve Fuller, *Kuhn vs. Popper: The Struggle for the Soul of Science* (New York, 2004).

<sup>18</sup> Thomas Kuhn, 'The Road since Structure', in *PSA: Proceedings of the Biennial Meeting of the Philosophy of Science Association* (1990), 3-13. See also Alexander Bird, 'Naturalizing Kuhn', *Proceedings of the Aristotelian Society* 105 (2005), 109-27.

<sup>19</sup> Stephen Toulmin, *Human Understanding* (Princeton NJ, 1972).

evolutionary approach to science as process and praxis is found in the work of David Hull.<sup>20</sup> Each of these contrasting approaches has attracted support within and without the history of science community. Kuhn's concept (or perhaps more accurately his terminology) of paradigm shift has become widespread in other disciplines and entered common usage.<sup>21</sup>

An equally seminal publication, Steven Shapin and Simon Schaffer's *Leviathan and the Air-Pump* (originally published in 1985 and re-issued with a new preface in 2011) sought to present scientific change as the result of sets of social processes.<sup>22</sup> This trope was taken up by many who were critical of what they saw as the arrogance of modern science, Donna Haraway's feminist discourse *Modest\_Witness@Second\_Millennium* (1997) being but one example.<sup>23</sup> Many have sought to answer Steven Shapin's *The Scientific Revolution* (1996), the opening sentence of which was quoted above. A collection of essays entitled *Rethinking the Scientific Revolution*, edited by Margaret Osler in 2001, contains opinions from both sides of the argument.<sup>24</sup> These found Richard Westfall broadly *pro* the concept of a scientific revolution, Osler herself broadly *contra*, along with a range of studies exemplifying the detail that the *contra* side masses to illustrate the evolutionary, messy and culturally-determined aspects of the same events. Katharine Park and Lorraine Daston, prefacing their collected account of early modern science, employed the term Scientific Revolution peripherally and cautiously, although one or two of the contributors were not quite so reticent.<sup>25</sup> A relatively recent defence of the 'Revolution' concept is found in the writings of W.R. Shea.<sup>26</sup> More recently still,

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<sup>20</sup> David L. Hull, *Science as a Process: an Evolutionary Account of the Social and Conceptual Development of Science* (Chicago, 1988).

<sup>21</sup> For an example from a very different field, see Hans Küng and David Tracy, eds., *Paradigm Change in Theology* (New York, 1989).

<sup>22</sup> Steven Shapin and Simon Schaffer, *Leviathan and the Air-Pump: Hobbes, Boyle, and the Experimental Life*. With a new introduction by the authors. (Princeton NJ, 2011).

<sup>23</sup> Donna Haraway, *Modest\_Witness@Second\_Millennium. FemaleMan@\_Meets\_OncoMouse<sup>a</sup>: Feminism and Technoscience* (New York and London, 1997).

<sup>24</sup> Margaret J. Osler, ed. *Rethinking the Scientific Revolution* (Cambridge, 2000).

<sup>25</sup> This reference and explanation occur on page 13 of a 17-page introduction. See Katharine Park and Lorraine Daston, eds., *Early Modern Science* (The Cambridge History of Science) (Cambridge, 2006), 13.

<sup>26</sup> William R. Shea, 'The Scientific Revolution Really Occurred', *European Review* 15:4 (2007).

David Wootton's strongly worded polemic *The Invention of Science: A New History of the Scientific Revolution* (2015) scoffs at the discourses, common since Kuhn, and also to be found in the writings of Shapin and Schaffer, which depict scientific findings as socially constructed. A more measured approach is to be found in H.F. Cohen's lengthy re-analysis of what he terms the 'master narrative', in which he describes certain major developments over the course of the seventeenth century as 'revolutionary'. His description of the mechanism of 'change over time' is perhaps best summarised as a set of *contingent* 'transformations'. As the concept of contingency suggests, each generation of results depended on the previous results being reproducible, and Cohen proposed that a significant component of the developments in the seventeenth century was the emergence of 'procedurally and institutionally established self-correction'.<sup>27</sup> As will appear later, reproducibility of earlier findings became recognised as crucially important in the practice of the DPS and its sister societies.

The correctness of some details of the evidence drawn upon in *Leviathan and the Air Pump* has been questioned.<sup>28</sup> Nevertheless, the figure of the 'modest witness', extrapolated by Shapin and Schaffer from the writings of Robert Boyle in *The Christian Virtuoso* and elsewhere, contained attractive and plausible elements describing the conduct of experiment and the reporting of results, to which we shall return later. The social constructs of gentlemanly conduct drawn upon by the authors, and repeated in Shapin's later publication, *Never Pure*, are less convincing.<sup>29</sup> The recent re-issue of *Leviathan and the Air-Pump* (2011) contains a preface by the authors examining the response to their original publication. Acknowledging the work as a child of its time, produced with typewriter and surrounded by arguments pertaining to the Cold War, the authors nonetheless continued to regard the book as having approached their chosen problems

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<sup>27</sup> Cohen, *Modern Science*, 720.

<sup>28</sup> In *The Aspiring Adept: Robert Boyle and His Alchemical Quest* (Princeton, 1998), Lawrence Principe refuted many of the conclusions drawn by Shapin and Schaffer, claiming that they rested on inaccurate interpretations of Boyle's work.

<sup>29</sup> Steven Shapin, *Never Pure: Historical Studies of Science as if it was Produced by People with Bodies, Situated in Time, Space, Culture, and Society, and Struggling for Credibility and Authority* (Baltimore, 2010). See p.31 below for further discussion of these issues.

regarding the nature and production of knowledge with an interdisciplinary combination of methodologies which they see as having become inhibited, to some degree, since the days of the original publication.<sup>30</sup> Michael Hunter, in criticising Shapin and Schaffer (implacably, as they see it) made a strong plea for the role of biography, and for examination of individual responses to the ‘themes and polarities’ within historical communities, to approach a deeper study of the intellectual motivations of the participants in the processes of scientific change.<sup>31</sup> Seeking an appropriate methodology, Hunter cautioned against

presentist agendas seeking to establish timeless laws of the sociology of scientific knowledge ... instead we need to combine a sensitivity to the milieu in which the work was carried out and to the individuals who executed it with a deep understanding of their intellectual agenda.<sup>32</sup>

This is a persuasive argument, which can equally be applied in discussing the collective intellectual work of the communities formed by those individuals. The general approach invites engagement with early modern thinking as found in the language and contexts of individuals and the groups which they established, gathering a series of what might in another context be termed microhistories into a general contextualisation, and macro-evaluation.<sup>33</sup> Reviewing methodologies in history of science, Findlen noted the emerging role of microhistorical techniques, which engage minutely detailed retrieval of ‘singular episodes’ involving in particular those people whose voices had been previously unheard, with the potential to cast new and intriguing light on longer term events’.<sup>34</sup> The DPS and its

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<sup>30</sup> *Leviathan and the Air-Pump*, introduction (in particular, xi, xxii–iv).

<sup>31</sup> Michael Hunter, *Science and the Shape of Orthodoxy: Intellectual Change in Late Seventeenth-Century Britain* (Woodbridge, 1995), 13.

<sup>32</sup> Michael Hunter, ‘Scientific Change: its Setting and Stimuli’, in Barry Coward, ed., *A Companion to Stuart Britain* (Oxford, 2003), 225–6. Hunter sought ‘a new structure for looking at the evolution of ideas within the period, in which the exposition of general themes and polarities is combined with detailed attention to individual responses to them.’

<sup>33</sup> An evolution of Carlo Ginzburg’s methodologies of microhistory towards a grouping of narratives is to be found in his *Threads and Traces: True False Fictive* (Berkeley, 2012).

<sup>34</sup> Paula Findlen, ‘The Two Cultures of Scholarship?’, *Isis* 96, no. 2 (2005). Findlen also claims that Thomas Kuhn’s framework for the history of science, with its emphasis on periods of ‘normal science’ punctuated by paradigm shifts, had been fruitful for Ginzburg’s ideas. Returning to Carlo Ginzburg, ‘Clues: Roots of a Scientific Paradigm’, *Theory and Society* 7:3 (1979), I do not find quite the direct

circle have until now been largely unheard, at least in their own terms and language, inviting just such a discovery in their case. Microhistories also have the virtue of being of a manageable scale in a field in which larger studies may become unmanageable.<sup>35</sup> The biographical emphasis common to many microhistories (although microhistory of concepts rather than individuals is not unknown) is in sympathy with Michael Hunter's advocacy of intellectual biography as a technique useful in the longer-term description of intellectual change over time.

The cultural context of the seventeenth-century developments in which the DPS was immersed was coloured by the Irish colonial setting, placing them on a geographical periphery and, as some would see it, on an intellectual periphery. A further context for their deliberations was the church 'as by law established' which held a religious outlook on reason forged during two centuries of doctrinal controversy and political challenge. The members of the DPS lived during a time of instability in thought and government, tempered by desire for improvement, utility, and the duty to one's neighbour. Thomas Hobbes' *Leviathan*, one part of the intellectual duel presented by Shapin and Schaffer, promoted disturbing views of the temporal authority in the realm. On the far side of a narrow strip of water, Narcissus Marsh perceived another 'Leviathan' in Louis XIV of France and implored his God to 'put a hook in his nostrills'.<sup>36</sup> The sensitivities of the Irish ruling classes to the practice of colonial government were put forward in an appeal not only to history but to a sense of natural justice, established from a religious basis, in William Molyneux's *The Case of Ireland...Stated* (1698). In a recent study, Michael Brown has described an Irish 'Anglican Enlightenment' in which the concepts of the benign nature of God were challenged by the bloody outcomes of the Wars of the Two Kings, and in which thinking such as Molyneux's became part of 'a wider culture of Anglican empiricism articulated in a series of historical essays on the condition of nations'. Indeed, Brown claimed that 'the Anglican Enlightenment

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relationship with Kuhn which Findlen asserts, but rather a borrowing of the concept of paradigm. As noted earlier, Kuhn's 'paradigm shift' terminology has been spread widely and adopted in many ways which he did not originally envisage.

<sup>35</sup> Findlen, op.cit. discussed the number of studies which were, perforce, collaborations.

<sup>36</sup> Marsh, *Diary*, 34.

required an urtext, and William Molyneux provided it' in the form of *The Case of Ireland ... Stated*.<sup>37</sup> As we shall see in the chapters below, the cultural context within which natural philosophy found its sphere in late seventeenth-century Ireland was very much that of the established church, the intellectual background of natural theology and religion well worked over by the Anglican bishop of Worcester, Edward Stillingfleet (1635–99), who by the time of the Wars of the Two Kings, was no longer 'a young cleric in a hurry' (as he was described by William Poole) but 'the spokesman of late-seventeenth-century Anglicanism', a respected scholar of the established Church, a Church which approved the use of reason in the understanding of the scriptural and created orders.<sup>38</sup>

This thesis generally follows Hunter's recommendation of examination of individual responses to 'themes and polarities' as a means to examine participation in larger intellectual patterns. As a central source, I draw upon the papers and correspondence of the DPS, as presented in K. Theodore Hoppen's 2008 edition, collated with other correspondence and documents, which were chosen to illustrate interests and attitudes particular to the individuals discussed.<sup>39</sup> Following an overview of the historiography of the new knowledge to be attained by natural philosophy, given in this introductory chapter, the epistolary networks of the DPS members, and their engagement with print, are examined in Chapter 2. The themes and concerns which emerged from a combination of close and distant reading in Chapter 2 guided the choice of case studies presented in later chapters. Chapter 3 addresses modes of observation of natural history, with its local variations. The consideration of the earth and the heavens, with its implications for the reading of the book of scripture, is presented in Chapter 4. Experimental investigation in the laboratory forms the basis of Chapter 5. Each chapter draws together a series of case studies, chosen to bring approaches and findings on particular topics into focus,

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<sup>37</sup> Michael Brown, *Irish Enlightenment* (Cambridge MA, 2016), 81.

<sup>38</sup> William Poole, *The World Makers: Scientists of the Restoration and the Search for the Origins of the Earth* (Oxford, 2010), xi. Hereafter Poole, *World Makers*. For the latter description of Stillingfleet, see Sarah Hutton, 'Science, philosophy and atheism: Edward Stillingfleet's defence of religion', in Richard Popkin and Arie Vanderjagt, eds, *Scepticism and irreligion in the seventeenth and eighteenth centuries* (Leiden, 1993).

<sup>39</sup>Hoppen, *DPS Papers*.

and gathered under broad headings, rather than divided into present-day disciplines. In presenting the explorations of William Molyneux, Narcissus Marsh, and their community in early modern Ireland, I return to their own reports and language, which testify to their experiences in the making of matters of fact as witnesses, disseminators, and evaluators.

### Making the new knowledge

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The making of matters of fact was not a simple process—not, at least, as simple as William Molyneux's view of experimental results as being so forceful as to be undeniable. The nature of knowledge, truth, and fact, and the means by which fact was to be apprehended, were subjects of intense debate, and of subtly changing language, in the seventeenth century, continuing into the early decades of the eighteenth century.<sup>40</sup> In one set of views, the debate consisted in the ongoing struggle between 'ancients' and 'moderns'. William Molyneux was emphatic about this in his writings, declaring

how unsatisfactory were the ancient Notions of Philosophy, which then consisted rather in Disputes, and Verbose empty Stuff, than in any Curious Discovery of Natures Actions.<sup>41</sup>

This struggle was ably caricatured in several publications by Jonathan Swift, *The Battle of the Books*, published in 1704 as the prolegomena to *A Tale of a Tub*, being one such. By 1704, the controversy between ancient and modern learning had become something of a cliché, but two decades earlier, the rejection of 'ancient learning' was a concept invoked by many, such as William Molyneux, who regarded themselves as modern.

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<sup>40</sup> For a discussion of systems of scholarship see (for example) Anthony Grafton, *Defenders Of The Text: The Traditions of Scholarship in an Age of Science, 1450-1800* (Cambridge, MA, 1991); Rens Bod, Jaap Maat, and Thijs Weststeijn, eds, *The Making of the Humanities: Volume II - From Early Modern to Modern Disciplines* (Amsterdam, 2012). A review of the language and tools at the disposal of those involved in the process by which 'natural philosophy ... extricated itself from a Christianised Aristotelianism' is to be found in the editors' introduction to J.A. Schuster and Peter R. Anstey, *The Science of Nature in the Seventeenth Century: Patterns of Change in Early Modern Natural Philosophy*, 6; and in more detail in Stephen Gaukroger's paper in the same collection, 'The Autonomy of Natural Philosophy: From Truth to Impartiality', 133–65.

<sup>41</sup> Molyneux, *Sciothericum*, a.

Despite such protests in the writings of those advocating ‘new learning’, the methods of discussion and the appearance of the texts changed slowly. Although the newly established Royal Society was encouraged by its royal patron to ‘shape out’ the new, they were also to ‘perfect the old’ by means of experiments.<sup>42</sup> As described by Anthony Grafton and others, much in the world of learning remained as it had long been, appealing to tradition, the ancients, and belief systems.<sup>43</sup> Educational establishments in the universities were both slow to change and subject to political control.<sup>44</sup> Philip Pettit, writing on Hobbes, remarked on his ‘[denunciation] of rhetoric in his opponents, while using one of the most powerful tools of rhetoric under the guise of scientific orthodoxy’.<sup>45</sup> There were many attempts to balance the arguments, and to reconcile old and new. The first secretary of the French Académie, Jean Baptiste du Hamel (1624–1706), was one of those to attempt a reconciliation in his *De Consensu Veteris et Novae Philosophiae* (Paris, 1663), a book collected by Edward Stillingfleet (who cited it in his *Origines Sacrae*), and also collected by Marsh in its 1669 edition. In a similar vein, the Dutch physician Theodore Jansson van Almelooven (1657–1712) claimed in his *Inventa Nov-Antiqua* (1684) that many discoveries in medicine had been anticipated by ancient physicians such as Hippocrates and Galen: for William Molyneux this represented ‘a foolish attempt’.<sup>46</sup>

Francis Bacon’s reforms, which were the cornerstone of the new learning, set out

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<sup>42</sup> ‘We look with favour upon all forms of learning, but with particular grace We encourage philosophical studies, especially those which by actual experiments attempt either to shape out a new philosophy or to perfect the old.’

Royal Society Charter, [https://royalsociety.org/~/media/Royal\\_Society\\_Content/about-us/history/2012-Supplemental-Charter.pdf](https://royalsociety.org/~/media/Royal_Society_Content/about-us/history/2012-Supplemental-Charter.pdf). Accessed 13 June 2018.

<sup>43</sup> Anthony Grafton, *Defenders of the Text*. Recent questioning of the extent of the division between ancients and moderns is to be found in Dmitri Levitin, *Ancient Wisdom in the Age of the New Science: Histories of Philosophy in England, c. 1640–1700* (Cambridge, 2015), 225. Hereafter Levitin, *Ancient Wisdom*. Levitin cites in particular an earlier study by Kristine Haugen.

<sup>44</sup> See Nicholas Tyacke, ed., *The History of the University of Oxford Vol.4: Seventeenth-century Oxford* (Oxford, 1997); Gerhard Wiesenfeldt, *Leerer Raum in Minervas Haus: Experimentelle Naturlehre an der Universität Leiden, 1675–1715* (Amsterdam, 2002); Steven J. Reid and Emma Wilson, eds, *Ramus, Pedagogy and the Liberal Arts: Ramism in Britain and the Wider World* (Woodstock, 2013).

<sup>45</sup> Philip Pettit, *Made with Words: Hobbes on Language, Mind, and Politics* (Princeton NJ, 2008), 54. It is perhaps significant that Hobbes acted as assistant to Bacon, revealing another, more intimate layer of communication of scholarly ideas analogous to those discussions around the water-cooler beloved of present-day writers on the phenomenon of ‘hidden knowledge’.

<sup>46</sup> William Molyneux to Thomas Molyneux, 24 June 1684, *Dublin University Magazine* 18 (1841), 483. Hereafter *DUM*.

how knowledge was to be made and managed. In the Latin version of his *Advancement of Learning*, Bacon described the *ars tradendi*, which became ‘the Method of Tradition’ in the English version (first published in 1605). He saw this method as allowing the receiver of knowledge to be lazy in simply accepting tradition as fact. In setting out a ‘new machine for the mind’, Bacon went further:

Nevertheless as a man may proceed on his path in three ways: he may grope his way for himself in the dark; he may be led by the hand of another, without himself seeing anything; or lastly, he may get a light, and so direct his steps; in like manner when a man tries all kinds of experiments without order or method, this is but groping in the dark; but when he uses some direction and order in experimenting, it is as if he were led by the hand; and this is what I mean by Learned Experience. For the light itself, which was the third way, is to be sought from the Interpretation of Nature, or the New Organon.<sup>47</sup>

Describing his ‘New Atlantis’, Francis Bacon set out his concept of a research station: ‘Salomon’s House’ with the ‘Merchants of Light’ functioning as gatherers of information on a global scale, while the ‘Deprepators’ collected the experiments gathered by the ‘Merchants’, and the ‘Compilers’ arranged the information. He also mentioned ‘Mystery-men’ who collected experiments from mechanical and liberal arts, and artisanal practices; those ‘Miners’ who tried new experiments; and ‘Dowry-men or Benefactors’, who sought out useful applications of knowledge. He continues with those who

after diverse Meetings and Consults of our whole Number, to consider of the former Labours and Collections ... direct New Experiments, of a Higher Light, more Penetrating into Nature than the Former. These we call Lamps.

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<sup>47</sup> Francis Bacon, *Works*, 4, 413. For a discussion of this topic see the introduction to Julie Robin Solomon and C.M. Martin, eds, *Francis Bacon and the Refiguring of Early Modern Thought: Essays to Commemorate the Advancement of Learning (1605 - 2005)* (Aldershot, 2005); also Stephen Gaukroger, *Francis Bacon and the Transformation of Early-Modern Philosophy* (Cambridge, 2001).

We have Three others that do Execute the Experiment, so Directed, and Report them. These we call Inoculators.

Lastly, we have Three that raise the former Discoveries by Experiments, into Greater Observations, Axiomes, and Ap[h]orismes. These we call Interpreters of Nature.<sup>48</sup>

These imagined roles map well to the activities of the DPS and the other societies, in their gathering, organising, discussion, and interpretation of philosophical topics. Bacon's methodologies, later adopted both by the Royal Society and by its intellectual offspring such as the DPS, may have claimed novelty, but the concepts of testability are to be found in the humanist methods of textual criticism, crystallised in the approaches of the self-styled Republic of Letters, and amongst practitioners of the law in both civil and ecclesiastical settings. These methods would have been familiar to the clerics among the DPS group from the intellectual apparatus of biblical studies, and in particular to Marsh, whose interests were formed by the circle of biblical scholarship combined with oriental studies at Oxford. The intellectual history of the DPS as a community of the curious is connected to influences which the members brought from a humanist and theological formation, which gradually melded with those ideas acquired during the course of their later intellectual lives. Awareness of these questions and influences allow a nuanced view of the past. Frances Yates, seeking to balance the whig histories of science, suggested that

the history of science in this period, instead of being read solely forwards for its premonitions of what was to come, should instead be read backwards, seeking its connections with what has gone before. A history of science may emerge from such efforts which will be exaggerated and partly wrong, but it could equally be argued that the history of science from the solely forward-looking point of view has also been exaggerated and partly wrong, misinterpreting the old thinkers by picking out, from the context of their

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<sup>48</sup> Francis Bacon, *New Atlantis* (London, 1627), 32–3.

thought as a whole, only those elements which seem to point in the direction of modern developments.<sup>49</sup>

This thesis aims to retrieve a richer description of the ways in which the community of the ‘curious’ and the individuals within it functioned in their context, according all of their actions a validity conferred by that time, place and mindset.

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#### Seeking knowledge: curiosity, charity, reason and religion

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The members of the DPS, like the members of the Royal Society, used the term ‘curious’ (often in association with ‘ingenious’) to describe people, as well as objects, procedures and phenomena. In *Leviathan*, Hobbes wrote that

curiosity, which is a lust of the mind ... a perseverance of delight in the continued and indefatigable generation of knowledge ... exceedeth the short vehemence of any carnal pleasure.<sup>50</sup>

The concept and role of curiosity and the curious in the early modern period has been discussed widely.<sup>51</sup> For earlier writers, particularly those with a Judaeo-Christian perspective, curiosity was related to sinfulness, to greed and to the search for forbidden knowledge, as in the biblical story of the fall of Adam and Eve from their primal state of innocence through eating the fruit of the Tree of Knowledge. This view, elaborated by Augustine in his confessions (where curiosity is equated with the ‘lust of the eyes’), and subsequently by Aquinas, achieved a wide circulation.<sup>52</sup> Hobbes’ language trembles on the edge of this interpretation, using Augustine’s negatively valued word ‘lust’ with its carnal connotations, but

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<sup>49</sup> Frances Yates, ‘The Hermetic Tradition in Renaissance Science’, in Charles S. Singleton, ed., *Art, Science, and History in the Renaissance* (Baltimore, 1967), 270.

<sup>50</sup> Thomas Hobbes, *Leviathan, or, The Matter, Forme, & Power of a Commonwealth Ecclesiastical and Civil* (London, 1651), 26. *Leviathan* is found in the collections of both Marsh and Stillingfleet. As one might expect, Stillingfleet also collected a number of books and pamphlets contributing to the discussion of *Leviathan*, both positive and negative.

<sup>51</sup> For reviews, see Neil Kenny, *Curiosity in Early Modern Europe: Word Histories* (New York, 1998), which examined the language, in particular, and Barbara M. Benedict, *Curiosity: A Cultural History of Early Modern Inquiry* (Chicago, 2002).

<sup>52</sup> Peter Harrison, ‘Curiosity, Forbidden Knowledge, and the Reformation of Natural Philosophy in Early Modern England’, *Isis* 92 (2001), 265–290.

introducing the ambiguity of ‘delight’ and relating it to ‘indefatigable’ efforts in the pursuit of knowledge. The church, whether Calvinist, Lutheran or Roman Catholic, was most inclined to follow Augustine in expressing a negative attitude: male curiosity was less likely to attract condemnation than female, with Eve’s sin in Paradise frequently cited as an example of the harm arising from female curiosity.<sup>53</sup>

Francis Bacon’s reform of natural philosophy transformed this generally negative view of curiosity, drawing a sinful, idle vice into a biblical context where it could appear as virtuous. As Peter Harrison has shown, Bacon overturned the view of the church fathers, who held that ‘vain’ curiosity was both pointless and unworthy. Instead, Bacon engaged the concept of that useful knowledge which the creator had fitted the mind of man to seek and employ for the good of his neighbour. In a biblical allusion which has become famous, Bacon inserted a text from the prophet Daniel beneath the image of a ship sailing through the pillars of knowledge in the frontispiece of his *Instauratio Magna* (London, 1620): ‘Multi pertransibunt & augebitur scientia’ (many shall go to and fro, and knowledge shall be increased).<sup>54</sup>

Societal disapproval of the new philosophies emerged as satire (for example, the character of Sir Nicholas Gimcrack from Thomas Shadwell’s *The Virtuoso*, first produced in 1676). Later, similar satires were employed by Swift (as in *Gulliver’s Travels*, where the philosophers busy themselves extracting sunbeams from cucumbers). Satire and ridicule were sufficiently disturbing for Thomas Sprat’s *History of the Royal Society* to feel the need of a defence against

the Wits and Railleur of this Age... I confess I believe that *New Philosophy* need not (as *Caesar*) fear the pale, or the melancholy, as much as the humorous or the merry: for they perhaps ... may do it more injury than all the arguments of our severe and frowning dogmatical adversaries.<sup>55</sup>

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<sup>53</sup> For a recent review of this topic, see Line Cottagnies, John Thompson and Sandrine Parageau, eds., *Women and Curiosity in Early Modern England and France* (Leiden, 2016).

<sup>54</sup> Bible, O.T. Daniel 12:4.

<sup>55</sup> Thomas Sprat, *The History of the Royal Society* (London, 1667), 417.

To temper these attacks, natural philosophy pointed to the utilitarian benefits that might be expected from its efforts, which Bacon had characterised as a charitable work. Further, it was tantamount to a religious duty to marvel at the work of the creator and thus to be inspired to venerate him. In Marsh's terms, to study the works of the creator was, in effect, to promote his glory.<sup>56</sup> Rational application of the 'true end of all our studies' supported the 'curious and ingenious' study of nature, which both Bacon and Boyle commended for its usefulness, and was also marshalled in justification of the Baconian programme of the Royal Society by Joseph Glanvill and Thomas Sprat. Reason and revelation were in mutual support of philosophical activity, particularly in the writings of Boyle.<sup>57</sup>

We have already noted Michael Brown's invocation of an empiricist Anglican Irish Enlightenment, among other modes of Irish Enlightenment experience.<sup>58</sup> We shall see in the following chapters how far Anglicanism can serve as a cultural lens through which to examine the natural philosophy of Marsh, Molyneux and their circle of 'establishment' figures on the unstable fringe of the British colonial enterprise. A plausible intersection of the political with the philosophical rests on the intimate interdependence of the state and the established church. For conforming, orthodox Anglicans, such as Marsh and Stillingfleet, the authority of Providence was integrated with the political authority of the government, a government with which Marsh found himself thoroughly involved in Ireland, acting as Lord Justice at various periods from 1699 onwards.

The theology of Providence, under the influence of John Tillotson (1630–94, Archbishop of Canterbury from 1691), saw the whole world as the outworking of God's providential care, thus supporting the argument against atheism.<sup>59</sup> These arguments for the existence of the creator from the design of creation were

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<sup>56</sup> Marsh, *Diary*, 50.

<sup>57</sup> Boyle, *Works* 12, 424: 'True philosophy being but reason improved by meditation, conferences, observations, and experiments, and the arts and disciplines produced by them; those things, that may be said of the consistency of reason with theology, and its usefulness to it, may justly be applied to the friendly agreement of true philosophy and divinity, and to the utilities of the former to the latter.'

<sup>58</sup> Michael Brown, *Irish Enlightenment*, Chapter 2.

<sup>59</sup> John Tillotson, *Several Discourses upon the Attributes of God* (London, 1699).

supported in Edward Stillingfleet's *Origines Sacrae*, first published in 1662. Stillingfleet's original text emphasised the authority of the scriptures and the existence of natural theology as a refutation of atheism, while calling upon the natural philosophy advanced by the Royal Society to support these arguments. Significantly, as noted by William Poole, Stillingfleet's revision of *Origines Sacrae* (which was published posthumously) gave the arguments against atheism derived from new findings in natural philosophy primacy over those arguments relating to the scriptures and natural theology, which had been to the fore in the original version.<sup>60</sup> Stillingfleet, who was described by Sarah Hutton as 'the spokesman of late-seventeenth-century Anglicanism', was the first bishop appointed by William III, and one of those appointed to oversee reform in the Irish church. His correspondence and controversy with John Locke, and his correspondence with Robert Boyle on spiritual matters, together with his ongoing collection of books on natural philosophy, illustrate his close connections with intellectual developments in the latter half of the seventeenth century as well as with the stable government of church and state, defended against the unorthodox, Catholic or dissenter.<sup>61</sup> An improving church within a culture of improvement, bringing the light of the scriptures to the 'poor blind deluded Natives of this kingdom' could rely on support from Baconian experimental enquiry into the book of nature, as on scholarly enquiry into the book of scripture.<sup>62</sup>

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#### Hypothesis, experiment, observation and error

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Bacon's followers in the academies established across Europe, including the DPS in its turn, crystallised both concept and practice from his proposals, although his

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<sup>60</sup> Poole, *World Makers*, 19–20. Stillingfleet's forces were marshalled against Descartes in particular, and his approving citations of Boyle's works show his support for Boyle's Christian natural philosophy. See in particular *Origines Sacrae*, Book III, ch. 2 for the discussion of the origins of the universe.

<sup>61</sup> Stillingfleet's career is summarised in Barry Till, 'Stillingfleet, Edward (1635–1699), bishop of Worcester and theologian', *ODNB*.

<sup>62</sup> The printing of the Bible in Irish was described by Marsh in these terms in a letter to Archbishop Sancroft, and by the former Jesuit and Anglican convert Andrew Sall in a letter to Robert Boyle: see Michael Hunter, *Boyle Studies: Aspects of the Life and Thought of Robert Boyle 1627–91* (Woodstock, 2015), 92–3.

vocabulary of *observatio*, *experiencia* and *experimentum* was still fluid. In a Latin letter from 1665, cited by Lorraine Daston, Henry Oldenburg emphasised that the purpose of the Royal Society was to ‘reconstruct philosophy’ by building up ‘a treasury of observations and experiments’.<sup>63</sup> Bacon’s occasional recourse to a deliberate manipulation of nature to provoke an observable effect was to become a strongly emergent pattern beside the observation of phenomena occurring in nature, and those trials which were a largely tacit and undescribed pattern of artisanal and medical practice. It was Bacon who expanded the vocabulary to include the concept of the ‘instantia crucis’ which was designed to distinguish between alternative proposals or theories.<sup>64</sup>

The testing of proposals by experiment is thus fundamental to the operation of Baconian natural philosophy, although the definition of hypothesis, and the distinction between ‘experimental’ and ‘speculative’ natural philosophy in the implementation of the Baconian programme, has caused much debate. Isaac Newton’s apparent rejection of the formation of hypotheses, encapsulated in a quotation from his 1667 *Principia* (*hypotheses non fingo*), has been applied to suggest that he did not form hypotheses testable by experiment. Peter Anstey set out to show that Newton’s attitude to the formation of hypotheses conformed to the seventeenth-century distinction between the experimental and the speculative, showing that ‘hypothesis’ did not denote a testable proposal, intended to be of operational use, but carried more of the sense that modern writers would convey by ‘grand unified theory’ (GUT).<sup>65</sup> Examining the development of experimentalism

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<sup>63</sup> For discussion of this letter and its context, see Lorraine Daston, ‘The Empire of Observation 1600–1800’, in Lorraine Daston and Elizabeth Lunbeck, eds, *Histories of Scientific Observation* (Chicago, 2011), 84.

<sup>64</sup> For a discussion of Bacon’s concept and modern approaches to it, see Rose-Mary Sargent, ‘Baconian Experimentalism: Comments on McMullin’s History of the Philosophy of Science’, *Philosophy of Science*, 68:3 (2001), 311–18.

<sup>65</sup> Anstey noted the term ‘Experimental Philosophy’ as being used by Samuel Hartlib as early as 1635, although Mordechai Feingold considers this to be an anachronism, introduced into histories written rather later: see Mordechai Feingold, “‘Experimental Philosophy’: Invention and Rebirth of a Seventeenth-Century Concept”, *Early Science and Medicine* 21:1 (2016), 1–28. Feingold claimed that ‘it was only around 1660 that Boyle and his Royal Society colleagues decide to appropriate the term “experimental philosophy” to describe their activities, thereby imbuing it with a fixed conceptual and polemical meaning’. A debate between Anstey and Feingold can be found on the University of Otago blog: Anstey’s post ‘Experimental Philosophy before the Restoration’,

as practised by Boyle and the early Royal Society, Clericuzio claimed that Boyle tended to eschew system.<sup>66</sup> However, Hunter has shown that Boyle's attitude to hypothesis in constructing trials was sustained from 1666 until the publication of the *Natural History of Human Blood* in 1684. Boyle declared himself to favour the reporting of observations rather than the production of hypotheses, while also suggesting that the inhibition of theorising could prove equally unproductive.<sup>67</sup>

Another view of philosophical process available to the DPS was that of William Petty, who described the intention of the Royal Society to 'explode' the 'meerly phantasticall' and thus to promote experimental learning.<sup>68</sup> As we shall see, the members of the DPS were quite reticent in discussing underlying theories for their experimental activities, suggesting that they followed the example of Boyle and Petty in assigning hypothesis (on the grand scale) its place in the design of trials, queries and experiments.

As mentioned previously, H.F. Cohen proposed that a characteristic of early modern natural philosophy was self-correction, which operated at the level of the group or network as well as that of the individual.<sup>69</sup> Interest in error, and in the treatment of experiments which did not work as intended, or could not be repeated, forms the obverse to the modern tendency to depict the development of science as an inevitable and heroic story of progress. Examining this side of the currency of

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<https://blogs.otago.ac.nz/emxphi/2016/05/experimental-philosophy-before-the-restoration/>, accessed 12 August 2018; and Feingold's response 'A Response to Anstey's "Experimental Philosophy before the Restoration"', <https://blogs.otago.ac.nz/emxphi/2016/06/a-response-to-ansteys-experimental-philosophy-before-the-restoration>, accessed 12 August 2018. For Peter Anstey's original view see Peter Anstey, 'Experimental Versus Speculative Natural Philosophy', in Peter Anstey and J.A. Schuster, eds, *The Science of Nature in the Seventeenth Century. Studies in History and Philosophy of Science*, vol 19 (Dordrecht, 2005).

<sup>66</sup> Clericuzio states this point particularly strongly in a review of Anstey's account of Boyle's philosophy: see review by Antonio Clericuzio, 'Peter R. Anstey: The Philosophy of Robert Boyle', *Isis* 94:2 (2003), 375–76.

<sup>67</sup> As noted in Michael Hunter, 'Scientific Change: Its Setting and Stimuli', *A Companion to Stuart Britain*, 222: 'Boyle laid stress upon his hypotheticalism, which was always an adjunct of his fact-collecting, even though he sought to make a distinction between the two.'

<sup>68</sup> William Petty, *The Discourse Made before the Royal Society the 26 of November 1674, Concerning the Use of Duplicate Proportion in Sundry Important Particulars Together with a New Hypothesis of Springing or Elastic Motions* (London, 1674).

<sup>69</sup> Cohen, *Modern Science*, 720.

matters of fact, Jutta Schickore examined the treatment of error in the works of Bacon and Boyle. Emphasising that Bacon's work was essentially about the processes of reasoning about experimental observations and not about experimental praxis, Schickore asserted that Bacon's concept of error resided in the mind, whereas Boyle's concept of error and of 'unsuccessing experiments' resided in the experiments themselves, in the process and materials under observation.<sup>70</sup> This is not entirely supported by the texts. Although Boyle did discuss the materials, and the skills of the operators, he was also concerned with errors of interpretation, which could be dissipated by renewed trials:

whilst [divers of the Philosophical Theories that have been formerly applauded] are look'd on with such a weak and determinate degree of light, they may appear very artificial and well-proportion'd Fabricks ... if but a full light of new Experiments and Observations be freely let in upon them, the Beauty of those (delightful, but Phantastical) structures does immediately vanish.<sup>71</sup>

Subjecting reported observations to further trial, observation and experiment was, as we shall see, a feature of the natural philosophy practised by the DPS and its community.

### Spreading the new knowledge

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Various means of communication served to transfer concepts and collected observations between the DPS and its wider networks. Personal correspondence was particularly important and was often disseminated to people other than the original recipient, both as scribal copies, or in print form: the journals of the learned societies contained many items derived directly from epistolary originals. Print sources other than journals—pamphlets, monographs, collections and

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<sup>70</sup> Jutta Schickore, *About Method: Experimenters, Snake Venom, and the History of Writing Scientifically* (Chicago, 2017), 17-18.

<sup>71</sup> Boyle, *Works* 2, 'Proemial Essay', 13.

*bibliothcae*—all served to transmit and mediate emerging and novel concepts.<sup>72</sup> The boundaries, quantity, and distribution of knowledge have been said to have been changed radically by the advent of print: many writers have seen the roots of the ‘revolution’ in scientific thinking in this post-Gutenberg acceleration of information dissemination.<sup>73</sup> Certainly, the fifteenth, sixteenth and early seventeenth centuries saw an information explosion, although, as with the present changes due to the internet, questions were raised as to the quality of the information offered, and as to the means of establishment of knowledge and authority. Healy has commented that the advent of print, together with publishing in the vernacular, ‘gave old and new misinformation a second and alarmingly long life’. <sup>74</sup> Eisenstein proposed that print encouraged the scientific revolution by its ‘fixed’ nature when contrasted with the more labile manuscript transmission, which was somewhat misinterpreted by Latour in the thesis of the ‘immutable mobile’. Adrian Johns (in particular) and others have disputed this, Johns arguing strongly that piracy rendered the print edition significantly less reliable.<sup>75</sup> The consumers of print, and of scribal exchange, in the DPS and its sister societies, were not uncritically receptive of the information offered to them. Although Hoppen saw the DPS as subject to a Baconianism that ‘justified the compilation and collection of almost any kind of information’ with ‘all too often’ a focus on ‘the strange and bizarre’, particularly when receiving reports of strange cases in medicine and natural history, I found that a characteristic of their activities was the quest for reliability and reproducibility of reports, even in the cases which were least susceptible to those criteria.<sup>76</sup>

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<sup>72</sup> For a discussion and examples see Ann Blair, *Too Much To Know: Managing Scholarly Information Before the Modern Age* (New Haven, 2010).

<sup>73</sup> The literature describing the ascent of print is vast: see for example Eisenstein; Lefevre; Johns.

<sup>74</sup> Healy, T., ‘Foreword’, in Anthony Grafton, April Shelford, and Nancy Siraisi, eds, *New Worlds, Ancient Texts: the Power of Tradition and the Shock of Discovery* (Cambridge, MA, 1992), viii.

<sup>75</sup> As pointed out by Michael John Gorman, ‘The Elusive Origins of the Immutable Mobile’: see <https://web.archive.org/web/20120628201904/http://www.stanford.edu/group/STS/immutable/mobile.htm> (accessed 16 September 2018) for his essay and Eisenstein’s reply. For the debate between Eisenstein and Johns see Elizabeth L. Eisenstein, ‘An Unacknowledged Revolution Revisited’, *The American Historical Review*, 107:1 (2002) 87–105 and Adrian Johns, ‘How to Acknowledge a Revolution’, *The American Historical Review* 107:1 (2002), 106–125.

<sup>76</sup> Introduction to the *DPS Papers*, xxx. Hoppen’s views are more complex than these brief quotes can convey, but the tone of the commentary in this section of his introduction suggests that he saw the DPS as rather less than ‘scientific’.

One effect of wider availability of print was to facilitate just such verification of disseminated claims: through citation, in the textual realm, and repetition, in the experimental realm. Even if misinformation did occur (and it did) it could more easily be subjected to correction. Circulation of responses to reports and concepts deemed incorrect or controversial was also facilitated. In the case of the DPS and its circle, interaction with print gave them familiarity with theories to be considered, experiments to be performed, and instruments to be acquired. Patterns of use of texts, such as annotation and the production of interleaved copies specifically designed for the purpose of addition of information (such as Narcissus Marsh's copy of Baudrand's 1670 edition of Ferrari's *Lexicon Geographicum*), exploited the graphical interface between reader and book and now reveal the purposeful acquisition and manipulation of knowledge. Textual exchange was not an exclusive property of print, nor did print become the exclusive medium of such exchange, but it appears undeniable that print facilitated a range and volume of exchange difficult to achieve by scribal copying. The exchange facilitated by print might also stimulate further ideas and the pursuit of knowledge. Conversely, the lack of opportunities for printed dissemination might inhibit the growth of such knowledge. The paucity of print culture in Dublin, decried more than once by Marsh, has been blamed (at least in part) for the fitful history of the natural history project underlying the genesis of the DPS, and for the short life of the society itself, although the shifting composition of the group and the instability of the political environment seem likely to have been more salient factors.<sup>77</sup>

Although a particular edition might enjoy relative fixity, and be re-issued in its entirety, texts were also issued in translation (which had its own hazards for the stability of the author's intended message) and were edited and 'methodised' in ways which reflected the attitude of the editor, rather than that of the original author. Texts not intended to be published (such as lectures) could be circulated by

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<sup>77</sup> Toby Barnard, 'The Dublin Society and other improving societies, 1731–85', in James Kelly and Martyn J. Powell, eds, *Clubs and Societies in Eighteenth-Century Ireland* (Dublin, 2010), 57. Barnard also traced the demise of the DPS to competition for sociable activity, and the dispersal of critical members.

students in manuscript, and in some cases emerged into print, full of errors, to the disgust of their originators. An example of this is the publication of *Collectanea Chymica Leydensia* (1684), attributed to the English student Christopher Love Morley, which contained material from lectures at Leiden by three rival professors, among whom were two whose courses were taken by Thomas Molyneux.<sup>78</sup> This fluid relationship between manuscript and print as media is also shown by the many instances of correspondence circulating in pre- and post-publication scribal copies, as well as entire printed books being copied in manuscript (such as Thomas Salusbury's mathematical treatise, copied for Mark Bagot of Mount Arran in Carlow, member of the DPS, which eventually made its way into Marsh's own collection).<sup>79</sup>

Harriet Knight has claimed that texts were given epistemological status by their arrangement, and that the imposition of an editor's order, according to the Baconian systems of tabulation of knowledge, for example, raised the credibility of a given text, in conjunction with the usefulness of the text itself. In the 'Considerations about the Section Entitul'd Natural History in generall' which accompanied Boyle's letter to Oldenburg of June 1666, Boyle pointed out 'that many things cannot be warily enough deliver'd without employing more words then many men are willing to allow'.<sup>80</sup> This caution extended to his judgements of the imperfections of his published works. As has been discussed in the case of *Human Blood*, not only did Boyle intend (as with other works) that it should act as a prompt to others to undertake some of the trials which had not yet been performed, but he himself began to revise and react to the text within a very short time of its creation. Print could thus have a transitory role, mediating its contents even to its own author, in contrast to Eisenstein's concept of fixity.

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<sup>78</sup> For the controversy surrounding Love's publication, see John C. Powers, *Inventing Chemistry: Herman Boerhaave and the Reform of the Chemical Arts* (Chicago, 2012), 53–5.

<sup>79</sup> Although the second volume of this work was largely burnt in the Great Fire of London in 1666, the first edition (1661) of the first volume was not a rare work and survives in 41 copies (ESTC).

<sup>80</sup> Peter Anstey and Michael Hunter, 'Robert Boyle's "Designe about Natural History"', *Early Science and Medicine*, 13 (2008), 83–126.

Just as the activities of the Merchants of Light made Bacon's imagined Salomon's House a centre of information gathering, so the societies of the curious became houses of information exchange in the real world. In a comprehensive survey of the nature and function of the networks of correspondence which served the self-styled Republic of Letters, Harris pointed out the developments of scale associated with the growth of the global knowledge economy. Together with this growth in scale, there was a growth in density, both literal (at knowledge centres) and virtual (in correspondence and exchange networks). The mechanism was dependent on the effectiveness of communications, rather than on a simple 'tally' of practitioners. Harris presented evidence in support of a model of active coordination of effort by the members of research communities, thereby 'effectively amplifying their numbers'. In his model, the mechanisms supporting these developments originated in administrative and commercial motivations, which almost accidentally became functional for 'intellectual commerce', thus supporting the rise of the Republic of Letters with its self-proclaimed purposeful exchange of information.<sup>81</sup>

Anthony Grafton has explored the nature of intellectual correspondence as a highly developed social genre among developed social genres. He emphasised the common traits shared by Huguenot and Jesuit networks: while opposed in ideology, they shared traits of movement and distance. Grafton mapped what he referred to as a 'lost continent' in terms of connected groups, each group comprised of individuals in a distinct hierarchy. He drew together the protocols of his 'lost continent' describing a 'state' where

If you could master Latin—and, ideally, Greek, Hebrew, and Arabic; become proficient at what now seem the unconnected skills of mathematics

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<sup>81</sup> Steven Harris, 'Networks of Travel, Correspondence, and Exchange', in K. Park and L. Daston, eds, *Early Modern Science. The Cambridge History of Science* (Cambridge, 2006), 341–62. An earlier but similarly formal network of patronage and mannerly correspondence was described by McLean in his analysis of Renaissance Florence: Paul D. McLean, *The Art of the Network: Strategic Interaction and Patronage in Renaissance Florence* (Durham NC, 2007).

and astronomy, history and geography, physics and music [you might] turn up at the door of any recognized scholar from John Locke in London to Giambattista Vico in Naples, bearing a letter from a senior scholar, and greet your host in acceptable Latin or French [and be assured of ] a warm and civilized welcome, a cup of chocolate (or, later, coffee); and an hour or two of ceremonious conversation on the latest editions of the classics and the most recent sightings of the rings of Saturn.<sup>82</sup>

Within the codified, formal structure of the letter and the highly developed structure of the network, a set of expectations and patterns of meeting them was established. The pattern of letters of introduction which allowed the young Thomas Molyneux access to some of the finest minds in Europe closely matches the patterns described by Grafton. The expressions of mutual esteem found in the correspondence of the DPS with its sister societies also bears out Grafton's very general findings.

Correspondence could be circulated to persons other than the original addressee, either in scribal copies or in print. Copies of the letters of 'eminent men' were circulated in both media, examples being Galileo, Mersenne, and Descartes.<sup>83</sup> Examples of scribal transmission in the circle of the DPS include the correspondence of John Wallis with Henry Oldenburg on the theory of music (originally dated 1664) which was transcribed into a commonplace book in Narcissus Marsh's collection at a later date.<sup>84</sup> Marsh's own correspondence with Wallis on the subject of comets was transcribed and circulated among the learned at Oxford and further afield, as will appear in Chapter 4. With the development of the learned journals, material originally framed as personal letters between members of the societies emerged into the public sphere of print, as described later in the case of the Molyneux brothers,

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<sup>82</sup> Anthony Grafton, 'A Sketch Map of a Lost Continent: The Republic of Letters', ARCADE 1:1 (May 1, 2009), <https://arcade.stanford.edu/rofl/sketch-map-lost-continent-republic-letters>, accessed 1 July 2018.

<sup>83</sup> Roger Ariew, 'Descartes' Correspondence before Clerselier: Du Roure's *La Philosophie*', *Journal of Early Modern Studies* 1:1 (2012), 43-63.

<sup>84</sup> Transcript in Marsh Z3.4.24. See David Cram and Benjamin Wardhaugh, *John Wallis: Writings on Music* (Woodstock, 2014).

amongst other members of the DPS. The members of the DPS exchanged observations in correspondence with their peers in London and Oxford on many topics, detailing trials that each group was making and would be glad to hear of from the other, thus facilitating the repetition and extension of experiments which was becoming a feature of the framework of the new knowledge, as both Bacon and Boyle had recommended.

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#### The language of the new knowledge

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Much has been made of the language in which the new discoveries were conveyed, whether by contemporary commentators such as Thomas Sprat; by the savage pen of Jonathan Swift, who satirised the new philosophical language; or by scholars of our own age, such as Steven Shapin and Simon Schaffer, as we have seen. The transfer of the language of philosophical communication into the vernacular accelerated from the mid-seventeenth century onwards. Over the same period, an exploration of the nature of language itself and its uses in philosophy, and the search for patterns of consistent expression for logical processes attracted thinkers such as Francis Bacon, George Delgarno (c.1616–87) and his collaborator John Wilkins (1614–72), the Jesuit Athanasius Kircher (1602–80) and the pedagogue Jan Comenius (1592–1670), as well as the German polymath Gottfried Leibniz (1646–1716), whose project was the most mathematically based.<sup>85</sup> This language of the new knowledge was to be designed not merely to provide a replacement for Latin as it gave way to the vernacular, but to express in its idealised structures the ontological significance and structure of its topics, removing the ambiguities of conventional vernaculars. While Trevor-Roper's distinction between the 'vulgar Baconianism' represented by Hartlib (a 'foreigner') and the 'pure Baconianism', which he linked to Wilkins and the Royal Society, is no longer tenable, each group certainly saw

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<sup>85</sup> See, for example, John Wilkins, *An Essay Towards A Real Character, And A Philosophical Language* (London, 1668). Recent work on Kircher is to be found in Daniel Stolzenberg, 'The Universal History of the Characters of Letters and Languages: An Unknown Manuscript by Athanasius Kircher', *Memoirs of the American Academy in Rome*, 56/57 (2011/2012), 305–321. Surveys are to be found in Vivian Salmon, *Language and Society in Early Modern England: Selected Essays, 1981–1994* (Amsterdam, 1996) and Robert Stillman, *The New Philosophy and Universal Languages in Seventeenth-Century England: Bacon, Hobbes, and Wilkins* (Lewisburg PA, 1995).

itself as an inheritor of the virtuous Verulam's concern for clarity, in distinction to the rhetorical confusion promoted by 'the Schools'.<sup>86</sup> To some extent, it must be admitted that historians of science have taken the anti-'scholastic' polemic at face value, divorcing the language and methods of the new knowledge from their antecedents. It is only now that the connections between the formation and methods inherited from humanism, and particularly from philology, are beginning to be recognised.<sup>87</sup> Robert Boyle himself acknowledged that

besides the unintentional deficiencies of my style, I have knowingly and purposely transgressed the laws of oratory in one particular, namely, in making sometimes my periods or parentheses over-long: for when I could not within the compass of a regular period comprise what I thought requisite to be delivered at once, I chose rather to neglect the precepts of rhetoricians, than the mention of those things, which I thought pertinent to my subject, and useful to you, my reader. <sup>88</sup>

The language of the reports of the Royal Society was a subject of comment and polemic in Thomas Sprat's *History of the Royal Society* (London, 1667) and also in the writings of the members. For example, William Petty mentioned the language to be used by the natural philosopher in his *Discourse... concerning the Use of Duplicate Proportion* (London, 1674). The *Discourse* sought to present simple applications of higher theories 'which Notion a Child of 12 years old may learn in an hour'. It also contains Petty's discussion of 'Atoms' which he described, as he claimed, without 'Chymical Speculations'.<sup>89</sup> This little book (it is a slender duodecimo) was to serve, in Petty's view, as an exercise in popularisation of the activities of the Royal Society. He was concerned to strip away the mysterious (as he says it was the purpose of the whole Royal Society to do) and to lay out before the public, in

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<sup>86</sup> H.R. Trevor-Roper, 'Three Foreigners and the Philosophy of the English Revolution', *Encounter: Literature, Arts, Politics* 14 (1960), 3-20.

<sup>87</sup> Fokko Jan Dijksterhuis, 'The Mutual Making of Sciences and Humanities: Willebrord Snellius, Jacob Golius, and the Early Modern Entanglement of Mathematics and Philology', in Rens Bod, Jaap Maat, and Thijs Weststeijn, *The Making of the Humanities: Volume II - From Early Modern to Modern Disciplines* (Amsterdam, 2012).

<sup>88</sup> Boyle, *Works* 2, 18.

<sup>89</sup> William Petty, *The Discourse[ on] Duplicate Proportion*, preface.

accordance with Bacon's concept of democratisation of knowledge, clear demonstrations of modern ideas.

Sprat's polemic has been roundly condemned as a 'worthless document' by Joseph Agassi, who poured equivalent scorn on the historians who cite it as authoritative.<sup>90</sup> Among these is Tina Skouen, who in her 2011 paper referred to Sprat's *History* as 'the most frequently cited work when it comes to describing the relationship between science and rhetoric in seventeenth-century England': indeed, on the basis of the *History* Skouen saw Sprat not as a condemner but as a rescuer of rhetoric.<sup>91</sup> The debate has been continued by Jarvis, who described 'a return to what historians of science may consider a worn-out concern'. Drawing on various approaches to studies of the public sphere such as coffee-house culture and newspapers; on the critical categories applied in the study of 'propaganda', and on the description of 'the creation of a remarkable number and variety of voluntary associations ... which helped establish the conditions for the possibility of Enlightenment', Jarvis cast the Society as just such a voluntary association, claiming that Sprat effectively 'wrote the Society into... a more democratic and sociable organisation than it had yet become'.<sup>92</sup> Jarvis recommended the work of Henry S. Turner on corporations and the networks of forms (an aspect of inter-related texts and productions which has been relatively neglected in history of science in favour of analysis of networks of people) as potentially relevant to discussion of the place and nature of Sprat's *History*.<sup>93</sup>

The diction of the Royal Society members as a product of their time was the subject of a much older analysis, also in *Isis*, in which John Arthos refers to writers such as Robert Plot as deriving their language from classically-based poetic diction while

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<sup>90</sup> Itself something of a polemic, Agassi's book invites the reader to consider inductivism as 'a myth, a post hoc justification of some belief in some theory and a post hoc condemnation of some refuted view and of those who ever believed it.' Joseph Agassi, *The Very Idea of Modern Science* (Dordrecht, 2013), 296.

<sup>91</sup> Tina Skouen, 'Science versus Rhetoric? Sprat's History of the Royal Society Reconsidered', *Rhetorica: A Journal of the History of Rhetoric* 29:1 (2011), 23–53.

<sup>92</sup> J. Ereck Jarvis, 'Thomas Sprat's "Mixt Assembly": Association and Authority in The History of the Royal Society', *Restoration: Studies in English Literary Culture 1660-1700*, 37:2 (2013).

<sup>93</sup> Henry S. Turner, 'Lessons from Literature for the Historian of Science (and Vice Versa): Reflections on "Form,"'; *Isis* 101:3 (2010), 578–89.

ostensibly avoiding elaborate language.<sup>94</sup> Products of their time and formation, the members of the Royal Society seemed largely to have failed to escape the conventions of their day, in Arthos' view. The attitude of the Royal Society to language as the mediator of epistemology has also been probed in a long-lasting debate about the meaning of its motto, 'Nullius in Verba'. Clive Sutton's 1994 article emphasised the mistranslation and misappropriation of the sentiment of 'Nullius in verba', referring to the philosopher of science, Karl Popper, as among those who invoked the translation as 'nothing in words' to imply an emphasis on facts derived from experimental investigation.<sup>95</sup> Sutton's interpretation tends towards an alternative emphasis which is to take nothing on authority but to test (experiment) for oneself. In support of his interpretation, Sutton mentioned the 1663 election of the Royal Society, which was held on St Andrew's Day. He quotes a member as having said 'I had rather it [had] been on St. Thomas's Day, for he would not believe till he had seen and putt his fingers into the holes; according to the motto, NULLIUS IN VERBA'. The Royal Society's attitudes were shared by others. Thomas Ahnert's observations on the Collegium Experimentale established in Altdorf by Johann Christoph Sturm (1635-1703) describe a similar mindset, embracing both a reliance on experiment and a rejection of dogmatism, whether imposed by religious authority or by a particular school of thought.<sup>96</sup>

Since the assertions of Shapin and Schaffer in *Leviathan and The Air-Pump* regarding the establishment of fact, and the relationship of the character of the witness to the status of the testimony, the status of the members of the witnessing communities has continued to be explored in the literature. The nature of science as a social production has been discussed at length by Shapin and his collaborators, most recently in *Never Pure: Historical Studies of Science as if it was Produced by People with Bodies, Situated in Time, Space, Culture, and Society, and Struggling*

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<sup>94</sup> John Arthos, 'Poetic Diction and Scientific Language', *Isis* 32:2 (1940), 324-38.

<sup>95</sup> Clive Sutton, '"Nullius in Verba" and "Nihil in Verbis": Public Understanding of the Role of Language in Science', *The British Journal for the History of Science* 27:1 (1994), 55-64.

Thomas Ahnert, 'The Culture of Experimentalism in the Holy Roman Empire: Johann Christoph Sturm (1635-1703) and the Collegium Experimentale', (2002), <http://sammelpunkt.philo.at:8080/308/>, accessed 20 August 2018.

<sup>96</sup> Thomas Ahnert, *Character, Self, and Sociability in the Scottish Enlightenment* (Basingstoke, 2011).

for Credibility and Authority (2010). This book, with its lengthy sub-title which echoes and puns upon its seventeenth century equivalents, claimed that the epistemological status of the 'facts' established by the Royal Society and associated experimentalists was seen as providing the foundation of a longed-for post-Restoration stability, founded on divinely-conferred authority. A simpler role for the witness of experimental observations, as found in Robert Boyle's writings, had already been discussed by Lawrence Principe in *The Aspiring Adept* (1998). Principe showed that the concept of the witness was at once less complex and less novel than claimed by Shapin and Schaffer, having its roots in legal traditions, and in the expression of testimony to faith.<sup>97</sup> Principe noted that a similar concept was to be found in the writings of Bacon himself, and had been a component of earlier alchemical practice in establishing observations. Similarly, the communities of scholarship typical of the self-proclaimed Republic of Letters were accustomed to the hermeneutic circle of interpretation of texts followed by the re-examination of that interpretation, and by re-interpretation. It is this simpler concept of witness that equated experiment with 'matter of fact' for William Molyneux, although the credibility of report was also important to Molyneux and his peers, as will appear in the succeeding chapters.

#### Accounts of the Dublin Philosophical Society

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The opening section of this chapter introduced the DPS and touched on the broad influences which shaped its activities. Here, I review accounts of the society itself, from its inception until the present day; the composition of its membership, and the rules under which the society operated; the spaces and arrangements for their meetings, discussions and experiments; and provide an outline of the relationships which were established with similar societies, notably with the Royal Society in London and with the Oxford Society. The Dublin context itself is also outlined, including the relationships of the DPS to the College of Physicians and to the academic community within Trinity College.

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<sup>97</sup> Lawrence Principe, *Aspiring Adept*, 108.

Accounts of the membership and activities of the DPS are found in the correspondence of the members, in the minutes of the society, and in the minutes of the related groups in London and Oxford, namely the Royal Society and the Oxford Society. Other than their own papers, the earliest accounts of the DPS and its members are from the writings of Walter Harris (1686–1761), the eighteenth-century Dublin lawyer and historian. Harris' marriage to the great-grand-daughter of the historian and antiquary James Ware prompted him to undertake a revision and republication of Ware's *History and Antiquities of Ireland* and related writings, originally published in 1639.<sup>98</sup> Following the pattern of Ware's collected writings, which included an entire volume on the writers of Ireland, Harris extended his work to give accounts of writers from the intervening period. Notable contributors to the DPS were included among these, one of whom was the physician Allen Mullen.<sup>99</sup> The accounts were largely laudatory, and as might be expected, emphasised the publications by Mullen, the Molyneux brothers William and Thomas, and Narcissus Marsh.

In 1844, William Wilde, a prominent nineteenth-century Dublin physician, antiquary, and historian of medicine in Ireland, read a memoir of the DPS to the Royal Irish Academy, of which he was a member.<sup>100</sup> Earlier, he had been responsible for a serialised biography of Thomas Molyneux, William Molyneux's younger brother, whose status as a successful physician had been recognised with a baronetcy.<sup>101</sup> Wilde's account of the DPS made much of the progress achieved by a group which he regarded as highly able and as indicative of the possibilities for improvement for Irish science. The Royal Irish Academy was seen by Wilde and his contemporaries as a natural descendant of the DPS, which he described as

the great prototype of all our learned societies ... These men formed the

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<sup>98</sup> The work on the writers of Ireland was James Ware, *De Scriptoribus Hiberniae* (Dublin, 1639) which Harris extended. For Harris, see Philip Carter, 'Harris, Walter (1686–1761), historian', *ODNB*.

<sup>99</sup> Harris' biography of Mullen has been repeated in every account of his life since, often without attribution. See further detail in Chapter 5, 216.

<sup>100</sup> William Wilde (1815–76) is possibly best known as the father of the writer, Oscar Wilde, (1854–1900).

<sup>101</sup> The biography was serialised in the *DUM*, as noted previously

stellae majores of Irish literature and science at this period; and nearly every one of those of whom we have any subsequent account attained to considerable eminence either here or in England.<sup>102</sup>

K.T. Hoppen's extensive and detailed studies of the society were first undertaken some thirty years ago. He concluded that, unlike the Royal Society, the DPS did not arise from a long and distinguished tradition of scientific thought. While recognising that the members were typical of their era, his study sought to describe the progress of the 'hard sciences' in a way which tended to exclude those unsuccessful theories and approaches which did not survive further investigation.<sup>103</sup> Hoppen's work is of great value as a comprehensive survey but his dismissal of the earlier period of natural philosophy in Ireland as of little consequence to its successors was challenged by Toby Barnard, who enumerated the work and influence of an earlier generation of philosophers, connected to Samuel Hartlib.<sup>104</sup> Hoppen re-evaluated some of his earlier analysis in his preface to the relatively recent publication of the collected papers of the society but his view remained that the attitudes of its members were at least in part founded on 'a combination of Baconian fact madness and a stress on the particular' and that the society had contributed relatively little to the general account of scientific progress.<sup>105</sup>

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#### Membership, motivations, and context

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The community which became the DPS gained impetus when, in the early 1680s, William Molyneux embarked on the process of collecting information for a natural history of Ireland in collaboration with the London publisher Moses Pitt. This project inherited something of the approach of an earlier natural history begun by the Boate brothers, brought to the press by Samuel Hartlib (1600–62) in 1652. As discussed by Toby Barnard, the Boates were part of an earlier generation of natural

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<sup>102</sup> William Wilde, 'Memoir of the Dublin Philosophical Society of 1683', *Proceedings of the Royal Irish Academy (1836-1869)* 3 (1844), 160–76.

<sup>103</sup> K. Theodore Hoppen, *DPS Papers*, xxix.

<sup>104</sup> T. C. Barnard, 'The Hartlib Circle and the Origins of the Dublin Philosophical Society', *Irish Historical Studies* 19:73 (1974), 56–71.

<sup>105</sup> *DPS Papers*, Introduction, xxx.

philosophy in Ireland. Rooted in the culture of improvement, these descriptions and records were important as the basis of a later flowering of a largely Protestant ideal of sociability as leading to self-improvement in a peri-Enlightenment culture of improvement in both person and estate.<sup>106</sup> The natural history of Ireland which had been begun by the Dutchman Gerald Boate (1604–50) and his brother Arnold (1606–53) was completed by Hartlib, whose endeavours were undertaken (according to the title page of the book as eventually published) ‘for the Common Good of Ireland and more especially, for the benefit of the Adventurers and Planters therein’.<sup>107</sup> Precedents for the study of natural history as a preparation for improvement were not unusual. Gerard Boate, who had trained at Leiden, would have been aware of the Dutch records of their colonies in both East and West. In the context of the English colonial enterprise, the application of necessary improvement based on philosophical queries to the Irish situation was mirrored to a large extent by the activities of the American colonists interested in natural philosophy. Transatlantic ties to the earlier generation of natural philosophers had been established by the colonist John Winthrop, who had been in correspondence with Benjamin Worsley and others who were associated with the ‘Hartlibian’ group in interregnum Ireland.<sup>108</sup> Both Winthrop and Worsley had studied at Trinity College Dublin and shared interests in the production of saltpetre, for use in both agriculture and gunnery, and in transformational alchemy. The Rosicrucian and millennialist ideation associated with these improvers was part of the mindset of Hartlib’s generation, and their influence can be traced in the alchemical correspondence of Robert Boyle and George Starkey, and in the transformational aspects of William Petty’s political arithmetic, as described by McCormick.<sup>109</sup>

Beginning as informal conversations in the provost’s lodgings in Trinity, the ‘Club’ described by Narcissus Marsh in 1682 discussed the assembly of an atlas of Ireland,

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<sup>106</sup> Toby Barnard, *Improving Ireland? Projectors, Prophets and Profiteers, 1641-1786* (Dublin, 2008).

<sup>107</sup> Gerard Boate, *Ireland’s naturall history being a true and ample description of its situation, greatness, shape, and nature* (London, 1652), t.p.

<sup>108</sup> Michael Hunter, (review), ‘Ted McCormick. William Petty and the Ambitions of Political Arithmetic’, *The American Historical Review* 115:5 (2010), 1524–25.

<sup>109</sup> Ted McCormick, ‘Alchemy in the Political Arithmetic of Sir William Petty (1623-1687)’, *Studies in History and Philosophy of Science* 37:2 (2006), 290-307.

which would build on existing maps.<sup>110</sup> Tantalisingly, the auction catalogue of the books and instruments of William Molyneux's son, Samuel, suggests that there may have been papers from this time, but they do not survive.<sup>111</sup> William Molyneux, having engaged with Moses Pitt on the larger atlas project, was responsible for the transformation of the club into a society, modelled on the Royal Society.<sup>112</sup> The newly-established society became still more formal with the taking of rooms in a house known as Crows Nest, off Dame Street in Dublin. There, as we shall see in more detail in the later chapters of this thesis, the society established the apparatus of natural philosophy, not only in having rooms for discussion, but in a laboratory, a repository, and a garden. The dates of the surviving minutes show a pattern of meetings which took place during the academic terms, demonstrating the close ties which remained to the university. As recorded by William Molyneux in a letter to his brother, the initial period of the society saw weekly meetings on Mondays.<sup>113</sup> As discussed further below, the papers of the society record that political events distracted the members from their purpose in the years leading up to the Wars of the Two Kings, disrupting the pattern of meetings.

The characteristics of the membership of the DPS matched those of the Royal Society in many respects. From an initial roll-call of fourteen members who subscribed to the first set of rules established by the newly-founded DPS, the membership grew to almost 100 known members over the lifespan of the organisation, and may have included more who were not documented.<sup>114</sup> William Molyneux acted as the first

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<sup>110</sup> Marsh to Michael Boyle, 18 May 1682. Bodleian MS MS Rawl. letters 45, f.51. According to Marsh, this group was discussing the use of Petty's maps as a basis for the new atlas.

<sup>111</sup> *A catalogue of the Library of the Honble Samuel Molyneux ... to be sold by auction on Tuesday the 20th of January, 1729-30* (London, 1730), 77. The Harvard copy of this catalogue gives the prices and purchasers. (<http://nrs.harvard.edu/urn-3:FHCL.HOUGH:4435984?n=90>.)

Listed as 'Experiments made by the Society of Dublin in the years 1682, 1683, 1684, 1685, 1686', the manuscript realised £6.7s.0d, sold to 'Willcox.'

<sup>112</sup> The sociable aspects of the Royal Society are reviewed in Michael Hunter, *Science and Society*, 33-4 and 76-7. Patrick Walsh provided a brief account of the DPS in 'Club life in late seventeenth- and early eighteenth-century Ireland: in search of an associational world, c. 1680-c. 1730'; Toby Barnard reviewed the place of the DPS in the genesis of improving societies in Ireland in 'The Dublin Society and other improving societies, 1731-85': both papers in James Kelly and Martyn J. Powell, eds, *Clubs and Societies in Eighteenth-Century Ireland* (Dublin, 2010).

<sup>113</sup> William Molyneux to Thomas Molyneux, 8 January 1684. 'Since my last to you concerning this particular, we have constantly every Monday had a meeting *DUM, 477 / DPS Papers* no. 214.

<sup>114</sup> See *DPS Papers*, Introduction, xxii, and nos. 525, 526.

secretary of the society, with the physician Charles Willoughby referred to as 'Arbiter Conventionis' or 'director'. At first, as William Molyneux noted in a letter to his brother Thomas, it was felt that the title 'President' was 'too great' for the society, but it was determined that an election of officers should take place on All Saints Day 1684.<sup>115</sup> The minutes for that day show that the proceedings were conducted 'according to the method of the Royal Society of London' and William Petty was then elected as the society's first president.<sup>116</sup> Two days later, another meeting saw Petty bring proposals for the future governance and regulation of the society, which were reportedly well received. Ties to both the Royal Society and government circles were emphasised at that meeting, at which prominent members of the Royal Society attended and were admitted to membership of the DPS:

... the Honourable Sir Cyril Wiche Kt., prime secretary to the lord lieutenant and president of the Royal Society, was pleased to be admitted into our society, and so likewise was Sir Robert Reading baronet, one of the council of the said society.<sup>117</sup>

The officers of the society were elected by a procedure described in detail by William Molyneux in a letter to his brother in November 1684. He estimated the attendance at eighteen at the All Saints day meeting and election on 1 November, although fourteen subscribed to the rules on 3 November.<sup>118</sup> It is interesting to note

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<sup>115</sup> William Molyneux to Thomas Molyneux, 30 October 1683: 'Our convention is regulated by one chief, who is chosen by the votes of the rest, and is called Arbiter Conventionis, at present Dr. Willoughby (the name president being yet a little too great for us.)'. DUM 472 and *DPS Papers* no. 212. The minutes of 28 January 1684 record Willoughby as 'director': *DPS Papers* no. 8.

<sup>116</sup> *DPS Papers* no. 37.

<sup>117</sup> *DPS Papers* no. 38. For Cyril Wyche (c.1632-1707) and Robert Reading (1640-89) see the Royal Society Fellows Directory (<https://royalsociety.org/fellows/fellows-directory/>) and links therein.

<sup>118</sup> William Molyneux to Thomas Molyneux, [8 November 1684], DUM489: 'This day sennight being All Saints' day, was our anniversary election in our society. We met in the morning about ten, where we had printed catalogues of all our fellows. Every one present (which I think were about eighteen) took a catalogue and marked with a P. S. and T. those he would have stand for resident, secretary, and treasurer. hen all delivered up their papers to the old secretary, who publicly counted in an unmarked catalogue who had marks on their names for being officers; so he that had most marks stood. This is the method practised in the Royal Society, and takes off the odium of a man being proposed and refused, as likewise no one knows who proposes and refuses. Sir William Petty and Dr. Willoughby had equal marks for president; but upon a second election, Sir William carried it by four votes, so he stood. Afterwards we had a handsome dinner at a tavern, and so we concluded the day. At our dinner, Sir Cecil Wythe [recte Cyril Wyche], prime secretary to the lord lieutenant, a

that Petty only carried his election as president by four votes, on a run-off between himself and Charles Willoughby. At that meeting, William Molyneux was 'continued secretary' and William Pleydall was elected treasurer.<sup>119</sup>

The importance of the links established by the secretaries of the societies was emphasised in their communications, and is explored further in Chapter 2. Hoppen's list of the officers of the society and their duration in office shows that William Molyneux initially assumed that role, succeeded by St George Ashe in May 1685.<sup>120</sup> Edward Smyth (c. 1662–1720) served as secretary from 10 May 1686 until the meetings paused in April 1687. Later, the physician Charles Willoughby, who had presided over the initial meetings until the election of William Petty as president, was elected secretary in May 1693, although Hoppen comments that he never seems to have performed those duties. Owen Lloyd (1664–1738), a Trinity College divine, was acting as secretary by June 1693, and continued until the end of the society's meetings fell into abeyance again at the end of the 1690s. Petty was succeeded as president by William Stewart, Viscount Mountjoy (1650-92), who served until April 1687. Titled members continued to be preferred as president, with the Hon. Francis Robartes (1650-1718) elected in May 1693, succeeded by Sir Cyril Wyche at some point before February the following year. The later period of revival from 1707-9 also saw a titled member, the 8<sup>th</sup> earl of Pembroke, in the president's office. According to the rules drawn up in imitation of the Royal Society, the president was to

preside at all meetings, to regulate the discourses thereat so that there be no interruption, cavils, heat or confusion, but that everyone have fair liberty

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privy counsellor, and now president of the Royal Society, gave us his company, and desired to be of our society; as likewise did Sir Robert Redding, Knt. and Bart. At our meeting the Monday following our president brought in a paper of advertisements to us, proposing some expedients for our future progress, so that I hope we shall go on vigorously. They continue me secretary, and Mr. Plowdall, treasurer.'

<sup>119</sup> Hoppen notes that William Pleydall is almost unknown apart from this reference. *DPS Papers*, vol. II, 963.

<sup>120</sup> Officers of the DPS, the Oxford Society and the Royal Society for the period of the existence of the DPS are listed by Hoppen, with their periods of office, in the *DPS Papers*, vol. II, appendix A, 927-30.

of proposing and speaking his mind, and this as briefly and pertinently as may be.<sup>121</sup>

The secretary, apart from his duties of correspondence, was to keep three books: one of statutes, membership and benefactions; one a register of minutes, experiments, discourses and letters; and a book of accounts. This duty was initially combined with that of treasurer, but the offices were separated from the first election on 1 November 1684. The society had, as noted above, a system of subscriptions to defray the expense of demonstrations, experiments and the premises at Crows Nest.<sup>122</sup> William Molyneux initially assumed this role, before appointment of William Pleydall at the first election of officers. Pleydall was succeeded by the mathematician George Tollet (d. 1719). Francis Cuffe (c.1654-94), M.P. for Mayo, was elected in May 1693.

It is no surprise, given the available pool of individuals with suitable education and interests, that the Dublin community of natural philosophers was firmly attached to the colonial structures of Ireland. In his introduction to the DPS papers, Hoppen showed the extent to which the members of the DPS were drawn from the upper levels of colonial Irish society, remarking upon the representation of the clergy among them. Comparing these numbers to the lower numbers of clergy in the Royal Society, he attributed the difference to the relative lack of a secular elite in Ireland.<sup>123</sup> The members of the DPS were almost all members of the Anglican church 'as by law established': Hoppen mentions only one Roman Catholic, Mark Bagot, whose scribal copy of part of Thomas Salusbury's *Mathematical Collections* was later acquired by Marsh, as mentioned above.

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<sup>121</sup> DPS Papers no. 525.

<sup>122</sup> The rules state that 'every fellow at his admittance be obliged to pay nine shillings or two cobs, and ever after during his continuance in the society a weekly contribution of a quarter cob, for the defraying of all public charges of experiments, letters, etc. and other conveniences that are to be purchased'. DPS Papers no. 525.

<sup>123</sup> DPS Papers, Introduction, xxi-iii. Hoppen compared the DPS membership to the Royal Society as described in previous work by Lotte Mulligan.

As is evident from his role in its early proceedings, William Petty, who had carried out the survey of forfeited Irish estates, known as the ‘Down Survey’, from that same premises in Crows Nest, was significant both in the regulation of the new society, and in its ties to an earlier generation. Petty had been one of the eight names recorded in 1660 as founding members of the Royal Society, providing a direct link for the young DPS with its model. In addition to the early associations with prominent members of the Royal Society such as Cyril Wyche and Robert Reading, those who were members of the DPS were often also admitted to fellowship in the older institution, and were allowed a reduction in subscription fees.<sup>124</sup> Influences from the Oxford group known as the ‘invisible college’, to which the Royal Society traced its origins, were again represented by William Petty. Petty’s philosophical connections were extensive. He had spent time in Paris in the household of William Cavendish, Duke of Newcastle, a wealthy Royalist, during the political upheavals of the 1640s. There, Cavendish was the centre of a circle of exiled virtuosi, and his household included Thomas Hobbes, author of *Leviathan*.<sup>125</sup> Petty had come to Ireland during the Interregnum, where he was one of three associates of Samuel Hartlib in Ireland at the time, the others being the physician Benjamin Worsley (1618-77), who was mentioned above for his involvement in a scheme for the manufacture of the gunpowder ingredient saltpetre, and the young but already influential Robert Boyle.<sup>126</sup> The relationship of Boyle and Petty was still cordial some forty years later, but Worsley fell into dispute with Petty over the ‘Down Survey’.<sup>127</sup>

The DPS, explicitly modelled on the Royal Society, reflected not only the older group’s procedures and practices in governance but also its relationship to state and

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<sup>124</sup> ‘Our Society, sensible of the charges your members are at in promoting experimental philosophy, our common design, have ordered that such members of the London Society as are likewise of the Dublin, shall be accountable but for 26 shillings a year (unless they are willing to pay more).’ *DPS Papers* no. 285.

<sup>125</sup> Lynn Hulse, ‘Cavendish, William, first duke of Newcastle upon Tyne (bap. 1593, d. 1676).’ *ODNB*.

<sup>126</sup> Thomas Leng, *Benjamin Worsley (1618-1677), Trade, Interest, and the Spirit in Revolutionary England* (Martlesham, 2008).

<sup>127</sup> Worsley, Benjamin (1617/18–1677), Physician and Projector, *ODNB*. Petty’s view of the dispute is to be found in his account of the Down Survey: William Petty (Thomas Larcom, ed.) *The History of the Survey of Ireland, Commonly Called the Down Survey* (Dublin, 1851).

government. The founding aims of the Royal Society included the glory of God and the support of the divinely ordered and ordained systems of state. This is illustrated by the image which now appears as the frontispiece to Thomas Sprat's *History*, in which a bust of Charles II, recently restored to the throne and presiding over a renewed order, adorns a central pillar, flanked by Francis Bacon and the president of the Society. Instruments, including an air-pump, and books, complete a scene of due order, utility, and tranquillity.<sup>128</sup> The origins of the Royal Society were firmly connected to the politics of Restoration England and to the retrieval and restoration for society at large of those improving values attributed to the benign influence of a stable monarchy. This attitude was adopted by William Molyneux, when addressing the conventionally laudatory preface of his *Sciothericum telescopicum* (1686) to Henry Hyde, second Earl of Clarendon, who had been appointed Lord Lieutenant of Ireland in 1685. Molyneux praised Edward Hyde (the first Earl) for his defence of philosophy against Thomas Hobbes' *Leviathan*.

Your Illustrious Father, of Happy Memory, was no unactive Speculative Philosopher, but was zealous and forward in promoting the Noble Design of the Royal Society, as appears to his immortal Praise in their Incomparable History... Neither did he only countenance Philosophy by his Authority and Favour, but actually drew the Sword in its defence against the great Sea Monster that would have destroy'd the Virgin; as is manifest from his Learned and Ingenious Treatise against the Leviathan.<sup>129</sup>

The preface made much of the utility of various aspects of natural philosophy which were rightly to be supported by the establishment, as represented by this illustrious patron of the DPS, himself a fellow of the Royal Society. Although the language was adorned with phrases calculated to flatter his patron, Molyneux used the opportunity to set out the advantages of the new style of natural philosophy over the old, and to emphasise the connections and virtues of the Royal Society.

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<sup>128</sup> Michael Hunter has recently completed a study of this frontispiece, which was originally intended for John Beale's treatise on the Royal Society and only later adopted for Sprat's treatise. Michael Hunter, *The Image of Restoration Science: The Frontispiece to Thomas Sprat's History* (Oxford, 2017).

<sup>129</sup> Molyneux, *Sciothericum*, preface.

Ironically, the very stability sought under the restored monarchy proved short-lived, and Clarendon, supporting the Jacobite persuasion, ended his days without taking the oath in support of William and Mary. The DPS sought and obtained Clarendon's patronage, strengthening the ties to the colonial government. William Molyneux's language in the preface to *Sciothericum Telescopicum* was echoed in St George Ashe's speech to Clarendon when the society waited on the Lord Lieutenant on 25 January 1686, to obtain his patronage. By this time the society's president was William Stewart, Viscount Mountjoy (1650-92). Clarendon's approbation of Mountjoy's appointment was expressed in a letter to John Evelyn, as noted by Hoppen.<sup>130</sup> Had political events not overtaken the fortunes of many on both sides of the Irish Sea as the decade progressed, the society was indeed set fair to realise its founder's hopes.

In the Dublin of the 1680s, the DPS was not alone in its interests in natural philosophy. Those having a professional interest in natural philosophy included physicians and apothecaries, and medical men were among those who became members of the DPS, with an apothecary, Robert Witheral, becoming the society's landlord when it took rooms in his premises at Crow Street. The Irish College of Physicians, which had been initiated as a professional association by John Stearne in 1654, received recognition from the Crown in 1665 and a Royal charter in 1667. As described by Kelly, the arrival of William Petty in Ireland, initially as physician-general to the army, was influential in the formal recognition of Stearne's 'Fraternity of Physicians', Petty being named as one of the fourteen foundation members in the Crown letter of June 1665.<sup>131</sup> This fact serves to emphasise further Petty's influential position in the generation immediately preceding the establishment of the DPS. In addition, the university, to which qualified individuals such as Narcissus Marsh were frequently appointed from England, became a meeting place, initially for the 'Club' described by Marsh, and later for the newly-formed DPS (with a brief coffee-

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<sup>130</sup> For the relationship with Clarendon, see *DPS Papers* no. 82, and footnote; and no. 527 (address by St George Ashe).

<sup>131</sup> James Kelly, 'The emergence of scientific and institutional medical practice in Ireland, 1650-1800' in Greta Jones and Elizabeth Malcolm, eds, *Medicine, Disease and the State in Ireland, 1650-1940* (Cork, 1999).

house interlude, as recorded by William Molyneux) until it took its rooms in Crows Nest. As well as those appointed from further afield, the university provided locally-educated individuals who were active in the pursuit of philosophical topics, and who gravitated to Molyneux's new organisation as it took shape.

The Oxford Society, mentioned by William Molyneux in January 1684 as having been founded 'within these three months', had a similarly close relationship to the much larger university foundation at Oxford. It established close links with the Dublin group through its secretary, the chymist Robert Plot, who was also secretary to the Royal Society at the time: William Molyneux was conscious of the importance of this link and mentioned it to his brother Thomas in his letter of 8 January 1684.<sup>132</sup> As discussed further in Chapter 2, relationships were established and continued through correspondence between the societies, conducted through the secretaries, as well as through more informal contacts between individual members who were personally known to one another. No formal link was established with the like-minded group which met in York, known as the York Virtuosi. Their focus included antiquarian and artistic interests: the artist and engraver Francis Place and the glass painter Henry Gyles were prominent members.<sup>133</sup> As with the initial 'Club' phase of the DPS, the York group seems to have been less formal than the Dublin and Oxford societies, although individual members, such as Martin Lister (of whom more below), did establish extensive connections with both the Royal Society and the Oxford Society. Although formal correspondence and the exchange of minutes between the societies was important to the transmission of ideas, it is also important to recognise the role of individual and informal correspondence, in which concepts and attitudes could be exchanged with somewhat less caution, and sometimes at greater length.

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<sup>132</sup> William Molyneux to Thomas Molyneux, [8 January 1684], *DUM 477/DPS Papers* no. 214: 'such another philosophical meeting as our own, begun within these three months at Oxford ... This encouragement from so great a man, and as he is secretary both to the Royal and Oxford Societys, made us think upon modelling ourselves into better form; and accordingly, the Bishop of Ferns [Narcissus Marsh], Sir Wm. Petty, Dr. Willoughby and I, were pitched upon to draw up rules ...'.

<sup>133</sup> See Anna Marie Roos, *The Correspondence of Dr. Martin Lister (1639-1712). Volume One: 1662-1677* (Leiden, 2015), 21.

Gathering in the provost's lodgings, in the sociable environment of a Cork Street coffee-house, or in their rooms in Crows Nest, the founding members of the DPS embarked on the gathering and discussion of new knowledge. In William Molyneux's words, the society might

perhaps become as famous as any in Europe... Notwithstanding, we'll go as far as we can; and if we can go no farther, but grow weak, decay, and die, we are but *in statu quo prius*.<sup>134</sup>

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#### The bishop and the thinker: Marsh and Molyneux

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Among the founding members of the DPS, Narcissus Marsh and William Molyneux emerge as significant in similar but distinct ways, as will be seen in the chapters which follow. In 1683, Marsh was provost of Trinity College, while Molyneux was free to pursue his philosophical interests without pressure of the 'worldly business' which Marsh found to be both distraction and burden.<sup>135</sup> These two men, whose views opened this chapter, provide case studies illustrating similarities and differences among the circle of natural philosophers. As we have seen, William Molyneux held clear views on experiment as 'matter of fact' and was clearly invested in the new knowledge, rejecting the 'Schools' and those aspects of the old philosophy which reduced investigation to speculation. Narcissus Marsh, observing the creator's work through his telescope, also brought his formation in logic and his critical views of texts to the judgement of natural philosophy, and his understanding of creation.

Their formation may well have had much in common, although Marsh was educated in England and Molyneux in Ireland. In autobiographical accounts, each recorded that he had been a model schoolboy. William Molyneux's description of

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<sup>134</sup> William Molyneux to Thomas Molyneux, n.d. (after February 1684). *DUM*, 477 / *DPS Papers* no. 19.

<sup>135</sup> Early in his time in Dublin, Marsh complained of 'the multitude of business and impertinent [unimportant] visits which the Provost is obliged to' (*Diary*, 23), and later wrote to his Oxford correspondent Thomas Smith (1638-1710) on 4 May 1700 that 'worldly business, which of all things I do hate' had kept him from replying to Smith's earlier letter. Bodleian MS Smith 52, 85-6.

his *Life* was addressed to his brother Thomas and eventually published by his kinsman Capel Molyneux. There he recalled that he

was bred up at a Grammar School, and can say no more concerning my behaviour there, but though I had over me one of the most severe Schoolmasters in Dublin, I was never whipt at school for any idle or waggish trick.<sup>136</sup>

Similarly, Marsh ‘was never once whipt or beaten’. <sup>137</sup> Their basic university training at Dublin and Oxford would have followed a similar scholastic curriculum.<sup>138</sup>

The portrait of Narcissus Marsh as an historical figure, and as a scholar, began to develop soon after his death. His successor as Archbishop of Dublin, William King (1650–1729), gave the sermon at Marsh’s funeral, outlining those virtues by which the deceased primate was to be remembered. His sermon gave faint praise to Marsh’s accomplishments and interests, saying that

by way of diversion and as an Ornament to his conversation, he added the knowledge of several Curiosities and Arts that he found valued and fashionable in the World. Such as Mathematicks, Natural Philosophy and Musick, he did not endeavour to be profound in these but contented himself with what was useful in them, and with so much as enabled him to Converse and Correspond with those that were the greatest Masters of them.

King went on to remark on Marsh’s collection of manuscripts as having recommended him to ‘the Courtship of many great Men, so that you will find him frequently with Honour mentioned in the works of the Learned, both at home and abroad’. <sup>139</sup>

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<sup>136</sup> Molyneux, *Life*, 54.

<sup>137</sup> Marsh, *Diary*, 17.

<sup>138</sup> The curriculum in Trinity College Dublin remained the same until Swift’s day: see James A. Rembret and Alan Sears, *Swift and The Dialectical Tradition* (Dordrecht, 1988), 65–7.

<sup>139</sup> From the transcript of King’s sermon appended to Marsh, *Diary*, 76.

Marsh's biography has been outlined in various writings since his death, and by himself in his diary, now available in a modern edition by Raymond Gillespie. His own account of his early years is brief. He was born at Hannington in Wiltshire in December 1638, the youngest of five children: he noted that all of them, including his two sisters, received a good education. Marsh was sent to a succession of local schoolmasters before taking up a place in Oxford as a commoner in Magdalen Hall in May 1655. The studies which King described as having been undertaken as an 'ornament' to his profession of divinity, in 'old Philosophy, Mathematicks and oriental languages' were begun then. Gillespie has remarked that the area of Marsh's birth was noted for its support for the king during the difficult era of the 1640s but that Magdalen Hall was known as having Puritan affiliations. As Gillespie remarked, Marsh's lifelong tendency to austerity, shown initially in his youthful habit of Friday fasting, may have been prompted by one of his schoolmasters, John Crouch of Hannington, who went so far in the direction of dissent as eventually to become a separatist preacher in London.<sup>140</sup>

Magdalen Hall was also one of the chief centres of oriental studies in Oxford at the time, and Marsh's application in this area, combined with his interests in mathematics and astronomy, drew him to the attention of Seth Ward (1617–89, mathematician, bishop of Exeter and member of the Royal Society) who offered him a chaplaincy. Marsh was ordained a little under age, and made a brief excursion from Oxford to take up a living in Swindon. This turned out to have unforeseen consequences. Marsh, finding that there was an expectation that he would marry a particular woman, repudiated the living and returned to his scholarly life in Oxford.<sup>141</sup>

Marsh's scholarly activities while in Oxford also gained him the patronage of John Fell (1625–86), then dean of Christ Church Oxford, who recruited him to assist with William Beveridge's *Synodikon*, published by Fell's University Press in 1672.<sup>142</sup>

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<sup>140</sup> Marsh, *Diary*, 4.

<sup>141</sup> Ibid., 19–20.

<sup>142</sup> A copy survives in Marsh's Library, Dublin, but not in Marsh's personal collection: it is in the collection of Edward Stillingfleet.

Marsh spent a year correcting and proofreading the commentaries of Balsamon and Zonaras on the Greek councils of the early church, working through Beveridge's notes and supervising the whole work at the press.<sup>143</sup> Two of Beveridge's works survive in Marsh's own collection: the 1658 treatise on Hebrew, Chaldaic, Syriac and Samaritan, which is bound together with the companion Syriac grammar.<sup>144</sup> According to Marsh's ownership inscription, the 1658 volume was acquired by Marsh immediately upon its publication. It seems impossible that Beveridge and Marsh were not known to one another before Fell's professional involvement in their relationship. However, by the time that *Synodikon* was being prepared for the press, Beveridge was a parish priest in London, and Marsh, still resident in Oxford, must have seemed to Fell an ideal candidate for the task. Fell's eventual promotion to the position of bishop of Oxford, and his good standing with influential people in both political and religious contexts, made him a powerful mentor for the young Marsh. Fell's press undertook a wide range of material, from William Beveridge's theological work, with which Marsh found himself involved, to Robert Morison's publications on botany. Having imported technical expertise from continental Europe, the university press rapidly established itself as an authoritative producer of high-quality books.<sup>145</sup>

While in Oxford, Marsh 'began at leisure hours to revise Du Trieu's Logic'.<sup>146</sup> The claim made in his diary that he then printed it at Oxford has not been thoroughly supported as no edition has been explicitly attributed to him by recent scholarship, although the edition published at Oxford in 1678 was said by James Wills in 1842 to contain some notes on Gassendi authored by Marsh.<sup>147</sup> The Jesuit Philippe Du Trieu

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<sup>143</sup>Marsh, *Diary*, 22.

<sup>144</sup> William Beveridge, *De Linguarum Orientalium Praesertim Hebraicae, Chaldaicae, Syriacae, Arabicae, & Samaritanae; Grammatica Linguae Domini Nostri Jesu Christi sive Grammatica Syriaca Tribus Llibris* (London, 1658); this bears a note in Marsh's hand 'N. Marsh, Exon: Coll: soc: 1658.' Marsh also owned a translation into Irish by John Richardson of sermons by Beveridge and Tillotson on the principal points of Christianity, *Seanmora ar na Priom[h] Phoncibh na Chreideamh*, printed in London by Elinor Everingham in 1711.

<sup>145</sup> I.G. Philip and Paul Morgan, 'Libraries, books and printing', Nicholas Tyacke, ed., *Seventeenth-Century Oxford* (Oxford, 1997), 619–86.

<sup>146</sup> Mispeled 'Du Trier' in the *Diary* manuscript, probably the result of a transcription error.

<sup>147</sup> Mordechai Feingold in Tyacke, *op.cit.*, 294. The nineteenth-century writer James Wills noted that Marsh 'edited Philip de Trieu's "Manuductio ad logicam," to which he added the original Greek text,

had produced his introduction to logic in 1614, with a succession of editions following the first. By the first Oxford edition in 1662, an appendix by the atomist Jesuit Pierre Gassendi had been added to it. The Oxford edition of 1678 contains a very short note on Gassendi's text, although there is no explicit attribution to Marsh. Whatever Marsh's role in the Oxford edition, it is certain that the 'Provost's Logic', as his Irish edition was nicknamed, was still in use decades after his death.<sup>148</sup>

Marsh's diary is, as its editor has pointed out, a confessional document, which observes some conventions of the genre. The serious aspects of study were accordingly given an expected and conventional emphasis, but Marsh also recorded his keeping of a consort of music in his rooms, particularly his playing of the bass viol, for which he lamented the 'loss of time and vain conversation'.<sup>149</sup> Penelope Gouk has described the strong connections between music and natural philosophy in Restoration Oxford.<sup>150</sup> Marsh not only played the bass viol but also contributed an essay on the sympathetic vibrations of lute and viol strings to Robert Plot's *Natural history of Oxfordshire*, which was published by Fell's press in 1677. The behaviour of nodes in a vibrating string, which, according to Anthony Wood, had been observed by Thomas Pigot of Wadham College and William Noble of Merton College in 1673, was disseminated in Marsh's essay.<sup>151</sup> Marsh's interest in acoustic phenomena continued and the founding of the DPS saw him compose 'in two or three days time' an essay on sound which was eventually published by the Royal

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and some notes on Gassendi's tract, De Demonstratione, printed at Qxford, 1678.' James Wills, *Lives of Illustrious and Distinguished Irishmen: From the Earliest Times to the Present Period, Arranged in Chronological Order, and Embodying a History of Ireland in the Lives of Irishmen* (Dublin, 1842).

<sup>148</sup> Mary Pollard, 'The Provost's Logic: an unrecorded first issue', *Long Room* 1(1970), 38-40.

<sup>149</sup> Marsh, *Diary*, 20.

<sup>150</sup> Penelope Gouk, 'Performance Practice: Music, Medicine and Natural Philosophy in Interregnum Oxford', *The British Journal for the History of Science* 29:3 (1996), 257-88.

<sup>151</sup> Anthony Wood (Philip Bliss, ed.), *Athenae Oxonienses* (London, 1820), 367. 'He also made a new discovery or certain phaenomenas in music; an account of which was drawn up in a letter by Dr. Wallis dat. Mar. 14. an. 1676, which was remitted into the said Phil. Trans. numb. 134. p. 839. But before that time, viz. an. 1673, the very same discovery was made by Will. Noble M.A. of Mert. Coll. very well skill'd in the practic part of music, far beyond Pigott, which he keeping to himself, only imparting it to one or more friends, Pigott being a more forward and mercurial man got the glory of it among most scholars. See in Dr. Wallis his letter before-mentioned, and in Dr. R. Plot's book entit. The natural History of Oxfordshire, cap. 9. par. 199, 200.' Pigott is mentioned in Thomas Molyneux's letter to his brother of 16 July 1683 (*DUM*, 325), as being someone with whom Thomas was 'very well acquainted'.

Society in the *Philosophical Transactions*.<sup>152</sup> This work, for which Marsh seems to have coined the word ‘microphone’, made analogies between the behaviour of light and that of sound in reflection and refraction. ‘Microphone’ for Marsh meant a homologue of the concept of the microscope, performing the same operation on sound as the microscope does on light, and would perhaps be closer to the modern use of the word ‘amplifier’. Marsh’s deep and abiding interest in mathematics saw him collect many mathematical texts, and his diary contains a record on 25 April 1690 of his use of ‘Knotty Algebra to divert melancholy thoughts these sad calamitous times’.<sup>153</sup>

William Molyneux is probably better known for his contribution to political thought than as a natural philosopher, although his correspondence with the philosopher John Locke and his shaping of the ‘Molyneux question’ in relation to perception in the mind of a man born blind has also been well described. His correspondence with his brother Thomas, and their publications in the emerging journals of their day have received less attention; and his publication of books focussed on optics and instrumentation is rather less well known than his publication of the *Case of Ireland...stated*. Molyneux, having taken his degree, was sent to London to the Middle Temple to study law, and said of his studies that although he did not apply himself to ‘drudgery’, as his family means freed him from the obligation of earning his living, he

was not wholly idle in the business for which I was sent over, as appears from the large collections and common place books, which I can yet produce as witnesses of my labours.<sup>154</sup>

His connections to John Locke, together with the political writings on the status of Ireland in its colonial context, have come to define Molyneux’s historical significance. In the ODNB, O’Hara cited Molyneux’s epitaph on his tomb in St Audoen’s Church,

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<sup>152</sup> Narcissus Marsh, ‘An Introductory Essay towards the Doctrine of Sounds’, *Philosophical Transactions* XIV (1684), 472-88.

<sup>153</sup> Marsh, *Diary*, 35.

<sup>154</sup> Molyneux, *Life*, 55.

Dublin, refers to ‘the man whom Locke was proud to call his friend’. O’Hara also described Molyneux’s position as a wealthy member of the Anglican ascendancy in Ireland, linking this to Molyneux’s views of Ireland’s status in relation to the colonial system.<sup>155</sup> Viewing Molyneux as ‘the father of Irish science’, O’Hara summarised the biography by J.G. Simms, as edited by P.H. Kelly, and Hoppen’s account of the DPS.<sup>156</sup>

In his most well-known publication, *The Case of Ireland ... stated*, Molyneux put forward a view of Ireland’s parliament as enjoying some historical equivalence to the status of the parliament in England. The motivation was less that of nationalism than of economics: the immediate impetus arose from the imposition of trade restrictions on Ireland by the parliament in London. In drawing on the early, pre-Reformation history of the relationship between England and Ireland, Molyneux attempted to unite the apparent interests of the Irish across the confessional divide, while favouring the interests of the monied classes for whom trade was of utmost importance.

In his *Life*, Molyneux described his early interest in natural philosophy and the works he had read on related topics:

I had always a strong bent and inclination to the philosophical and mathematical studies, even when I was in the University, wherein I could never approve of that verbose philosophy there professed and taught, but still procured the books of the Royal Society, the Philosophical Transactions, Des-Cartes’s Writings, Dr. Bacon’s Works, Gassendus, Digby, fine. In these sorts of Authors I chiefly delighted, even in my first academic studies; but I did not apply myself so fully to mathematical learning, as about the year 1650. <sup>157</sup>

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<sup>155</sup> James O’Hara, ‘Molyneux, William (1656–1698), experimental philosopher and constitutional writer’, *ODNB*.

<sup>156</sup> Hoppen, *Common Scientist*; J.G. Simms, P. H. Kelly, ed., *William Molyneux of Dublin, 1656–1698* (Dublin, 1982).

<sup>157</sup> Molyneux, *Life*, 75–7.

In common with Marsh, Molyneux sought relief from care in the practice of mathematics. When recalling his response to his wife's illness, he wrote:

The diversion I took to was chiefly in books, and especially in mathematics: this was the grand pacifier. These were the opiates that lulled my troubled thoughts to rest.<sup>158</sup>

Molyneux's autobiography included an enumeration of his friends and acquaintances with interests in natural philosophy, giving succinct characters of each of them, and recalling his correspondence and interactions with them. The first person that he mentions is Bartholomew Van Homrigh, a merchant, who was a member of the DPS but who did not make any recorded contributions to the meetings. Mayor of Dublin, and appointed to trusted office, Van Homrigh was the father of Esther Van Homrigh, known as Vanessa to Jonathan Swift. Molyneux emphasised the personal trustworthiness of Van Homrigh, and the confidence placed in him by those in authority. St George Ashe, then the Provost of Trinity, was mentioned as Molyneux's 'particular friend and intimate'. In the chapters which follow below, Molyneux's interaction with others is discussed in further detail. He concluded the list with

Mr. John Locke, the incomparable author of the Essay of Human Understanding ... as for learning and profound judgment, his works speak sufficiently, particularly his forenamed Essay, than which no age has seen a more admirable piece.

His association with these like-minded individuals, with whom he could discuss the natural philosophy which was one of his prime interests, was of more importance to him than any contact with those who held elevated social positions:

An ostentatious man would perhaps have preferred and mentioned, before all these learned acquaintance, a visit from a person of quality, or a title, but

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<sup>158</sup> Ibid., 30.

to me there seems no comparison...<sup>159</sup>

This esteem for contacts in the learned world was shared by both Marsh and Molyneux; both engaged in discussion and entered into controversies; both also engaged in collaborative approaches to the gathering of data. Both were aware of some emerging tensions between religion and natural philosophy. In personal correspondence, and in reading and publishing of their observations and interpretations, both engaged with their contemporaries in the pursuit of knowledge relating to the created world. In doing so, they took part in its dissemination and acceptance.

In the chapters which follow, I trace the cloud of witnesses gathered about these two men and their community of the curious within the DPS and further afield. Corresponding with the learned world, the members of the DPS engaged with topics as diverse as the classification of insects, the nature of comets, or the formation of stones in the body and in the earth. Individual members of the learned societies exchanged views on books containing radical opinions which could affect the stability of society, as well as the interpretation of creation. As we shall see, the themes and concerns taken up by Marsh, Molyneux and their circle of the curious in early modern Dublin enabled them to take part in a cycle of knowledge, and to become witnesses to the making and reception of ‘matters of fact’.

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<sup>159</sup> Ibid., 30.

## CHAPTER 2

### A CLOUD OF WITNESSES: NETWORKS, TOPICS AND TEXTS

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*...there are Two chief ways whereby Knowldg may be advanced, viz.*

*(1.) By inlarging the HISTORY of Things; And (2.) By improving  
INTERCOURSE and COMMUNICATIONS.<sup>1</sup>*

*...by mutual discourse and communication of studies to improve  
ourselves in useful philosophy<sup>2</sup>*

In November 1686, Edward Smyth, then a student at Trinity and serving as secretary to the Dublin Philosophical Society (DPS), wrote to John Benbrigg of the Oxford Society desiring him to 'let us ever share in those ingenious communications with which you have so much obliged us already'.<sup>3</sup> The surviving evidence of those communications between natural philosophers based in Ireland and their peers further afield in the Republic of Letters forms a valuable record of their thinking, and of the place of their activities within their culture, thus addressing a primary question for this thesis. The correspondence and the minutes of the societies reflected the mutual interests of the members but in addition, both corpora were connected to other learned and philosophical works. In all, the connections indicated a substantial engagement with print, examples I describe being drawn from the collection and reading of Narcissus Marsh, the reading and references of William Molyneux, and the printed references of others connected with issues considered by the DPS. These contextual documents afford a broader intellectual background to the concepts included in the correspondence itself.

The first part of this chapter offers an account of the contact networks as captured in the DPS papers, describing the spatial distribution of the network, and setting

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<sup>1</sup> Joseph Glanvill, *Essays On Several Important Subjects In Philosophy And Religion* (London, 1675), Essay 3, 2.

<sup>2</sup> Ashe to Dodwell, *DPS Papers* no. 278.

<sup>3</sup> *DPS Papers* no. 351. John Benbrigg (variously Bainbrigg, Bainbridge, Bonbrigg) was a fellow of University College Oxford and joined the Oxford Society in June 1684. He was elected secretary on 23 April 1686. See *DPS Papers* 1, 90, fn. 1.

out the connections between individuals and groups. The focus then moves to the topics of interest discussed in the letters, describing how members of the DPS communicated their interests in natural philosophy to each other and to like-minded individuals and societies within and without Ireland. In the third section of the chapter, I examine the culture of discussion revealed within the community by a combination of digital techniques and close reading, and explore the possible roles for the Irish philosophical community within its wider milieu.

Epistolary networks supported patterns of connectivity, both between individuals and, more formally, between organised groups. These patterns are explored in this chapter, both by a return to the language of the correspondence, and by visualisation techniques derived from social network analysis. The intersection between the societies and other more informal circles, seen in the extended networks and reading of Narcissus Marsh and William Molyneux, revealed a significant engagement with members of the Republic of Letters on various levels. Members of these communities were also connected by relationships other than those of mutual interest in natural philosophy, being linked by ties of friendship or kinship, and patronage or recommendation. Influences and connections such as these were a significant backdrop to the circle's interests and activities in natural philosophy.

In examining the patterns of communication established by the community of natural philosophers, this thesis combines close reading with digital humanities techniques to give a distant reading of the networks and topics. The appropriate and useful application of tools such as network analysis, topic modelling and text mining to historical questions has been a subject of active debate within the digital humanities community.<sup>4</sup> Discussing word clouds, topic modelling and other tools

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<sup>4</sup> A comprehensive discussion of the application of digital methods is found in 'Digital Methods and Tools for Historical Research: A Special Issue', *International Journal of Humanities and Arts Computing* 8:1 (2014). The introductory text by Daniel Alves sets out some of the challenges and opportunities presented to historians by the availability of these tools; the articles address these topics by means of individual case studies. The digital humanist Scott Weingart, who has particular interests in digital treatment of questions in history of science, also addresses fundamental questions as to

of distant reading in the *Historian's Macroscope*, Scott Weingart noted:

This takes us back to the question of what 'topics' and 'bags of words' really are. The tokens, the individual lemmatized (or not) words, may at first appear to be coherent 'topics' as one might understand from a catalogue, but their original contexts have become blurred. As far as using topic models, word clouds, and phrase nets for historical analysis [goes] we have to be leery of using them to create detailed stories. Think of them as streams, as associations, as generative direction finders, instead.<sup>5</sup>

It is with these types of associations and 'generative direction finding' that this chapter is largely concerned, as a prelude to the detailed stories of discussions of natural history, cosmology, and chymistry within the community of natural philosophers, which are taken up in the succeeding chapters.

### Forging the links

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In 1682, William Molyneux, in conjunction with the London printer Moses Pitt (bap. 1639, d. 1697), planned the publication of a natural history and atlas of Ireland, envisaged as part of a more ambitious work. This prompted the construction of an 'interrogatory' by Molyneux. Based on Baconian patterns of inquiry, this document was designed to collect information from outlying areas by correspondence.<sup>6</sup>

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organisation and development of arguments in his blog, 'The Scottbot Irregular'. Scott Weingart, 'The argument clinic', <https://scottbot.net/argument-clinic/> 26 July 2017. Accessed 10 March 2018.

<sup>5</sup> Shawn Graham, Ian Milligan, and Scott Weingart, 'Topic Modeling with Paper Machines', The Historian's Macroscope: Big Digital History, [http://www.themacroscope.org/?page\\_id=60](http://www.themacroscope.org/?page_id=60).para 10. Accessed 10 March 2018.

<sup>6</sup> This ephemeral single-sheet document survives in one copy, held in the Bodleian Library. The title is given in full here as it indicates the relationship to correspondence: William Molyneux, *Whereas There Is an Accurate Account and Description of Ireland Designed to Be Made Publick in the English Atlas Undertaken by Moses Pitt of London: And in Order Thereto, Some Gentlemen in Dublin Have Agreed to Meet Weekly for Reviewing Such an Account, as Shall from Time to Time Come from under the Pen of Mr. William Molyneux, as Also to Bring in Some Materials to the Said Description; This Is Earnestly to Entreat All Persons That They Would Be Pleased Freely to Communicate Their Answers to These Following Quæries, or Any of Them, Directing Them to Mr. William Molyneux Nigh Ormonds Gate in Dublin, or to Any Other of Their Acquaintance in Dublin That May Communicate to Them the Said Mr. Molyneux, Not Forgetting to Specifie in Their Letters the Place of Their Habitation That They May Be Again Written to If Occasion Requires* (Dublin, 1682).

Molyneux's initiative in pursuing the natural history of Ireland followed from the assembly of an informal group, described by Narcissus Marsh as a club (as we have seen in Chapter 1), which was eventually given a formal status as the DPS. Information continued to come to William Molyneux by correspondence, although Pitt's monetary troubles ensured that six of the proposed eleven volumes of his atlas never saw the press.<sup>7</sup> Pitt's project provides a starting point for this thesis, and for the DPS alike. For the texts themselves and associated metadata, the central corpus I explored was that of the *DPS Papers* in the earlier period of the society's existence, excluding the later brief revival under William Molyneux's son, Samuel. These papers, which include both minutes and correspondence, were generously made available in electronic format for this study by the editor and publisher.<sup>8</sup> Information from the central corpus was supplemented by correspondence metadata gathered from other sources, to give a sense of the wider social circles, and by details of print sources mentioned and collected, giving a sense of the intellectual background.

The nature of the connections within such networks have been modelled mathematically in recent decades, allowing a degree of quantitative evaluation of the relationships. The concept that almost everything and everyone is connected via 'six degrees of separation' has been explored in literature and film as well as mathematics. Social media networks exhibit a connectedness which was recalculated for Facebook in 2016 as 3.57 degrees.<sup>9</sup> This apparent connectedness in contemporary social media can be illusory, fictive, constructed. As with twenty-first-century data, a certain level of caution is necessary in interpreting the significance of historical network data. The fact of correspondence does not, by itself, indicate the nature of the connection; and the incompleteness of the data is a given due to accidents of historical record.

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<sup>7</sup> Pitt's financial woes affected his other work for the Royal Society. Charles A. Rivington, 'Early Printers to the Royal Society 1663-1708', *Notes and Records of the Royal Society of London* 39, no. 1 (1984), 1-27. For a detailed account of the atlas, see E. G. R. Taylor, "'The English Atlas' of Moses Pitt, 1680-83", *The Geographical Journal* 95:4 (1940), 292-99.

<sup>8</sup> See above, Chapter 1, and Acknowledgements.

<sup>9</sup> 'Three and a Half Degrees of Separation', Facebook Research, accessed 13 February 2018, <https://research.fb.com/three-and-a-half-degrees-of-separation>.

The networks discussed here arose during the time in which the community of natural philosophers grouped itself into formal societies, which in turn set up formal links. Outside these formal structures, informal contacts and groups established themselves, exchanging views on topics which intersected with the interests of the formal societies. Discussions originally undertaken with a particular purpose in mind could acquire a different emphasis in response to an altered context. A central example of just such a turn was Molyneux's initial programme of information-gathering on the natural history of Ireland, which became generalised as part of the philosophical enquiries connected with the DPS. This is illustrated by a letter to a country member of the newly formed DPS on 22 March 1683/4, in which William Molyneux acknowledged the receipt of an account of the county of Roscommon, and referred to the progress of the society, with particular reference to the links formed with the 'curious and ingenious' outside Ireland.<sup>10</sup>

The links between the members of the DPS who were dispersed across Ireland, and the links of the Dublin society with its model, the Royal Society in London, and with its sister society in Oxford, are evident in the proceedings and papers of all three societies. For the related societies, a formal and reciprocal communication of the minutes of meetings was an early feature, forming a solid pattern in the correspondence. This provided a forum for the exchange of reports and data within the minutes themselves, with covering notes to the minutes allowing for elaboration of detail and further queries.

In forging these links between the societies, the DPS was following one of the principal recommendations made by William Petty to the society in his 'Advertisements', that

they provide themselves with correspondents in several places, to make such observations as do depend upon the comparison of many experiments, and not upon single and solitary remarks.<sup>11</sup>

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<sup>10</sup> *DPS Papers* no. 221.

<sup>11</sup> *DPS Papers* no. 526.

This was evidently taken seriously as an aim of the society, complementing the Baconian history-taking which was an avowed characteristic of the society's operations. The texts of the covering letters which enclosed the minutes, and of the minutes themselves, show that each group recommended trials to the other, generating further experiments and accounts, venturing into the discussion of concepts and mentioning publications, and exchanging collected specimens in their search for points of similarity and difference between Ireland and the wider world.

In the case of those writing from within Ireland, the group was relatively small. As elsewhere, networks were established through friendship and kinship, common education, introductions, patronage, and religion. Many correspondents would have met in person at some point, and some were bound by close family ties. Observations were sometimes gathered from a secondary network of people not normally engaged with natural philosophy, such as St George Ashe's brother Thomas, who gave him information about a strange case of bleeding.<sup>12</sup> Some others, whose names do not survive in the documentary record, are mentioned in the letters as having passed information or specimens to the members of the DPS, such as the anonymous 'gentleman of good reputation' who informed William Molyneux about the effects of Lough Neagh water on various timbers.<sup>13</sup> These links all contributed to the gathering of information. In the evaluation of the reliability the 'matters of fact' acquired in this way, the reputation of the contributors was evidently significant.

Within the collection of material, the facets of space, time, and topic afforded simple high-level categories, which are reflected in the division of the discussion which follows here. The first part considers the correspondence in relation to space and time. As noted earlier, members of the Irish circle perceived themselves to be 'out of the way' of the learned world. The group's perception of their peripheral situation prompted an examination of the geographical distribution of the senders and receivers of the surviving correspondence. Both the timeline and the spatial

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<sup>12</sup> *DPS Papers* no. 253. This case is discussed further in Chapter 3 below.

<sup>13</sup> *DPS Papers* no. 166, no. 253 (Ashe).

distribution of the correspondence reflected the political instability in Ireland, which caused disruption to the personal lives of the members of the DPS, with Marsh, St George Ashe and the Molyneux brothers leaving the country for a time.

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#### Patterns of connection: spatial, temporal and personal

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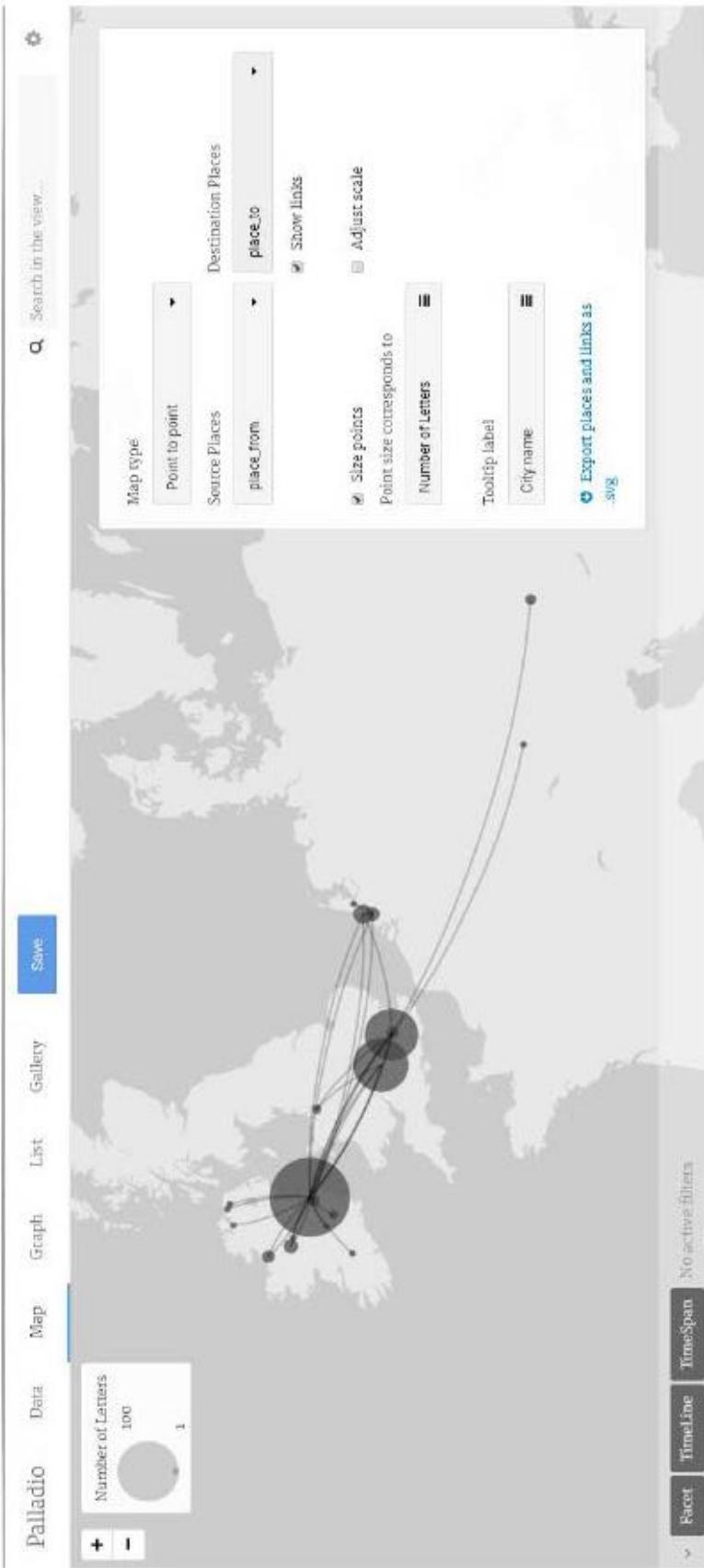
To explore the spatial relationships of the core network as represented in the *DPS Papers*, the dates and places of the correspondence were entered initially into an Access database designed to output data suitable for use in the online tool Palladio, developed by the Humanities+Design group at Stanford.<sup>14</sup>

Figure 1 represents the places from which letters included in the *DPS Papers* were sent and received over the years 1683 to 1706. Paired links show the survival of reciprocal correspondence, with the scale of the nodes again given by the number of letters associated with each place. The geographical space occupied by the surviving elements of the correspondence indicated the possibilities for intellectual exchange over large distances. The size of each point represents the number of letters sent to and from that place.

As might be expected of this set, representing the correspondence of the DPS itself within the period from its foundation in 1683 until the end of the first revival in 1700, the largest concentration of surviving letters was sent from Dublin. London and Oxford, the locations of the related societies with which the Dublin society maintained a formal relationship, are also prominent. This data represents survival of letters, and although it is tempting to read the diagram as a true representation of the relative volume of correspondence from each place, it must be remembered that survival rates may not be similar for all origins.

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<sup>14</sup> 'Palladio, accessed 17/08/2018, <http://hdlab.stanford.edu/palladio>.



**Figure 1.** A view of the spatial dimensions of the correspondence in the first period of activity of the DPS.  
Paired links indicate letters sent and received from each place.

The extremes of the spatial distribution arose from a number of factors. Within the remoter places in Ireland, an active country member of the DPS was John Keogh (c.1650–1725), who lived in Strokestown, Co Roscommon, where he earned his living as a clergyman and schoolmaster, and carried on an active intellectual life as mathematician and natural philosopher.<sup>15</sup> Travel to continental destinations meant that personal ties were established to cities such as Leiden, where Thomas Molyneux went to pursue medical studies; and Vienna and Augsburg, where St George Ashe met with natural philosophers during his chaplaincy to Lord Paget, William III's ambassador to Vienna.

Exchange of letters could be swift. Letters and packets, such as those containing books, were sent via the postal networks, which operated with a high degree of reliability. The post between England and Ireland had been re-established in 1660, when a single sheet from England to Dublin cost six pence, and from Dublin to any part forty miles distant two pence, with longer distances double.<sup>16</sup> Excuses for tardiness in response to letters were more likely to be given in terms of lack of time, illness or some pressing personal matter rather than blame being assigned to the postal network itself. Political disruption and the vagaries of the weather were also given as reasons for delay.

Figure 2 shows a timeline of the data. The pattern observed prompted a return to close reading, which showed that the cluster on the timeline in the early part of the dataset did indeed represent a burst of activity on the part of the society, with an initial enthusiasm for their activities and topics. The frequency of the meetings was also greatest over that time period. Within this set, William Molyneux's correspondence (highlighted in blue) showed a pattern of variation consistent with his early activity in establishing the society, acting as secretary initially, and his steady continuing contribution to its affairs.

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<sup>15</sup> O'Hara, James G. 'Keogh, John (c. 1650–1725), Church of Ireland clergyman and scientist.' *ODNB*.

<sup>16</sup> Edward Gibbon Wakefield, *An Account of Ireland, Statistical and Political: In Two Volumes* (Longman, Hurst, Rees, Orme, and Brown, 1812). For a more recent account of postal networks, see Nikolaus Schobesberger et al. 'European Postal Networks', in Noah Moxham and Joad Raymond, eds, *News Networks in Early Modern Europe* (Leiden, 2016), 19–6.

Returning to close reading of the texts also showed that political events impinged on intellectual history, in this as in other spheres. Even during the initial period of the establishment of the society, William Molyneux found himself discouraged by conflicts from travelling as he had hoped to do. Writing to John Keogh in 1684, he noted that his intention to travel into Flanders had been disrupted:

I told you when I last saw you that I thought to go this Spring into Flanders, but the present tumults in that place have diverted my intentions, so that I shall be at home all this year, where I shall be glad to hear from or see you.<sup>17</sup>

Part of the motivation for William's journey was to visit his brother Thomas, who was then studying medicine in the famous college at Leiden, and the tumults he referred to were presumably the so-called 'war of the reunions', which was part of the ongoing struggle for territory between Louis XIV and his Dutch neighbours.<sup>18</sup>

The Leiden to Dublin correspondence between the Molyneux brothers, Thomas and William, marked another geographical extreme of the first group of letters. It was also via Thomas Molyneux that the DPS first connected to that prominent member of the republic of letters, Pierre Bayle. In 1684, Bayle was resident at Rotterdam, and was responsible for the publication of the newsletter for the learned community, *Nouvelles de la Republique des Lettres*. As mentioned earlier, Thomas Molyneux had left Ireland to expand his medical studies just as William and his Dublin circle were beginning the formalisation of their society. One of the most interesting facets of the correspondence between William and Thomas (frustratingly incomplete and surviving since the 1840s only as a fragmentary publication in the Dublin University Magazine in 1841) is the references which it includes to the chymical interests and background of the brothers, and their intention to establish a laboratory in Dublin for the investigation of physicochemical phenomena.

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<sup>17</sup> DPS Papers no. 221.

<sup>18</sup> Cathal J. Nolan, *Wars of the Age of Louis XIV, 1650-1715: An Encyclopedia of Global Warfare and Civilization* (Westport CT, 2008).

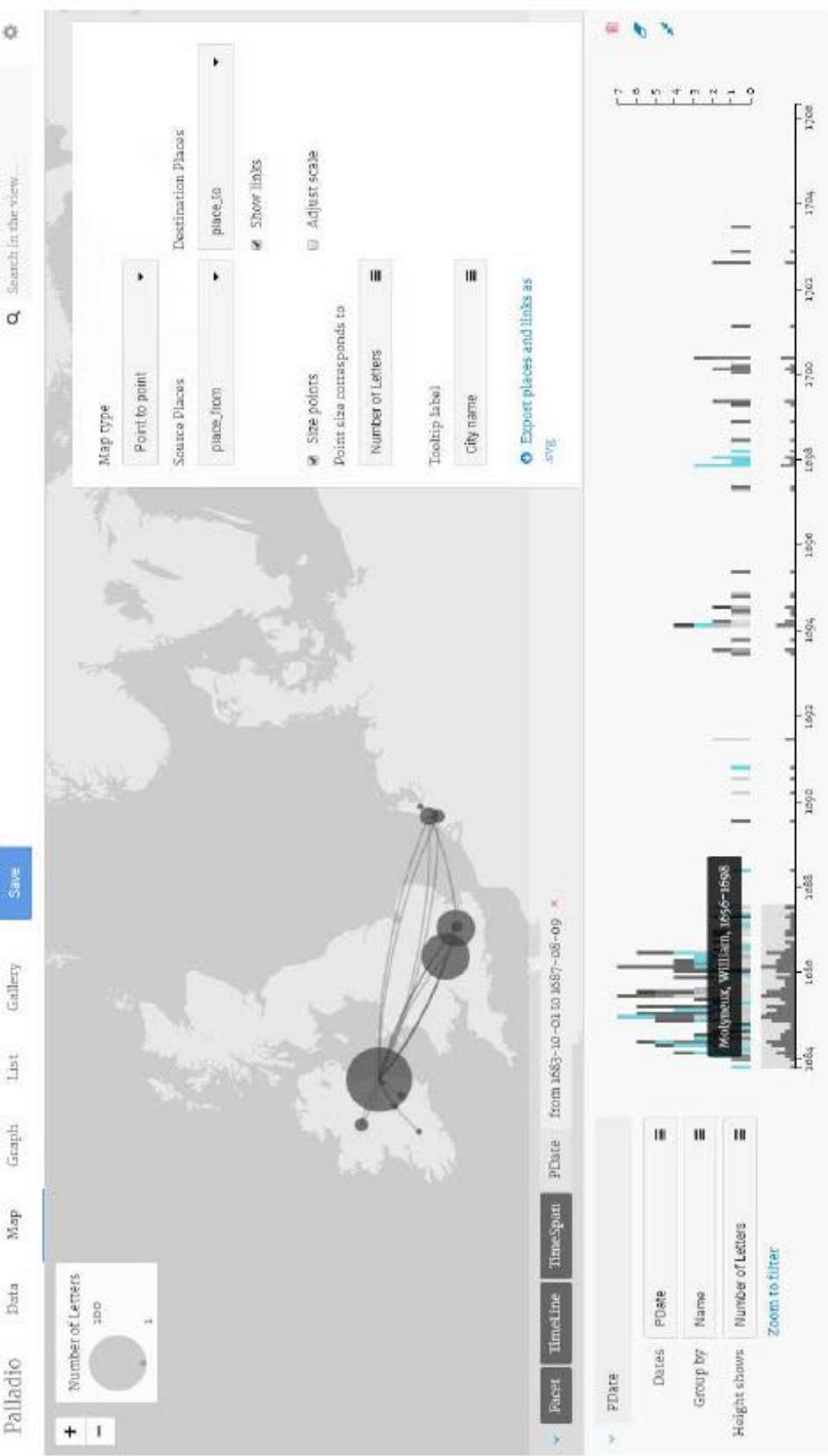


Figure 2. Timeline of data, with William Molyneux's correspondence highlighted, and the earlier period selected.

Within this personal and sometimes intimate correspondence between the brothers, we find an example of how a ‘problem in hydrostatics’, describing the behaviour of solutes in menstrua, was discussed in ever-widening circles. Thomas first described to his brother a ‘phansy’ which he had sent to Bayle, for consideration and possible wider circulation in the *Nouvelles de la République des Lettres*. William then mentioned it to Halley, saying that he differed from his brother.<sup>19</sup> Bayle published the theory in the *Nouvelles*, and the debate ‘between two intirely loving brothers’, as William described it, continued in two publications in the *Philosophical Transactions of the Royal Society*. This exchange is of interest not only because of its theoretical content, but also because of its presence in both private and public spheres, illustrating the diverse circles in which such questions could potentially find a forum for discussion.<sup>20</sup>

As seen in Figure 2, the timeline of the correspondence was interrupted in the late 1680s: evidence from the letters themselves shows that the unsettled nature of life in Ireland at this period made it difficult and occasionally impossible to carry on the intellectual activities of the society. For example, on the 12<sup>th</sup> of August 1685, St George Ashe, by then secretary of the DPS, wrote to William Musgrave, then secretary of the Oxford Society, telling him that

our company has of late been very thin, and people’s heads so much diverted with politics that next meeting I believe we shall adjourn until the term.<sup>21</sup>

As the arrival of James II in Ireland and the subsequent events of the Williamite wars made the Anglican community fear for their safety in Ireland, both Molyneux brothers and Narcissus Marsh were displaced. William Molyneux left for Chester, where he was joined by his brother Thomas; Narcissus Marsh sought refuge in

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<sup>19</sup> DPS Papers no. 331: ‘I have by this post sent to my brother a paper that relates to a problem in hydrostatics: why heavy bodies dissolved in menstruum specifically lighter than themselves, swim therein and do not sink to the bottom. Concerning this my brother has proposed his thoughts in the Novels de la république des lettres. But I take the liberty of differing from him in some particulars.’

<sup>20</sup> The details of the debate and the theoretical background to the phenomenon as observed by the brothers are more fully discussed in Chapter 5.

<sup>21</sup> DPS Papers no. 302.

London, and then in Oxford, where he stayed with Arthur Bury (1623/4–1713), author of the controversial *Naked Gospel* (London, 1691).<sup>22</sup> St George Ashe also left Ireland at this time, travelling to Vienna and Augsburg as secretary to the British ambassador at Vienna, Lord Paget. His correspondence reported a wide range of topics of interest, including mining, metallurgy and astronomy. His 1690 letter to Edmond Halley as secretary of the Royal Society detailed a visit to the astronomer Georg Christoph Eimmart and his collaborator Wurtzelbauer at Nuremberg and enclosed, among other information, data on a lunar eclipse. The two astronomers mentioned by Ashe communicated their observations to Theodore Haak (1605–1690).<sup>23</sup> In an example of ‘learned correspondence’ ensuing from connections within the community of natural philosophers, the records of their observations were eventually published in the *Philosophical Transactions*.<sup>24</sup>

The geographical expansion of the correspondence within Ireland seen in the later portion of the correspondence is largely due to the travels of Edward Lhwyd (1660–1709), naturalist, philologist, antiquarian, in pursuit of his researches for his publication *Archaeologia Britannica* (1707). Both William and Thomas Molyneux (Thomas after William’s death in 1698), and Owen Lloyd, then secretary of the DPS, wrote to Lhwyd as he travelled to various places within Ireland. Lhwyd was an active collector of knowledge on many fronts, and his travels and correspondence connected various circles in Ireland and across Britain.<sup>25</sup>

Correspondence was delivered by hand as well as through the postal network. The name of the bearer was sometimes noted, which is particularly relevant in the case

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<sup>22</sup> J. Benedict, ‘Bury, Arthur (1623/4–1713), college head and writer on theology.’ ODNB. Marsh’s friendship with Bury and his wife Mary, and with Frances Southcote, widow of the Oxford orientalist William Guise, gave him support while in exile, and also resulted in a number of books from Guise’s library being given to Marsh (see below). Bury’s *Naked Gospel* survives in Marsh’s own collection.

<sup>23</sup> For Haak, see Pamela R. Barnett, ‘Theodore Haak and the early years of the Royal Society’, *Annals of Science* 13:4, (1957), 205–218; William Poole, ‘A Fragment of the Library of Theodore Haak (1605–1690)’, electronic British Library Journal (2007), <http://www.bl.uk/eblj/2007articles/pdf/ebljarticle62007.pdf>, Accessed 12 September 2018.

<sup>24</sup> G. C. Eimmart and J. Ph. Wurtzelbaur, ‘Two Observations of the Last Eclipse November 30th Last, Made At Nuremberg; The One By Mr. G. C. Eimmart, the Other By Mr. J. Ph. Wurtzelbaur: Communicated by Mr. Theodore Haak R. S. S.’, *Philosophical Transactions* XVI (1686), 146–47.

<sup>25</sup> Richard Sharpe, *Roderick O’Flaherty’s Letters: To William Molyneux, Edward Lhwyd, and Samuel Molyneux, 1696–1709* (Dublin, 2013).

of letters of introduction. Two surviving examples of this type of letter, with philosophical connections, were sent from Narcissus Marsh to Robert Boyle. In one, written on 3 July 1682 (before the establishment of the DPS) Marsh introduced the young physician Allen Mullen as the bearer of the letter to Boyle, and referred to Mullen's earlier publication of the dissection of an elephant which had been burnt in an accidental fire in Dublin.<sup>26</sup> Mullen had also dissected a beaver (castor) and Marsh told Boyle that this dissection would also be communicated to him.<sup>27</sup> Marsh also wrote a letter of introduction to Boyle for Thomas Molyneux, in which Marsh's esteem for Boyle's natural philosophy is evident:

Nor can any one pretend to an acquaintance with the ingenious world abroad, who besides your Books has not some knowledg of your person and your admirable contrivances for the ~~advancement~~—empovement of Experimental philosophy.<sup>28</sup>

These letters called upon a strong connection between Boyle and Marsh, who was sufficiently trusted to make introductions.<sup>29</sup> The letter to Boyle was just one of the letters of introduction carried by Thomas Molyneux as he travelled through England to Leiden. Through the good offices of members of philosophical circles in London, Oxford and Cambridge, he then obtained further introductions to those in Leiden.<sup>30</sup>

Although, as mentioned previously, connectivity of this sort can become very broad

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<sup>26</sup> The letter of introduction for Mullen described how 'Mr Mullan, Batchelour in Physick of this College ... had an opportunity the last summer to exercise [his skill in anatomy] on an occasion, that rarely occurs; namely in dissecting the Elephant, which was burnt here in Dublin; whereof he will give you as perfect an account, as can be expected from one in those circumstances, that he then was, if you desire it; he having committed all to writing. He will also give you some account of a Castor, that he here dissected.' Narcissus Marsh to Robert Boyle, 3 July 1682, Boyle *Correspondence* 5, 296–8.

<sup>27</sup> This letter was excluded from the *DPS Papers* as it fell outside the appropriate date range for the society's activities. It is included here for its significance for the activities of natural philosophy in Ireland and its communication to Boyle, then resident in England.

<sup>28</sup> Boyle *Correspondence* 5, 406–7.

<sup>29</sup> As the dates fell outside the range of the collected edition of the papers of the society, these letters were not included in Hoppen's edition.

<sup>30</sup> Thomas Molyneux's description of his travels, and the engaging pen-pictures of those he met, contain many examples of those to whom he carried letters of introduction and of his own friendship networks in the colleges he visited. See *DUM*, 315–27.

indeed, I chose to explore the additional philosophical connections and influences afforded to members of the DPS via two members in particular: Narcissus Marsh and William Molyneux. In social networks, relationships between individuals can be explored with a variety of techniques which go beyond visually inspecting lists of people who are connected in some way, whether by correspondence or by some other, less direct, tie (examples being kinship, influence, or patronage). Networks of connections such as these can be quantitatively as well as qualitatively examined using graphs, in which the individuals are represented as nodes or vertices, and the connections between them are represented as edges or ties.<sup>31</sup>

Metrics indicating connectivity can also be applied to the data to aid in the detection of individuals critical to the functioning of the network. The most commonly deployed metrics are degree centrality and betweenness centrality. Degree is defined as the number of edges connected to a node; this is a somewhat unsophisticated measure of connectedness. Betweenness centrality is computed as the proportion of the shortest paths in the network which pass through a given node. This metric indicates which nodes have potential significance as information brokers in their network. Although these metrics will yield skewed results from incomplete data such as the material in this study, they can still be useful as a numerical check on assumptions derived from close reading. Figure 3 shows a representation in Gephi of the network derived from the DPS data alone. The size of the nodes indicates the betweenness centrality metric. The roles of the secretaries of the societies are evident in this network: for the DPS, St George Ashe and William Molyneux are prominent. Betweenness centrality metrics also indicated that the secretaries acted as information brokers, connecting parts of the network, St George Ashe again emerging as not only very active, but as playing a role in the connections between parts of the community. The data must be treated with a certain caution, but with this focussed dataset, complete in its own terms, can be meaningful.

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<sup>31</sup> For a note of the tools used and explored, see Appendix.

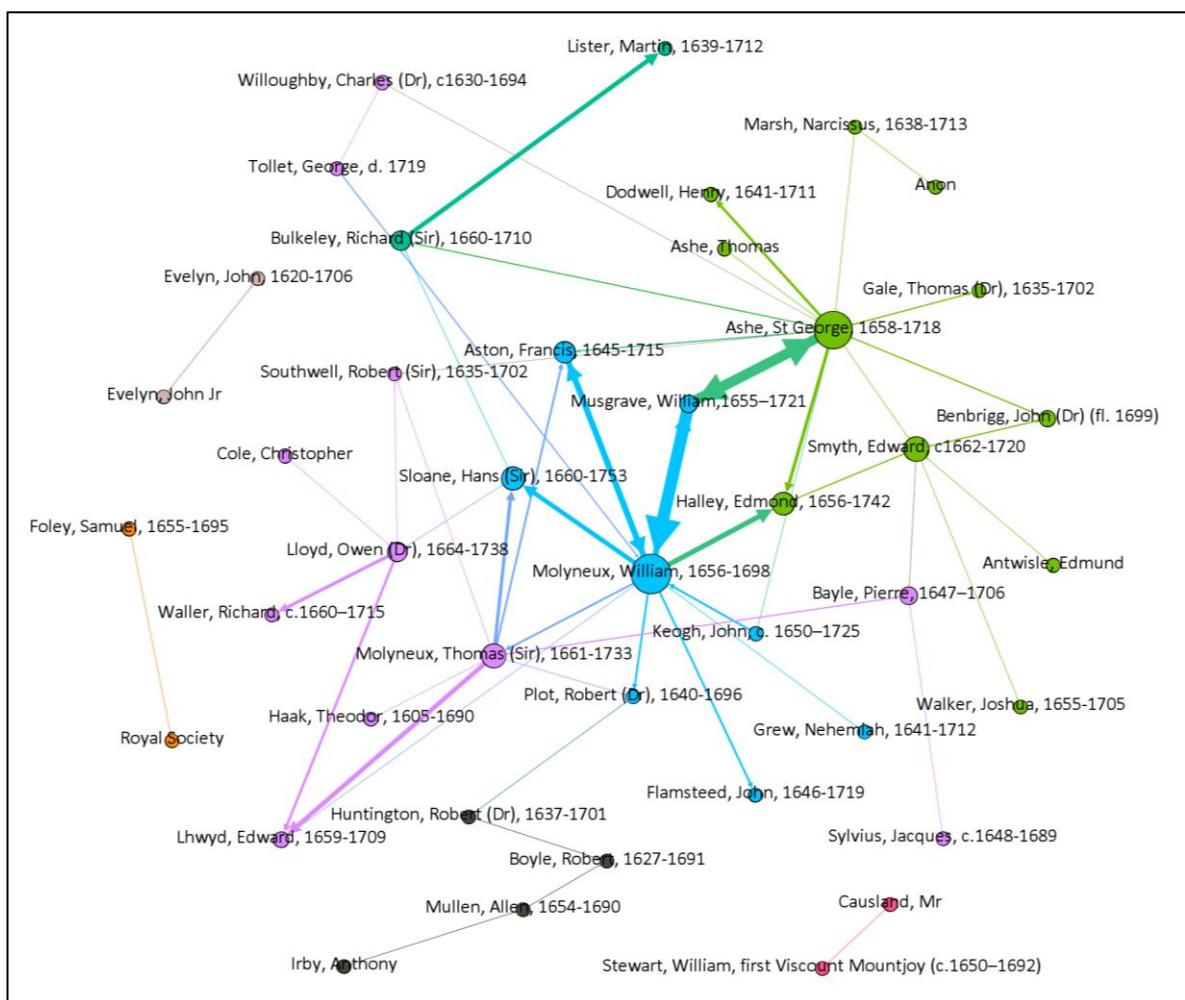


Figure 3. Network derived from the DPS data.  
Grouped by modularity. Nodes sized by betweenness centrality.  
Visualisation in Gephi.

The general sense of connectivity conveyed by this data was supplemented by adding known correspondence networks of Narcissus Marsh and William Molyneux, which showed two distinct patterns of connection. Marsh connected an extra group of people to the community, with a major focus of those letters being his connections to Oxford colleagues, where his discussions on scholarly topics established during his time there were continued. An intersecting circle added by Marsh's correspondence was centred on Robert Boyle: these letters largely concerned the publication of the Old Testament of the Bible in Irish but did contain occasional references to natural philosophy, such as astronomical events. Similarly, the connections of William Molyneux to the astronomers John Flamsteed (1646–1719) and Edmund Halley (1656–1742), and of both William and Thomas Molyneux to the philosopher John Locke (1632–1704), some of which were already included in the core DPS data, extended the view of the wider community within which discussions took place on various topics, in particular those related to astronomical observations.<sup>32</sup> Interesting though these connections are, the lacunae are obvious: there is no surviving correspondence connecting Marsh and Molyneux, and yet they were connected on many different levels. To follow these links, prosopographical data is necessary.

Capture of the detail of these connections was beyond the scope of this study, but an approach to such data is possible through the open online tool 'Six Degrees of Francis Bacon' (SDFB), which allows a very general overview of connectedness between individuals and groups, drawn originally from the prosopographical data in the ODNB. These views can reveal connections and influences which complement correspondence data, and in some cases are derived from examination of correspondence in concert with other documents from the historical record. This dataset showed relationships which were also seen in the correspondence networks.

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<sup>32</sup>Frances Willmoth, 'Flamsteed, John (1646–1719), astronomer'; Alan Cook. 'Halley, Edmond (1656–1742), astronomer'; J. R. Milton, 'Locke, John (1632–1704), philosopher'; all *ODNB*.

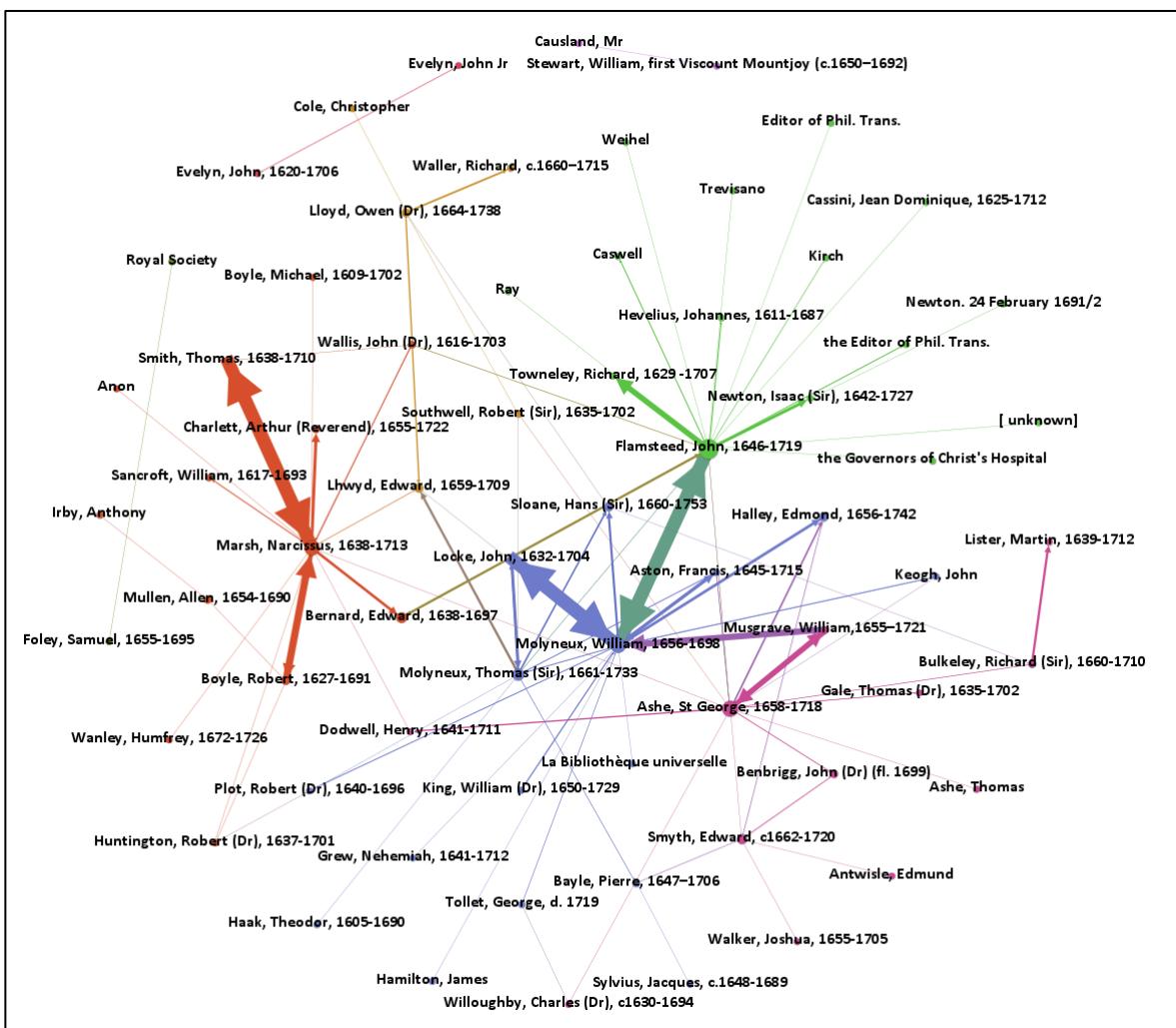


Figure 4. Network derived from the addition of correspondence metadata of William Molyneux and Narcissus Marsh to the DPS data, Grouped by modularity. Nodes sized by betweenness centrality. Visualisation in Gephi.

The first- and second-degree connections of Narcissus Marsh generated from the SDFB data shows sub-networks associated with Marsh which centred on Robert Boyle, William Molyneux and John Fell (Figure 5). Of these, that of Marsh with Robert Boyle, through the transactions relating in particular to the publication of the Irish translation of the Old Testament, and that of Marsh with William Molyneux, showing the DPS connection, were as expected from the correspondence networks. The third cluster of relationships was not revealed by correspondence. It centred on John Fell, dean of Christ Church Oxford and promoter of the University Press, bringing Marsh's intellectual life and formation into prominence. Fell's patronage of Marsh was largely responsible for Marsh's advancement in the scholarly world and, as Michael Hunter has noted, Fell was also connected to the circle responsible for the translation of the Irish Bible, providing lodgings for the Jesuit convert and translator Andrew Sall at Christ Church Oxford. Hunter also referred to Fell's ambition to educate a generation of highly-qualified missionaries suitable for the region controlled by the East India company, showing the close links between the study of languages and mathematics, and the intersection of commerce and evangelism in the colonial context.<sup>33</sup> The ties between Robert Huntington and Marsh were also picked up by this view of their social network. Huntington, who succeeded Marsh as Provost in Trinity College Dublin, was an adventurous and successful orientalist, who sold a significant collection of near-Eastern manuscripts to the Bodleian in 1690 for more than £1100.<sup>34</sup> These relationships provide a context for other mutual links and possible intellectual influences within the community of natural philosophers. Molyneux, viewed similarly in the Six Degrees tool (Figure 6), shows strong connections to John Locke and to John Flamsteed, as expected from his surviving correspondence. His connection to the Irish scholar and historiographer, Roderic O'Flaherty (Ruaidhrí Óg Ó Flaithbheartaigh, 1627x30-

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<sup>33</sup> Michael Hunter, *Boyle Studies: Aspects of the Life and Thought of Robert Boyle* (1627-91) (London, 2016), 105–6.

<sup>34</sup> Huntington's donations of material to both Merton College Library and to the Bodleian, and the later sale of the larger collection of manuscripts, are described in G. J. Toomer, *Eastern Wisedome and Learning: The Study of Arabic in Seventeenth-Century England* (London, 1996), 286.

1716x18) is also seen, as is a connection to the controversial John Toland.<sup>35</sup> In the case of both Marsh and Molyneux, the social connections data derived from the scholarly articles in the ODNB complements and expands the impressions of connectivity gained from the correspondence metadata.

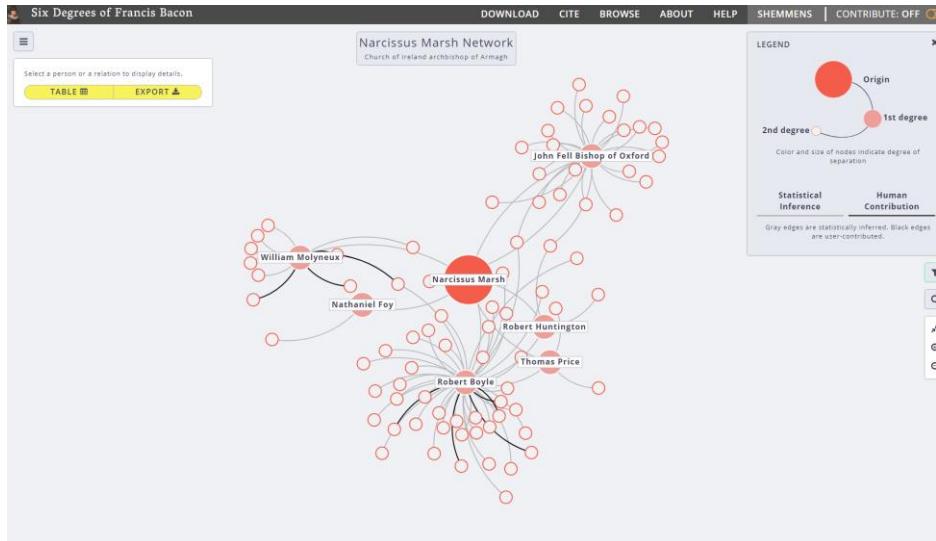


Figure 5. First- and second-degree connections of Narcissus Marsh (SDFB).<sup>36</sup>

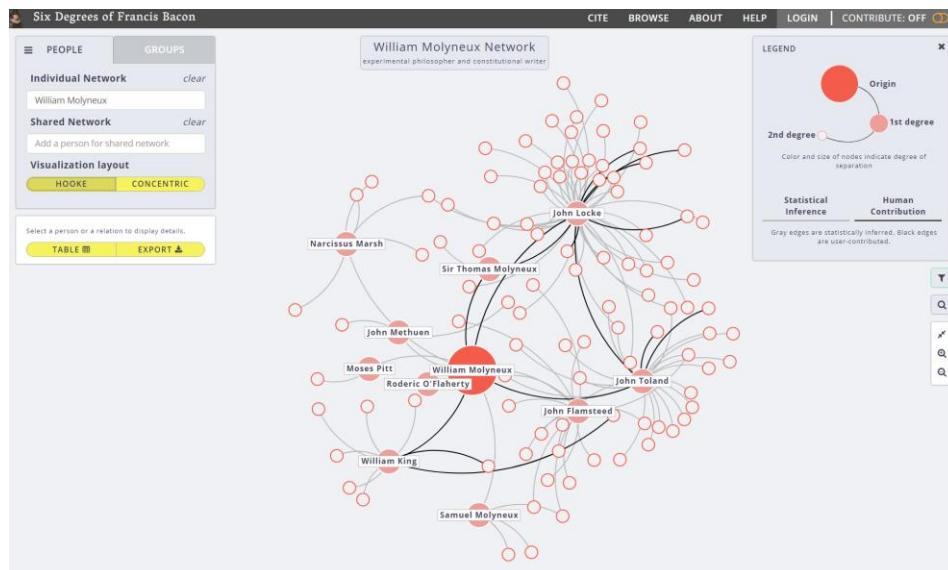


Figure 6. First- and second-degree connections of William Molyneux (SDFB).<sup>37</sup>

<sup>35</sup>See Richard Sharpe, *Roderick O'Flaherty's Letters: To William Molyneux, Edward Lhwyd, and Samuel Molyneux, 1696-1709* (Dublin, 2013).

<sup>36</sup>'Narcissus Marsh Network [2, 1639-1713, 61-100%].' Six Degrees of Francis Bacon. [http://www.sixdegreesoffrancisbacon.com/?ids=10007990&min\\_confidence=60&type=network](http://www.sixdegreesoffrancisbacon.com/?ids=10007990&min_confidence=60&type=network), 20 January 2018.

<sup>37</sup>'William Molyneux Network [2, 1657-1698, 61-100%].' Six Degrees of Francis Bacon. [http://www.sixdegreesoffrancisbacon.com/?ids=10008357&min\\_confidence=60&type=network](http://www.sixdegreesoffrancisbacon.com/?ids=10008357&min_confidence=60&type=network), 20 January 2018.

Both close and distant reading revealed topics of interest discussed among the community. A simple inspection of the texts of the correspondence, minutes, and associated papers yields an impression of patterns of queries. From the first, the DPS identified themselves with the Royal Society in London and with the Baconian principles of that group. This can be seen in their use of Baconian techniques to construct histories of topics of interest, such as those produced to investigate the properties of mineral waters. Some queries were theoretical, such as those directed to the behaviour of materials in solution, discussed by William and Thomas Molyneux. Some were ‘useful’, such as William Molyneux and Richard Bulkeley’s improvements to a type of carriage, following those made by Mr Clignet, a Dutchman resident at Limerick, or William Petty’s rather less successful attempts to build a catamaran to improve transport between Ireland and England.<sup>38</sup> Many of these concepts appeared in the correspondence between the DPS and the circle of their peers.

In conjunction with the description of the networks of relationships, I also explored the topics discussed in the correspondence of the DPS. The options available for mining and/or modelling the content of texts are extensive, although many are designed for much larger corpora, and assume modern language and spelling. Although Natural Language Processing tools have been applied to seventeenth-century texts, most notably in the case of the 1641 Depositions Project, the obstacles faced in those cases were considerable.<sup>39</sup> The modernised text of the *DPS Papers* removed many of these obstacles. Other challenges remained, such as the size of that part of the available corpus chosen for further investigation, which is discussed further below. The combined texts of the minutes, papers and correspondence of the *DPS Papers* (excluding, as mentioned earlier, the later period from 1707 to 1709),

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<sup>38</sup> A long-running thread on transport was begun by William Molyneux, writing to William Musgrave in *DPS Papers* no. 225. See further discussion below.

<sup>39</sup> Mark Sweetnam and Barbara Fennell, ‘Natural Language Processing and Early-Modern Dirty Data: Applying IBM Languageware to the 1641 Depositions’, *Literary and Linguistic Computing* 27:1 (2012), 39–54.

when shorn of their scholarly apparatus, run to some 223,233 words, with the overall size of the correspondence section of the text as examined consisting of 80,261 words, divided into 205 letters of considerably varying lengths. Tracing discussion of topics in natural philosophy between groups in the community by the application of distant reading techniques was an attractive possibility, although the application of any form of distant reading to a small corpus such as this was an experimental treatment. My aim was to afford a possible disruption of preconceived notions by an alternative means of viewing the texts: rather than tagging or keywording the letter-texts manually, I applied a series of digital tools to the texts, with the full knowledge that any results must necessarily be complemented by close reading.

The simplest tool one can apply to a ‘bag of words’ is the word cloud. Exploring the DPS correspondence corpus using one such tool, the Voyant Tools Cirrus component, one very quickly realises that this type of text is not instantly amenable to this type of automated reading. It does, however, emphasise a characteristic of this corpus. These are letters, often between persons representing organisations, with the purpose of communicating minutes of meetings. Although some of the letters are long, many give lists of topics of interest, treated briefly. The first iteration of the Cirrus tool from the Voyant tools suite yielded the cloud seen in Figure 7. This approach also allowed the generation of stop-lists to remove the correspondence-associated terms, including names and some modes of address. The terms are of interest in themselves, revealing the terms of address and cordial relations in this corresponding community and included *honour*, *honoured*, *humble*, *servant*. Terms indicating the general milieu included *minutes*, *society*, *clerk*, *copy*, *discourse*; and terms indicating time included *suddenly*, *lately*, and *immediately*. When the most common words were removed by adding them to the stop-word list, the remaining words showed something more of the nature of the correspondence, with a focus on the society, such as *minutes*, *account*, *received*, *know*, *desire*.



Figure 7. Voyant Cirrus 1



Figure 8. Voyant Cirrus 2

The general sense of correspondence seeking information, which had been derived from close reading was confirmed by this exploration of the ‘bag of words’ and prompted the use of other tools to explore other relationships within the language used by the writers. The simple word frequency tool also pointed to some terms which were both frequent and related to natural philosophy. The most prominent was *air* at 183 occurrences, with *water* at 145 occurrences. *Experiment\**, *trial\** and *observ\** were also common terms, with *account* and related terms such as *report* having appeared in the first word cloud.

Removing the reader further from the text can be achieved by automated topic modelling. The topic modelling tool Mallet was combined with the visualisation tool Palladio with the corpus split into letters, preserving the association between the letter form, with its associated dates and correspondents, and the topics found. The letters are not all in English, and one or two contain lengthy mathematical demonstrations, although it was encouraging to note that Mallet managed to separate these types of text from the others. Progressively removing the terms identified previously as belonging to the group I have loosely termed dictaminals generated a set of word associations which the tool grouped as topics. Familiarity with the texts through close reading allowed me to label these in a quasi-meaningful way. Although the quantitation of these topics within the corpus was used to examine variation, this was only carried out using the most prominent topic detected in each division of the text. It would possibly be more informative (although considerably more complex) to engage with the proportional representation of each topic, but with such a small corpus, the validity of the conclusions would be questionable, and any advantage to be gained over close reading would be minimal. It was evident that the tool could at least distinguish between languages, and the groupings prompted me to examine the variation over time and to explore the discussion of topics in a grouping by society. The core question of who was discussing what with whom was not determined by the use of this approach, but the results suggest that more meaningful analyses may soon be within reach as digital tools approach natural language more closely.

Table of 'topics' generated with Mallet

Topic	Number of letters
gen-observations-experiments	86
months-dictaminals	43
blood-cases-medical	10
insects-nat-hist-horny-girl	8
giants-causeway-fossils-measurement	7
ooke-level-maths	7
irish-elk-rarities	7
lough-neagh-misc	6
barometer-experiments	5
hevelius-sights	5
latin-corr	3
optics-microscopes	3
french-corr	2
geology-archaeology	2
geometry-demo-tollet	2
geometry-measurement	2
land-transport	2
longitude-dispute-hearne	2
vienna-augsburg-ashe	2
nat hist lat	1

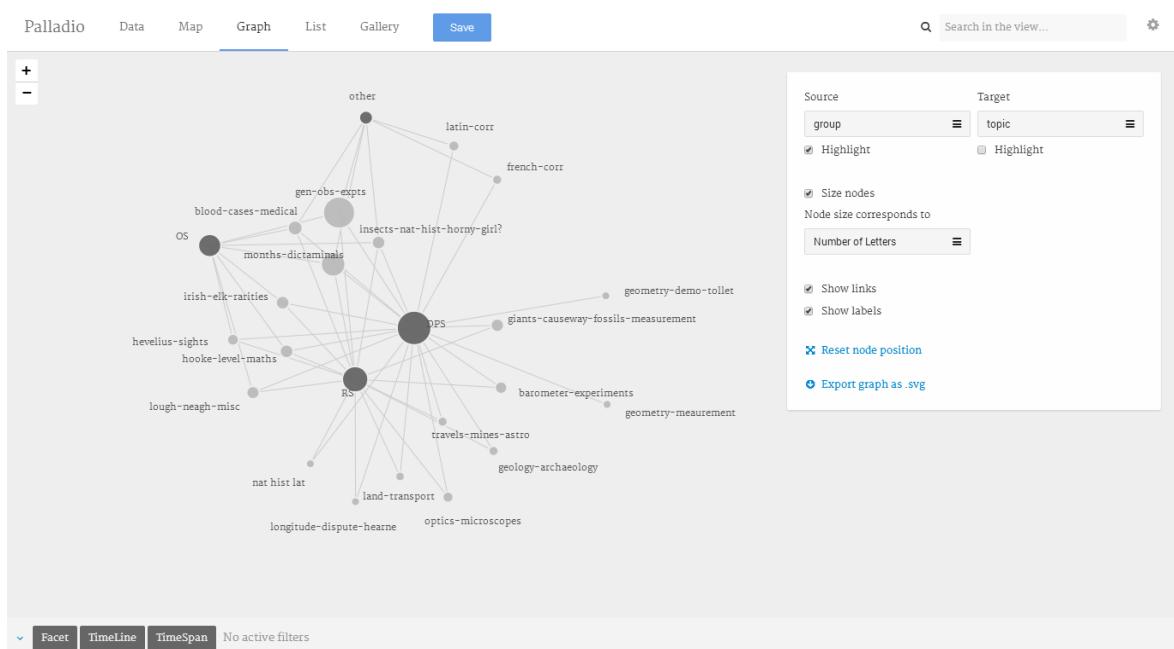


Figure 9. Topics and societies linked by discussion



Figure 10. Grouping of discussions and the distribution of topics over time.

Plotting the development of topics of interest over time formed another facet for analysis. The ‘topics’ detected using Mallet were plotted in Palladio to demonstrate this temporal variation in the material under discussion. Visualisation of the topics in Palladio revealed that the ‘topics’ varied over time in a plausible pattern and were associated with the people and groups expected from close reading of the texts. A visualisation of the topics and the groups as a network is shown in Figure 9. In this graph, the dark nodes represent the groups; the light nodes the topics. Those topics discussed between two of the groups form paired links in this view; the view suggests that those topics showing more links were discussed more widely. Topics in general observations, blood, the remaining dictaminals, and the natural history grouping were discussed between the DPS and the Royal Society, and also with the Oxford Society.

As noted above, a frequent feature of the letters was the compression of many topics into a list. This format resists any automated approach but is evident to close reading. An example of this type of list is found in a letter from Francis Aston of the Royal Society to William Molyneux on 3 April 1684, which listed the topics of interest in the previously sent minutes of the DPS and expanded upon them, which proved to be of interest in itself. The letter expressed particular interest in patterns of crystal growth in salts, previously commented upon by the DPS. Aston mentions a book on the subject by the York physician and member of the Royal Society, Martin Lister (1639–1712), with the hint that he presumes that they have seen it.<sup>40</sup> Publication of DPS items in the *Transactions* is mentioned, and there is a request for a report of progress in experiments on magnets and on the differences between arterial and venous blood. Aston followed this quick succession of subjects with a rather longer account of Lister’s experiments relating to the behaviour of mercury in different atmospheric conditions, in which the (still controversial) weight of the air ‘is not denied, but admitted in the hypothesis’.<sup>41</sup> Similarly, St George Ashe, writing to Henry Dodwell on 31 March 1685, listed many topics together, some of

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<sup>40</sup> Martin Lister had much in common with the DPS: as mentioned in chapter 1. For further discussion of his philosophical activities, and his influence on the DPS see chapters 3, 4 and 5.

<sup>41</sup> *DPS Papers* no. 222.

which (draining bogs, land transport) have a particular significance in the context of colonisation and ‘improvement’, and which echo some of Aston’s previous requests. This letter also noted Ashe’s sense of encouragement through correspondence from ‘those abroad’.

In a corpus this size, which is frequently one-sided and incomplete because of the accidents of survival, it is also important to note that topics which appeared only once, such as the extended discussion of a caterpillar specimen between St George Ashe and Narcissus Marsh, were not detected, while discussion of a general experimental and observational approach was apparent. The illusion of quantitation presented by this type of topic analysis must thus be balanced by close reading. The approach was fruitful in drawing attention to some features of the correspondence, but it is clear from the fact that the majority of letters were tagged with one ‘topic’ that the application of MALLET was, in itself, less successful than I had initially hoped.

As noted previously, one initial path of inquiry which I addressed to the DPS texts concerned how the members expressed themselves, and how their language was used to couch their investigations. Word-clouds and topic modelling, as seen above, showed the discussion of various topics such as a generalised set of experiments, blood, mineral waters and air. I also applied corpus linguistics tools to the language surrounding these philosophical activities. The grouping of terms around human-defined topics (as compared to the less well-defined ‘topics’ detected by MALLET) such as salts, air, water, liquors, blood and magnets as revealed by corpus linguistics provoked thought and led to more intimate examination of the texts, both by close reading and by further digital analysis, in pursuit of the ‘direction finding’ recommended by Scott Weingart. For these additional experimental approaches, I combined the minutes, papers and correspondence to give a larger corpus with which to work (being conscious that this would lead to repetition of material that seemed important enough to the society to record in the minutes and also to discuss in papers and correspondence).

The language used to describe the making of the new knowledge was investigated to evaluate what terms were used to describe action: experiment, trial, query, and observation were key terms identified by their frequency. I also chose to examine description and communication terms such as *account* and *discourse*, which had emerged from the initial word clouds. To carry out these measurements, I chose the online tool SketchEngine.<sup>42</sup> This presents various possibilities for the analysis of texts, with concordance and part-of-speech tagging available. I used an additional corpus to give a comparison with the word use in the combined DPS minutes and correspondence (DPSc), which was the OCR-derived text of Thomas Birch's *History of the Royal Society* (HistRS) available from Google Books.

A particular aspect of interest was the repetition or extension of accounts, trials and experiments in the societies. I found that the words *further* and *farther* were associated with account: in the DPSc, *further* was particularly associated with *account*, within the phrase *a further account of*; in the HistRS this was also the case, with *account: discourse/experiment/observation* being the most frequent associations, followed by *discovery, trial* and *inquiry*.<sup>43</sup> This pattern showed the invitation to repetition and extension of experiments and observations within the discussions of the societies and agreed with my impressions from close reading.

Threading of keywords within the correspondence, which is an intermediate approach between close and distant reading of these correspondence texts, was also used to examine discussions over time, detecting words and phrases with simple SQL queries in the Access database. This is a more satisfactory approach than the topic modelling: it has quantitative elements, and an immediate, functional suggestion for further exploration. Examining particular threads, such as the discussion of the Connough worm, and Lough Neagh, showed that some topics were discussed in short bursts. Another among these was an instance of a 'useful' or 'improving' application of natural philosophy, the issue of transport. The thread was initiated by William Molyneux, sending minutes to William Musgrave.

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<sup>42</sup> Sketch Engine, <https://the.sketchengine.co.uk>. Accessed 1 June 2018.

<sup>43</sup> The modernisation of the text in the DPSc appeared to have replaced 'farther' with 'further'.

Molyneux mentioned both the possible improvements in carriages and William Petty's suggestions for experiments on transport, which Molyneux then sent on to Francis Aston of the Royal Society.<sup>44</sup> William Petty's list of queries and experiments was later published.<sup>45</sup> Later, in a letter to St George Ashe, Richard Bulkeley described the performance of the carriage he had made to Clignet's design, which Ashe then enclosed in a letter to Musgrave<sup>46</sup>. The thread continued with a letter from Bulkeley to Martin Lister a year later, discussing the properties of the materials used in the calash, part of which was then published in 1685.<sup>47</sup>

The reputedly poisonous Connough or Connaught worm, discussed between William Molyneux and Francis Aston of the Royal Society, and then a little later, Molyneux and William Musgrave, resulted in publication, as did the putative petrifying quality of Lough Neagh, which was discussed in a rather larger number of letters. Again, this item was discussed between the secretaries of the societies prior to publication. I explore these latter discussions further in chapters 3, 4 and 5 below, drawing upon other texts to provide further context.

The occurrence of these very specific keywords is to be contrasted with the occurrence of the keyword 'experiment', which had a wider distribution, occurring in 46 of the letters, which is consistent with the Mallet observation. These examples serve to indicate that the Mallet topic modelling had some validity, despite the small corpus, and could yield results consistent with other approaches. However, they also emphasise that more specific questions could be better answered by close reading, and by drawing upon related documents to provide a wider context.

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<sup>44</sup> DPS Papers no. 226.

<sup>45</sup> William Petty, 'Experiments to be made relating to land-carriage, proposed by the learned Sr. William Petty Kt', *Philosophical Transactions* XIV (1684), 666–7.

<sup>46</sup> DPS Papers nos 296, 297.

<sup>47</sup> DPS Papers no. 347. 'Part of a letter from Sr. R.B. to Dr. L. concerning a new sort of calesh', *Philosophical Transactions* XV (1685), 1028-9.

As we have seen, the place of Ireland on the geographical and, for some, the intellectual periphery of the learned world, did not lead to isolation. The members of the DPS sought connection and discussion with their peers, as revealed in the language of their correspondence and minutes, and in the broad scope of their network of connections. In the final section of this chapter, I address the intellectual connections and shared cultural background of the DPS and its wider community, as seen in their engagement with print culture, and with the various modes of investigation and experiment particular to their locality. The chapter concludes with a view of the ‘generative direction finding’, advocated by Scott Weingart as a useful application of digital techniques in historical studies, looking towards the development of discussions in the chapters which follow.

The intellectual life of a community appears in its own correspondence and published writings; in correspondence and other documents relating to connected individuals and communities; and in engagement with print on many levels. Seeking engagement with underlying concepts in the letters of the DPS, I found that many of the letters of the DPS corpus were in an abbreviated and note-like format, lacking explicit intellectual commentary. To seek further details of the concepts considered by individuals within the community, and in keeping with Michael Hunter’s plea for a focus on intellectual contextualisation and attention to the individual in the history of ideas, I turned to a consideration of the intellectual life of the DPS as revealed by instances of texts associated with individuals by authorship, by collection of texts into libraries, or by citation or reference in publications or within private correspondence. This is the more important because in addition to the exploration of topics, language and procedures in natural philosophy itself, the findings of shared concerns and reading afford an exploration of the influence of the colonial environment on the conduct on natural philosophy and its underlying world views. The Anglican affiliations of the vast majority of the members of the DPS invite the consideration of the relationships between Irish Anglicanism and attitudes to empiricism, as proposed by Michael Brown in his

work on the Irish Enlightenment. As we have seen, the philosophical activities of Narcissus Marsh and William Molyneux represented two similar but distinct aspects of the new patterns of acquisition, recognition and definition of knowledge. Here, I explore their shared background as seen in their engagement with print, a background which in turn was shared by the Anglican confessional culture of which they were a part.

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#### Local concerns, wider influences

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In the case of the community of natural philosophers in Ireland, the concepts of experiment and trial, and the topics of those actions, were found to intersect to a large degree with their model community of the Royal Society. Although the topics themselves were similar, the specific role of local contributions to investigation lay in three broad types of investigation which were dependent on collection and collation of data, and so have a *prima facie* case for involvement of a geographically (and, some would argue, intellectually) peripheral group.

Firstly, those topics in natural history specific to the geographical region were dependent on local observation, an example being the queries established by Samuel Hartlib in correspondence with Robert Boyle and followed up consistently by Irish natural philosophers; secondly, topics which required distributed data gathering, such as the observation of astronomical events; and thirdly, the repetition or extension of laboratory and medical trials, which should not (as William Petty noted in his *desiderata*) rely only on single investigators, but should be shown to be reproducible. A survey of previous work on this type of network by Steven Harris took as self-evident that information moved from the local to the general over time. This pattern was seen in the networks of the DPS and its peers, in agreement with the description given by Harris.<sup>48</sup>

The language of the correspondence of the members of the DPS and its circle is

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<sup>48</sup> Steven Harris, 'Networks of Travel, Correspondence, and Exchange', in K. Park and L. Daston, eds, *The Cambridge History of Science* (Cambridge, 2006), 341–62.

characterised by requests for further accounts and trials to expand and test the reproducibility of observations, which is taken up in the chapters which follow. H.F. Cohen has suggested that an important aspect of the early modern culture of natural philosophy was just such a phenomenon of 'procedurally and institutionally established self-correction' in which observations and trials were communicated, examined by many, and repeated. The motto of the Accademia del Cimento, advocating 'provando e riprovando', exemplifies Cohen's claim.<sup>49</sup> Examples of possible mechanisms for this type of feedback and correction have also been proposed by other historians of science. Among these, examples include Giovanna Pomata, who examined the role of 'observatio' in the building of medical networks in the sixteenth century, and Shapin and Schaffer's view of the role of the 'virtual witness' in the seventeenth century.<sup>50</sup> Both invoked the contextual network of the individual in the generation and reception of knowledge. Despite the disparate timeframes of the two studies cited, the concepts described show marked similarities. The DPS community also exhibited similar patterns of investigation and reception of knowledge.

As mentioned previously, some threads which were observed in the correspondence as being long-lived or quantitatively important also resulted in publication in the *Philosophical Transactions* and elsewhere, such as those concerning the Connough worm and the petrifying waters of Lough Neagh. Threading of keywords or key concepts thus emerged as another possible measure of the significance of a topic. The cases of the Connough worm and the petrifying waters are explored further in chapters 3 and 4 respectively.

The communities of natural philosophers in Ireland and England shared a cultural background, which in turn influenced the possible queries and the underlying

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<sup>49</sup> See Luciano Boschiero, *Experiment and Natural Philosophy in Seventeenth-century Tuscany: the History of the Accademia del Cimento* (Dordrecht, 2007); Marco Beretta, Antonio Clericuzio, and Lawrence Principe, eds, *The Accademia del Cimento and its European Context* (Sagamore Beach MA, 2009).

<sup>50</sup> Gianna Pomata, 'Observation Rising: Birth of an Epistemic Genre, 1500–1650', in Lorraine Daston and Elizabeth Lunbeck, eds, *Histories of Scientific Observation* (Chicago, 2011); Steven Shapin and Simon Schaffer, *Leviathan and the Air-Pump*.

motivation of individuals. The engagement with print through collection and citation also revealed characteristics shared with others external to the local group. Despite feelings of disconnection and isolation, members of the DPS such as William Molyneux and Narcissus Marsh were up to date with developments in the wider community. For example, Marsh, although feeling himself to be disconnected from the learned world by his residence in Ireland, nevertheless continued to collect books and manuscripts in his search for truth, while also pursuing an active interest in astronomical events. These two activities coincided in a letter to Marsh's friend, the Oxford astronomer and orientalist Edward Bernard, on 8 April 1679. Beginning conventionally, with an apology for not having written for some time, Marsh quickly moved to a subject of philosophical interest: a solar eclipse.<sup>51</sup> Marsh's complaints about the business which had kept him from writing were extended to complaints about the weather, and about his sense of intellectual isolation in Ireland. This melange of convention, situation, and observation characterises the surviving correspondence of Marsh. A similar melange is to be found in the correspondence of Marsh's community of the 'curious' in early modern Ireland, indicating in itself a shared culture and attitudes.

Marsh's situation also serves to illustrate a wider context and shared culture within the colonial structures of late seventeenth-century Ireland. The Royal Society was strongly connected with government in England, and the DPS, as a largely Anglican grouping whose members had establishment backgrounds, emulated its model in this as in its philosophical practices. As an Oxford-educated divine, connected with government circles and with strong interests in natural philosophy, Marsh might be expected to have much in common with mainstream Anglican thinking, as represented by Edward Stillingfleet (1635–99), whose collection Marsh acquired. For some, Stillingfleet represented the Anglican world view commonly called Latitudinarian, although this label was questioned even at the time, Robert Grove doubting their real existence:

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<sup>51</sup> Marsh to Edward Bernard, 8 April 1679. Bodleian MS Smith 45, f15.

There has been a great deal of talk of late years of a certain sort of Men which they call Latitudinarians: But I could never yet learn who they are, or what they hold, or where they dwell. After so much prattle as hath been about them, I am as unresolved in all these points, as Geographers are in determining the Country of the Pygmies, or Amazons; and, it may be, it is because that indeed there are no such People; notwithstanding all the noise, and the many pretty Stories that have passed concerning them.<sup>52</sup>

More recently, Dmitri Levitin has also questioned this label and its relevance to Stillingfleet's career, which he saw as founded on Stillingfleet's scholarship rather than his churchmanship.<sup>53</sup> Stillingfleet aimed to support unity and rationality in his religious and political milieu, and wrote extensively on the underlying reasons for the avoidance of instability and schism, drawing on arguments for natural religion in particular, and exploring the challenges and supports for traditional religious understandings of the universe and creator which were then emerging from the latest natural philosophy. An Anglican world view deriving from his *via media* might thus be expected to exist in his library and to be reflected in the collection of Marsh. Supporting this expectation of a shared collection, I found that there is an exact overlap (edition as well as title) in 89 cases between Marsh and Stillingfleet's books in the extant collections. This small but significant overlap includes standard works such as Aristotle's *De anima*, but also included John Sergeant's 1698 publication, *Ideae Cartesiana*, in which Cartesian concepts of eternal truths were discussed. In astronomy, significant earlier seventeenth-century works such as Galileo's apologist, Tommaso Campanella (*Apologia pro Galileo, mathematico Florentino*, 1622), in both cases bound with Francesco Sizzi's treatise *Dianoia astronomica* (1611), written in response to Galileo's 'Starry Messenger', and Kepler's *Prodromus ad mysterium cosmographicum* (1621-2) were also held in

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<sup>52</sup> Robert Grove, *Vindication of the Conforming Clergy from the unjust Aspersions of Heresie, in answer to some part of Mr Jenkyn's Funeral Sermon upon Dr Seaman* (London, 1676), 24.

<sup>53</sup> Dmitri Levitin has questioned some of the historiographical assumptions which have been made about Anglicanism at this period: the classification 'latitudinarian' is among those examined, particularly in relation to Stillingfleet, whose career rested on his scholarship. See Levitin, *Ancient Wisdom*, 19-20.

common. Both had copies of Hobbes' *Leviathan* in the 1651 edition. Syro-Chaldaic and Ethiopic dictionaries were both to be found on the shelves of these two divines, with the apparatus of biblical scholarship, chronology, and theological commentary. Both also owned James Ware's *De praesulibus Hiberniae* (Dublin, 1665).

William Molyneux was also aware of a similarly wide circle of thought, as shown by the wide range of references in his published works. In the first 'Experiment' of *Dioptrica*, Molyneux acknowledged an hypothesis published in one of the learned journals. Later, he again cited some of the same authors and their propositions in support of a demonstration. Many of these were authors of whom the circle of natural philosophers and philosophically-aware theologians such as Stillingfleet would have been aware. They included Johannes Kepler (1525–1630), *Dioptrice* (the edition of Augsburg, 1611 was owned by Stillingfleet); the Basque mathematician Pierre Herigone (1580–1643), possibly the *Cours mathématique* (1634–7) of which Marsh owned the second edition of 1644; the Jesuit Claude François Milliet Dechales (1621–78), possibly his *Cursus mathematicus* (1690) also in Marsh's collection; another Jesuit, Honoré Fabri (1606/7–88), whose *Synopsis optica* (1667) was sufficiently popular to be owned by both Stillingfleet and Bouhereau; Cherubin de Orleans (1613–97), *Dioptrique Oculaire* (1671); and Johann Zahn (1641–1707), whose *Oculus artificialis sive Telescopium* was also in Stillingfleet's library. The holding of these works in common by those interested in varying aspects of natural philosophy revealed something of the common intellectual background underlying the development of their world view. Although brief, this list of examples suggests a wide awareness of learning present in the community of natural philosophers in Ireland, belying their sense of peripheral isolation. Molyneux wished to transmit the most recent findings in support of his experiments, which were essentially thought-experiments testing various possibilities. Further aspects of Molyneux's citations are described in Chapter 4, in the context of his discussion of 'useful' additions to the understanding of optics.

In the proceedings of the DPS, experiments were often referred to particular

members for repetition, or for further enquiries to be made: further examples of this are to be found in the chapters which follow. The apparatus of print and citation was drawn upon to support or refute views taken. One such, the ‘impertinent’ proposal of one William Hearne concerning longitude and latitude, was passed to the society’s mathematician, George Tollet, for an answer. This was provided, complete with a comprehensive list of citations from printed sources, referred to as ‘the best writers’, who were explicitly invoked to support Tollet’s claims.<sup>54</sup> The writers cited were given minutely as to edition, page, and even the line, and included those common to the reading of Marsh, as well as Molyneux. These were the Jesuit geometrician Claude Millet Dechales (in common with Molyneux); the Dutch cartographer Willem Blaeu (c.1570–1630), whose treatise on the use of the globe was printed in several editions; another Jesuit mathematician Pierre Gaultruche (1603–1681), whose works were common to both Stillingfleet and Marsh; yet another Jesuit natural philosopher of very wide interests, Gaspar Schott (1608–66); and the geographical treatise of Bernhardt Varen (1622–60), again read by both Marsh and Stillingfleet. The controversy was transmitted to the Royal Society, and an appeasing opinion was given by the mathematician Dethlev Cluver (1645–1708), who concluded that the dispute arose from a misunderstanding.<sup>55</sup> William Molyneux and the DPS held otherwise and the affair still rankled sufficiently with Molyneux to be mentioned in his *Life*, Hearne having taken to print after his argument had been dismissed by the DPS:

After hearing both parties, the Society, by an argument in two written lines which I produced to them, absolutely determined, that the lines of latitude

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<sup>54</sup> The citations on longitude and latitude were referred to as follows: ‘This controversy being about the meaning of a definition, all that can be had or required to determine it is the authorities of the best writers.’ *DPS Papers* no. 295

<sup>55</sup> Birch, *History of the RS* IV, 422: mention of the problem being referred to Mr Cluverus, whose opinion is recorded on p. 423. Christian Bruhns, ‘Clüver, Detlev’ in *Allgemeine Deutsche Biographie* 4 (1876), S. 351–352 [Online-Version]; URL: <https://www.deutsche-biographie.de/pnd128386312.html#adbcontent>. Clüver is also recorded in the Royal Society’s list of fellows and features in the correspondence of Thomas Molyneux as active at the time Molyneux visited London in 1683. Son of the Danzig geographer Philipp Clüver, he studied at Oxford and was a correspondent of Leibniz, writing to him from London in the 1680s and later from Hamburg; correspondence with John Wallis and Pierre Bayle also survives (see EMLO).

run east and west; and the lines of longitude run north and south. This so afflicted poor Hern, who held the contrary, that he published something afterwards in print against this determination, and against the argument which I had produced to the Society, on which they founded their decision: and within a short time, (so great was his concern, as some said,) that he sickened and died.<sup>56</sup>

Information gathered in small samples and case studies, such as those I have chosen from the context of the DPS, has been used to reveal connections in a wider context, as shown by Robert Mayhew's approach to the reconstruction of the intellectual context of early modern science. He used the works cited in just two texts on geography to map the production, dissemination and reception of ideas in what he described as a 'thought experiment ... as a way into questions about the functioning of the scientific community in early modern Europe'. Although his data-set was as small as the samples I chose to illustrate some of the patterns of reading and citation within the community of the DPS, Mayhew's study similarly illustrates the amount of information about a particular culture of knowledge production which can be gleaned from a small number of texts.<sup>57</sup>

The contacts of the DPS with information brokers in the wider community also appeared in their network, resulting in the appearance of material from the DPS in the journals of the learned. Gathering of information from peripheral correspondents, as proposed by William Molyneux as a mechanism to gather knowledge of the natural history of Ireland, already had considerable precedents by the early 1680s. The Baconian ideal had been established in *New Atlantis*, where Francis Bacon's distributed model for collection and processing of knowledge had been clearly set out. Within the groupings of the learned societies, individuals such as Samuel Hartlib (1600–62), Henry Oldenburg (1619–67), and Pierre Bayle (1647–1706) actively sought items of knowledge to be gathered and redistributed. The

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<sup>56</sup> Molyneux, *Life*, 64–5.

<sup>57</sup> Robert Mayhew, 'British Geography's Republic of Letters: Mapping an Imagined Community, 1600–1800', *Journal of the History of Ideas* 65:2 (2004), 251–76.

same distribution networks which carried news of discoveries within the republic of letters also carried news of other sorts, including the political and the secret. The term ‘intelligencer’ was used until the 1640s to signify a collector of information of the more secret sort, and then acquired the additional sense of newsmonger.<sup>58</sup> It came to be applied to those such as Hartlib and Oldenburg, and also to another founder member of the Royal Society, Theodore Haak (1605–90), all of whom disseminated news of discoveries and (from time to time) physical specimens within the circles of the learned. Oldenburg’s activities as intelligencer mirrored the activities of Samuel Hartlib in the previous generation. Both Oldenburg and Hartlib, as migrants from continental Europe, were able to exploit their connections in their places of origin as well as settlement. Theodore Haak is less well known than either Hartlib or Oldenburg, probably because his role in the production of the society’s nascent journal, the *Philosophical Transactions*, was less formal. Described by Thomas Molyneux as a ‘good old man’ when he met him in London, Theodore Haak was generous in introducing the young Molyneux to his circle of connections. John Wallis credited Haak with being the moving force behind the original meetings in London in 1645 which led to the establishment of the Royal Society. Like Hartlib and Oldenburg, Haak was a member of the circle of Jan Amos Comenius (1592–1670), Moravian pedagogue and reformer. Over Haak’s long life (he outlived both Hartlib and Oldenburg) he transmitted many contributions for publication from his continental contacts, as well as books for review. He was a correspondent of the French minim friar and polymath Marin Mersenne and, through him, was in contact with intellectual circles in Paris, all of which served to disseminate ideas both in scribal letters and in print.<sup>59</sup>

In Ireland, members of the DPS and its circle consumed the publications of the learned societies, arrangements being suggested for a Dublin bookseller to carry the

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<sup>58</sup> Joad Raymond, ‘Introduction: networks, communications, practice’, in Noah Moxham and Joad Raymond, eds, *News Networks in Early Modern Europe*, 3.

<sup>59</sup> Haak’s biography is summarised from the available sources in William Poole, ‘A Fragment of the Library of Theodore Haak (1605–1690)’.

*Philosophical Transactions* at a good rate.<sup>60</sup> They were also contributors to these print media, as noted below in detailed accounts of those letters which became publications. The establishment of the printed journals instigated by the intelligencers during the 1660s relied heavily on interpersonal correspondence. Many of the reports published in the journals originated as personal letters, and the form was preserved in the published work, albeit with an altered, formalised language. Henry Oldenburg in his capacity as first secretary of the Royal Society, and Pierre Bayle, who initiated the publication of the *Nouvelles de la Republique des Lettres*, both exemplify the philosophical agencies through which personal correspondence was transferred to the public sphere, with the epistolary form being adopted as the standard published form of learned communication. Contributions were actively sought from the DPS members, with publication discussed in the correspondence.

Natural philosophers and the circles to which they belonged had several purposes for their correspondence: the exchange of observations; the exchange of items of interest; the exchange of ideas and concepts; and the cultivation of relationships such as those of friendship and patronage. The consequences of the geographical dispersion of the network meant that those on the periphery communicated feelings of isolation and separation from 'the learned world' and frequently couched their requests for information in very general terms. In particular, those who were physically on the periphery of their world, like Marsh, wrote to their friends in search of general information perceived as unavailable in their location. But as with Marsh's continuing collection of texts, the active collection and transmission of information observed in the networks belied individual feelings of isolation, and

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<sup>60</sup> As for example suggested by William Musgrave to William Molyneux: 'If a bookseller will constantly take any number considerable, he shall be allowed them at the rate of 9d per Transaction, as they are delivered out of hand.' *DPS Papers* no. 276. This was taken up, as shown in William Molyneux's later letter to Musgrave: 'The enclosed letter is from a bookseller in town, to whom I made your proposal. He willingly accepts thereof, and is resolved from time to time to take off a certain number of the Transactions for the use of this place. Several here are very desirous of them, and when they know that this bookseller has them, they will look no further, for it is difficult to supply some few single persons with this book by itself, but the bookseller, that has parcels of books about 4 or 5 times a year, may convey them to us easily.' *DPS Papers* no. 280.

the members of the DPS found much to engage their peers in the information they sent, prompting requests for ‘further accounts’.

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‘Generative direction finding’: close and distant reading

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The application of digitally-based tools—some derived from social network analysis and some from linguistic analysis—allowed the exploration of the connectedness of individuals and communities in time and space, and afforded an alternative to close reading in discerning the topics which engaged the members of the DPS and its wider philosophical community. The type of ‘generative direction finding’ recommended by Scott Weingart as an outcome of the use of digital tools drew the focus of this chapter back from the digital views of the texts, outlined above, to further close reading of the correspondence corpus and related documents. The results of these explorations assisted in directing the contents of the later chapters of this thesis.

Computer-based tools for the analysis of the texts themselves revealed word clustering and word use which in turn led to a deeper exploration of the relationships between the expression of concepts used and exchanged within the community. The topic modelling, keyword searches and corpus linguistic tools which I applied to the available texts usefully tested assumptions derived from close reading and led to new avenues for exploration, even though the data is incomplete and the conclusions necessarily limited.

It must be observed that this material forms a very small corpus indeed by the standards of the tools used. During development phases of the very many variations of NLP tools, tiny corpora (a few sentences) referred to as ‘toy’ corpora are used, because the expected results from a useful performance by the tool are very clear. The small group of texts used here forms an intermediate stage in the exploration of texts by automated means: it is not as small or clear-cut as a toy corpus, but it does have some expected outcomes derived from various approaches to close reading, grouping findings on topics such as those related to blood, strange

cases in physic, and the observation of the ‘monstrous’ horny girl, which are explored further in the chapters which follow. The dialogue between close and distant reading also stimulated me to explore further such areas as the discussions of a controversy relating to astronomical observation between the Danzig astronomer Jan Hevelius and the Royal Society, and mentions of blood, fossils, and geological specimens also appeared in the topic groupings from the correspondence.

The scope of the spatial relationships within the network, visualised digitally, encouraged a wider reading of the role of observations made from the geographical periphery of colonial Ireland, where Robert Boyle found himself lacking in ‘hermetic thoughts’ and Narcissus Marsh considered himself to live ‘out of the way of learning’.<sup>61</sup> Although the sense of isolation may have been particularly strong among those on the colonial periphery, others from the learned world recognised the dynamism of English learning at the period, requesting news from that intellectual centre. For example, Marsh’s close friend and regular correspondent, the astronomer and orientalist Edward Bernard (1638-96), was also in correspondence with the Lübeck theologian Justus Christoph Schomer (1648-93) who, like Marsh, requested news of doings in England when he returned home after a visit to Oxford, alluding to the esteem in which English learning of the time was held in Germany.<sup>62</sup>

Examination of the networks by digital tools also returned my focus to the individuals who formed the community, and to their intellectual and personal connections. The trust arising from personal ties conferred credibility on observations and information gathered from relatives of members of the DPS, and from other individuals who were of good reputation. Further exploration of the texts also revealed connections with those such as booksellers, whose roles in transfer of information are not captured by simple top-level correspondence

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<sup>61</sup> Boyle to Frederick Clodius, between April and May 1654, Boyle *Correspondence*, vol. 1, 165-168 (quote from p. 166); Marsh to Thomas Smith, 30 August 1698, Bodleian MS Smith 52 fols. 67-8.

<sup>62</sup> Schomer to Edward Bernard, 26 June 1676, Bodleian MS Smith 8 fols. 71-4.

metadata. The close ties of kinship between the Molyneux brothers were echoed in the expressions of brotherhood and affection evident in the signatures of Marsh's letters addressed to his Oxford connections. Expressions of honour and respect in forms of address were undoubtedly conventional, but nevertheless indicated a culture of esteem for the opinions and information exchanged within the community. This environment of trust did not preclude disagreement. From time to time, misunderstandings and disputes arose over interpretation of results, which were sometimes discussed at third hand, as in the case of a dispute over the use of telescopic sights versus the naked eye for astronomical observations (discussed further below in Chapter 4), and the energetic discussion of longitude, occasioned by a paper submitted to the DPS. As mentioned above, the dispute on longitude gave rise to correspondence from George Tollet, citing all the authorities he could muster to support his case, but was referred to a mathematician in the Royal Society, Dethlev Clüver, for review. This type of dispute and the discussions of matters of interpretation yielded glimpses of the 'self-correction' mentioned by H. Floris Cohen as a fundamental characteristic of the philosophical community.

In making the case for a reconstruction of the community of the Republic of Letters, Howard Hotson argued strongly that the information available from correspondence corpora cannot be considered complete when only the letters are included. Hotson's concept of reconstruction took as one of its models the *Via lucis* of the Moravian pedagogue, philosopher and newsgatherer Jan Comenius, mentioned above as one of the influences on Theodor Haak.<sup>63</sup> In the context of my study of the community of natural philosophers which made up the DPS, Michael Hunter's long-standing argument for a view of the individual in the discussion of developments in intellectual history supported the capture of data related to linked concepts from print and manuscript sources other than correspondence, drawing on the conceptual development of individuals as an enrichment of the textual information. Moving from close reading of the correspondence to examples of the

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<sup>63</sup> Howard Hotson, 'Highways of Light to the Invisible College: Linking Data on Seventeenth-Century Intellectual Diasporas', *Intellectual History Review* 26, no. 1 (2 January 2016), 71–80, <https://doi.org/10.1080/17496977.2015.1032123>.

texts connected with individuals through citation and collection indicated possible further directions for investigation of the religious, political and social environment in which philosophical developments and discussions took place.

The allocation of the material discussed to topics or subject headings, as revealed in the correspondence was of particular interest, as I hoped to be able to describe exchanges on topics between individuals. This aspect of my research emphasised the list-like structures in many of the letters, and the breadth of the disciplinary divisions applied by the writers themselves. Even the ‘unsucceeding experiments’ in trialling various digital tools such as TextTexture (now superseded by Nodus) found a sense of success in providing different areas of focus for close reading<sup>64</sup>. The use of alternative visualisations of the text, such as alluvial diagrams and text networks, and keyword-in-context tools of the corpus linguistics suites, disrupted initial readings and suggested alternative foci for exploration. Avenues for further work, beyond the scope of the present study, also arise: the honorifics, dictaminals, and the language of intellectual patronage which ensured the functioning of the network might in themselves repay further study.

In advancing to more detailed descriptions of areas of interest for the DPS and its community, the directions found by the combination of close and distant reading applied in this chapter stimulated the choice of the broad topic groupings discussed in the succeeding chapters. The breadth of the discussions found in the correspondence informed a similar breadth in the division of the chapters and of concepts. Natural history, discussed in Chapter 3, explores the emerging grouping of descriptions of local animals and plants, together with nature ‘out of course’ in monsters, marvels and odd cases, and the description of form and function in creatures as revealed by the new technologies. The heavens and the earth, in the forms of astronomy and fossils, creation and chronology, and their dialogue with religious and political stability are discussed in Chapter 4; and Chapter 5 describes laboratory processes, with their broad implications for the understanding of the

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<sup>64</sup> See Appendix for discussion of this and other tools trialled.

underlying detail of the functioning universe as well as the immediate concerns of cure and utility. These groupings also draw together observational styles, with varying roles for those on the periphery: natural history, broadly descriptive; observation of the cosmos, frequently collaborative; laboratory processes, seeking reproducibility and exchange of accounts.

The significances, or matters of note, which emerge from examination of the texts hover between the quantitated and the qualitative, the descriptive and the measurable. This remaining record of the activities of these natural philosophers is imperfect through the accidents of history but in the words of Robert Huntington in the second letter of the extant corpus from the DPS: ‘you are merciful to us when you promise us straw, something to work upon’. This chapter has shown that there is a little more than straw. To return to the initial question, posed above, as to how the community regarded itself and its place in the network of the learned world, their own language can show, at least, that they observed natural productions; considered the heavens and the earth; performed laboratory operations; and, above all, communicated their findings, asking and being asked for repeated observations and extended accounts. The detail and diversity of these proceedings form the topics of the case studies examined in more detail in the following chapters.

## CHAPTER 3

### WITNESSING NATURE

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*Sir, I thank you for the insect you sent and for the letter that accompanied it ...<sup>1</sup>*

*I can read more Divinity... on a Box of beautiful Shells, of delicately painted Plants, curiously adorned Insects, Serpents, Birds, or Minerals; than in large Volumes of Notional Writers.<sup>2</sup>*

In 1685, probably while residing in his diocese of Ferns and Leighlin, Narcissus Marsh wrote a long letter to his friend and fellow founding member of the DPS, St George Ashe (1658–1718), then Professor of Mathematics at Trinity College Dublin.<sup>3</sup> Ashe had received a specimen of a caterpillar from a correspondent, which he had passed to Marsh for his opinion. Both Marsh and Ashe were interested in identifying the creature and its adult form. The observation of nature was sufficiently important to the DPS that the society formed the intention of examining groups of animals and plants to add to their account of Ireland. Each grouping of organisms was assigned to a particular member or partnership of members. Although almost nothing remains of this project but a couple of lists, it saw the society set up a grand experiment to assemble information about particular aspects of the natural history of various regions of Ireland, modelled on a pattern inherited by the Royal Society from Francis Bacon. Describing the renewed attempt in 1694 (which seems to coincide with the extant lists), Ashe wrote to his friend, mentor and relative, the theologian Henry Dodwell (1641–1711), telling him:

Our Philosophical Society (which is again revived) do begin to busy itself usefully in the search of natural history, we have published Queries, & dispersed 'em through all the counties of the kingdome & daily receive

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<sup>1</sup> Narcissus Marsh to St George Ashe, 19 June 1685, *DPS Papers* no. 288.

<sup>2</sup> Molyneux, *Dioptrica*, 273–4.

<sup>3</sup> In 1692, Ashe became Provost of Trinity, before taking up a series of ecclesiastical appointments.

pertinent accounts which may in time enable us to furnish out an accurate natural history of this kingdome.<sup>4</sup>

Within the Royal Society, the pursuit of descriptive natural history caused a dispute between those intent upon ‘ranking and filing’ of natural objects, and those with an experimental style of investigation, and a focus on utility. As we shall see later, William Molyneux found himself firmly on the side of those in favour of experiment.

In this chapter, I explore the reporting of cases in natural history by the DPS and its circle, which shows their application and extension of that Baconian programme of enquiry, and also how, from time to time, the apparently personal communication of ‘matters of fact’ in natural history became the material of public presentation in print. The first section of the chapter examines three cases of description of insects, which raise different questions, while having points in common: firstly, about the absence of poison or venom from Ireland, in the case of the ‘Connough worm’; secondly, Marsh’s interest in the classification of a caterpillar, raising questions of taxonomy; and thirdly, Thomas Molyneux’s account of an economically important beetle and its geographical distribution. A further aspect of the Baconian programme of the DPS is examined in the second section of the chapter, where the investigation of monsters and marvels, and of strange cases in medicine, are seen to take up Bacon’s recommendation to seek an understanding of nature when ‘vexed’. The DPS and its circle observed oddities and ‘pretergenerations’, collecting both specimens and accounts of cases, and the detailed workings of natural bodies were examined by dissection and by *in vivo* experimentation. The final section of the chapter gives an account of how the collection of ‘matters of fact’ in natural history arose from and contributed to the cycle of arrangement of knowledge and further enquiry. The collection of both items and observations were subject to an emerging methodisation current at the period, when both knowledge and its manifestations were being arranged, revised and systematised in various ways. Indeed, this was a

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<sup>4</sup> Ashe to Dodwell, 4 July 1694. Bodleian MS Eng Letters c. 29, 79.

necessary part of the process envisaged by Francis Bacon in his *New Atlantis* (1627): the description of Salomon's house assigned different roles to those who organised results, those who built upon them for use, and those who were called 'interpreters of nature'.<sup>5</sup>

As noted in the previous chapters, the publisher Moses Pitt had planned to collate a broadly-based natural history of Ireland, with the twin aims of satisfying the curiosity of the learned and leading to improvement of the kingdom, this plan being one of the factors which spurred the development of the DPS under William Molyneux. These interests were not new: questions as to the nature of the country, its climate, products, people, and mores had been raised in correspondence between Samuel Hartlib and Robert Boyle some thirty years prior to the existence of the formally-constituted DPS. The pattern of these queries conformed to the Baconian pattern of 'history-taking' and generated collections of facts, assembled in accounts and lists, and collections of physical specimens, which were assembled in repositories by the learned societies. A culture of exchange of specimens and accounts of them, both those typical of a particular locality, and those considered unusual, together with the exchange of facts witnessed by individual philosophers, contributed to the development of ideas about nature within their circle, whether locally or further afield.

As mentioned in the introduction to this thesis, William Molyneux had characterised experiment as 'matter of fact' in the preface to his *Sciothericum Telescopicum*, adding that findings made by experiment were so strong as to be undeniable. Another route to matters of fact lay in experience and observations of the natural world. Accounts of those items considered wonders or marvels – examples from the experience of the DPS were an extraordinary stag, a horny girl, and a double cat – were paired by the community of the curious in Ireland with descriptions of the everyday. A further means of gathering matters of fact was to observe the workings of organisms by dissection, or by experiments which changed

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<sup>5</sup> Francis Bacon, *New Atlantis: A Work Unfinished* (London, 1627), 33.

the normal functioning of the organism. The many-fold and changing nature of the concept of fact, as understood by the Royal Society, was noted by Daston and Park, who argued that ‘marvels played a brief but key role in forging a new category of scientific experience: the fact detached from explanation, illustration, or inference’.<sup>6</sup> How far that description matched the practice of the DPS is debatable, but certainly accounts of the unusual were gathered as being of interest, while being balanced by detailed observation of more usual natural phenomena.

The collection and organisation of information about nature in all its variety was a lively issue for the wider philosophical community in the late seventeenth century. Regional variation conferred a role on local societies, who could become witnesses to natural diversity, as envisaged by Bacon in his dispersed model of data collection. In the period just before the establishment of the DPS, both Robert Boyle and William Petty wrote lists of queries designed to be answered by sailor and savant alike in the gathering of knowledge about the various regions of the world which were then being further explored and exploited for trade by Europeans. The lists of desiderata and queries compiled by William Petty, which covered requirements for philosophical activity, as well as queries to be used in the investigation of mineral waters, are examples of this type of structured enquiry within the DPS. Indeed, lists which were designed to structure enquiry are all that remain of their projected continuation and expansion of the natural history of Ireland. These surviving lists represent the third iteration of those earlier queries, addressed to Robert Boyle in 1654 by Samuel Hartlib, in which he listed differences observed in the natural history of England and Ireland, seeking the underlying causes.<sup>7</sup> Queries such as these could most easily be answered by philosophers in the locale, able to observe these things at first hand. In further emulation of the patterns found in *New Atlantis*, the circulation of specimens, such as the caterpillar discussed by Marsh, could afford opportunities for deeper consideration of their place and role within

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<sup>6</sup> Lorraine Daston and Katharine Park, *Wonders and the Order of Nature, 1150-1750* (New York, 1998), 220.

<sup>7</sup> Hartlib to Boyle, 18 May 1654, Boyle *Correspondence* 1, 169–179.

creation, as well as for observation and description of local occurrence and behaviour.

Woven through this fact-gathering and observation was the social aspect of the societies. Strongly-held views on philosophical matters were negotiated, as were personal relationships and matters of priority in discovery. Description of natural objects and phenomena was also coloured by the economic and political context. Notably, a strong awareness of difference in practice between colonial English and native Irish traditions can be seen in some of the reports.

### Nature's watches

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For the seventeenth-century natural philosopher, insects came to increasing attention, possessing an unusual conjunction of properties. They were small; their purpose in creation was hard to discern; their origins and reproduction were enigmatic. As Brian Ogilvie has described, insects remained a relatively neglected order until Thomas Penney's mid sixteenth-century notes, with further notes by the English Aristotelian Edward Wotton (1492–1555) and the prominent Swiss natural historian Conrad Gesner (1516–65), were published as part of Thomas Moffett's posthumous *Theater of insects* (1634). Thomas Penney's grouping embraced all terrestrial arthropods, and even some annelid worms.<sup>8</sup> Before the Dutch physician and anatomist Jan Swammerdam (1637–80) published his *Historia insectorum generalis* in 1669, only Ulisse Aldrovandi's *De animalibus insectis* of 1602 and Moffett's posthumous work (in Latin or English) were in general circulation among the learned. In Italy, the physician Francesco Redi (1626–97), and the microscopist Marcello Malpighi (1628–94), who became known for a study of the silkworm, pursued description and delineation of insect development.<sup>9</sup> The microscopical examination of insects by Antoni van Leeuwenhoek in Holland, by Malpighi, and

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<sup>8</sup> Ogilvie, *Science of Describing*, 50–52.

<sup>9</sup> Redi's studies of the generation of insects, framed to show that spontaneous generation did not occur, was published in Italian in 1668 and then in Latin: Francesco Redi, *Experimenta circa Generationem Insectorum* (Amsterdam, 1671). Malpighi's study of the development of the silkworm, *Dissertatio Epistolica de Bombyce*, was published by the Royal Society in 1669

by Robert Hooke of the Royal Society in London also led to wonder at the detail of their structure.<sup>10</sup> A key text for the DPS was that of Jan Goedaert (1617–68), a printmaker and artist from Middleburg in the Netherlands, who became active as an entomologist. The original version of Goedaert's comprehensive book on insects was published in Latin at Middelburg in 1662. The version which became known as 'Godartius of Insects' was published in York in 1682, 'done into English and methodized' by the English physician, Martin Lister (1639–1712). As mentioned briefly earlier, Lister had not a little in common with his Dublin readers, in that he was a provincial member of the Royal Society and also a member of his local circle of the curious (known as the 'York Virtuosi').<sup>11</sup> He is probably now best known for his work on molluscs, but also wrote widely on spiders and other insects, salts, earths, stones and fossils. He recognised the value of Goedaert's treatise but was not convinced that it had ever been intended for publication. For his new 'methodized' English version, Lister had all the plates newly engraved by Francis Place, at his own expense, about which he grumbled in the preface, saying that only 150 copies were to be produced and complaining that the artist's work in natural history was not valued as it should be.<sup>12</sup>

More abstract philosophical attentions also turned to the insect world later in the seventeenth century. For example, in his *Dialogues*, first published in 1688, the Cartesian Nicolas Malebranche (1638–1715) gave his protagonist Theodor a defence of interest in insects. Unmentioned in the creation narrative, these 'products of corruption' along with some other disregarded creatures were nevertheless 'admired by angels' and instructive in themselves.<sup>13</sup> As with much else emerging from the observations and explications of natural philosophers, the characteristics of the insect world raised more detailed issues attracting theological discussion. In the context of the DPS and Royal Society, who as we have seen in the introduction

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<sup>10</sup> Antoni van Leeuwenhoek, *Anatomia, seu interiora rerum* (Leiden, 1687); Robert Hooke, *Micrographia* (London, 1667).

<sup>11</sup> Anna Marie Roos, *Web of Nature: Martin Lister (1639-1712), the First Arachnologist, History of Science and Medicine Library* (Leiden, 2011).

<sup>12</sup> Jan Goedaert, *Of Insects* (London, 1682), 'To the Reader' (unnumbered).

<sup>13</sup> Nicolas Malebranche, Nicholas Jolley (ed.), David Scott (trans.), *Malebranche: Dialogues on Metaphysics and on Religion* (Cambridge, 1997). Dialogue XI, 211.

to this thesis, were so strongly connected with the established church, an Anglican view of interest was articulated by the theologian Edward Stillingfleet (1635–99). Stillingfleet drew on the latest writings on insects from Francesco Redi, from Lister's translation of Goedaert, and from Robert Boyle and John Ray, as well as the writings of the ancients, to illustrate arguments about spontaneous generation and the interior anatomy of these small creatures, arguing that

Some of our own most diligent inquirers, after all their searches, declare that they can find no such thing as a spontaneous generation of animals; and I remember I have formerly read a discourse in MS. of Mr. Boyle's to that purpose. Our ingenious and learned Mr. Ray positively affirms, That there is no such thing in nature as equivocal or spontaneous generation; but that all animals, as well small as great, are generated by animal parents of the same species with themselves.<sup>14</sup>

The writings of Robert Boyle on insects, which were cited by Stillingfleet, appeared in both his *Essay on the Usefulness of Natural Philosophy* (1663) and in the later *Christian Virtuoso* (1690), in both cases using the example of the insect order in the argument for the creator from design. One of Boyle's descriptions united the recognition of mechanism (as articulated by Descartes and his school) using the metaphor of a watch, with the acknowledgement of the organising force of the deity:

God, in these little Creatures, oftentimes draws traces of Omnipotence, too delicate to be liable to be ascrib'd to any other Cause ... my wonder dwells not so much on Natures Clocks (if I may so speak) as on her Watches.<sup>15</sup>

For the Irish community of natural philosophers, the characteristics of insects could excite local curiosity, as in the case of the allegedly venomous Connough worm, or give rise to detailed considerations of classification, as in the case of the caterpillar sent to Marsh; or be of economic importance, as Thomas Molyneux reported in the

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<sup>14</sup> Edward Stillingfleet, *Origines sacrae, or a rational account of the grounds of Christian faith, as to the truth and divine authority of the scriptures, and the matters therein contained* (London, 1663), 23, and ch.1 passim.

<sup>15</sup> Boyle Works 1, 223.

case of the beetles which appeared in immense swarms. All, as works of the creator, inspired wonder in their observers at the intricacy of their existence.

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### The venomous worm and the ravenous beetle

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Ireland, it was reported, was somehow inimical to venomous creatures. Samuel Hartlib's 1659 publication on husbandry, intended to encourage improvement in agriculture, included a section on Irish methods in particular, with a set of interrogatories about Ireland. One of these was a query about 'Particular observations of the Antipathy of the Irish earth and Aire, against all poisonous creatures'<sup>16</sup> Hartlib's 1654 letter to Boyle also expressed curiosity as to the differences between the animal species seen in Ireland and those in England. The basis of Hartlib's endeavours to complete the natural history of Ireland, which had been begun by the Dutchman Gerald Boate, were undertaken (according to the title page of the book as eventually published) 'for the Common Good of Ireland and more especially, for the benefit of the Adventurers and Planters therein'.<sup>17</sup> It is very evident that these recurring queries had their basis not only in philosophical curiosity, but in the desire for improvement in the colonial territories.<sup>18</sup>

This query about venomous creatures, as well as one relating to petrifying waters, re-emerged in the correspondence of the DPS with the Royal Society, and the topic was deemed of sufficient interest for material from William Molyneux's letters on the subject to be published in the *Philosophical Transactions*.<sup>19</sup> The Connough (Connaugh or Connaught) worm was reputed to be the only poisonous creature

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<sup>16</sup> Samuel Hartlib, *The compleat husband-man: or, A discourse of the whole art of husbandry; both forraign and domestick. Wherein many rare and most hidden secrets, and experiments are laid open to the view of all, for the enriching of these nations. Unto which is added A particular discourse of the naturall history and hubandry [sic] of Ireland* (London, 1659), 'Alphabet of Interrogatories', 'P'.

<sup>17</sup> Gerard Boate, *Ireland's naturall history being a true and ample description of its situation, greatness, shape, and nature* (London, 1652), t.p.

<sup>18</sup> As discussed in more detail in Chapter 1. For Worsley and Winthrop, see also Walter Woodward, *Prospero's America: John Winthrop, Jr., Alchemy, and the Creation of New England Culture, 1606-1676*, (Chapel Hill NC, 2010), 259.

<sup>19</sup> William Molyneux, 'A Letter from William Molyneux Esq. Secretary of the Philosophical Society of Dublin, to a S. of the R. S. Giving an Account of the Connough-Worm', *Philosophical Transactions* 15 (1685), 876-79.

native to Ireland, causing poisoning in cattle and occasionally in other animals. In the DPS minutes of 3 November 1684, Allan Mullen was able to report that he had tried the effects of parts of the Connough worm on dogs, giving one the juice and another the skin of the worm, testing the idea that it was the hairy skin of the caterpillar which generated the effect. He found that the dog given the juice survived but the dog given the skin died within two days.<sup>20</sup> A rather less definite account of this experiment was included in William Molyneux's letter to Francis Aston (then secretary to the Royal Society) on 6 October 1684. This letter formed the basis of the publication in *Philosophical Transactions*, with some additional material taken from a later letter from Molyneux to Aston. This referred to

the imperfect account of our Connaugh worm, since which I have again seen Goedartius Of insects, and [in] him I find (as in that letter I surmised) our Connaugh described by the name of the elephant caterpillar, Numb. 125 or 126, I cannot exactly remember.<sup>21</sup>

The doubts expressed in this later letter as to the exact number given in Goedaert for the elephant caterpillar did not make their way into the 'P.S.' section of the published letter, which was presented as though it had been one letter.<sup>22</sup>

Birch recorded a discussion at the Royal Society on 26 November 1684 at which Molyneux's letter of 6 October was read (Birch ascribes it to William Musgrave but it is clear that this is an error). In the ensuing discussion at the meeting of the Royal Society, Martin Lister, whose particular interest in insects was well known in the Royal Society, gave it as his opinion that naked caterpillars were seldom poisonous but that the hairy ones often were.<sup>23</sup> In response to the discussion, Francis Aston wrote to William Molyneux on 11 December, mentioning Lister's opinion and asking for a repeated trial of the poisonous action of the worm with added detail:

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<sup>20</sup> DPS Papers no. 38.

<sup>21</sup> DPS Papers no. 251.

<sup>22</sup> William Molyneux, 'A Letter from William Molyneux ... Giving an Account of the Connough-Worm'

<sup>23</sup> Birch, *History of the RS*, IV, 335.

It was recommended to try again whether the Connaught worm would poison inwardly. It was said the hairiness of a caterpillar makes the poison.<sup>24</sup>

The Dublin group recorded in the minutes of their 12 January meeting in 1685 that the scarcity of the worm would very likely hinder them from making any advances in trials and that appears to have been the case, as no further experiments were reported.<sup>25</sup>

The letter as published by the Royal Society described the different practices of the English and Irish husbandmen to cure the effects of poisoning by the worm, the English resorting to drafts of Galenic or Helmontian character, and the Irish to sympathetic medicine, in which the ‘worm’ was sealed into a tree. Water in which the leaves or bark of that tree had been immersed was said to have a curative virtue for ever. A similar virtue was said to be conferred on any person who bruised a worm between his hands and let the juice dry on them: ever after, the water in which his hands were first washed in the morning was believed to be curative. Molyneux was dismissive of these cures and of the alleged poisonous nature of the worm, saying that its ugly appearance and large size compared to other caterpillars contributed to its reputation for venom. Martin Lister told the Royal Society meeting that the remedy used by the Irish against the venom of the worm was similar to that used against the ‘nurshro’, or field-mouse.<sup>26</sup>

William Molyneux made his report largely at second hand. He did not give the name of his correspondent but a letter reportedly extant in the collection of the Molyneux papers in Trinity College Dublin in 1914 contains sufficient of the facts as recounted by Molyneux to be very probably the source of his information. It was written to Molyneux by his cousin Nicholas Dowdall, who dated his letter at Greenehall, 4 October 1684. <sup>27</sup> Molyneux referred in his 25 November

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<sup>24</sup> DPS Papers no. 254.

<sup>25</sup> DPS Papers no. 46.

<sup>26</sup> Birch, op.cit.

<sup>27</sup> The letter was transcribed in full by William F. De Vismes Kane in ‘The Cattle Disease Called the “Connogh,” and Its Traditional Cure by Amulets and Charms’, *The Journal of the Royal Society of*

correspondence with Aston to 'a letter from a Mr Stanley' but this may have been additional information. This thread of discussion illustrates an exchange which encompassed the gathering of information from third parties, discussion between the societies and within them including the recommendation of further experiments, and a publication drawn from correspondence.

Thomas Molyneux's description of the ravenous swarms of beetles which had first made their presence felt in Ireland during the summer of 1688 is another example of a publication which was originally cast as a personal communication. This 'piece of natural history', written as if to St George Ashe in 1697 (by then, Ashe was Bishop of Clogher), was enclosed by Thomas Molyneux's brother William in a letter to John Locke in January 1697, with the following instruction, which does somewhat echo the distaste William Molyneux had expressed for these aspects of natural philosophy:

You may send it by the Penny-post to the Royal Society, to fill up an empty page in the Transactions. There is nothing to recommend it, but its being exactly True, and an Account of a Non-descript Animal. Formerly I had a Constant Correspondence with the Secretary of the Society, but of late it has faild; and therefore we take the Liberty of sending this through your [h]ands.<sup>28</sup>

The letter described swarms of biblical proportions, which had not been observed by Thomas Molyneux in person, but reported to him as a phenomenon worthy of Ashe's interest. As with many of the publications in the Royal Society's journal, this supposedly personal letter contains detailed explanatory material directed to the reader of the journal, rather than the original addressee. An assurance of the authenticity of what is to be presented was given as follows:

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*Antiquaries of Ireland, Sixth Series* 4:2 (1914), 143-7. The author thought that it was addressed to William's father, Samuel Molyneux, but it is much more likely that it was in fact addressed to William.

<sup>28</sup> Locke, *Correspondence* 5, 746-48. The dispute over natural history in the Royal Society at this time, and the precarious nature of its existence and administration, is discussed further later in this chapter.

I shall not trouble your Lordship with bare *Hearsays*; the following Account is what I took up upon sure Grounds, and what was generally confirmed to me, by the Relations of more than one; and I must here own myself especially obliged, for a great part of my Information, to a Letter, your Lordship did me the Favour to procure, from one of your Acquaintance on this Subject.<sup>29</sup>

The insects were reportedly so numerous as to darken the sky. Molyneux described the sounds that the swarms made while flying as ‘a strange humming noise, like the beating of drums at a distance’ – and while eating the leaves on every tree so that the branches were as bare as in winter – ‘a Sound very much resembling the sawing of Timber’.<sup>30</sup>

The swarms reportedly had difficulties in wet weather, when they fell from the trees to become food for waiting pigs and hens, who ‘ate them up in abundance’, and also for ‘the Poorer sort of the *Native Irish* [who] had a way of dressing them and lived upon them as Food’. Means of abating the attack on crops were sought and it was found that smoke would clear them from gardens and orchards. The swarms did not last long and would vanish completely towards the end of summer. The question as to how the insects passed the winter was raised, with some of Molyneux’s reporters suggesting that the insect was migratory and would go south for the winter as some birds were by that time known to do. Molyneux himself considered it likely that the beetles hibernated, both as adults and as their pre-adult stage (imago). He supported this theory with observations of large numbers of them found underground, even in previously undisturbed earth. Saying that some had called the infestation ‘locusts’, particularly by reason of the amount of damage they inflicted, he continued by describing the beetle as a member of the Koleoptera, with hard cases over its wings, and showing that it was not a true locust. He referred

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<sup>29</sup> Thomas Molyneux, ‘A letter from Dr. Thomas Molyneux, Fellow of the Royal Society, to the right Reverend St. George, Lord Bishop of Clogher; concerning swarms of insects, that of late years have much infested some parts of the province of Connought in Ireland’, *Philosophical Transactions* XIX (1697), 741–56, 742.

<sup>30</sup> *Ibid.* 743.

firstly to Aristotle; then to Ulisse Aldrovandi, Thomas Moffatt (citing the Latin version), and Walter Charleton; and also to Martin Lister's version of Goedaert, from whom he took an illustration, saying that it would give a better idea of the appearance of the creature than a long verbal description could. He also gave the common names for the creature in both French and English. A defence of this long paper about an insect seemed important to him, and in giving that defence, this letter again steps into a public mode. It is unlikely, given his other interactions in the DPS, that Ashe would have needed to have the letter's contents justified to him, but Molyneux defended it firmly against the 'pleasant scoffing Men in the world' who would take it upon themselves 'to say, what an extravagant Folly this is, to make so many words, and keep all this ado, about a poor contemptible Fly', and continued with a biblical exegesis showing that these 'bruchoi' are also mentioned along with the true locust, their name being derived from the sound they make. The philological exposition mentions not only the biblical sources but also Furetière's *Dictionnaire Universel*, published in 1690.<sup>31</sup> Through a long discourse, Molyneux allowed that the '*Native Irish*' unwittingly imitated their biblical forebears by eating the beetles; but he also reported that some of the

barbarous *Irish*, though Christian [entertained] several superstitious Fancies of this Vermin ... some imagining that they were the Souls of their deceased Friends killed in the battle of *Aghrim*, come in this manner by way of Transmigration, to infest their enemies, the *Heretick English*, because they saw that they were the most disturbed and suffered the greatest losses by them.<sup>32</sup>

Molyneux refuted this tale by saying that the English only appeared to lose more because their lands were more improved and so 'offered them the best Provision'. He acknowledged this lengthy passage as 'Physico-Theological Notions' and left them to his correspondent's evaluation. The description of this insect, its economic

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<sup>31</sup> For an account of this dictionary, which contained many technical and scientific terms, see John Considine, *Academy Dictionaries 1600-1800* (Cambridge, 2014), 47ff.

<sup>32</sup> Thomas Molyneux, 'A letter from Dr. Thomas Molyneux ... concerning swarms of insects', *Philosophical Transactions* XIX, 755.

ravages, its scholarly context, and the description of the response of the ‘barbarous Irish’ illustrates the breadth of the considerations evoked by the witnessing of natural phenomena, a facet of the activities of the members of the DPS and its community which will be discussed further below.

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### Marsh and the caterpillar

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The correspondence between St George Ashe and Narcissus Marsh about the specimen of a caterpillar was a rather different type of query, evoking a different level of response. For the extended natural history planned by the DPS, Narcissus Marsh had been assigned the section dealing with the history of insects in Ireland.<sup>33</sup> Although little remains of the DPS project, Marsh’s interest in insects was established early in the society’s existence, as is seen in a letter written on 30 June 1684, while he was in the country at his residence near Carlow (variously spelt as Stapleton or Staplestowen), the contents of which were recorded in the minutes of 7 July 1684:

I thought to have done much this Summer towards the completing the history of the generation of insects, on which subject I have meditated and made observations for many years together, but to my sorrow (if I ought to be sorry for being deprived of an evil) I find but very few sorts of insects here, and especially of flies the fewest I ever saw in any place, and of those not one rare or unusual. Yet I was surprised the other day to find on a plum tree a nest of the largest sort of bruchi full grown, to the number about 50, who had devoured all the leaves of the tree and yet lodged together still ... they are about an inch and a half long.<sup>34</sup>

What he meant by bruchi is not entirely clear: they may have been weevils, still described as bruchid beetles and certainly capable of chewing their way through a

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<sup>33</sup> Marsh owned a copy of Thomas Moffett’s work on insects which was sold in the nineteenth-century auction of so-called duplicates from Marsh’s Library, Dublin. Edward Stillingfleet’s copy was retained and remains in the library. For the sale, see *Bibliotheca Marsiana* (Dublin, 1833), 64.

<sup>34</sup> DPS Papers no. 231; minutes at DPS Papers no. 29.

large quantity of leaves; or it is more probable, given the terminology the two writers could easily have shared, that they may have been the cockchafer beetles which, as we have seen, swarmed at that period throughout Ireland.<sup>35</sup>

A further and more extended letter from Marsh was sent to St George Ashe in June 1685, in response to the sending of a specimen for his attention. It had been reported in the minutes of the society in May 1685 that Ashe

presented a very odd insect which grew to a tree in a large husk or shell, together with a letter to him giving an account thereof, and the history of insects in general, from Monsieur Dorchaize.<sup>36</sup>

Marsh promised to send the specimen back to Ashe 'because I suppose you will lay it up in the repository of your society', the DPS by this time having established not only a laboratory but also a repository for specimens at their rented premises in Crows Nest.<sup>37</sup>

In discussing the creature and its possible identity, Marsh refers to 'Godartius Of insects', which, as we have seen, had become a key text for the DPS in the description of insects. In the letter to Ashe, Marsh discussed the insect in detail, asking him to 'desire [his] friend to inform you as to what sort of tree he found it sticking', and referring to the number assigned in Lister's edition of Goedaert. Having discussed Ashe's query, he continued his letter with suggestions for the classification of such insects by reference to their developmental stages.<sup>38</sup>

The metamorphoses undergone by insects, through their various larval and pupal forms into the radically different adults, were of great interest to the virtuosi in view of the widely received concept that 'worms' of various descriptions were generated spontaneously from putrefaction, as were other species (even mice could be

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<sup>35</sup> Thomas Molyneux employed the term bruchoi to refer to these beetles in the letter to Ashe subsequently published in *Philosophical Transactions*.

<sup>36</sup> This was Francis (probably François) Dorchaize, whose paper on subterranean trees is printed as *DPS Papers* no. 132. Little is known of him apart from his correspondence with Ashe.

<sup>37</sup> William Molyneux to Thomas Molyneux, 14 June 1684. *DUM*, 483.

<sup>38</sup> *DPS Papers* no. 288.

'generated' under the right conditions). The Italian physician Francesco Redi had made an attack on spontaneous generation in 1668 which was slowly winning support by the 1680s, but it seemed entirely possible that egg, larva, pupa and adult were distinct organisms, which gave rise to each other only under certain circumstances. It was this process that 'Godartius' had studied in somewhat obsessive detail, keeping caterpillars and observing their pupation and emergence as butterflies or moths. Goedaert regarded the process as possibly influenced by circumstance, because occasionally a caterpillar would, instead of producing a butterfly or moth, release a cloud of 'flies'. By Martin Lister's time it was known that parasitism by ichneumon wasps was responsible for this phenomenon: he recognised the development of caterpillar to adult butterfly or moth as the normal course of events.<sup>39</sup> Marsh proposed, following Lister and Goedaert, that the characteristics of the chrysalis stage (or 'aurelia'; both words derived from the golden colour of many), and the cases that some caterpillars made as they prepared for pupation ('follicle') should be used as a means of classification and identification of larva and adult.

Marsh must have had access to Lister's version of Goedaert's book, and refers to it by its English title, but there is no record of a copy in his collection, the surviving copy in the Dublin library being from Edward Stillingfleet's collection (Stillingfleet also owned the Latin edition). A possible explanation for this lies in the disturbed politics of the time which forced Marsh to leave Ireland in March 1689, returning in December 1690. It appears from a letter to Edward Lhywd in 1707 that at least some of Marsh's books were 'lost in the late revolution'.<sup>40</sup>

Marsh not only attempted to identify the specimen but also set out to observe the development of a particular species from egg to adult. He described for Ashe an

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<sup>39</sup> There are numerous instances throughout Lister's version where he refers to this phenomenon as 'by-birth', for example, annotating Goedaert's account of his 'number 7', he writes: 'Both these I say are By-births, and not at all generated by the Catterpillar, but by their respective Parents: the Catterpillar which bore them, serving only as food to them, not a Mother. It's to be Observed that the Flesh-Flyes, did feed upon the very substance of the Catterpillar, or Chrysalis, as they would upon Carrion.' Goedaert ed. Lister, *Of Insects* (London, 1682), 11.

<sup>40</sup> DPS Papers no. 440.

opportunity he had taken to collect eggs from adults he had observed, and his plans to keep them through the various stages of development and to observe what type of case they made for themselves. His proposed scheme for classification was, he wrote, 'all conjecture and wants to be confirmed by experiments'.<sup>41</sup> In this, Marsh is seen to be advocating the extension of observation by further trials, designed to test a concept which he had set out as an explanation for previous observations.

### Nature out of course or vexed

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Francis Bacon had recommended the study of nature 'under constraint and vexed; that is to say, when by art and the hand of man she is forced out of her natural state, and squeezed and moulded'.<sup>42</sup> He had also mentioned 'Deviating Instances, that is, errors, vagaries, and prodigies of nature, wherein nature deviates and turns aside from her ordinary course'.<sup>43</sup> As Daston and Park have observed in their history of wonder, Bacon's form of 'history of pretergenerations' or 'nature out of course' was intended as a corrective to the tendency of philosophers to generalise from too little evidence. The study of exceptions to the philosophers' hastily-established rules was prescribed to encourage a more faithful account of natural phenomena. Bacon distinguished between superstitious stories, which were to be 'altogether rejected', and 'stories of prodigies, when the report appears to be faithful and probable' which he allowed.<sup>44</sup> He did make room for the possibility that even the seemingly fanciful might contain a grain of truth and could be revisited as time allowed, but he was firm in saying that 'I would not have the infancy of philosophy, to which natural history is as a nursing mother, accustomed to old wives' fables'.<sup>45</sup>

The members of the DPS were described by Hoppen as 'too often' inclined to collect

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<sup>41</sup> DPS Papers no. 288.

<sup>42</sup> Francis Bacon, *Great Instauration*, Translation from Bacon, *Works* IV, 29.

<sup>43</sup> Francis Bacon, *Novum Organum*, Aphorism 29. Translation from Bacon, *Works* IV, 169.

<sup>44</sup> Daston and Park, *Wonders and the Order of Nature*, 231. Further considerations of Bacon's 'torture' of nature are to be found in Carolyn Merchant, "The Violence of Impediments": Francis Bacon and the Origins of Experimentation', *Isis* 99 (2008), 731–60.

<sup>45</sup> Francis Bacon, *Paraseve*, Aphorism 3. Translation from Bacon, *Works* IV, 255.

odd cases.<sup>46</sup> He saw the attitudes of the DPS as similar to some of Robert Boyle's views of remedies which seemed fanciful in the light of modern medical knowledge, and to similar views in the Royal Society. However, a return to the patterns of investigation recorded in the DPS papers, and in the discussions of the Royal Society, does not show an uncritical approach to the observation of unusual cases: instead, investigation of 'monsters' such as conjoined twins always sought to include dissection, to expand the knowledge of the observed phenomena. This followed a long tradition (which continues in modern medicine) of observation of individual cases as a means to collate knowledge.<sup>47</sup> As detailed below, I argue that the philosophical community was active in seeking instances of the unusual which could inform interpretation, even if this was not an immediate consequence.

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### Monsters and marvels

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In late March 1685, St George Ashe wrote to the Dublin-born scholar and theologian Henry Dodwell (1641–1711).<sup>48</sup> Ashe noted the interest of the society in the 'new and rare' although declaring its aims to be 'mutual discourse and communication of studies to improve ourselves in useful philosophy'. He described the

monstrous productions [which] have been presented to us, viz. 2 children with 2 heads a piece, one of them had also 3 arms; a cat with 2 bodies and but one head; an egg newly laid with an imperfect chicken in it and a navel string as in viviparous animals... All these were carefully examined and dissected and the pictures of what was unusual taken.<sup>49</sup>

A further detail in the same letter was the account of a medical case in which a man suffered recurrent bleeding, as reported to Ashe by his brother. The examples

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<sup>46</sup> DPS Papers, Introduction, xxx.

<sup>47</sup> See Giovanna Pomata, 'Sharing Cases: The *Observationes* in Early Modern Medicine', *Early Science and Medicine*, 15:3 (2010), 193–236. A recent example is Trygve Nissen and Rolf Wynn, 'The clinical case report: a review of its merits and limitations', *BMC Research Notes*, 7:1 (2014), 264.

<sup>48</sup> Theodor Harmsen, 'Dodwell, Henry (1641–1711)', *ODNB*. Ashe had corresponded with Dodwell while a student in 1678, seeking to borrow books left by Dodwell in Trinity College Dublin, and continued to correspond with him over the succeeding decades.

<sup>49</sup> DPS Papers no. 278.

recorded by Ashe in his letter to Henry Dodwell, and those which follow in this section, show the varying aspects of the 'odd' specimens and cases exchanged between the sister societies and commented on in correspondence. Galenic and Hippocratic patterns of medical observation and collection of case studies were an established form, disseminated not only by scribal means but also in print.<sup>50</sup> The exchange of accounts of monsters and marvels by the curious also fell into this anecdotal pattern, which became consolidated in vocabulary and practice, and persists in modern medicine.

Creatures with two heads, giants, dwarfs, people with extra hair or nipples, and other 'sports' or 'freaks of nature' had been diligently sought and examined for centuries before the DPS and its circle recorded such things. The display of these 'marvels' in public had also been an aspect of popular culture as well as of philosophical interest, which continued into the eighteenth century (and is still seen today in the more lurid avenues of the press). This was an apt subject for ridicule, as in the alleged report of one Martinus Scriblerus, which was embellished with all the trappings of a real place and time:

Being about four years ago in the City of Madrid in quest of natural knowledge, I was informed of a Lady who was marked with a Pomegranate upon the inside of her right Thigh, which blossom'd, and, as it were, seem'd to ripen in the due season. Forthwith was I possessed with an insatiable curiosity to view this wonderful Phaenomenon... I bribed her Duenna, was admitted to the Bath, saw her undress'd, and the wonder display'd.<sup>51</sup>

This satirical account of a prodigy has many of the characteristics of earlier accounts: the personal observation, with details, and the date and place mock the accounts of

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<sup>50</sup> Giovanna Pomata, 'Observation Rising: Birth of an Epistemic Genre, ca. 1500-1650' in Lorraine Daston and Elizabeth Lunbeck, eds., *Histories of Scientific Observation* (Chicago, 2011), 45-80.

<sup>51</sup> The fictional philosopher was suspected of a more carnal interest in the lady's thigh by the husband of this wonder, and forced to flee. *The Memoirs of Martinus Scriblerus* (Dublin and London, 1741; although circulating from 1714), 8-10. Satire ridiculing the tendency of the public to believe the more outlandish reports had circulated much earlier than this, as had purposeful criticism: for example see Daston and Park, op.cit.; and William E. Burns, *An Age of Wonders: Prodigies, Politics, and Providence in England, 1657-1727* (Manchester, 2002).

odd cases recorded by natural philosophers such as those in the DPS. It was not a new phenomenon, nor did interest in it cease: an entry in the subject catalogue from Marsh's, dating from the mid-eighteenth century, records this interest under 'Mirabilia et Ostenta', with twenty-six entries under this heading.<sup>52</sup> These include the writings of the natural historian and collector Ulisse Aldrovandi (1522-1605) and the physician Fortunio Liceti (1577-1657). The contents of these books range from accounts of prodigies, and strange births with their reported portents, to systematic description of rarities arranged in collections. More unusual creatures were also reported from time to time, such as dragons and werewolves. Heinrich Kornmann (c. 1580-c. 1640) had a particular fascination with werewolves, saying that as God had created humankind from the dust of the earth, it would be no great difficulty for him to allow them to change shape.<sup>53</sup> It is difficult to know whether William Molyneux was in jest or serious when he wrote to Edmond Halley in 1686:

I shall procure for you two or three wolf's fangs, and could wish that I had all in Ireland to send you, especially from the jaws of the lycanthropes, for we are more infested with such brutes than with those of four legs.<sup>54</sup>

The Royal Society had accumulated a large number of specimens in its repository, including those which were commonly regarded as monstrous, such as conjoined twins.<sup>55</sup> Drawing specimens together and accumulating matters of fact about them connected the provincial communities of natural philosophers in Dublin and Oxford with the community in the capital. Each group eagerly sought news of unusual specimens from the others, and the accounts of some of those reported by

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<sup>52</sup> The majority of these catalogue entries are in Stillingfleet's collection.

<sup>53</sup> For Kornmann's attitude see Bernd Roling, *Physica Sacra: Wunder, Naturwissenschaft und historischer Schriftsinn zwischen Mittelalter und Früher Neuzeit* (Leiden, 2013), 251.

<sup>54</sup> DPS Papers no. 340.

<sup>55</sup> Nehemiah Grew, writing on the Royal Society's repository, sought to reduce the emphasis on the monstrous and exotic specimens and to describe the contents without reliance on discredited ancient authorities. See Nehemiah Grew, *Musaeum Regalis Societatis or a Catalogue & Description of the Natural and Artificial Rarities Belonging to the Royal Society* (London, 1681); for commentary see P. Fontes da Costa, 'The Culture of Curiosity at The Royal Society in the First Half of the Eighteenth Century', *Notes and Records of the Royal Society of London* 56:2 (2002), 147-66; and da Costa, *The Singular and the Making of Knowledge at the Royal Society of London in the Eighteenth Century* (Cambridge Scholars Publishing, 2009).

the DPS were published in the *Philosophical Transactions*. One example of such a specimen was brought to the attention of the DPS by the physician Allen Mullen. As mentioned in Chapter 1, Mullen was one of the most active members of the DPS, with wide interests in anatomy as well as chymistry, connected to his medical practice: his chymical contributions are discussed in more detail in Chapter 5 below. On 23 February 1684–5, he ‘presented a monstrous kitlin lately brought forth in this town’ the account of which was promptly published by the Royal Society together with ‘the sketches taken by Mr Sandys’.<sup>56</sup> The Oxford society secretary, William Musgrave, sought to have copies of this description sent to them.<sup>57</sup> Discussing the dissection, the minutes of the DPS recorded that

In the Journal des scavans, pour lundy 15 Juillet An. 1680, there is just such another monstrous cat described and cuts thereof given. ‘Tis very strange that two errors of nature (for so we may call monsters) should thus exactly agree.<sup>58</sup>

The cat described in the *Journal* had been dissected by a physician in Lyon, who recorded that it had one head and two bodies. It had been sent by one M. Moze to the physician M. de Ville for dissection, the skin being carefully removed and embalmed so that Moze could keep it in his cabinet of curiosities. The article detailed the dissection and the disposition of the organs found. Another conjoined birth, this time of a calf, was described to the DPS on 19 April 1686. On a more confined scale, the production of hen’s eggs with portions of the embryo or the albumen formed outside the shell was noted on several occasions.<sup>59</sup> An ‘imperfect

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<sup>56</sup> Edwin Sandys (d. 1708) was an engraver resident in Crane Lane and active in cartography and portraiture, as well as becoming a printer of the Dublin Gazette in 1705. See Mary Pollard, *A Dictionary of Members of the Dublin Book Trade 1550-1800* (Oxford, 2000), 508. She notes William Molyneux’s mention of Sandys in 1683 (q.v.) as having agreed with Moses Pitt for the production of Irish maps, and also records a 1690 letter from George Tollet to William King complaining that he found Sandys difficult.

<sup>57</sup> *DPS Papers* no. 276.

<sup>58</sup> *DPS Papers* no. 52. The article cited was ‘Histoire anatomique d’un chat monstre’, *Le Journal des Scavans* XVII (1680), 117–9.

<sup>59</sup> ‘Dr Mullen gave an account of a monstrous chicken with 2 bills, and also of an egg which at the big end had a fleshy substance in figure like a glass drop, the smaller part hanging out, at the extremity of which was a drop of blood. The shell was not quite closed. This fleshy substance taken out, was as big as the largest glass drop, included in a membrane very tough, the inside a collection of thin small

chicken' was included in the list of 'several monstrous productions' communicated by St George Ashe to Henry Dodwell in the course of his description of the activities of the society, as mentioned above. Ashe noted that 'All these were carefully examined and dissected and the pictures of what was unusual taken'.<sup>60</sup> Chickens were important to natural philosophy as readily available examples of development, and so a disrupted development of a chicken, or another creature, held implications for the understanding not only of that one specimen, but for the changing perceptions of how the 'seeds' of the parents were reflected in the offspring.<sup>61</sup>

The collection of facts about these 'errors' included those in humans, both living and deceased. The same letter from Ashe to Dodwell described '2 children with 2 heads a piece, one of them had also 3 arms'. In January 1685 the DPS discussed 'a male child with two complete heads, one something bigger than the other, and three arms'. The society was disappointed of the opportunity to dissect this child as it had been partially disembowelled before being brought to them: a female specimen with two heads was not available as the parents would not sell it.<sup>62</sup> A girl with horny growths all over her body was minutely described, and again drawn by Edwin Sandys. Papers written about her were included not only in English in the *Philosophical Transactions* but also in Pierre Bayle's *Nouvelles de la Republique des Lettres*.<sup>63</sup> A further case of a girl who had been born 'without a right arm, and having only one finger at her shoulder, which she moves in and out at pleasure' was described to a meeting on 16 April 1686.<sup>64</sup>

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tunicles crammed close in that membrane, the yolk and white much less than ordinary. Accurate figures hereof are taken by Mr Sandys.' *DPS Papers* no. 59.

<sup>60</sup> *DPS Papers* no. 278.

<sup>61</sup> Karin Ekholm, 'Harvey's and Highmore's Accounts of Chick Generation', *Early Science and Medicine* 13 (2008), 568–614.

<sup>62</sup> *DPS Papers* nos 47, 48.

<sup>63</sup> 'A Letter from Mr. St. George Ash, Sec. of the Dublin Society, to one of the Secretaries of the Royal Society; Concerning a Girl in Ireland, Who Has Several Horns Growing on Her Body', *Philosophical Transactions* XV (1685), 1202–4; 'Extrait d'une letter de M. Sylvius, Médecin et Membre de l'Académie a Dublin, écrite a l'Auteur de ces Nouvelles, Touchant une fille qui a plusieurs cornes en diver endroits du corps', *Nouvelles de la république des lettres* (1686) Juillet, 790–6.

<sup>64</sup> *DPS Papers* no. 7.

In these cases of monstrosity, and in the reports of odd cases in physic, the cultural background was often a matter for comment. The horny girl was born ‘of English parents’,<sup>65</sup> a boy bitten by a rabid dog was reported to be a Protestant,<sup>66</sup> the man who bled spontaneously was described as an innkeeper ‘born in Ireland’.<sup>67</sup> The details served to support the credibility of the reports and also showed the importance of locating the individuals within a particular community, whose characteristics and credibility could be extrapolated from the record of religion or nationality. Each report described the particular ‘monster’ or phenomenon in quite detached terms, conforming to a pattern which had become the norm in the learned societies since the advent of their journals. The facts observed in each case were gathered and could be evaluated and compared by the community of peers with similar interests. Physicians carried out dissections of both normal and abnormal creatures to compare their features, with each dissection serving to advance the understanding of anatomical function.

Marvellous productions of nature could also be found preserved long after the creature had ceased to appear in the locality where the remains were found, giving rise to speculation as to the preservation of created species. Thomas Molyneux published a paper on the ‘moose’ horns which had been found underground in a number of places in Ireland.<sup>68</sup> Returning to the pattern of standard queries posed about animals found in one country and not in another, Molyneux described an animal which was now extinct in Ireland, although once common there. The phenomenon of extinction could have seemed to suggest that the creator had somehow neglected some part of creation, or created something superfluous that could be discarded, but Molyneux dismissed this idea, saying that the creature had been ‘carefully preserved’ elsewhere although extinct in Ireland.<sup>69</sup> Molyneux’s

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<sup>65</sup> *DPS Papers* no. 307.

<sup>66</sup> *DPS Papers* no. 303.

<sup>67</sup> *DPS Papers* no. 253.

<sup>68</sup> Thomas Molyneux, ‘A discourse concerning the large horns frequently found under ground in Ireland, concluding from them that the great American deer, call’d a moose, was formerly common in that Island: with remarks on some other things natural to that country’, *Philosophical Transactions* XIX (1695), 489–512.

<sup>69</sup>For a comprehensive discussion of attitudes to extinction, see Poole, *World Makers*, ch. 9.

description of the size and shape of the horns was combined with observations which compared the annual shedding of antlers to a similar abscission site of deciduous leaves, or ripened fruit. This description is much more full, and carries more references to the literature and to comparative anatomy, than the descriptions of the ‘monsters’ above. Molyneux’s views of the possible cause for local extinction of the giant deer were based on reports of other deer species which had succumbed to epidemic diseases, as reported in cited books. He considered the occurrence of the giant deer in Ireland to be evidence of a past connection with America, and added observations of the occurrence of plants and other natural products to support this:

Ireland ... must in the many past Ages, long before the late Discovery of that New World, had some sort of Intercourse with it ...

I have some reason to believe to these Instances of the Moose Deer, Amber-greese and Sperma Ceti, of which Ireland partakes more than any other country of Europe from its neighbourhood with the [sic] Northern America, we may likewise add some of our more rare spontaneous plants, because they are found growing only in those western parts of Ireland and nowhere else in this whole country or any of the neighbouring kingdoms about us.<sup>70</sup>

Although Thomas Molyneux regarded this as a digression, these patterns of distribution contributed to the discussion of the relationships between parts of the earth and their possible disruption before, during and after the deluge described in Scripture. As discussed further in Chapter 4 of this thesis, the nature of the created earth was a topic of great debate at the time of the publication of Molyneux’s paper. Disturbances of the apparent order of creation, such as deluge, extinction, or monstrous, marvellous, and strange cases of human and animal beings, were taken up by the learned societies as casting light on the underlying purposes of the creator.

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<sup>70</sup> T. Molyneux, ‘A discourse concerning the large horns’, 506, 509.

Galenic and Hippocratic patterns of medical observation and collection of case studies were an established form, disseminated not only by scribal means but also in print. The exchange of accounts of monsters and marvels by the curious also fell into this anecdotal pattern, which became consolidated in vocabulary and practice, and persists in modern medicine. In the last decades of the seventeenth century, when the DPS was active, medical practice was eclectic in its use of concepts of disease. It could employ the doctrine of humours and the need for balance in broadly Galenic terms. It was equally possible for the concept of disease as an *ens* or entity in itself (as proposed by Jan Baptista Van Helmont, 1580–1644) to be applied as a fundamental set of concepts, with iatrocymical cures for these disease states. Many common treatments such as purgatives, emetics (whether Galenic or chymical), and bleeding were aimed at relieving obstruction and releasing the disease state. When Chinese medicine was brought to the attention of the West, the doctrines of pulse diagnosis and the concepts of flow of energies brought into balance in the practices of acupuncture and moxa found a ready echo in the pulse diagnosis practised in Europe and the concepts of obstruction and release of humours.<sup>71</sup> The learned societies collected and commented on usual and unusual cases in physic, and exchanged queries on them. Accounts of dissection of those dying of various common complaints attributed to obstruction by ‘the stone’ and other blockages, as well as those anecdotal cases which seemed to present anomalies, were accumulated by the physicians in the societies, as by their predecessors.<sup>72</sup>

As a vital fluid, blood had a prominent place in diagnosis and discussion, with debates over circulation ongoing, as we shall see later in this chapter. Robert Boyle’s *Memoirs for the Natural History of Humane Blood* emphasised this importance.

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<sup>71</sup> See, for example, Willem Ten Rhyne, *Dissertatio de Arthritide* (London, 1683).

<sup>72</sup> For example, in justification of his attitudes to the treatment of the stone, and of dropsy, the seat of which was held to be the liver, Van Helmont presented a series of cases, cures and results of dissections. See his *Oriatrike* (London, 1662), chap. LXIII.

Disorders of the blood, such as a case of spontaneous bleeding in a male patient, as reported to St George Ashe, were thus all the more interesting. St George Ashe mentioned his brother's account in a letter to Henry Dodwell as follows:

A very odd case was sent by my brother of a critical bleeder, an inhabitant of Trym, who for 2 years together bled every month or 5 weeks to the quantity of near a pottle at the end of the forefinger of his right hand, notwithstanding all remedies to the contrary.<sup>73</sup>

This case was transmitted to the Royal Society as part of the minutes of the DPS. There, it generated sufficient interest for the secretary, Francis Aston, to be asked to respond with an enquiry to the DPS:

Concerning the periodical bleeding of the man at Trim, it was desired to know what remedies had been used, as caustics, ligatures, or stanching liquors, &c.<sup>74</sup>

The minutes of the DPS on 23 March 1684-5 explained that

The remedies usually applied to the critical bleeding were: blood-letting, hare's fur, Roman vitriol, lint steeped in vinegar, ligatures. We know not of any caustic applied, but septic [recte styptic] liquors many, and all ineffectual.<sup>75</sup> As the unfortunate individual was long dead by the time the letter describing the case was written (a circumstance attributed by the observers to this infirmity) the matter does not seem to have been pursued further.

The background to the remedies applied to this unusual case would have been well known to the members of both societies, and particularly to the physicians among them. The list indicates the use of a mixture of Galenic and traditional methods

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<sup>73</sup> The report is at *DPS Papers* no. 278. The case was reported long after it had actually occurred (the man had died in 1669-70), in response to a query sent by the society to Thomas Ashe.

<sup>74</sup> Birch, *History of the RSIV*, 378; Aston's letter is at *DPS Papers* no. 275.

<sup>75</sup> *DPS Papers* no. 55.

(hare's fur, ligatures) and chymical remedies (Roman vitriol was a preparation of copper sulphate). The dispensatory compiled by William Salmon in the 1670s, which continued in use into the eighteenth century, cites Paracelsus' comment on vitriol as 'the third part of physic... a whole Shop is contained therein'.<sup>76</sup> Vitriol of various types (now recognised as solutions of ferrous or cupric salts) attracted the interest of the learned societies as well as medics. Preparation of these remedies is to be found in contemporary lists of *materia medica* and *pharmacopoeias* from English and wider European sources. As we shall see in Chapter 5, the consideration of the action of salts *in vitro* and *in vivo* was a very active topic in natural philosophy of the time.

As part of the general understanding of disease, obstruction and flow were important to medical practise, the purgatives, emetics and phlebotomy which were often prescribed being designed to relieve disease states by releasing obstruction or restoring flow and balance. The details of interesting cases concerning obstruction were communicated to the members of the DPS by various routes. On 7 December 1685, Allen Mullen described a patient of his with symptoms of hardness and swelling who 'suddenly found ease by voiding some hydatides [tapeworm larval cysts] by stool'. He found this puzzling as the normal seat of this type of cyst was known to be the liver. The oddness in this case was the means whereby these very recognisable cysts could have made their way to the gut to be eliminated as described. He supported his report by saying that 'he had an account of the matter of fact, not only from the patient's brother, but from 3 other good hands'.<sup>77</sup> Disease caused by the blockages and swelling proceeding from hydatid cysts was well known to early modern medicine, as to its antecedents. The Italian physician and natural philosopher Francesco Redi (whose interests in insects and spontaneous generation were mentioned above) had recognised that hydatid cysts had an animal origin. In a publication in the *Philosophical Transactions*, the anatomist and fellow of the Royal Society, Edward Tyson (1651–1708), had also described parasitism by

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<sup>76</sup> William Salmon (M.D.), *Pharmacopœia Londinensis: Or, the New London Dispensatory. In Six Books. Translated into English. The Eighth Edition, Corrected and Amended* (London, 1716), 331.

<sup>77</sup> DPS Papers no. 79.

worms in dogs and other animals, although it was not until 1766 that these observations were connected and the cause of the disease in humans was recognised as infection with *Echinococcus* tapeworms.<sup>78</sup>

Perhaps the most common form of blockage was ‘the stone’. Gallstones, kidney, and bladder stones caused excruciating pain, fever, and general morbidity. The disease was so deleterious that its surgical cure, in an age before anaesthesia, became a widespread and acceptable option.<sup>79</sup>

Once removed, the nature of the stones themselves became an object of study for the learned, and worthy specimens for their repositories. The size and weight of the stones was a particular matter for comment, as when Francis Aston of the Royal Society communicated a report of two such specimens to William Molyneux in March 1685: ‘a large stone bred in the guts and voided by stool’ and ‘a stone of the bladder ... which weighed 36 ounces’.<sup>80</sup> Several discussions of means of removing the stone were communicated between the societies and made public in the *Philosophical Transactions*. The meeting of 29 June 1685 heard comments from two of the society’s physicians, Allen Mullen and Patrick Dun, about Martin Lister’s proposal for cutting the stone by the os pubis. Dr Mullen informed that this way of section is treated of by one Van Rhuinhuyse, and Dr Dun assures that such a method has been long practised in France.<sup>81</sup>

Such a painful and risky procedure was to be avoided if possible, and reports were made of various individuals who had voided stones spontaneously. St George Ashe wrote from Leiden in 1686:

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<sup>78</sup> Edward Tyson, ‘Lumbricus Hydropicus; or An Essay to prove that Hydatides often met with in morbid Animal Bodies, are a Species of Worms, or Imperfect Animals’, *Philosophical Transactions* 16 (1691), 506-10.

<sup>79</sup> A succinct guide to the extraction of the stone is to be found in François Tolet, *Traité de La Lithotomie, Ou de l'extraction de La Pierre, Hors de La Vessie* (The Hague, 1686), complete with detailed illustrations. One of those subjected to the operation was Samuel Pepys, who celebrated the success of his operation annually (see D. Urquhart-Hay, ‘Samuel Pepys and His Bladder Stone’, *British Journal of Urology* 70:5 (1992), 509-13).

<sup>80</sup> DPS Papers no. 275.

<sup>81</sup> DPS Papers no. 65.

There has happened at Amsterdam an accident much like that of which we had an account from Scotland, viz. of a woman who having been 25 years troubled with the stone, voided a large one without pain. It was of an irregular shape, 5 inches round, and 28 drams the weight.<sup>82</sup>

Thomas Molyneux gave accounts of this phenomenon which were said to be 'grounded upon three instances of fact ... in this city'. The stone taken out of the first case was drawn to illustrate the account of the three cases sent by Owen Lloyd, then secretary of the DPS, to Richard Waller, secretary to the Royal Society, in 1693. These observations led to proposals for treatment which could avoid surgery: although a correction was communicated and published relating to the degree of cure possible.<sup>83</sup> Treatment of the stone was less difficult in women, Molyneux asserted, and the gentler means of extraction via the dilated urethra should be attempted. He noted the neglect of the disease in women, commenting that of the French cases which had generated

two vast collections of stones, that amount at least to several thousand ...  
not one in a hundred, I might safely say more, is taken out of a woman.<sup>84</sup>

As will be discussed further in chapters 4 and 5, the nature of stones and stoniness was of interest in the understanding of mechanisms of the body of the earth as well as the human body. These cases contributed to a collection of observations which was used to inform both the treatment of disease and speculation as to its cause, with the societies discussing accounts of similar occurrences in their experience, as well as the nature of these productions in all their local variety.

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<sup>82</sup> DPS Papers no. 344.

<sup>83</sup> DPS Papers no. 372: 'the Dr desires that [the] mistake in the latter end may be corrected, having been led into it by the parents of the child, who deceived him.'

<sup>84</sup> 'Dr Mullineux his account of a stone of an extraordinary bigness spontaneously voided through the urethra by a woman in Dublin', *Philosophical Transactions* XVII (1693), 817-824.

As a part of an experimental approach to the study of nature, dissection served particularly well to investigate mechanical concepts of function in plants and animals, with physical connections between the parts open to manipulation. Medical education had been informed by dissection since ancient times, although the acquisition of human specimens was intermittently difficult for those studying anatomy. Dissections were performed in public as well as in private, as spectacle and demonstration, and the anatomy theatre as a purpose-built space had an established form from the sixteenth century.<sup>85</sup>

With the improvement in observational techniques yielded by the microscope over the unaided eye, more and more detail of the mechanisms could be reproducibly observed, inducing wonder at their intricacy, as William Molyneux remarked in his *Dioptrica Nova*:

And indeed with this, our Contemplations may be endless; all things affording such admirable Appearances, such curious Contexture of Parts, and such delicate vivid Colours; that the Contrivance of the Almighty Creator is as visible in the meanest Insect or Plant, as in the greatest Leviathan or strongest Oak.<sup>86</sup>

The argument from design, invoked by Descartes, Boyle, Stillingfleet, and Locke, was reinforced as the intricacy of the structure of creation was revealed with the new tools, inspiring wonder in the observers.

Dissection of various organisms formed part of the learned ‘entertainment’ for the philosophical societies. The connection between form and function could be approached by comparison of the function of similar organs in different creatures.

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<sup>85</sup> Surveys of the didactic and the spectacular in anatomy demonstrations are to be found in Cynthia Klestinec, *Theaters of Anatomy: Students, Teachers, and Traditions of Dissection in Renaissance Venice* (Baltimore, 2011) and Bernadette Bensaude-Vincent, *Science and Spectacle in the European Enlightenment* (London, 2016).

<sup>86</sup> Molyneux, *Dioptrica*, 290.

One particularly important set of functions related to the blood and the circulatory system. The context of these studies sprang from William Harvey's description of the circulation of the blood, first presented about a decade before its first publication in 1628. It generated immense controversy because of its direct opposition to medical practices derived from a Galenic understanding of the flow of humours: put simply, blood circulation would mix the humours and so render the treatment of disease by bleeding ineffectual. That there was still some resistance to the concept of circulation was evident when William Molyneux demonstrated the circulation by vivisection of a newt using a microscope to observe the

visible Circulation of the Blood in Water-Newts (*Lacerta aquatica*) to be seen as plainly as Water running in a River, and proportionably much more rapid'.<sup>87</sup>

By the time *Dioptrica Nova* appeared, Molyneux's observations had been published in the *Philosophical Transactions*, with a claim for his priority, following a report of similar findings by the Scottish physician George Garden (1649–1733).<sup>88</sup>

The reception of these observations by the DPS and by the Royal Society is significant for two reasons. Firstly, William Molyneux was privately scathing about the reaction of some of his observers in the DPS. Writing to his brother Thomas, he expressed his frustration with the attitudes of disbelief which had greeted something which he thought to be plainly observable:

since I have shewn before our Society the dissection of Newts this summer, and the wonderful circulation of the blood, it makes some discourse about town as admirable; and yet our perverse Irish physicians impute it to the agonys the creature is in by being laid open.<sup>89</sup>

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<sup>87</sup> Molyneux, *Dioptrica*, 281.

<sup>88</sup> For Garden, see Michael Hunter, *The Royal Society and Its Fellows, 1660-1700: The Morphology of an Early Scientific Institution* (London, 1982). The priority claim is discussed further below.

<sup>89</sup> DUM, 484.

William Molyneux had also written to Nehemiah Grew to describe the same observations in more detail:

On these air bladders the blood vessels are most curiously ramified, to which, applying a microscope 'tis admirable to behold with what a prodigious swiftness their blood circulates, and this as plain as ever water was seen running in a channel. This I look upon to be the circulation of blood demonstrated ad oculum, and that after this sight 'tis impossible for the most perverse to deny it.<sup>90</sup>

He performed the demonstration twice for the DPS, to approval from William Petty, although the latter was unable to view it himself due to his failing sight.

The other significant aspect of this experimental observation arose from a similar observation by Dr Garden reported in a letter to Robert Plot, written in September 1685, and shared with the DPS by William Musgrave of the Oxford Society. This occasioned a letter from William Molyneux to Francis Aston, secretary of the Royal Society, describing his observations and giving evidence of their date. It is a very clear claim to precedence in an observation.<sup>91</sup> The letter was published in the *Philosophical Transactions* and a minute of the Royal Society noted that:

Mr. Aston declared, that he had received an account thereof from Dublin above a year before, which would appear both from the minutes and letter-books; so that this discovery must be owned to be Mr. Molyneux's, except Dr. GARDEN can bring authorities, which did not yet appear.<sup>92</sup>

Display of the findings from dissections was accompanied by interpretation, as in March of 1683/4 when the dissection of a bat was demonstrated by Richard Bulkeley. This was accompanied by an account of the dissection of a bat by Thomas

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<sup>90</sup> DPS Papers no. 237.

<sup>91</sup> William Molyneux, 'A Letter from William Molyneux Esq; To One of the Secretarys of the R. S. Concerning the Circulation of the Blood as Seen, by the Help of a Microscope, in the Lacerta Aquatica', *Philosophical Transactions* XV (1685), 1236–38.

<sup>92</sup> Birch, *History of the RS*, 448.

Molyneux which had been written about two years previously, when the author was a student.<sup>93</sup> The account is in Latin and shows evidence of Thomas' reading on the subject, in particular his attention to the Dutch physician, anatomist and chymist, Gerard Blasius (1627–82), and to Francis Willughby's *Ornithology*, published posthumously (Latin 1676, English 1678) by John Ray (1627–1705). Molyneux discussed the somewhat vestigial tail of the bat, which had given rise to controversy, according to Blasius. He had kept the bat alive for fourteen days, feeding it on spiders and all sorts of flies, which it consumed readily. He compared what he had observed with the published accounts available to him and found that Blasius had given an excellent drawing of the skeleton of the bat in chapter 26 of the second part of his *Anatomy*. Blasius, who taught at the Amsterdam Athenaeum from 1660 to 1685, was very active as a writer and the longest-serving among his colleagues.<sup>94</sup>

The view that bats should be classed with birds had been held by Ulisse Aldrovandi among others (Aldrovandi placed the bat and the ostrich together as 'birds of mixed nature') but Thomas noted that the bat gives birth to live young and has a completely different skeletal structure to that of a bird. In this, he pointed out, he agreed with Francis Willughby's view that the bat does not belong among 'Aves'. In this discussion, the relation of form to taxonomy is evident, as also seen in Marsh's discussion of classification of caterpillars earlier in this chapter.

As well as being the society's most active chymist, as discussed below in Chapter 5, and one of the most active experimentalists in the DPS, Allen Mullen was the most active and pro-active anatomist. His paper on the dissection of the elephant accidentally burned at Dublin became a standard work on elephant anatomy for centuries after its publication. This detailed work gave an account of the skeleton and the soft tissue anatomy of the pachyderm, noting its unusual skin. Published as a monograph, it was accompanied by the first of Mullen's accounts of the eyes of

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<sup>93</sup> DPS Papers no. 149.

<sup>94</sup> For Blasius, see Dirk Van Miert, *Humanism in an Age of Science: The Amsterdam Athenaeum in the Golden Age, 1632–1704* (Leiden, 2009), 92–3.

birds and other animals, which was introduced by a dedication to Robert Boyle.<sup>95</sup> As mentioned in Chapter 2, Mullen's connection with Boyle, which influenced some of his experiments on dogs, was initiated by a letter of introduction written by Narcissus Marsh, in which the dissection of the elephant was mentioned, as well as the dissection of a beaver.

Comparative anatomy of the heads of fowl of various types was communicated to the Royal Society and the DPS by Allan Mullen. He examined their hearing and sight, and the innervation of the bills, which he suggested was an adaptive feature to their feeding and lifestyle. His paper was read at the Royal Society in 1687/8 and published after the author's death, with accompanying illustrations, in *Philosophical Transactions*.<sup>96</sup> This paper described the blood supply to the capsule and lens, as well as the control of the mechanism of the eye.<sup>97</sup> Hunter has noted the influence of Boyle on Mullen in this paper, as well in his experiments on dogs, and has suggested that the influence of William Petty, who had carried out dissections with Boyle earlier, might also have been significant.<sup>98</sup>

The anatomy and function of plants had been described by Marcello Malpighi and Nehemiah Grew, both of whom had contributed findings to the Royal Society. Grew's method was adopted and his findings examined in a 'large garden bean' by Samuel Foley (1655–95), one of the clerical members of the DPS.<sup>99</sup> His experiments on beans were reported in March and May 1684, and his paper was registered in full in the DPS. Foley's trials convinced him that 'Dr Grew is in error as to the

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<sup>95</sup> Allen Mullen, *An Anatomical Account of the Elephant* (London, 1682).

<sup>96</sup> Allen Mullen, 'Anatomical Observations in the Heads of Fowl Made at Several Times. By the Late Allen Moulen, M. D. F.R.S. Read before the Royal Society, Feb. 1. 1687/8', *Philosophical Transactions* XVII (1693), 711–16.

<sup>97</sup> The following footnote is found in William Wilde, 'Memoir of the Dublin Philosophical Society of 1683': 'Mr. Dalrymple, in his admirable "Anatomy of the Human Eye," in writing of the vascularity of the lens and its capsule, says, that "Haller, in his Description of the Eye, quotes an Englishman of the name of Allen Moulin, as the first observer, and in fact the discoverer of these long-denied vessels." Mullen, or Moulin, was, however, an Irishman, and the diseases referred to are published along with his Dissection of the Elephant burned in Dublin in 1681, and entitled "New Anatomical Discourses on the Eyes of Animals."

<sup>98</sup> Michael Hunter, *Boyle Studies: Aspects of the Life and Thought of Robert Boyle (1627-91)* (London, 2016), 113–4.

<sup>99</sup> Sean Kelsey, 'Foley, Samuel (1655–1695)', ODNB.

process of their growth'. Using a microscope, Foley noted several differences in texture of the various layers, which he said were 'not noticed by the doctor'. He also made experiments with the orientation of the radicle, to test the work that Grew had published in *The Anatomy of Vegetables begun* (1672) and ten years later (so, two years prior to Foley's experiments) in *The Anatomy of Plants*. The dissection of the bean is minutely described, so as to enable repetition by the reader, and this is precisely what Foley carried out, examining Grew's reported observations at each step of his trial.

The experiments and observations described here show two important features of the activities of the DPS. They repeated and compared experimental results, and they also re-evaluated patterns of classification of organisms. Approaching classification through comparative anatomy added to the discourse about differences between individual specimens and representative groups of plants and animals, assisting the understanding of the organisation of nature.

#### Nature methodised: 'ranking and filing' and matters of fact

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The establishment of order and arrangement among collections of organisms was reflected in the ordering of matters of fact concerning the natural world. Envisaged by Bacon as the activity of the 'compilers', this outgrowth of natural history was to follow from the basic investigations undertaken by his philosophical collective. Bacon, and later Boyle, recognised the necessarily social aspects of natural philosophy, designing queries for collection and collation of ordered data. Martin Lister's methodised studies of insects and shells exemplified this view of the practice and process of natural history, as an important feature of natural philosophy. As mentioned briefly above, the mid-1680s saw the Royal Society enmeshed in a controversy about the importance of descriptive methods in natural history. These clashed markedly with experimental and mathematical approaches to philosophy within the Society, and their communities and sister societies began to take sides in this debate. This almost led to a split in the Royal Society, with the naturalists threatening to decamp to Oxford to join the society there, where the 'real'

natural history was to be found.<sup>100</sup> From the point of view of those who favoured the more mathematical expression of natural philosophy, the Royal Society barely escaped being derailed by that faction which wanted to concentrate on the ordering of collections. William Molyneux, writing to the astronomer royal John Flamsteed in early 1686, was direct in expressing his concern at what he had heard:

But I fear withal that there are a certain set of gentlemen in that society that would fain model the rest to their useless way of philosophising, I mean in search of shells, insects etc., neglecting those parts of philosophy that may be really useful to mankind, and idly condemn mathematics as a hindrance in investigating nature, whereas all sensible men will allow that nothing solid or useful in philosophy can be obtained without them.<sup>101</sup>

He repeated these views in rather more moderate terms a little later in the year to Edmond Halley, who had recently taken up the post of secretary

there was a party arising in the society that were for [re]jecting all kinds of useful knowledge, except ranking and filing of shells, insects, fishes, birds, etc. under their several species and classes, and this they termed natural history and investigating nature, never attending to the uses and properties of these things for the advantage of mankind, and reckoning chemistry, astronomy, mathematics, and mechanics, as rubs in their course after nature.<sup>102</sup>

It may or may not be coincidental that the scornful reference to shells and insects bore a striking resemblance to the published interests of ‘that accurate and experienced enquirer into natural history, Dr Lister’ (as he was described by Thomas Molyneux).<sup>103</sup>

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<sup>100</sup> For an account of this controversy, see Mordechai Feingold, ‘Mathematicians and naturalists: Sir Isaac Newton and the Royal Society’, in Jed Z. Buchwald and I. Bernard Cohen, eds, *Isaac Newton’s Natural Philosophy* (Cambridge MA, 2001).

<sup>101</sup> *DPS Papers* no. 321.

<sup>102</sup> *DPS Papers* no. 331.

<sup>103</sup> *DPS Papers* no. 155.

Reordering and editing of earlier works, such as Lister's edition of Goedaert, brought them into greater conformity with evolving standards of arrangement. It appears that in the seventeenth century the epistemological status of works was determined by their arrangement, and that earlier works were honoured by being 'methodised' so that they made a better fit with the evolving concepts of Baconian practice and process as applied to natural philosophy.<sup>104</sup> This could be carried out by the original author, as in Boyle's reworkings of his own material, or by a later editor or translator. Much to the irritation of those such as Henry Stubbe who decried the influence of the 'Baconical', the order imposed by the Baconian systems of tabulation of knowledge raised the credibility of texts and of investigators within the societies and their circle of adherents.<sup>105</sup>

The foregoing sections have illustrated various topics in natural history addressed by the societies, which were quite diverse in nature. The ordering of these facts into more systematic views of knowledge, addressing particular queries, became possible once these facts had been assembled. Accusations of fact-madness, like those of Henry Stubbe, could be countered by the usefulness of facts once gathered. What follows here addresses the role of lists of desiderata in structuring the collection of knowledge in the form of matters of fact; and discusses the arrangement of those facts, once assembled.

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#### Desiderata: knowledge collection

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The use of lists of desiderata, although appropriated and adapted by Bacon, had long been a common means of setting out the wishes and hopes of seekers after knowledge. Expressed as simple lists, or in diagrammatic forms based on the

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<sup>104</sup> The Baconian origins of the arrangement and intabulation of information and its later application are discussed in Harriet Knight, 'Rearranging seventeenth-century natural history into natural philosophy: eighteenth-century editions of Boyle's Works', in M. Eddy and D. Knight (eds), *Science and Beliefs: From Natural Philosophy to Natural Science, 1700–1900* (Aldershot, 2005), 31–42.

<sup>105</sup> 'Let us, therefore, not be concluded by the aphorisms of this Lord. Let his insulce adherents buy some salt, and make use of more than one grain when they read him; and let us believe better of the ancients than that their methods of science were so unfruitful.' Henry Stubbe, *The Lord Bacons Relation to the Sweating-Sickness Examined... a Reply by Way of Preface to the Calumnies of Eccebolius Glanvile* (London, 1671), 5.

patterns popularised by the pedagogue and reformer, Petrus Ramus (Pierre de La Ramée, 1515–72), they assisted researchers to form and pursue questions and aims.<sup>106</sup> Bacon himself drew up a list of desiderata to which researchers might usefully turn their attention, and the structure provided by lists of Heads and Queries came to be seen as a central characteristic of Baconian method, and even as having been originated by him. The Anglophone world is apt to ignore influences other than Bacon in the development of this form, but the desiderata of the lawyer and political writer Jakob Bornitz (c. 1560-1625), with their turn towards the establishment of political order, may have influenced both Hartlib and Oldenburg, and through them Petty and other natural philosophers based in Ireland.<sup>107</sup>

As mentioned above, from the time of the revival of the DPS in 1694, a renewed attempt was made to write a natural history of Ireland. Owen Lloyd (1664–1738, a Trinity divine and secretary of the DPS after 1693) wrote a letter to Richard Waller (c.1660–1715) describing Thomas Molyneux's proposal

that some of the society may bring in a list of animals, plants, fossils, and minerals, found in England and not in Ireland; in Ireland and not in England; rare in England and common in Ireland; common in England and rare in Ireland; which was accordingly ordered and undertook by these several persons, viz. birds by Mr Molyneux, insects by the lord archbishop of Dublin [Narcissus Marsh] and Sir Richard Bulkeley, quadrupeds by Charles Gwither, plants by Dr Scroggs and Mr Cox, minerals and fossils by Dr Molyneux, fishes by Dr Foley and the provost [St George Ashe].<sup>108</sup>

The queries and allocations for this project also survive in tabular form, recalling Bacon's recommendations for tabulation of facts about particular subjects., which would then be analysed once assembled. The substance of them is very close to the

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<sup>106</sup> For a summary, see P. Mack, 'Peter Ramus', *Routledge Encyclopedia of Philosophy* 8 (London, New York, 1998), 51-5.

<sup>107</sup> Vera Keller, *Knowledge and the Public Interest*, particularly Chapter 4. For Bornitz see Walter Braeuer, 'Bornitz, Jakob' in: Neue Deutsche Biographie 2 (1955), S. 471 [Online-Version]; URL: <https://www.deutsche-biographie.de/pnd124370675.html#ndbcontent>.

<sup>108</sup> DPS Papers no. 380.

wording of Samuel Hartlib's original query to Robert Boyle, written some forty years previously:

There are some things worth a philosophical pen in these places, viz. How it cometh to pass, that there are not frogs, toads, snakes, neither moles nor nightingales, rarely magpies? How some kind of fowls and beasts we have not in England? as divers hawks, cocks of the wood, pintails, wolves, foxes, greyhounds wondrous large; as also divers plants and fishes. Farther, to enquire what truth there is, concerning the generation of barnacles, which much abound there.<sup>109</sup>

The lists of animals present in Ireland and not in England, and vice versa, is another of the remaining components of the DPS project. Other traces of the queries remain in other contexts, such as the remarks on the 'greyhounds wondrous large' which appeared in Thomas Molyneux's 'Essay concerning giants'.<sup>110</sup> As we have seen, information, such as that from the lists, formed a social currency, and specimens collected while travelling could also be an acceptable exchange. For example, during his travels on the continent, St George Ashe promised to gather

specimens of several mines, minerals, and other natural curiosities of that country (which I do not despair of effecting) to make some small addition to [the Royal Society] museum.<sup>111</sup>

The DPS set up a repository for their own collection during their initial phase of operation in the late 1680s. As well as the physical specimens gathered and submitted by the members and their contacts, William Molyneux's 'book on dialling', *Sciothericum Telescopicum* was ordered to be added to the repository.<sup>112</sup> Experiments were frequently ordered to be committed to writing and registered. It

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<sup>109</sup> Hartlib to Boyle, 18 May 1654, Boyle *Correspondence* 1, 169–179.

<sup>110</sup> Thomas Molyneux, 'An Essay Concerning Giants. Occasioned by Some Further Remarks on the Large Humane Os Frontis, or Forehead-Bone, Mentioned in the Philosophical Transactions of February, 1684/5 Number 168.', *Philosophical Transactions* XXII, 487–508.

<sup>111</sup> *DPS Papers* no. 367.

<sup>112</sup> *DPS Papers* no. 110.

is not clear what may have happened to the repository during the troubled times of the Jacobite wars, but by the 1690s the society was again collecting, and applied to the Royal Society for their assistance. St George Ashe wrote to Robert Southwell in 1694 telling him

We have set apart a place, and begun a collection, of natural curiosities such as our country affords, and are promised the contribution of several ingenious men. But our chief hope is that you would be pleased to spare us out of your excellently furnished museum, such duplicates and specimens as may be no prejudice to it. We shall only use 'em for the same noble ends and purposes which you design, and make all the suitable returns which our poor kingdom may afford.<sup>113</sup>

Richard Bulkeley made a similar request to Martin Lister in 1694, seeking material for the collection and reporting a conversation with St George Ashe:

he desired me to let you know that over and above what either you or Dr Plott or any other person will think fit to send them of materials, he will lay out 5 or 6 or 8 pounds in getting as many other species (of shells, minerals, fossils, etc.) as can be gotten for it.<sup>114</sup>

These requests were met with generosity, as noted by Owen Lloyd, who wrote to Hans Sloane in 1695 thanking the Royal Society for their gifts.<sup>115</sup>

Some writers, such as Edward Lhywd, did not content themselves with second-hand observations and collection but travelled to collect information and specimens at first hand. Soft and wet tissue did not lend itself well to travel: botanical specimens fared better than other organisms which were preserved in various ways, including drying and embalming. In March 1685, Thomas Molyneux viewed such a collection which he described in a letter to Francis Aston at the Royal Society as

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<sup>113</sup> *DPS Papers* no. 368.

<sup>114</sup> *DPS Papers* no. 376.

<sup>115</sup> *DPS Papers* no. 387.

those natural curiosities Dr Herman preserves here in his balsam, which are not so considerable for their number, as that several of them have not hitherto been described by any writer, either of travels or natural history.<sup>116</sup>

Taking advantage of the networks established for the agendas of trade, religion, and colonial control, natural philosophers collected specimens and information from the wider world. Hans Sloane (1660–1753, Irish-born physician and naturalist, secretary to the Royal Society from 1693), defended the collection and description of specimens as a form of fact-gathering, which he outlines in the preface to his book on the fauna and flora observed on his voyages to the islands of the Caribbean:

The knowledge of Natural-History, being Observation of Matters of Fact, is more certain than most others, and in my slender Opinion, less subject to Mistakes than Reasonings, Hypotheses, and Deductions are; ... These are things we are sure of, so far as our Senses are not fallible; and which, in probability, have been ever since the Creation, and will remain to the End of the World, in the same Condition we now find them.<sup>117</sup>

The management of this information stream, increasing as exploration and trade increased, was a topic addressed by Francis Bacon, and worked out in various forms by the implementers of his strategies of discovery. In the case of the DPS and its antecedents, the collection of data in Petty's schemata, Hartlib's queries, and Boyle's queries reflect these patterns. As both Ann Blair and Vera Keller have discussed in recent publications, lists have a history of their own as an information management tool.<sup>118</sup> In the case of natural history, lists of creatures and phenomena were perhaps most famously adopted by Pliny as a form for dealing with nature.<sup>119</sup> Pliny's lists had the additional purpose of the description and management of colonial holdings,

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<sup>116</sup> DPS Papers no. 273.

<sup>117</sup> Hans Sloane, *A Voyage to the islands Madera, Barbados, Nieves, S. Christophers and Jamaica* (London, 1707), B1v.

<sup>118</sup> Ann Blair, *Too Much to Know*; Vera Keller, *Knowledge and the Public Interest*.

<sup>119</sup> The antecedents of these lists have given rise to a certain amount of dissent in the literature. Ogilvie insisted that too much had been made of the collection of material and information by Aristotle and Theophrastus, although other authors claimed that the use of questionnaires to collect information and report novelties was an organised strategy. See Ogilvie, *Science of Describing*, 93–5.

and a continuation of this motivation is also seen in the natural histories assembled by the DPS.

Collection and exchange of specimens throughout the Republic of Letters took place through personal and social networks, some established through scholarly affinities.<sup>120</sup> When the Royal Society set about publishing John Ray's work on fish, the DPS was asked by Francis Aston of the Royal Society 'to procure any true draft of fishes or other information about them which you probably guess we may not have'.<sup>121</sup> It was important that names were aligned in each description of a natural object (whether animate or inanimate), so that users of the information could achieve the same results, confirm each other's observations and make the same use of the material. Lister's adaptation of Goedear's work on insects was used for those purposes, as we have seen, becoming a standard for reference within a short time of its publication.

The physical form of lists and queries could invite both classification of the objects of study and the division of labour: this pattern is evident in the remaining elements of the project on natural history constructed by the DPS. Vera Keller's studies of lists referred both to the lists themselves and to the mechanisms by which the lists were generated and answers provided via networks of collection. She argued that the lists in Bacon's 'The New World of Sciences, or Desiderata' differed from their predecessors in that they remained unfulfilled, thus adding a sense of aims for advancement, and that their production in printed form 'signaled that he intended his desiderata to be fulfilled gradually, over time, and by more than one person'.<sup>122</sup> It was precisely this engagement of community which the mutual influence of Boyle and the Royal Society developed from Bacon's initial concepts, and which in turn

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<sup>120</sup> For the background to the networks of naturalists in the republic of letters, see Ogilvie, *Science of Describing*, ch.2, in particular 211–2. An example from the wider circle of the DPS was that of Martin Lister, whose correspondence shows evidence of his collecting activities. See Anna Marie Roos, *The Correspondence of Dr. Martin Lister (1639–1712). Volume One: 1662–1677* (Leiden, 2015).

<sup>121</sup> DPS Papers no. 285.

<sup>122</sup> Vera Keller, 'The "New World of Sciences": The Temporality of the Research Agenda and the Unending Ambitions of Science', *Isis* 103:4 (1 December 2012), 727–34.

was seen in Boyle's own purposes for his publications – again echoing the division of functions seen in Bacon's vision of 'Salomon's House'.

As the known world expanded, so there was an increasing reliance on travel and on networks of correspondence to collect specimens as well as observations. In a recent study, Hunter has described Boyle's thoughts on the collection of information on natural history, outlined in an unpublished work with the title '*Philosophica Peregrinans or the Travelling Naturalist*'. Likening the making of knowledge from one's own mental resources, without help from those in a position to acquire facts first-hand, to the silkworm who 'draws her whole Mansion together from her own bowels', Boyle invoked the authority of Bacon to support the process of collection of information by a technique of systematic interview, based on the pattern of queries already established. When Marsh's librarian, the Huguenot refugié divine, author and physician Elie Bouhéreau (1643–1719), set about arranging Marsh's books on the shelves of his library, '*Historia naturalis*' appeared alongside '*Medicis, Geographis et Peregrinatoribus*'.<sup>123</sup> This juxtaposition of natural history with travel literature is consistent with a relationship which was sustained in the Royal Society, with collated accounts of discoveries of organisms and products among the publications disseminated under its auspices.<sup>124</sup> Collated and mediated dissemination of information served to manage and locate the quantities of new discoveries transmitted to the Royal Society via its networks of correspondents, and the personal networks of those correspondents in turn. Collection of material and knowledge on natural history conferred a particularly useful role upon the peripheral members of the community, who contributed via their organising centres, where the material was gathered and transmitted further. Although this does not appear as an explicitly stated aim of the DPS, the practice is clear: lists of desiderata were produced, queries were raised and answered, and specimens were exchanged, in the continuing search for matters of fact.

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<sup>123</sup> Marsh's Library, MS Shelf Catalogue, completed c.1719.

<sup>124</sup> Jacob Pollock, 'The Voyage Account, the Royal Society and Textual Production, 1687–1707', *Studies in Travel Writing* 17:3 (2013), 281–99.

As emphasised by Hans Sloane in the passage cited earlier, description and classification of the natural world was an essential component of natural philosophy, forming part of the understanding of the nature and properties of matters of fact.<sup>125</sup> Systematic arrangement is a critical feature of the purposeful collection not only of objects but of information about those objects, and of queries seeking information about those objects. The curious collector, arranging items into 'like' groups, and even the librarian or encyclopaedist organising knowledge into 'like' groups, says something about what is observed concerning those items and, in Marjorie Swann's terms, gains increased social credibility from the knowledge and control of the collection.<sup>126</sup> Once objects had been added to a repository, the physical arrangement of the items – some beautiful, some odd, all engaging – stimulated the impulse to classify and the understanding of functional and ontological relationships between items.<sup>127</sup>

The arrangement of nature itself was seen as inherent in the process and design of the creative process. The most fundamental expression of divine order for these philosophical communities came from the account of creation in Genesis, where the orders of nature were called into being on successive days. Naming and ordering of creation being fundamental, it followed that it should be possible to discover or rediscover (after the disruption of Babel) the fundamental language in which these taxonomies could be expressed and represented, by symbols related directly to the essence of the concept or object. These concepts had reached the DPS, where a country member of the DPS also wrote a proposal for a universal character. This was John Keogh, a clergyman based in Roscommon, whose 'large discourse' was first read to the society on 14 December 1685, creating much discussion at the

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<sup>125</sup> 'Facticity in science has a history, and these early facts resemble those honored by later generations only in part'; Lorraine Daston, 'The Moral Economy of Science', *Osiris* 10 (1995), 2–24, 16.

<sup>126</sup> For the relationship of collector and collection see Marjorie Swann, *Curiosities and Texts: the Culture of Collecting in Early Modern England* (Philadelphia, 2001), particularly ch. 1.

<sup>127</sup> This general impulse is discussed in Michel Foucault, *The Order of Things: An Archaeology of the Human Sciences* (London, 2005; first published in French in ): for notes on critiques of Foucault's approach as it relates to early modern practice see Ogilvie, *The Science of Describing*, 16, fn.61.

meeting.<sup>128</sup> A similar contemporary attempt was made in the *Tractatus de literis et lingua philosophica* (1679) of Nathaniel Chamberlain, held in Marsh's and probably owned by Marsh.<sup>129</sup> The Royal Society members John Ray and Francis Willughby, who were working on the taxonomy of birds and fish, contributed to the scheme for a universal philosophical character developed by John Wilkins (1614-72), which was a major attempt to establish a new language of description based on ontological concepts.<sup>130</sup> Although the concept of a new language also attracted much derision and satire outside the community of natural philosophers (it did not escape Jonathan Swift's notice), it had a serious aim, and generated discussion of ontologies and a return to the objects to be classified. Wilkins' relationship with Ray was one of mutual influence in the discussion of arrangement and the supporting semantic structures.<sup>131</sup>

The terms animal and plant kingdoms were current in the seventeenth century: for an example, see Thomas Molyneux's paper on the 'gigantic os frontis'.<sup>132</sup> Within those historic divisions of nature, the assignment to the general orders or classes was undergoing continual development. The Royal Society undertook several publications on these topics, including John Ray's posthumous edition of Francis Willughby's *Historia Piscium* (1686), to the detriment of their finances (this contributed to the difficulties in publication of Newton's *Principia* and quite probably to the heat of the dispute between the naturalists and mathematicians). Contributions of material ('any true draft of fishes or other information about them

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<sup>128</sup> DPS Papers, no. 80.

<sup>129</sup> For the somewhat obscure history of this pamphlet, see Vivian Salmon, 'Nathaniel Chamberlain and his *Tractatus de Literis et Lingua Philosophica* (1679)' in *Vivian Salmon, Language and Society in Early Modern England: Selected Essays, 1981-1994* (Amsterdam, 1996). Approaches to a universal character had been current in Ireland earlier, in the context of tensions generated by a colonial vernacular imposed on the population. This is notable for its links, via Hartlib, to the European interest in the subject via Mersenne and Comenius. See Salmon, 'William Bedell and the Universal Language Movement in 17th Century Ireland', *ibid*.

<sup>130</sup> John Wilkins, *An Essay towards a Real Character, and a Philosophical Language* (London, 1668).

<sup>131</sup> Mary M. Slaughter, *Universal Languages and Scientific Taxonomy in the Seventeenth Century* (Cambridge University Press, 1982); she cites Phillip R. Sloan, 'John Locke, John Ray, and the Problem of the Natural System', *Journal of the History of Biology* 5:1 (1972), 1-53. Swift satirised universal languages in *Gulliver's Travels* where the philosophers in Lagado carry Things instead of using words.

<sup>132</sup> Thomas Molyneux, 'An Essay Concerning Giants'.

which you probably guess we may not have'<sup>133</sup>) for this natural history of fish were sought from the DPS via their then secretary St George Ashe. Richard Bulkeley was a subscriber to the volume, which departed from earlier classifications of fish simply as aquatic animals or animals living in water by adding that they must have hairless skin and fins rather than feet, and be unable to live long out of water. This did exclude the crocodile and the hippopotamus (previously classed with fish by Aldrovandi) but cetaceans were included, as although they were viviparous and their internal anatomy was like that of terrestrial quadrupeds, they met the other criteria.<sup>134</sup> Similar reclassifications on the basis of the anatomy of flying creatures were referenced by Thomas Molyneux in his description of the anatomy of the bat, and disseminated via the Royal Society in John Ray's edition of Francis Willughby's book on birds.<sup>135</sup>

Another publication by Ray was eagerly awaited by Thomas Molyneux, who wrote to Edward Lhywd

I fain would know what you hear of that catalogue of plants Mr Ray promises in his *Fascic. Stirp. Brit.* ... likewise, pray inform me what you think may be done by Mr Bobart, or any other, in perfecting Dr Morison's History of plants<sup>136</sup>

Thomas had acquired a *hortus siccus* while in Leiden, and had developed interests in the relationships between plant species and the possible implications of their geographical distribution, as seen in analogies drawn in his papers on giantism and on the antlers of the giant Irish elk.<sup>137</sup> Both Ray and Morison had compiled and

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<sup>133</sup> DPS Papers no 285.

<sup>134</sup> Sachiko Kusukawa, 'The "Historia Piscium" (1686)', *Notes and Records of the Royal Society of London* 54:2 (2000), 179–97.

<sup>135</sup> In completing the work of his associate Francis Willughby after the latter's death, Ray drew upon his own network to add birds not included by Willughby, some local and some exotic. See Tim Birkhead, *Virtuoso by Nature: The Scientific Worlds of Francis Willughby FRS (1635-1672)* (Leiden, 2016).

<sup>136</sup> DPS Papers no. 365.

<sup>137</sup> Thomas Moynuex's *hortus siccus* is in the collection of the National Botanic Gardens at Glasnevin. See M.J.P. Scannell, 'A 17th century hortus siccus made in Leyden, the property of Thomas Molyneux, at DBN', *Irish Naturalists' Journal*: 19 (1979), 320–21.

arranged botanical collections which revised earlier classifications and brought groups of plants together based on their functional structures.

Despite William Molyneux's reservations on the topic, the 'observation, ranking, and filing' of creatures generated a particular set of matters of fact among those to be sought by the natural philosopher. Similarly, the collection and description of odd cases in medicine and anatomy, and the investigation of form and function, generated matters of fact which could be shared, repeated and extended. The community of the curious in Ireland accumulated, discussed and transmitted their findings in natural history, and took part in their mentors' project of exchange of knowledge. Defending the activities of the Royal Society, Joseph Glanvill wrote that

the main intendment of this Society is to erect a well-grounded Natural History, which takes off the heats of wanton Phansie, hinders its extravagant excursions, and ties it down to sober Realities.<sup>138</sup>

This could be achieved both by observation and trial, and by comparison and repetition of experiments. Marsh's account of the caterpillar stands as an example of the way in which observation became intimately connected to arrangement and categorisation, which could take new forms based on anatomy and behaviour, and the views of monsters and the marvellous, of form and function, all contributed matters of fact to be examined by the community of witnesses. Those in provincial centres could find a purpose in communication of their findings to a centre of power and influence. A significant role for those on the geographical periphery was thus assured by the spatial distribution of the objects of study. Those in the networks of knowledge who could observe local specimens, or exchange views on the geographical variation of nature and the world, found their correspondence and material valued. Occasionally, as in the cases of Edward Lhywd and Hans Sloane mentioned above, London members of the Royal Society travelled to remoter areas,

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<sup>138</sup> Joseph Glanvill, *Plus Ultra, Or, The Progress and Advancement of Knowledge since the Days of Aristotle in an Account of Some of the Most Remarkable Late Improvements of Practical, Useful Learning, to Encourage Philosophical Endeavours: Occasioned by a Conference with One of the Notional Way* (London, 1668), 89–90.

collecting specimens and making observations for themselves.<sup>139</sup> But in the main, the Royal Society was content to make use of reports from observers they regarded as reliable. The same applied in microcosm within the provincial societies. As seen in the reports of both the Molyneux brothers, and of St George Ashe, the credibility of the observations, often founded on the identity of the observer, was noted in the correspondence, together with the opinions of the person drawing the data together. These mediated sets of observations passed in one direction, from periphery to centre; queries for elaboration of those observations then traversed the network in the opposite direction.

From the minutiae of what Robert Boyle referred to as 'God's watches' in the insect kingdom, to the existence and operation of venom, the ravages of a beetle, and the intimate details of organisms revealed by the microscope and dissections, the observations of this circle of natural philosophers connected to the DPS contributed to the understanding of nature as a whole, and more particularly to the record of specific variants of flora and fauna observed in Ireland. They did not restrict their observations to these local aspects of natural history, but also collected and exchanged information on the marvels and strange cases they encountered, and the intimate details of the functioning of created nature. As reliable witnesses of nature, their testimony was circulated in correspondence and was sufficiently valued by the gatekeepers of the learned societies to become circulated as knowledge in print.

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<sup>139</sup> For an overview of the travels of early modern materials and people, see Elizabeth Yale, *Sociable Knowledge: Natural History and the Nation in Early Modern Britain* (Philadelphia, 2015).

## CHAPTER 4

### WITNESSING THE COSMOS

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*Our late refiners upon the Creation and the Deluge are unanimously agreed, that the old interpreters of Moses were all blockheads: and which of them will furnish us with a more rational and lasting exposition, time must show.<sup>1</sup>*

*There is no part of Philosophy wherein the Mathematicks are not deeply ingredient, and on them depend the Arts of War as the Delights of Peace, and even Sacred Theology itself ... consider how far the Chronology of the Holy Scriptures is help'd out by Astronomy, and the Doctrine of Eclipses.<sup>2</sup>*

The community of natural philosophers in Ireland was motivated by the pursuit of matters of fact, and by a desire to glorify the creator in describing creation. As we have seen in the previous chapter, wonder at the intricacies of creation as shown in the structure of the smallest of living things could turn to praise of the divine designer; and in the view of the DPS and its circle, the understanding of nature could lead to the improvement of the lot of humankind, as intended by a benevolent deity. This chapter turns to an account of the contemplation of the works of the creator in the heavens and the earth. Here, I discuss the supporting improvements in instrumentation, and describe the disputes that arose between philosophers, contending for the truth of accounts of creation and the nature of the earth. The chapter concludes with the disparate views of the ingenious, and the advocacy of trial and experiment in the search for truth: truth which could in turn support orthodoxy, piety, and stable government.

For some natural philosophers in Ireland, these overarching values were queried

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<sup>1</sup> William Nicolson to Edward Lhwyd, 31 January 1698. *Letters on Various Subjects* (London, 1809), 103. For Nicolson, see D.W. Hayton, 'Nicolson, William (1655–1727), Church of Ireland bishop of Derry and antiquary', ODNB.

<sup>2</sup> Molyneux, *Sciothericum*, preface.

through an engagement with chronology and the textual criticism of the Bible. For others, observation of the physical characteristics of the earth and its stony inclusions gave rise to a search to understand processes of petrification. Observation of the changing heavens, and the appearance of comets, inspired other sets of cosmological queries. Philosophical engagement with the created cosmos figured in print, marginalia, and collection, and in correspondence and minuted discussions within and between societies.

The purposes of natural philosophy included the continuation of the humanist programme of enquiry into the nature and history of the cosmos, as into the histories of created beings. In investigating the work of the creator, philosophers drew upon scripture, and the discussion of its sources and reliability, as well as upon observation and description of earthly phenomena. During the sixteenth and seventeenth centuries, scriptural and classical texts came under renewed scrutiny for the accuracy of their chronology and their accounts of geography, the two disciplines known as the eyes of history.<sup>3</sup> Tensions in the interpretation of creation and the authority of the creator held perceived implications for the stability and order of church and state. While humanistic techniques made inroads into previously stable textual interpretations, the same was true both of the observation of the physical nature of the earth and the structures of its being, and of the observation of the heavens via improved instruments. A further support to the interpretation of both astronomy and chronology was provided by mathematics, as indicated in the epigraph to this chapter, taken from William Molyneux's *Sciothericum Telescopicum*. Both Marsh and Molyneux found that mathematics formed a welcome distraction in troubled times, as well as underpinning astronomical observations and the assessment of chronologies.

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<sup>3</sup>The origins of this phrase are lost: for discussion of the eye metaphor in relation to chronology and history see Daniel Rosenberg and Anthony Grafton, *Cartographies of Time: A History of the Timeline* (Princeton NJ, 2013), and Stephen Boyd Davis, 'May Not Duration Be Represented as Distinctly as Space? Geography and the Visualization of Time in the Early Eighteenth Century', in David Beck (ed.), *Knowing Nature in Early Modern Europe* (London, 2015). Rosenberg and Grafton trace it to Ortelius, in a quotation favouring geography over chronology; Davis to David Chytraeus in 1563.

It has been argued by Peter Harrison that the terms used to describe the acquisition of knowledge in religion, via experiment and experience, were co-opted by natural philosophers, as were the legal terms of witness and testimony.<sup>4</sup> The relationship between religion and science existed in a state of tension throughout the early modern period and became the subject of many later triumphalist accounts of the rational prevailing over the irrational. In these accounts, much is lost of the early modern mindset, including the concept of natural religion, a counterpart of the natural theology of Thomas Aquinas, which aimed to establish that the conduct of humankind was subject to an innate and self-evident Law of Reason. Richard Hooker's *Of the Lawes of Ecclesiastical Politie* (1595) was one of the earliest formulations of this philosophical and theological framework, which was later expanded and developed by Lord Edward Herbert of Cherbury (1582–1648) and the Dutch theologian and lawyer Hugo Grotius (1583–1645). Later, John Locke (1632–1704) developed these ideas, in particular in *The Reasonableness of Christianity* (1695). This treatise was, in part, written in response to those who had aligned Locke's thinking with that of the 'Donegal heretic' John Toland (1670–1722), whose challenging writings had met with an outraged response from the established church.<sup>5</sup>

The implications of mechanistic theories, such as those of René Descartes (1596–1650) and Isaac Newton (1642–1727), stimulated debate on cosmogony and cosmology. The study of the earth itself, and its intimate connection to natural philosophy in the post-Restoration period in England, has recently been reviewed comprehensively by William Poole, who noted the engagement of Anglican theology with these issues, in particular that of Edward Stillingfleet. A similar review of the issues from a Dutch viewpoint has been made by Eric Jorink.<sup>6</sup> Thomas Burnet (c.1635–1715), William Whiston (1667–1752) and John Woodward (1665–

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<sup>4</sup> Peter Harrison, 'Experimental Religion and Experimental Science in Early Modern England', *Intellectual History Review* 21:4 (2011), 413–33.

<sup>5</sup> Toland's precarious position, and the correspondence of William Molyneux with Locke mentioning these difficulties, are discussed further below.

<sup>6</sup> Poole, *World Makers*; Eric Jorink, *Reading the Book of Nature in the Dutch Golden Age, 1575–1715*, (Leiden, 2010).

1728), to name but three of the Anglophone writers who attempted to deploy adaptations of Cartesian or Newtonian theories in proposing mechanisms for the birth and development of the earth, were all connected with the Anglican confession. Their debates were received with a degree of scepticism and did not escape ridicule.<sup>7</sup> A much-cited letter from the cleric William Nicolson (1655–1727) on mechanisms of cosmogony, addressed to the antiquary and naturalist Edward Lhwyd, refers to ‘Dr Burnet’s roasted egg, Dr Woodward’s hasty pudding, or Mr Whiston’s snuff of a comet’: all were proposals for the mechanistic cause of the universal deluge.<sup>8</sup> Jocose comments such as these did not indicate dismissal by the learned community, and all three authors are to be found, together with answers and commentaries, on the shelves of Marsh’s own collection, and that of Edward Stillingfleet, and stimulated engagement from Marsh, as we shall see later.

Interest in the nature and formation of the earth also led to interest in its components and their behaviour. Mechanisms of petrification and the production of fossils were subjects of comment and interest shared between members of the DPS, the Irish circle and those further afield. Examples of these were the interest shown in the extraordinary rocks known as the Giant’s Causeway to be found on the coast of County Antrim, the alleged petrifying qualities of the waters of Lough Neagh (also in Antrim), and, as we have seen in the previous chapter, the preserved horns of a giant deer described in detail in the *Philosophical Transactions* by Thomas Molyneux. The production of stones in the human body (as seen in Chapter 3) and the production of stones in the earth raised intersecting questions, and the nature of stony bodies was investigated in the laboratory, as discussed further in Chapter 5.

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<sup>7</sup> Burnet and Whiston were both ordained clergy, and Woodward attracted the patronage of John Tillotson, drawing him into the sphere of influence of the church. Thomas Burnet, *Telluris Theoria Sacra* (London, 1681), with an English version appearing in 1684, and further revisions and editions issued later; see Scott Mandelbrote, ‘Burnet, Thomas (c. 1635–1715), natural philosopher and headmaster’, ODNB; William Whiston, *A New Theory of the Earth* (London, 1696), see Steven Snobelen, ‘Whiston, William (1667–1752), natural philosopher and theologian’, ODNB; John Woodward, *An Essay Toward A Natural History of The Earth* (London 1695). See J.M. Levine, ‘Woodward, John (1665/1668–1728), physician, natural historian, and antiquary’, ODNB; and Levine, *Dr. Woodward’s Shield: History, Science, and Satire in Augustan England* (Ithaca NY, 1991).

<sup>8</sup> Nicolson to Lhwyd, 31 January 1698. William Nicolson, *Letters on Various Subjects*, 104.

As with the collection and description of creatures gathered into accounts of natural history, the observation of the properties of the earth and the heavens required the contribution of geographically distributed observers, and there is evidence of the participation of the Dublin circle in a culture of exchange of specimens which informed studies of the created world. Many meteorological and astronomical observations were also collaborative, with the experiences of many observers collated for one event, or group of events. Collaboration and comparison was a particularly significant aspect of astronomical observation. Data from observed phenomena were shared in the private sphere of personal correspondence and in the public sphere of print, with significant transfer from one to the other.

### Revealed truth tested: the veracity of Biblical accounts

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The second meeting of the DPS for which minutes are extant (22 October 1683) heard a discourse by Dudley Loftus (1618–95) on a topic in scriptural studies. This was followed by a chymical topic: ‘Dr Molin *de alkali et acido*’, of which more is to be found in Chapter 5.<sup>9</sup> The DPS intended to have a parallel set of discussions on theological topics, but unlike the discussions on topics in natural philosophy, this seems to have taken place without record and without formal structures. Commenting on the plans for discussion on theology in a letter to the Oxford antiquary and chymist Robert Plot (1640–97), Robert Huntington remarked:

Several of the number (pray don’t call them the assembly of divines) meet at 5 upon Sunday nights (as the whole company does on Mondays) to discourse theologically ... how to establish religion and confute atheism, by reason, evidence, and demonstration.<sup>10</sup>

Loftus, as a biblical scholar himself who had contributed an Ethiopic translation for Brian Walton’s polyglot Bible (published in 1657), was well placed to comment on his chosen topic, Père Simon’s *Histoire Critique du Vieux Testament* (first published

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<sup>9</sup>For Loftus see Elizabethanne Boran, ‘Loftus, Dudley (1618–1695)’, ODNB. Also see the biographical note in the *DPS Papers* II: 952.

<sup>10</sup> Robert Huntington to Robert Plot, 18 December 1683; see *DPS Papers* no. 213.

in 1678). Richard Simon (1638–1712) was an Oratorian priest, Orientalist and theologian, who published commentary and analysis on the text of both Old and New Testaments of the Bible. Simon's book on the Old Testament had a complex publishing history and reception. By the time that Loftus presented Simon's findings to the DPS, an altered version of the text had already been produced by Daniel Elzevir in Amsterdam from a transcription which had been circulated in manuscript. The work went through a number of editions and translations, and gave rise to responses, challenges and commentaries. The degree to which biblical texts could be relied upon as the unchangeable word of God had already been a matter for considerable debate but Simon raised further problems about the trustworthiness of the scribal transmission of the texts, shaking one of the pillars of reformed religion, that of scripture.<sup>11</sup> His work was castigated in 1685 by the reformed theologian and philosopher Jean Le Clerc (1657–1736), who asserted that Simon's interpretative stance could be taken for that of any persuasion, from Calvinist to Spinosan.<sup>12</sup>

The juxtaposition of chymistry and theology in the DPS meeting may have awoken links in the minds of the hearers. Moses, prominent as the law-giver of the Old Testament, was also given a place in hermetic chymical philosophy as a keeper of knowledge, and Dmitri Levitin has recently claimed that the debate about Mosaic philosophy became *the* pre-eminent debate in natural philosophy in the closing years of the seventeenth century.<sup>13</sup> The combination of topics at the meeting of 22 October 1683 thus serves to illustrate a mindset which was natural to the DPS, while appearing strange to the modern mind.

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#### Cosmology and chronology intersect

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The humanistic apparatus brought to bear upon the output of the ancients included

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<sup>11</sup> 'Sola scriptura, sola fide, sola gratia': three pillars, sometimes extended to five by the addition of a turn to the deity in Solo Christo and Soli Deo gloria.

<sup>12</sup>Jean Bernier, 'Le Problème de la tradition chez Richard Simon et Jean Le Clerc', *Revue des sciences religieuses*, 82:5 (2008), 199–223, <https://doi.org/10.4000/rsr.2155>.

<sup>13</sup> Levitin, *Ancient Wisdom*, 37.

the techniques of chronology, history, geography, and philology. The study of sacred and ancient geographies situated the histories and scripture spatially, while philology assisted the scholar in the detection of forgeries and the interpretation of truths. Linking these disciplines was the technical study of chronology, which connected known astronomical events with those described in historical texts, underpinned by mathematics and astronomy. To be able to situate events such as creation, the biblical flood, and the life of the historical Jesus in ‘real’ historical time conferred an additional validity on those events. The reformers could point to a faulty ecclesiastical calendar in need of correction, with a consequent claim that the reconstruction of past calendars in classical eras was necessary in order to understand the historicity of sacred events. Late in the sixteenth century, Joseph Scaliger (1540–1609) had begun a synthesis of the work of many other scholars: for the reformed church, his work became pivotal. Chronology, as Anthony Grafton has written, ‘offered essential help to the theologian reading his bible, the doctor reading his Galen, and the naturalist reading his Pliny’.<sup>14</sup> The reinterpretation of such a pervasive concept had power to disrupt thinking in all these spheres.

As already discussed, Edward Stillingfleet (1635–99) drew significantly on contemporary chronological scholarship in arguing for the divine authority of the scriptures, supported as one of the pillars of rational Anglican theology, which called upon scripture, reason and tradition, as advocated by Richard Hooker.<sup>15</sup> In his *Origines Sacrae*, Stillingfleet cited Joseph Scaliger’s opinion of chronology as an essential in history: chronology formed ‘the life and soul of History, without which History is but a confused lump, a mere Mola’.<sup>16</sup> Forming an aside to Stillingfleet’s discussion of chronologies derived from ancient heathen civilisations, this section of his book dealt with contradictory interpretations of chronologies by Scaliger and his opponents, particularly the Jesuit Denis Petau (1583–1652), and with the

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<sup>14</sup>Anthony Grafton, *Defenders of the Text*, 105.

<sup>15</sup>Hooker’s position is widely cited in Anglican theology. See H.R. McAdoo, *The Spirit of Anglicanism* (London, 1965).

<sup>16</sup>Edward Stillingfleet, *Origines Sacrae: Or, A Rational Account of the Grounds of Natural and Revealed Religion* (Oxford, 1702), 59. This is the posthumous edition published by Richard Bentley, Stillingfleet’s chaplain and biographer.

attempts by other writers to reconcile and mitigate these conflicts. Some proposed mechanisms for the operation of creation trod dangerously close to making the action of the creator redundant. Stillingfleet marshalled the resources of his personal library to support the role of the creator. In his *Origines Sacrae*, he recounted the nature of the universe, and set out the necessity of the deity to creation.<sup>17</sup>

Although Narcissus Marsh did not publish on these topics, as he was urged to do, or indeed write much that is explicit in his surviving correspondence, his collection is rich in the apparatus which supported investigation into the historical and geographical realities of the lands mentioned in scripture, and into the chronologies of biblical and contemporary events.<sup>18</sup> His notes form links between books, joining (for example) geographies with grammars, and chronologies with geographies. This is particularly evident in the marginalia on Marsh's interleaved copy of the 1670 Paris edition by Michel Baudrand (1633–1700) of the Servite monk Filippo Ferrari's *Lexicon Geographicum*. On the double-columned pages, ruled in imitation of the structure of the original, Marsh frequently added notes derived from the *Historia Aethiopica* (first published in 1681) by the German orientalist Hiob Ludolf (1624–1704).<sup>19</sup> He also makes reference to the writings of the Huguenot biblical scholar Samuel Bochart (1599–1677), found on his shelves in the *Opera omnia, hoc est Phaleg, Canaan, et Hierozoicon* (1692), as well to as many standard classical reference books. Similarly, Marsh's 1662 Oxford edition of Helwig's *Theatrum historicum et chronologicum* is also interleaved and annotated, although not as extensively. This work, with its proportional representation of time in the scale of

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<sup>17</sup> 'Of the origin of the universe' forms chapter one of *Origines Sacrae*.

<sup>18</sup> Marsh apparently did attempt a reconciliation of the Hebrew and Chinese chronologies, and appears to have sent an account of this to Bernard. On 27 December 1690 Bernard wrote to Marsh: 'I make bold to signifie to yr Grace, that the worthy consort of your renowned friend, the much esteemed Madam Guise, sent hence upon the 24th of November a parcel of oriental mss put up in a large boxe with the great Menology of the Armenian Church and your own dissertation upon the chronology of the Chinese, which we hope is arrived safely before this salutation'. Bodleian MS Smith 4, 41. The Menologion may have been the manuscript numbered 1328 in Bernard, *Catalogi librorum manuscriptorum Angliae et Hiberniae in unum complecti* (Oxford, 1697). My thanks are due to William Poole for notice of his view of this discussion.

<sup>19</sup> This is another book missing from Marsh's collection. He must have had access to it at some point, but it is no longer in his library.

the tables of events, was first published in 1609, and went through many editions: Locke, echoing Scaliger, thought chronology essential to a true understanding of history, although for pedagogical purposes preferring those that omitted the controversies ('all that learned Noise and Dust of the Chronologist') and recommended Helwig's work as well as that of the German mathematician and theologian Aegidius Strauch (1632–1682) as didactic chronologies.<sup>20</sup>

Soon after Marsh came to Dublin, he was in correspondence with the Oxford orientalist Edward Pococke.<sup>21</sup> Among topics that they discussed was the 'Tract of the Sybils' produced by Isaac Vossius (1618–89), son of the eminent Leiden scholar Gerard Vossius.<sup>22</sup> Pococke lamented that it was

derogatory to Rabbinical learning... and particularly (which is *magis dolendum* [the more sorrowful]) to bring disrespect and contempt on the Hebrew Bible... I hear, that by some at coffee meetings, it is cried up.<sup>23</sup>

The book in question was *De Sibyllinis aliisque quae Christi natalem praecessere oraculis*, which circulated widely and by 1680 had appeared in both London and Leiden editions. It dealt with the question of the significance of Greek (thus respectable although pagan) prophecies of the coming of the Messiah, linking the classical histories with the biblical ones, and lending support to the historicity of the biblical texts. By this time, the texts ascribed to the Sybilline oracles were widely suspected of being forgeries, but Isaac Vossius asserted their origin in Jewish antiquity. Vossius was already suspect in protestant circles, particularly in England, as he gave the chronology of the Septuagint primacy over that of the Hebrew Bible. Pockocke suggested to Marsh that

the original text might be vindicated from such sceptical arguments, by

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<sup>20</sup> John Locke, *Some Thoughts concerning Education* (London, 1693), 218.

<sup>21</sup> G. J. Toomer, 'Pococke, Edward (1604–1691), oriental scholar', *ODNB*.

<sup>22</sup> T. Seccombe, 'Vossius, Isaac (1618–1689), philologist and author', *ODNB*.

<sup>23</sup> Edward Pococke to Marsh, February 1680. The originals of these letters are presumed lost, and parts of the text are preserved in Leonard Twells, account of Pococke's Life in *The Lives of Dr. Edward Pocock, the Celebrated Orientalist, by Dr. Twells ...* (London, 1816), this citation from volume 1, 313.

some of learning and vigour, such as yourself.<sup>24</sup>

Marsh confessed himself

very much grieved at what you say concerning some mens design to invalidate the authority of the Hebrew text, and thereby of all the Old Testament.<sup>25</sup>

In a later letter, Marsh was caustic about the lack of ability to distinguish between Isaac Vossius and his distinguished father:

I find Dr. Vossius's last, as well as former books, have not done much good (I wish they have not done the contrary) here ... whatsoever Dr. Vossius says, because his name is Vossius, *ipse dixit*, is enough to make it believed; which seems to me the more insufferable, because they cannot, or else will not make any distinction between Gerard and Isaac Vossius.<sup>26</sup>

Although hopeful that the appointment of a professor of Hebrew to Trinity College Dublin might 'breed up' scholars capable of making sound judgements, Marsh's nervousness at the controversy arose from a context in which the scrutiny applied to texts such as those of the Sybilline oracles was casting doubt on the historicity and veracity of the biblical texts in their turn. When combined with the questions arising from observation of heavenly events such as eclipses, and earthly objects such as fossils, the testing of revealed truths was searching, and further challenges to the authority of the church were built upon these scholarly queries by those such as the actively controversial deist John Toland. Described by Edward Lhywd as 'of excellent parts, but as little a share as may be of modesty or conscience; and one of the best scolds I ever met', Toland drew fire from the established church.<sup>27</sup> His writings, apparently denying mystery of any kind in religion, and thereby

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<sup>24</sup> Twells, *Lives*, 314.

<sup>25</sup> Marsh to Pococke, 17 April 1680, Twells, *Lives*, 315.

<sup>26</sup> Marsh to Pococke, 29 April 1680, Twells, *Lives*, 316.

<sup>27</sup> This remark, which has been cited by Justin Champion in his *Republican learning, John Toland and the crisis of Christian culture, 1696-1722* (Manchester, 2003) is taken from a letter from Lhwyd to Martin Lister, n.d. 1695, published in R.T. Gunther, *Early Science in Oxford*, XII, 277-8.

challenging much that the orthodox held dear, excited the ire of Marsh, among others, and were ultimately burned at the hands of the public hangman. Lhwyd thought, however, that the brash Irishman might be the very person to disabuse John Woodward of his theories of the earth (characterised by Lhwyd as ‘whimsies’), precisely because of his nature as a scold.<sup>28</sup>

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### Mysterious earth, mysterious Creator

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There were two essential routes to the understanding of the timetable of creation. As we have seen, one route relied heavily on textual information: descriptions and narrative were drawn both from scripture and from texts which were seen as supporting the scriptural account. The other turned to observation of the world itself, and the objects within it. In particular, a geological horizon was sought to support the concept of a universal deluge, and the destruction of large numbers of beasts and humans not rescued by the biblical ark. This category of observation was calculated to yield matters of fact in support of the historicity of biblical events. Various mechanisms were proposed for the generation and process of the deluge. Critics of Burnet, Whiston and Woodward sought to argue from these mechanisms to the resulting positions of the various layers of the earth and the fossils within them. Among these critics was the mysterious L.P., whose *Two Essays*, published in 1695, pleased Edward Lhwyd by including a couple of pages of material from a letter originally sent from Lhwyd to the Royal Society naturalist John Ray. Lhwyd was largely unconvinced that the author could be Toland, saying as much in his letter to Martin Lister, cited previously. Lhwyd characterised Toland in the same letter as ‘eminent for railing in coffee-houses against all communities in religion, and monarchy’. He had previously mentioned Toland to Lister in connection with some amber stones (‘an electrine spar’) that the Irishman had insisted were appearing spontaneously in a well: Lhywd dismissed this as the fancy of someone who was not ‘conversant’ with studies in natural philosophy.<sup>29</sup> Whoever L.P. was, he could list an impressive selection of books which he advised his reader to consult

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<sup>28</sup> Lhwyd to Martin Lister, n.d. 1695.

<sup>29</sup> Lhwyd to Martin Lister, 13 March 1694. Gunther, *Early Science in Oxford* XII, 232.

for further support for his arguments, and claimed attention to 'plain Examination of matter of Fact, as it stands in Nature'.<sup>30</sup>

The assertions made about the earth's early history were testable. Each theory made predictions about what would be found beneath the earth's surface. The rich variety of subterranean finds, taking many forms, had excited the curiosity of natural philosophers for at least a century. The processes of petrification which could possibly produce such things had been enquired into by the Royal Society and other learned groups. It had been observed that petrification could take place within the living body, as well as in the body of the earth. The stones extracted from humans were collected, weighed, and examined, not only for their medical history, mentioned in Chapter 3, but also for the possible information within them as to the nature of their generation.

In particular, the discovery of stones in the earth which resembled the forms of living creatures begged for an explanation from the curious. Writing to Martin Lister in November 1694, Richard Bulkeley described the DPS as being 'upon a philosophic ferment', and having 'produced many curious discoveries in earths, formed stones and minerals, and other fossils, and very great curiosities some of them'.<sup>31</sup> Each of these earthy objects raised issues both for the Aristotelian view of the origin of forms and qualities, and also for the mechanistic and corpuscular alternatives upon which Robert Boyle had written extensively, as well as Robert Hooke, Nehemiah Grew and Martin Lister in the Royal Society (Lister being a correspondent of St George Ashe as well as of Bulkeley), Robert Plot in Oxford, and others including Edward Lhwyd and John Ray.<sup>32</sup>

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<sup>30</sup> L.P., *Two Essays Sent in a Letter from Oxford to a Nobleman in London* (London, 1695), 2.

<sup>31</sup> DPS Papers no. 384.

<sup>32</sup> For reviews, see Poole, *World Makers*, particularly chapter 9; and also Rhoda Rappaport, *When Geologists were Historians* (Ithaca NY, 1997); Paolo Rossi, *The Dark Abyss of Time: The History of the Earth and the History of Nations from Hooke to Vico* (Chicago, 1984).

The classification of materials found under the earth—fossils—had been based largely on that of Georg Agricola since the sixteenth century.<sup>33</sup> Agricola distinguished between metal ores; gemstones; rocks; and stones which appeared to hold some sort of figure or pattern. The modern use of the word ‘fossil’ began to emerge from his uses, to denote material which could have an organic origin. As to how these organic items had become stony, and had appeared beneath the earth, opinion remained divided in the Royal Society as in other learned groups. In the Royal Society, Martin Lister took issue with the Danish philosopher Nicolas Steno (1638–86) as to the origins of the formed stones, considering them *lapides sui generis*, stones after their kind. Lister had shown that although some formed stones resembled living creatures, some did not resemble any currently in existence (for example, the large ammonites plentiful in England, or the trilobites discovered in the east). Steno had followed the Italian natural philosopher Fabio Colonna (1567–1640) in proposing that the items known as ‘glossopetrae’ or ‘tongue stones’ not only strongly resembled the teeth of living sharks but were actually the teeth of sharks long dead. Henry Oldenburg was responsible for a translation into English of Steno’s work concerning the formation of such fossils, which appeared as *The Prodromus To A Dissertation Concerning Solids Naturally Contained Within Solids*.<sup>34</sup> It was Steno who argued that fossils could change their chemical nature without losing their form --- in modern terms, organic material being transformed into inorganic. Martin Lister and Johann Daniel Geyer of the Leipzig academy both supplied critiques of Steno’s work, but in 1671 Robert Hooke declared to a meeting of the Royal Society that he was convinced that ‘all those shells are the *exuviae* of animals’.<sup>35</sup> Hooke’s convictions about the nature of figured stones had been expressed to the society in 1666, when he had ‘brought in a petrified fish called *Echinus Spaticus*, by which he conceived his notion of figured stones to be

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<sup>33</sup> Lutz W. Weber, ‘Georgius Agricola (1494–1555), Scholar, Physician, Scientist, Entrepreneur, Diplomat’, *Toxicological Sciences* 69:2 (2002), 292–94, <https://doi.org/10.1093/toxsci/69.2.292>.

<sup>34</sup> Nicolas Steno, *The Prodromus To A Dissertation Concerning Solids Naturally Contained Within Solids English'd by H.O.* (London, 1671).

<sup>35</sup> Exuviae are shed skins or exoskeletons. The citation is from Birch, *Birch, History of the RS*, II, 487.

confirmed.<sup>36</sup> Lister examined the stones by chymical means, and argued from the results that the stones behaved as the surrounding stone did.<sup>37</sup>

The topic was still in dispute in 1698, when Thomas Molyneux wrote to Edward Lhwyd about his forthcoming *Lithophylacii Britannici ichnographia*, a catalogue of stony specimens classified as to their resemblances to organic life-forms. Hoppen has described Lhwyd's hypothesis as to the origin of these stony formations as 'more ingenious than accurate', relying as it did on 'seeds' carried by the air. Molyneux referred to the controversy as 'pusling [puling, weak]'. In Hoppen's interpretation, Molyneux was bored by the ongoing debate. Whether or not this was the case, it was evidently still a live issue for many and would continue to have implications for the early history of the earth for decades, if not centuries. These questions were not trivial. Although Hoppen was of the opinion that the time spent in discussion of the questions regarding stones of various kinds by both the Royal Society and the DPS was relatively limited, both societies queried the nature of stones. Whether formed or figured, earthy or bodily, stony productions were of evident interest.

Examination of the formation of stones in the body as well as in nature (in the case of Lough Neagh and other petrifying waters) was of significance in considerations other than that of the determination of the nature of fossils, in particular the understanding of the origins of forms and qualities, in which transformations from one state to another was of importance, and the DPS discussed quite a number of specimens of both figured and formed stones from diverse sources. St George Ashe brought figured stones 'resembling petrified shells' to a meeting in 1684, which (perhaps citing Lister) were reported to be 'thought of late by some to be *lapides sui generis*'. Other stony specimens shown at the same meeting, this time by William Molyneux, were 'some curiously figured rock crystal found nigh Catherlagh

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<sup>36</sup> Birch, *History of the RSII* 297. For a discussion of drawings by Hooke and Waller of a range of fossils, see Sachiko Kusukawa, 'Drawings of Fossils by Robert Hooke and Richard Waller', *Notes and Records of the Royal Society of London* 67:2 (2013), 123–38, <https://doi.org/10.1098/rsnr.2013.0013>.

<sup>37</sup> For a full account of this discussion see Roos, *Web of Nature: Martin Lister (1639-1712), the First Arachnologist* (Leiden, 2011).

[Carlow] in a field'. However, the person who had given these particular specimens to William Molyneux had not recorded how they were originally positioned. They were described as

hexagonal prisms, determined at one end by a hexagonal piramis [=pyramid], as curiously edged as if cut by art. On the other end they seem to determine in a root as if fixed thereby to another stone.

At the same meeting, stones which had a bodily origin were presented, which were described as

a stony substance, bigger than a large white pease, of an irregular shape and yellowish substance. Of these stones there is a person of quality, of a very sickly constitution in this town, that has voided at several times above a hundred by siege, and several as big as the end of one's finger.<sup>38</sup>

The chymical mechanisms by which crystalline formations and other figures were produced also linked to this line of queries, and embraced the interest shown in the basalt figures of the Giant's Causeway in County Antrim. At another meeting, Samuel Foley (1655–95), one of the clerical members of the DPS and later Bishop of Down and Connor, whom we encountered in Chapter 3 studying the growth patterns of a bean, took a keen interest in the growth of crystals and the generation of formed stones:

[He] produced a pretty figurate stone ... and exposed a pot wherein were seen the curious shootings of salt of vitriol into various regular figures, as triangular, quadrilateral, and pentagonal.<sup>39</sup>

Foley took up these concepts in a long discourse on formed or figured stones, which he called an 'entertainment' in the spirit of the philosophical entertainments produced at the meetings. He acknowledged that one of the many explanations for these intriguing formations was that they were a *Iusus naturae* [a sport of nature].

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<sup>38</sup> DPS Papers no. 26.

<sup>39</sup> DPS Papers no. 14.

He outlined both Hooke and Plot's views as to the origin of the stones, continuing to Robert Plot's concept relating the shape of the stones to the shapes generated by particular salts. Plot had extended this with a relation of the shape of the crystals to the shape of the animal which had produced them: so, he observed that sal ammoniac was prone to produce crystals which were in the shape of the hartshorn, and 'salt of vipers shoots into shapes somewhat like those animals placed orderly in the glass'.<sup>40</sup> Plot's ideas could be plausibly extended to produce stones figured like animals by a spontaneous process (evoking a background of vitalist concepts), which was an appealing explanation for their existence without the complication of the deluge, or stratification.

Formed stones were sent by Lhywd to the Dublin group in 1700. His letter to Thomas Molyneux, describing his gift, linked the observation of the stones to the 'better understanding some of our late philosophers, such as Mr Whiston, Dr Woodw[ar]d etc'.<sup>41</sup> The 'etc' probably included Thomas Burnet, author of the widely disseminated *Sacred Theory of the Earth (Theoria Telluris Sacra)* (1681/1684/1697. Burnet's account of cosmogony adapted some previous theories of the flood, drawing on Cartesian mechanisms to explain the observed phenomena. It attracted the attention of the Royal Society in 1681 when it was described as

a book lately published by Mr. Burnet of Cambridge concerning an hypothesis to solve all the phenomena of Noah's flood consonant to the scriptures, the writings of the antients, and the Cartesian philosophy.<sup>42</sup>

Among the book's detractors was John Keill (1671–1721), a pupil of the Scottish Newtonian David Gregory (1661–1708), who followed his mentor to Oxford in 1694. His first book on this topic, *An Examination of Dr. Burnet's Theory of the Earth*, in which he attacked Burnet's theory of cosmogony, appeared in 1698. It generated something of a pamphlet war. Keill responded with a further book on the same

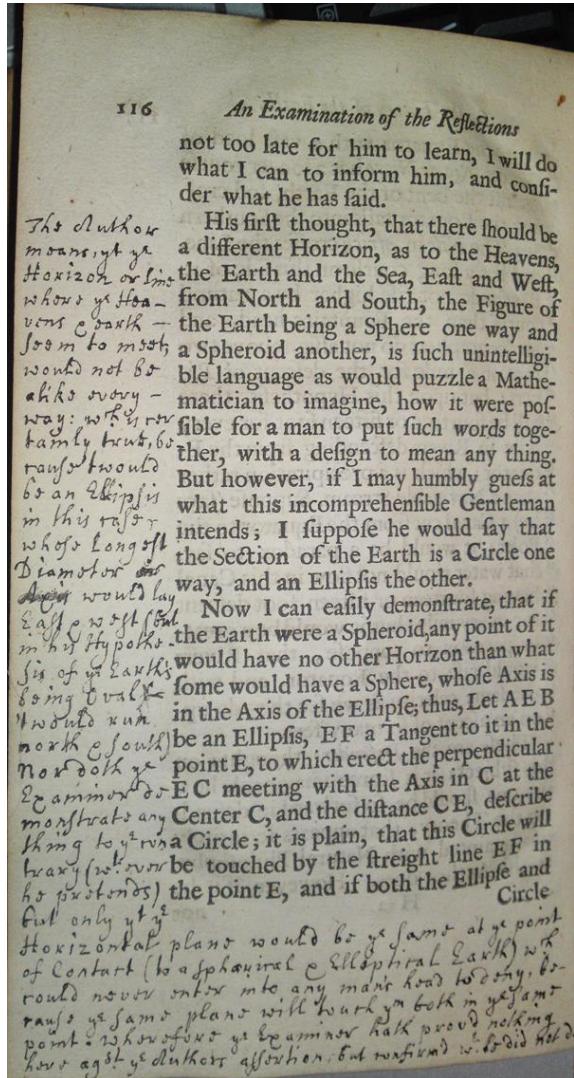
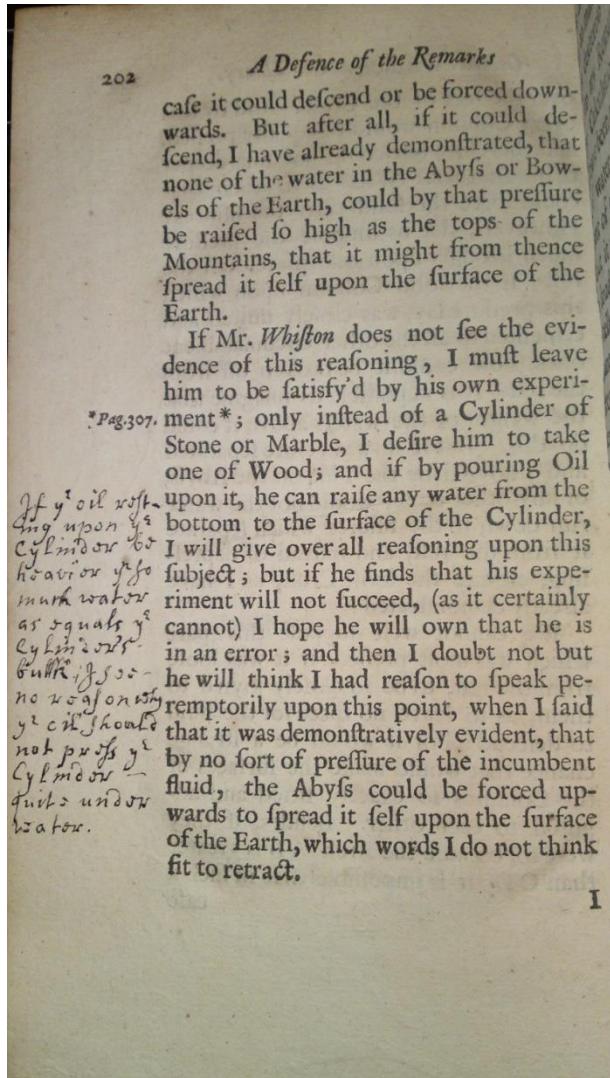
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<sup>40</sup> Robert Plot, *The Natural History of Oxfordshire* (Oxford, 1677), 122. Marsh contributed a paper on sympathetic vibration in lute-strings to this volume (289–99).

<sup>41</sup> *DPS Papers* no. 410.

<sup>42</sup> Minutes of 9 February, 1681 in Birch, *History of the RSIV*, 69.

topic in 1699, *An Examination of the Reflections on the Theory of the Earth Together with a Defence of the Remarks on Mr. Whiston's New Theory*. These books were both seen by Narcissus Marsh, who strongly disagreed with Keill's views.



Marsh's marginal notes in John Keill, *An Examination of the Reflections on the Theory of the Earth Together with a Defence of the Remarks on Mr. Whiston's New Theory* (London, 1699).

Writing to Arthur Charlett, master of University College Oxford, on 30 November 1699, Marsh commented 'I have by me Mr Keill's second Book (but could not find time to read it)'. He evidently did eventually read it, for he made fairly extensive

marginal comments on the text. In particular, Marsh's comments related to theories about the shape of the earth and thus of the formation of the horizon, to the composition of the layers of the earth, and to the mechanisms proposed by Keill for the movement of the waters of the deluge. In the letter to Charlett (which is largely concerned with a palaeographical enquiry about an Irish manuscript), Marsh gave an acerbic opinion of Keill's first attack on Burnet:

'Tis not very decent for a grave reverend Divine to be ridicul'd by a young pretender to Mathematicks for asserting those things wherein the Divine certainly is in the right & the pretended Mathematician hath quite mistaken his figures and, soaring too high, hath unadvisedly dropt into the pit.<sup>43</sup>

William Whiston attempted a redemption of Burnet's theory by suggesting in his 1698 book *A Vindication of a New Theory of the Earth* that a divinely ordained comet, passing close to the earth on its Newtonian parabolic path, had changed both the shape and the orbit of the earth (this was the theory ridiculed in Nicholson's letter as 'a snuff of a Comet').

At the same time as these controversial views of the physical processes of cosmogony and the historical truth of the scriptural account of creation were being exchanged, the theological establishment was concerned to prevent a more unsettling application of the doubts raised. If no concept was completely refractory to reason, and nothing could be held to be truly miraculous, that raised many questions as to the existence and role of the deity. Robert Burton, in his *Anatomy of Melancholy* (1621) commented on 'our great Philosophers' asserting that 'too much learning makes them mad' and classing deists with the atheists (whether he was responsible for coining the term 'deist' is not clear). The sense of a delicate balance between the application of reason to the documents and structures of religion, and the application of that same reason to controversial topics in natural philosophy was reflected in the writings of John Locke and Robert Boyle, who were concerned

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<sup>43</sup> Marsh to Arthur Charlett, 30 November 1699. Bodleian MS Ballard 8 fol. 6; also printed in *Letters of Eminent Literary Men* (London, 1843).

to show that their philosophy was neither atheist nor deist. That balance and reticence were notably absent from the writings of John Toland, which, as we have seen, incensed Narcissus Marsh.

Toland's initial assertion in print that nothing in religion was beyond reason met with a vigorous (and to some, disproportionate) reaction from Narcissus Marsh and the religious authorities of the established church in Ireland. As mentioned earlier, *Christianity not Mysterious*, published in 1696, was burnt by the common hangman, and Marsh commissioned Peter Browne, later bishop of Cork, to write an answer to it. *Two Essays Sent in a Letter from Oxford to a Nobleman in London* (1695) brought the disputes about the nature and impact of the flood to a more extreme materialist conclusion. Whether written by Toland, or by a supporter, the *Two Essays* served to disseminate these views further.

For some, Toland's views were similar to those expressed by John Locke. For Locke himself, the association was undesirable. The implications of the controversy surrounding Toland for the practice and processes of natural philosophy as a whole were discussed between William Molyneux and Locke in their personal correspondence. They were both careful to distinguish between Toland's heretical views and Locke's rational thoughts, aware that this distinction was important in avoiding charges of atheism for Locke. In challenging Locke in print, Stillingfleet was not minded to accept this distinction. In his *Discourse on the Trinity*, he accused Locke of facilitating heresy, if not actually guilty of it himself.<sup>44</sup>

William Molyneux's correspondence with Locke explored not only the difficulties caused by Toland's (mis)appropriation of Locke's concepts, but also the views expressed by Locke on the theological consequences of recently published concepts in natural philosophy, whether those of Newton or Whiston:

a Passage you have in your *Thoughts of Education* ... That the

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<sup>44</sup> G. J. Rogers, 'Stillingfleet, Locke and the Trinity', Allison P. Coudert et al., eds., in *Judaean-Christian Intellectual Culture in the Seventeenth Century* (Dordrecht, 1999), 207–24.

Phænomenon of Gravitation cannot be Accounted for by Meer Matter and Motion, but seems an Immediate Law of the Divine Will so ordering it. And you conclude that Section thus – *Reserving to a fitter Opportunity [sic] a fuller Explication of this Hypothesis, and the Application of it to all the Parts of the Deluge ...* This seems to Imply that you have some thoughts of Writing on that subject; it would be a mighty satisfaction to me to know from you the certainty thereof. I should be very Glad also to hear what the Opinion of the Ingenious is concerning Mr Whistons Book.<sup>45</sup>

Molyneux's interest in the 'opinion of the ingenious' illustrates the importance to him of the social exchange of views on these controversial topics in cosmogony.

### Instrumentation and interpretation

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In parallel with the study of the earth itself, the nature of the wider universe and those celestial objects surrounding the earth was a lively topic in the investigations of natural philosophers. Once it had been realised, through the observations of travellers, that the skies were variable and that the positions of the objects were observable in different ways, it became important for data to be gathered from observers in different geographical locations. The improvement of instruments and the reliability and reproducibility of observations was also a constant concern. These improvements, and the gathering of data, both featured in the activities of the intersecting circles of natural philosophers. Over the years since the development of the telescope, various attempts were made to improve the astronomical instruments then in general use by fitting them with telescopic sights, as observations of the positions of astronomical objects had hitherto relied on the naked eye, with no instrumental assistance.

It was in this context that a prolonged controversy arose between the celebrated astronomer Jan Hevelius and the Royal Society's Robert Hooke over the merits of telescopic sights versus the unaided eye, later discussed between William

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<sup>45</sup> Locke, *Correspondence* 5, 701–705.

Molyneux and Edmond Halley. Molyneux, whose *Sciothericum telescopicum* had proposed fitting a telescopic sight as an adaptation to a sundial, corresponded with Halley on a wide range of astronomical topics. He also corresponded with the Royal Astronomer, John Flamsteed, exchanging data and calculations. Molyneux's later publication, *Dioptrica Nova*, brought more of his views on the processes and purposes of natural philosophy into the public sphere and provided an occasion for reflection on some of these earlier controversies.

Narcissus Marsh collected texts connected with astronomy and optics in both manuscript and print. His interests in the nature of the universe extended to personal observation of astronomical phenomena, which were communicated to his immediate circle and then further disseminated to a wider circle of the curious. In particular, his observations of the appearance of a comet led him to construct a theory of comets on his available evidence, which was circulated with his detailed observations.

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#### Molyneux's useful optics

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William Molyneux presented his newly published *Dioptrica Nova* to Marsh.<sup>46</sup> The typography of the half-title emphasised the 'USEFULNESS in many Concerns of Humane Life' of the instruments and techniques described. Molyneux's preface dedicated the work to the Royal Society and his status as a fellow was given typographical prominence on the title page. His dedication of the second part was to 'Henry Osborn of Dardystown', a gentleman whose means enabled him to pursue philosophical interests without disturbance on the 'froathy Sea of Business'.<sup>47</sup> Osborn had also discovered the horns of the giant deer which Thomas Molyneux described for the *Philosophical Transactions*.

In the second part of *Dioptrica Nova*, Molyneux referred to the concepts of

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<sup>46</sup> The inscription reads 'To the Most Rever'd Narcissus L[or]d Archb[isho]p of Cashel/His Grace, From the Author, Will: Molyneux'.

<sup>47</sup> Osborn was responsible for sending a 'pair of horns' to William Molyneux, who sent them on to his brother Thomas. These horns, which Osborn described as the third set found by 'casual trenching in my orchard' featured in Thomas' Molyneux's account of the giant deer. See Chapter 3, 111.

refraction of light by different media (air or various liquids) as described by Descartes and ‘abundantly rectified’ by Leibniz, demonstrating his awareness of their writings and concepts. He added a reflection on final causes to this account, supporting the existence and benevolence of the creator by appealing to the design of the properties of light:

For ‘tis manifest, that the Ray proceeding from C, does not consult with it self, how it may with the greatest ease arrive at the Point E, or D, or G; neither is it carried by it self to those Points. But the Great Creator of all things, has so made Light, that this most beautiful, orderly, and admirable Event should result from its very Nature.<sup>48</sup>

His reference to the creator made, Molyneux returned to a reference to Fermat’s treatment of the topic, which he recommended to his readers. That light was a ‘body’ was self-evident to Molyneux by its behaviour:

the various Properties of Light, that do necessarily belong to a Body, are so many and evident, that they leave no room for any farther doubt in this matter.<sup>49</sup>

To demonstrate this, he used a corpuscular metaphor to describe the passage of light through the refracting medium, considering that

the Resistance, that Light suffers in its passage through different Diaphanous Bodies, to proceed from the Medium Hindering of the *Diffusion* or *Distribution* of Light through *more* of the Parts of this Medium.<sup>50</sup>

Molyneux also drew on Ole Romer’s observation of the speed of light to reinforce his argument for light as a body.<sup>51</sup> He gave the latest references to publications in

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<sup>48</sup> Molyneux, *Dioptrica*, 195.

<sup>49</sup> Molyneux, *Dioptrica*, 198.

<sup>50</sup> Ibid.

<sup>51</sup> William Molyneux, *Dioptrica*, 199: ‘The Second Property, that confirms *Light* to be a *Body*, and a *Body* moved or thrust forward, is, That it requires *time* to pass from one place to another, and does it

learned journals and to 'Mr. Newton's Incomparable Piece, *Philosophiae Natur. Princ. Mathem. Lib. I. Schol. Prop. 96*'. Having described the empirical observations and their nature, he turned to the usefulness of this discovery in improving the accuracy of geography and navigation, with a reference to the work of Flamsteed and Halley. The breadth of Molyneux's reading may be seen from the marginal citations in the text, and from mentions within the text: for example, he cites those authors who have described the production of lenses. The passage given in the footnotes is further evidence of his reading and of his personal contacts, such as the French academician, chymist and lensmaker Jacques Borelly (1623–89), whom Molyneux had met in Paris in 1685:<sup>52</sup>

Mons. Borelly has given the World the Secret of his manner of Grinding great Glasses in Cyphe, Jouranal des Scavans, Ann. 1676. July 6. but has not yet obliged us with the Discovery: Tho he be a Person of the greatest Candor and Freedom, and the most communicative; as I am obliged to express with much Gratitude for his Civilities shew'd me in Paris 1685. at which time he gave me an Object-Glass formed by this way for a Telescope 24 Foot long.<sup>53</sup>

Molyneux brought his readers from a verbal and mathematical description of an

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not in an *instant*, but is only of all Motions the *quickest*. For the Experiment proving this, we are obliged to the Ingenious Mons. *Romer*'.

<sup>52</sup> Borelly (Borelli, Borel) is frequently confused with earlier writers with similar surnames: see Pierre Chabbert, 'Jacques Borelly, membre de l'Académie royale des Sciences', *Revue d'histoire des sciences et de leurs applications* 23:3 (1970), 203–227.

<sup>53</sup> Molyneux, *Dioptrica*, 215. The whole passage reads: '...here I shall mention the chief Modern Authors that have contrived Engines for Grinding Glasses, that those who please may consult them. Mr. Hook in his Micrographia describes an Engine for this purpose. Hevelius in his Selenographia, Chap. I, II. describes another for Modelling the Forms or Dishes for Grinding Spherick Glasses. And in the First Part of his Machina Coelestis, Chap. XXIII. describes one for Grinding Conick-Glasses. Ant. Mar. Schyrleus de Rheita in his Oculus Enoch & Eliae, Lib. IV. has a Machine for Conick-Glasses. Maignan at the end of his Perspectiva Horaria describes Machines both for Spherick and Conick-Glasses. Des-Cartes in his Dioptricks has another for Conick Glasses. Mons. Borelly has given the World the Secret of his manner of Grinding great Glasses in Cyphe, Jouranal des Scavans, Ann. 1676. July 6. but has not yet obliged us with the Discovery: Tho he be a Person of the greatest Candor and Freedom, and the most communicative; as I am obliged to express with much Gratitude for his Civilities shew'd me in Paris 1685. at which time he gave me an Object-Glass formed by this way for a Telescope 24 Foot long. The celebrated Mons. Fatio de Duillier (of whom Dr. Burnet gives deservedly so excellent a Character in his Letters of Travails) in the Jouranal des Scavan, Ann. 1684. Novemb. 20. describes an Invention of his own, for exactly forming the Dishes for Grinding Spherick Glasses; which indeed is very ingenious, and perfectly new.'

optical phenomenon to the latest interpretation of that phenomenon, with references to discussions surrounding that interpretation, and a justification of his own view; and then to the application of the extended understanding of the phenomenon as useful in a practical way. This presentation of the concepts with which he was dealing serves to demonstrate his assimilation, processing, and communication of the information available in his circle.

In Molyneux's own time, the publication of *Dioptrica* had unintended consequences. It resulted in a letter from John Flamsteed which was the last to be exchanged by them. Flamsteed, having shared his calculations with Molyneux, as well as sharing correspondence from his collaborators Gascoigne and Townley, and having discussed all this and given permission to Molyneux to use it, was obviously enraged at what he saw as disrespect to Gascoigne, who was no longer alive to defend his priority, and to himself. The letter sent by Flamsteed on 7 January 1691 claimed that he had seen the first nine sheets of the publication, after some prevarication from the publisher. It is evident from the full text of the book, which eventually saw print in 1692, that Molyneux did acknowledge both Gascoigne and Towneley, together with Flamsteed's role in transmission of the information, and his calculations. It seems that Flamsteed may have taken a partial reading of the book amiss. By this time, Flamsteed had also fallen out with Halley, and with Newton. Meantime, the offending *Dioptrica* had been approved for the press: that this approval had been granted by Halley may have further inflamed Flamsteed's sense of injustice.

For all Flamsteed's sensitivities about priority (for both himself and others), he had not acted upon earlier advice from Molyneux urging him to publish his observations on the effects of astronomical bodies on the tides. The data on which Flamsteed had based his calculations had been collated in part from observations taken at Dublin by Molyneux, who was keen to see it disseminated further.<sup>54</sup>

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<sup>54</sup> An argument about the tides had arisen between Halley and Flamsteed, exacerbated by a note added to Molyneux's paper in *Philosophical Transactions* about tides in Dublin. For an account of this dispute, see Alan H. Cook, *Edmond Halley: Charting the Heavens and the Seas*, (Oxford, 1998), 175–6.

Molyneux's own sensitivities about plagiarism were expressed in *Dioptrica* in reference to his own work:

This I have borrowed from my own *Sciathericum Telescopicum*, Published at *Dublin 1686. Quarto.* And I hope, one may be allow'd to transcribe from himself without being called a *Plagiary*.<sup>55</sup>

*Dioptrica* also provided an occasion for Molyneux to revisit the controversy between Jan Hevelius and Robert Hooke about the use of telescopic sights as compared to the naked eye, and to advocate the use of telescopic sights for many applications. The dispute between Hevelius and Hooke became sufficiently heated that the Royal Society sent Edmund Halley to Gdansk to visit the eminent Polish astronomer and observe at first hand the results which Hevelius claimed were possible. In a 2001 thesis, Voula Saridakis reviewed this dispute and its context, remarking that

Certain social factors had direct bearing on this controversy including the personal interactions of all the participants involved, pressure from the Royal Society to eye-witness claims made by the participants, and hostility and xenophobia among the participants that crossed national boundaries.<sup>56</sup>

The perceived threat to the smooth conduct of natural philosophy was, she argued, the motivation underlying the 1679 journey by Halley.

Molyneux's account, written over a decade after Halley's attempts at a rapprochement, took his reader back to the reasoning behind Hevelius' objections to the use of telescopic sights. He wrote that had Hooke addressed the issues raised by Hevelius (which Molyneux asserted he had not) the 'renouned' Hevelius would have been convinced by the argument. This could not be put to the test, but it illustrated Molyneux's conviction that the reasonableness of the methods and

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<sup>55</sup> Molyneux, *Dioptrica*, 235.

<sup>56</sup> Voula Saridakis, 'Converging Elements in the Development of Late Seventeenth-Century Disciplinary Astronomy: Instrumentation, Education, and the Hevelius-Hooke Controversy', 26 November 2001, <https://theses.lib.vt.edu/theses/available/etd-11162001-113447/>.

approaches advocated by the community of natural philosophers could not fail:

...the best way of reconciling him to them, had been, fairly to have laid down the Dioptical Reasons of their Performance and Exactness. Upon a right understanding whereof, all those Objections would be answered, and would naturally vanish. This had been the right Method of proceeding amongst Candid Philosophers: Whilst vilifying his Instruments, and slighting his Performances with them as no better than those in the Age before him, did but exasperate the Noble old Man, and made him adhere more obstinately to his former Practice.<sup>57</sup>

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#### Witnessing comets

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In late November 1680, an amazing – and for some troubling – sight appeared in the skies. A comet of extraordinary brightness, and with a very long tail was observed, exciting the ‘curious and ingenious’ and terrifying those who saw it as an omen of doom. Those in the protestant community in Ireland, and in particular, those outside the centres of colonial power where they might have felt protected, fell into the latter category. To these people, the memory of the events of 1641 was very recent, and they were ‘full of Apprehensions of a new Irish Plot, or a second Massacre of Protestants’.<sup>58</sup> In Dublin, by contrast, the then Provost of Trinity College, Narcissus Marsh, readied his telescope and, when he could, he made observations, together with others in the college.

Comets were intriguing and frightening in almost equal measure to the seventeenth-century mind. The classical authors contained a substantial history of interpretation of all unusual celestial phenomena as bad omens, and this attitude persisted into the late seventeenth century, perhaps supported by the instability all too evident in the politics of the time. An example is the reception of the classical

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<sup>57</sup> Molyneux, *Dioptrica*, 231.

<sup>58</sup> Edward Wetenhall, *A Judgement of the Comet, Which Became First Generally Visible to Us in Dublin December XIII, about 15 Minutes before 5 in the Evening Anno Dom. 1680* (Dublin, 1682), preface.

Latin poet Manilius, whose *Astronomicon* was translated into English verse by Thomas Creech in 1697, and reached a popular audience. The publication was adorned with a frontispiece showing the chaos portended by astronomical events. At the end of the first book, Manilius referred to comets, describing them as tokens of impending doom and portents of death. He also associates comets with war and rebellion, as in Creech's translation: 'They sudden Tumults, and strange Arms declare,/ And when close Treach'ry shall start up to War'.<sup>59</sup>

Comets were said to bring marvels, induce fantastic births, and foretell disasters of varying degrees which could extend to the imminence of the Second Coming and the end of all things. These scary stories were dealt a somewhat scathing blow in the 1682 pamphlet cited earlier. Written by Edward Wetenhall (who was then bishop of Cloyne and Ross/Kilmore and Ardagh, and later became a member of the DPS), the pamphlet placed the focus firmly on 'matters of fact'.<sup>60</sup> According to the preface addressed to the reader by the stationer, the material in the pamphlet, which represented Wetenhall's response to the 'consternation' expressed by some of the Protestant community in the face of heavenly omens and earthly disturbances, had been in circulation in manuscript to the affected community in his diocese for some time. Wetenhall had directed the publisher to make it clear that these were his actual responses to the comet as they occurred to him at the time.

Countering the worries of those who saw the comet as confirming their worst fears, Wetenhall observed that the ancient poets who had been the source of descriptions of the effects of comets were less than reliable:

... 'tis below the Dignity of Art of an Heroick Poet to omit any imaginable  
aggravatory of Horror.

and went on to quote examples from Latin, providing them with somewhat tongue in cheek translations, for example translating crinem/crinis as 'Brush' when it could

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<sup>59</sup> Thomas Creech, *The Five Books of M. Manilius, Containing A System of the Ancient Astronomy and Astrology together with the Philosophy of the Stoicks done into English Verse* (London, 1697), 35.

<sup>60</sup> Wetenhall, *A Judgement of the Comet*, 35.

be more accurately and less trivially rendered as ‘hair’. Firmly rejecting astrology, he declares ‘I do … look upon Judicial Astronomy as the impudentest, as well the eldest, cheat in the world, of all that pretend to knowledge’.<sup>61</sup> Wetenhall’s most telling set of arguments was gathered into a table, showing that contradictory sorts of events are attributed to the influence of comets. But even this was subject to a comparison with the printed record: he says in the appended ‘Advertisement’ that he has since seen just such a table by Hevelius, which was reported in the *Philosophical Transactions* of the Royal Society.

Marsh, regarding the comet as opportunity rather than omen, made systematic observations as soon as he could. These observations were sent months later in a letter to his friend Edward Bernard, who was then the Savilian Professor of Astronomy in Oxford, as deputy (ultimately successor) to Christopher Wren. In addition to his interests in mathematics and astronomy, Bernard was an orientalist and student of near Eastern languages. This spectrum of interests was very similar to Marsh’s own and the two men kept up an active correspondence until Bernard’s death in 1697. Describing his experience of the comet, Marsh was careful to note that

the observations that I made were imperfect and unconstant, partly for want of good instruments (my Telescope being the best I had to confide in), partly through the variety of the weather; but chiefly because the College standing East of the City, I was forc’t to observe it Alwaies ^ over the City so ^ through the Smoke of the town, which many times render’d it invisible here, when 3 miles off the place it might well be seen.<sup>62</sup>

Although he could not begin immediately on the appearance of the comet, he did gather a record from others: he himself could make no ‘particular observations, more than with the naked eie’ until 17 December but had ‘this following account of the foregoing days of it’s [sic] appearance [from 13 December to 17 December] out

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<sup>61</sup> Ibid., 28.

<sup>62</sup> Marsh to Bernard, 9 April 1681. Bodleian MS Smith 45, ff 27–30.

of the Countrey' presumably because the visibility was better there. He added that on the night of the 14<sup>th</sup> in Dublin he 'observed the blaze to be about 40 degrees in length, & but 2 d[egrees] north of Cor Vulturis [a bright star in the constellation Aquila or the Eagle]. On the 15<sup>th</sup> Marsh recorded detailed observations, presumably sent to him, and then added what he could see himself, which was that the relative positions of the bright star and the tail of the comet had changed and also that because of their relative positions he could see that the tail was 'thin & transparent & also below the fixt stars, because that star shined through it'. He records an observation of the length of the tail made by William Petty that night, although (pace Michael Hunter) it would seem that the measurement was sent to Marsh, rather than being a joint observation.<sup>63</sup>

Marsh made a clear distinction between the foregoing observations and the subsequent details, which were recorded by 'myself and some others of the College, my assistants'. The large telescope used by Marsh (which he seems to distinguish from another telescope) was 16 feet 4 inches and may have resembled one of the instruments depicted on the engraved title page of Jan Hevelius' *Cometographia* (1668), a copy of which is in Marsh's own collection. While the observations of the comet were continuing, Marsh also recorded a sighting of a fiery meteor, which apparently flew very low over the town with a hissing noise. But he says that he 'saw it not myself, and the reports of those who did are so various, that I shall say no more of it'.

The motion of comets could be discerned by measuring parallax (essentially, change in position relative to other particular objects), which had also been used to show that comets belonged to the upper reaches of the heavens and not to the region between the moon and the earth. Astronomical distance calculation by parallax requires either terrestrially distant observers (as applied by Cassini and his collaborator Richier in the determination of the distance to Mars, and from that the

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<sup>63</sup> For Hunter's view, see Michael Hunter, 'Robert Boyle, Narcissus Marsh and the Anglo-Irish Intellectual Scene in the Late Seventeenth Century', in Muriel McCarthy and Ann Simmons, eds, *The Making of Marsh's Library: Learning, Politics and Religion in Ireland 1650– 1750* (Dublin, 2004), 51–75.

distance to the sun), or comparison of apparent position of the observed object with respect to more distant astronomical objects over a set amount of time (Flamsteed used the diurnal parallax of Mars to make a similar calculation from one position).<sup>64</sup> Marsh drew the path of the movement of the 1680 comet, and concluded that it was not moving around any particular ‘star’, either (as he says) fixed or planetary.

He concluded the letter with a diagram and hypothesis of comets laid out in points:

1. In (or upon or near) the Sun are Maculae or dark spots, & Faculae or bright blazes. The first are an opake matter, the latter pellucide, which collecting the suns raies, as a burning glass does, make the appearance of the bright blaze.
2. Those Faculae (as well as the Maculae) are sometimes cast off from the Sun by it's revolution on it's own Axis & that of the vertex are washt off farther & farther, until at last they become too remote to be seen any longer, or else are by degrees rub'd &grated to pieces & so resolved in the Aether.
3. A (or at least, this) Comet I conceive to have been one of these Faculae thus cast off, whose train was nothing but the Sun-Beams darted through it's body, like raies through a burning glass or rather through a glass ball filled with water as one night (when the Comet on the suddain disappeared & so frustrated the expectation of Severall, who came to me on purpose to observe it) I represented it to the Satisfaction of all the beholders.

By this hypothesis I believe all the phenomena of this Comet may be solved, (why it appear 'd nearest the Sun & the Earth, biggest, swiftest in motion

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<sup>64</sup> Collaboration in the measurement of astronomical distance by parallax is an instance of the necessity of comparison of measurements made by spatially distributed observers. See Albert Van Helden, *Measuring the Universe: Cosmic Dimensions from Aristarchus to Halley* (Chicago, 1985), chapter 12, for a discussion of the measurements made by Cassini and his collaborator, and by Flamsteed. Van Helden concluded that neither measurement was accurate due to the errors in the instruments used.

with the longest train at first or which few daies &c) & were I certain that no Comet had ever at first appeared opposite to the Sun, I should think it might serv to solve those of all Comets what soever.

He described his diagram as ‘unproportionall’ but the track he depicted more closely resembled the arc of a parabola rather than one of a circle.

These observations on the 1680 comet were circulated by various means to the community in Oxford and in London. The first record that survives, which is almost contemporaneous with Marsh’s letter to Bernard, was sent to Robert Boyle by Henry Jones (then bishop of Meath) as an enclosure to a letter concerning the Irish Bible and lectures in Irish at Trinity. On 13 May 1681 Jones wrote:

Haveing some curiositie for observing the late Comet, I gave what was on that collected to the provost heare from whom I send in returne the enclosed paper, with which I present you, as well knoweing what use to make of it. He was well fitted for such observation by Instruments which he had, & none other that I knowe hereabout.<sup>65</sup>

Unfortunately, this enclosure has not survived.

It is evident by surviving descriptions that Marsh’s observations and hypothesis circulated quite widely. The Oxford mathematician and astronomer John Wallis (1616–1703) wrote to Marsh on 16 June 1681:

I thank you for your communications of the late Comet to us att Oxford, which by the favour of Mr. Bernard I had a sight of, I made myself no Other but by the bear Eye without Instruments.

In the same letter, Wallis discussed Marsh’s hypothesis of comets directly with Marsh, comparing it to the earlier hypothesis advanced by the English astronomer Jeremiah Horrocks (1618–41), and recording discussions in the Royal Society and

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<sup>65</sup> Henry Jones to Robert Boyle, 13 May 1681, Boyle *Correspondence* 5, 271–273.

his correspondence with Robert Boyle on the matter. The passage is lengthy but it is important for its description of Wallis' agreement with Marsh and its record of the discussion of this hypothesis over some years:

I remember (about 8 or 10 years ago) upon a discourse in the Society, what might be thought the reason that about the year 1650 and before, spots were so frequently seen in the Sun, as that it was rare to misse of them; whereas for near 20 years passed, they had been so rare, that, if we had not a good esteem for the reporters, we might be apt to doubt, whether any such had been at all, at least, so frequent; I suggested (first to Mr Boyle privately, & he would needs have me speak it out,) that since the year 1650, we had seen a great many comets (more than in many years before:) & I supposed, that the matter of those Spots, had been spent in those Comets. And long before that time, amongst the Papers of Mr Horrocks (heretofore committed by the Society to me to digest), I mett with a like Hypothesis of his (I know not whether I have somewhere mention it in my extracts out of them.) He imagined that Comets might issue out of the Body of the Sun, (And had a Figure to that purpose much like yours) but with this difference, that, having finished their circuit, they returned thither again: whereas your hypothesis supposes them to be spent, & consumed into the Aether.<sup>66</sup>

This letter, along with two others from Wallis, were important enough to have been preserved in a commonplace book now held in the Royal Irish Academy.<sup>67</sup> Wallis also copied Marsh's letter on comets in its entirety and complete with diagrams into his own commonplace book, together with copies of correspondence on the topic with Marsh, and other material on comets.<sup>68</sup> These observations and correspondence are of particular significance for its glimpses of a circle of natural philosophers active in Dublin just prior to the establishment of the DPS, which itself

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<sup>66</sup> Wallis to Marsh, 16 June 1681. Bodleian MS Don d 45, f171.

<sup>67</sup> John Wallis to Marsh, 16 June 1681, Royal Irish Academy MS 12 D 34, 1-10. This manuscript contains much later material as well as the copies of three letters from Wallis. None is in Marsh's hand.

<sup>68</sup> Bodleian MS Don D 45. The manuscript also contain workings on Euclid, and a mathematical note to Robert Boyle.

was initiated in the Provost's lodgings at Trinity College. Commenting on these connections which centred on the observation of the comet, Hunter noted the significance of earlier correspondence sent by Wallis to Robert Boyle, and also the presence of William Petty, who was, as we have seen, to be influential in the regulation of the DPS.<sup>69</sup>

Writing to John Flamsteed on 13 August, in reply to a letter now missing, John Wallis mentioned the letter to Marsh of 16 June, which he had sent via Thomas Gale, then president of the Royal Society, as an enclosure to be sent on. Wallis wrote that he thought that this comet was the nearest to the earth of any that he had seen:

by the prodigious length of the tail; and by the great angle the position of the tayl made with a line from the sun through the head of the comet. (Both of which I take to arise from its nearness to us, and being so near to a conjunction with the sun) Of this (with what else I had observed) I gave an account (in Trinity term last) to Dr. Marsh, (at Dublin) inclosed (but unsealed) in one to Dr Gale that he might peruse and communicate, (if he thought fit) and then send it forward. Of the origine of comets I am not so well satisfied as to deliver an opinion. I can hardly think them to be permanent Bodies, making, (as some have thought) excursions into our system or solar world. <sup>70</sup>

Marsh's idea of the disappearance of comets was in agreement with and possibly derived from that of Jan Hevelius, whose *Cometographia* of 1668 (in Marsh's own collection) proposed that comets, although moving on a parabolic path rather than the straight path proposed by Galileo, continued on that path and never returned. The orbit of comets was of further significance to Isaac Newton, who calculated the parabolic path of the 1680 comet in support of his theory of universal gravitation. Subsequent work by Edmond Halley allowed the observation of the return of comets with the one that bears his name, which had a relatively short period,

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<sup>69</sup> Michael Hunter, 'Robert Boyle, Narcissus Marsh and the Anglo-Irish Intellectual Scene in the Late Seventeenth Century'.

<sup>70</sup>John Wallis to John Flamsteed, 13 August 1681. Letter 411, Flamsteed, *Correspondence* 1, 795.

appearing in 1682 (and earlier, featuring in the Bayeux tapestry as a backdrop to the events of 1066). It is not clear what happened to the 1680 Great Comet: a comet with a similar orbit to that of 1680 appeared in 2012 but disintegrated at perihelion (the point of its orbit nearest to the sun), suggesting the possible fate of that of 1680.

In his hypothesis of comets, Marsh laid out a summary of his observations, labelling the points, and then proceeded to his ‘solution’ of the object of study. This hypothesis was taken seriously by the correspondents to whom it passed at Oxford and beyond, as shown by its being copied in its entirety by Wallis, as well as being commented on in a long thread of very focussed letters between the two men. Other hints of the sense of community and real connection between Marsh and Wallis are revealed by the language of the letters, for example, that of 17 August 1681, in which Wallis, thanking Marsh for his letter of 6 August, added

As also for your former and the present you sent me by Mr Foley [probably Samuel Foley, later a member of the DPS]: which I greedily read over most of it the same day, with great approbation.<sup>71</sup>

Discussions of these details of the behaviour of comets form an illustration of the style of reporting of matters of fact in astronomy, with the exchange of observations from different locations serving to confirm to the ‘ingenious’ the behaviour of the heavenly objects.

### Views of the ingenious

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As mentioned above, the Royal Society, in its title, connections and Charters, was in many ways a product of the restored monarchy in England, with its connotations of a future stability and order which could permit and promote a high order of learning. It is in this context that the DPS and its circle discussed and viewed the created world. They were conscious of the need to maintain order, as were their counterparts in England. On the periphery, and feeling themselves under threat as

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<sup>71</sup> John Wallis to Marsh, 17 August 1681, Bodleian MS Don D 45, f. 173.

members of a colonial minority, most were in a position where the maintenance of 'right order' and stability in politics and religion, as in philosophy, was a matter of great importance to them. As we have seen, the majority of those associated with the DPS were also members of the church 'as by law established', holding religious views which were subject to challenge both from Roman Catholicism and Protestant dissent. In their world view, both atheism and superstition were to be discouraged, as tending to destabilise order in church and state. Narcissus Marsh's sharp reaction to Toland's challenge to the mysterious in religion exemplifies these sensitivities: if religion could be questioned, so could the established order. In contrast to Toland's brashness, William Molyneux, who questioned some aspects of the colonial relationship between England and Ireland in his *Case of Ireland... stated*, defused the sense of challenge to established order by dedicating the book to the monarch. Both Marsh and Molyneux also connected their studies to the creator, Molyneux in his writings being explicit in his avowal of an orthodox Anglican piety which he saw as relying on matters of fact and an informed reason to establish the existence of the deity. Marsh, both in surveying the heavens and evaluating the timelines established by detailed chronology, also turned all his studies to the glory of his creator.

Re-evaluation of biblical texts, and an apparent displacement of the creator by mechanistic explanations of the workings of creation, exercised the minds of the most prominent among the community, as well as those on the periphery, whose studies form the subject of this thesis. Examples of influential natural philosophers who took these questions seriously to heart (although from differing viewpoints) are Robert Boyle, whose commentaries on natural philosophy are suffused with the relationship of the objects of study to their creator, in active combat against atheism; and Isaac Newton, whose pursuit of biblical chronology was at least in part a consequence of his engagement with the mathematical ordering of the universe, and has also been seen as his search for the rational purity of natural religion, which

led him, privately at least, rather far from doctrinal conformity.<sup>72</sup> These thinkers, and the whole community of the Royal Society, engaged with these debates: religion was not a peripheral concern but a central question, as fundamental as any other in the understanding of the universe.

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### The argument from design

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As the philosophers deepened their enquiries into the nature of the universe, they began to evaluate earlier accounts of its functioning. The various accounts of the earth's origins and development (the roasted egg, the hasty pudding, the snuff of a comet) all sought to describe the mechanism of the early days of the earth, its form, and the deluge (whether universal or merely regional). The same considerations applied to the concepts derived from observation of celestial systems, with the systems of Newton and Descartes attaining some prominence. Although these were (in purely semantic terms) mechanism, the concept of a unified system which could explain the functioning of nature from origins to daily workings, without necessary recourse to the creator, was a fundamental difficulty recognised by natural philosophers as carrying them dangerously close to deism, if not to atheism, and exploited by their critics.

The difficulties with the existence of the deity and with supernatural intervention in creation led to a series of attempts to enlist the preternatural in aid of the supernatural. Among these were the writings of Joseph Glanvill (1636–80), whose *Saducismus Triumphatus* (published posthumously in 1681) sought to dispel scepticism concerning witchcraft, magic, and ghosts, arguing from these supernatural phenomena to the existence of the deity. Glanvill's book was edited by the prominent philosopher Henry More (1614–87): Glanvill himself was described in the minutes of 25 November 1680 as an eminent member of the Royal Society.<sup>73</sup> The Cambridge philosopher and orientalist Ralph Cudworth (1617–88)

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<sup>72</sup> For a discussion of Newton's attitudes to religion, see Rob Iliffe, *Priest of Nature: The Religious Worlds of Isaac Newton* (Oxford, 2017).

<sup>73</sup> Birch, *History of the RS*, IV, 58.

also drew upon the existence of supernatural events and beings to support the existence of the immortal soul, and beyond this, the deity.<sup>74</sup>

Among the most respected of those associated with the Royal Society, Robert Boyle was also deeply religious, and the views expressed in his 1690 publication, *The Christian Virtuoso*, represented his way of dealing with a universe which he admitted could function almost like a clock mechanism. Boyle firmly proposed the argument for the deity from design, asserting the rationality of belief, and its historicity:

That this vast, beautiful, orderly, and (in a word) many ways admirable System of things, that we call the World, was fram'd by an Author supremely Powerful, Wise, and Good, can scarce be deny'd by an intelligent and unprejudic'd Considerer. And this is strongly confirm'd by Experience, which witnesseth, that in almost all Ages and Countries, the generality of Philosophers, and contemplative Men, were persuaded of the Existence of a Deity, by the consideration of the Phaenomena of the Universe.<sup>75</sup>

The corollary to that argument was the existence and nature of the immortal soul. William Molyneux turned to similar arguments in *Dioptrica*, finding them

more forcible against *Atheism*, than Multitudes of Notional Proofs drawn from Ideas, Apparitions of *Specters*, *Witches*, &c. (not that these should lose their due Strength).<sup>76</sup>

Among the circle of natural philosophers in Ireland who touched upon these issues and with the publications and concepts which had raised them, William Molyneux was probably the most engaged. In *Dioptrica* he argued that the natural

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<sup>74</sup> Ralph Cudworth, *The True Intellectual System of the Universe* (London, 1678), 715. ‘Spirits, Angels or Demons, though Invisible to us, are no Phancies, but Real and Substantial Inhabitants of the World; which favours not the Atheistick Hypothesis; but some of them, as the Higher kind of Miracles, and Predictions, do also immediatly enforce the acknowledgment of a Deity.’

<sup>75</sup> Boyle, *Works* 11, ‘The Christian Virtuoso’, 295–6.

<sup>76</sup> Molyneux, *Dioptrica*, 273.

philosopher must be aware of final causes in a way which tended to support the argument from design:

Wherefore they are in a great Error, who reject Final Causes in Natural Philosophy, which, besides affording us occasion of admiring and adoring the Divine Wisdom, do often discover to us a curious Principle of finding out the Properties of those things whose inward Nature is not so clearly known by us, as that we can explain the immediate efficient Causes and Instruments, which the Almighty Mover employs in producing those Effects, and obtaining those Ends.<sup>77</sup>

In this, Molyneux echoed Robert Boyle's *Disquisition on Final Causes*, where Boyle wrote:

For Certainly it becomes such Men to have Curiosity enough to Try at least, Whether it can be Discover'd, that there are any Knowable Final Causes, to be Consider'd in the Works of Nature. Since, if we neglect this Inquiry, we live in danger of being Ungrateful, in Overlooking those Uses of Things, that may give us Just Cause of Admiring and Thanking the Author of them, and of Losing the Benefits, relating as well to Philosophy as Piety, that the Knowlege of them may afford us.<sup>78</sup>

Boyle had claimed that both those whom he termed Epicureans (Gassendi excepted) and the Cartesians had neglected final causes in their philosophy, the former because they held that

the World being made by chance ... no Ends of any Thing can be suppos'd to have been intended

and the latter as they thought

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<sup>77</sup> Ibid., 195.

<sup>78</sup> Boyle *Works* 11, 81.

all the Ends of God in Things corporeal to be so Sublime, that 'twere Presumption in Man to think his Reason can extend to Discover them.<sup>79</sup>

The consideration of such things seemed trivial to some. Final causes received short shrift from Charles Allen, whose *Operator for the Teeth* was published in Dublin in 1686. Allen, who was not a member of the DPS, presented a copy of his work to a meeting in 1686. He appended a section dealing with the pulse, and the circulation of the blood, to his account of dentistry. His findings tended to agree with those of Descartes, attributing the pulse to the movement of the blood, caused by fermentative swirling of the blood in the anatomy of the heart. A caustic paragraph ends the work:

I cou'd add many other things to authorize what we have said concerning the Beating of the Pulse, and Circulation of the Bloud: but I hope this will suffice to rational men, and such as are of a Mechanical Genius. As for those that attribute all things to final causes, and have recourse upon every occasion, to the designs and intentions of Nature ... in my opinion, such persons had a great deal better study Astrology; or, if they are big with devotion, go and comment upon Job, or Paraphrase some Psalms, than meddle with Physical matters.<sup>80</sup>

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#### Scripture, reason, and matters of fact

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As we have seen earlier, Robert Huntington, writing to Robert Plot in December 1683, described the more theologically-inclined members of the DPS as having established their own meetings to focus on 'how to establish religion and confute atheism, by reason, evidence, and demonstration'.<sup>81</sup> The tone of the letter as a whole tends to the humorous and Huntington seems to have been doubtful of the abilities of the group. He may have been justified, as there is no remaining output from their discussions, except as included in the general meetings. The subject of the reliability

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<sup>79</sup> Ibid., 82.

<sup>80</sup> Charles Allen, *The Operator for the Teeth* (Dublin, 1686), 58.

<sup>81</sup> DPS Papers no. 213.

of the text of the biblical Old Testament, which was discussed in the general forum at the second meeting of the DPS, had received much attention from clerical circles in England and elsewhere, with responses from establishment figures such as Edward Stillingfleet. As noted earlier, Anthony Grafton has argued that the questioning of the biblical texts had a tendency to destabilise the authority of all texts; once that authority had been destabilised, all authority could then be questioned. The debate over Richard Simon's output typified the interest taken in the status of the biblical texts, which lends an immediacy to the problem of biblical and para-biblical interpretation and historicity. This set of views and concepts gained importance in the late seventeenth century, in parallel with a natural philosophy which sought to explain not only how matter worked, but how it had come into being and continued to exist.

It was in this context that attempts to synchronise known historical events with textual records attracted the interest of many in the late seventeenth-century community of natural philosophers, among whom Isaac Newton is perhaps the most prominent. He attempted to apply contemporary mathematics to ancient chronology, and in doing so, he became interested in the biblical accounts of the architecture of Solomon's temple, which he saw as indicating the level of mathematical sophistication available to the ancient Hebrew people. He also interested himself in the accounts of Moses, as lawgiver (in the biblical context of the ten commandments) and the relationship with Egyptian and hermetic concepts which had become associated with the biblical figure.<sup>82</sup> It is also in this context that Narcissus Marsh collected and read sacred chronology and geography, leading him to make additions to Baudrand's edition of Ferrari's *Lexicon Geographicum*.

The play of ideas within peripheral communities, such as the Dublin one, reveals the pattern of engagement with concepts of cosmogony. The facts regarding creation and the universal deluge could be examined from two angles: textually via chronologies, themselves tested against the chronologies provided by other

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<sup>82</sup> See Jed Z. Buchwald and Mordechai Feingold, *Newton and the Origin of Civilization* (Princeton NJ, 2012) for a discussion of the issues.

peoples, such as the Egyptians and the Chinese; or via the structure of the rocks, and the formation of *fossilia*, whether crystalline or resembling the form of animals or plants. Here, too, the DPS showed their awareness of the questions, if not any clear answers: they collected and compared crystalline formation, and recognised that these could ‘shoot’ *in vitro* into shapes reminiscent of organic forms; they also engaged with the ‘pusling’ [puling, weak] controversy as to the facts of the generation of such things, and the underlying anxieties about transformation and transubstantiation—whether of base metals to gold, or bread to the Roman Catholic sacramental mystery of the real body of Christ, which these Anglicans would have condemned as Papist and superstitious.

In all, they aimed to eschew ‘fancies’ and speculation. Speculative natural philosophy was decried by St George Ashe as

little else than a learned romance, which may amuse and divert, but can never satisfy the mind of man, which is fed only by experiment and demonstration, and not with gay empty speculations or spruce [spurious] hypotheses.<sup>83</sup>

Facts gathered in literary and historical studies shared an existence with facts from observations of creation. The recording of ‘matters of fact’ could only come about when they had been made observable—by trials or experiments, by instrumental observation, by first-hand experience, or by trusted report of a witness or witnesses. Instances of all these modes of observation are present in the records of the DPS, as are observations of natural history.

Experiment, trial and observation took various forms depending on the nature of the matters of fact being sought. Each round of investigation generated further questions, and in some cases crossed into the development of more general theories or hypotheses, rather than staying bound to the useful or immediate. Attitudes to the formation of generalised hypotheses varied. As touched upon in Chapter 1, it

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<sup>83</sup> DPS Papers no. 124.

has been widely asserted that Boyle eschewed hypothesis, but this is not strictly true. In *Some Considerations touching Experimental Essays*, Boyle mentioned the difficulties of some writers in transferring experimental findings into systems, when they had not built up an expertise in systematic thinking comparable to their expertise in their chosen experimental field. He considered that 'whilst this vanity of thinking men obliged to write either systems or nothing' was in force, it resulted in unthinking borrowings from other writers, or the repetition of half-digested concepts. What was worse, in Boyle's estimation, was that the perceived necessity to produce a system suppressed the publication of some material because it was insufficient to form a system. He did not forbid 'very learned men' from publishing systems of physiology, because it might prompt them to expand on their investigations themselves or perhaps

the curiosity of Readers, whether they like or disapprove the Hypothesis propos'd, is wont to be thereby excited to make trial of several things, which seeming to be Consequences of this new Doctrine, may by their proving agreeable or repugnant to Experiment either establish or overthrow it.<sup>84</sup>

Boyle's statement set out the pattern adopted by the Royal Society and imitated by its sister societies. There was a concern that the communication of matters of fact be clear and concise, showing precisely how the observations were made so that it would be possible to reproduce them. Marsh's reports of his observations in astronomy and his forays into acoustics were consistent with this model, although he did suggest an explanation for his findings. Molyneux was also relatively concise in his public language, and although he showed himself aware of the larger hypothetical structures conceived by Leibniz and Descartes, he did not attempt to construct such a system himself. Boyle was inclined to allow 'the hypotheses of astronomers', while being concerned that mechanistic views of physiology might, as Descartes had, go too close to removing the role of the creator.

In a recent study, Levitin undertook a complete critique of the narrative of a

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<sup>84</sup> Boyle *Works* 2, 'A Proemial Essay', 12.

'distinctive English Early Enlightenment' driven by Latitudinarians within the established church, and the heterodox outside it.<sup>85</sup> Rather, he showed that intellectual change was already grounded within the formation and enquiry that was part and parcel of the 'remarkable vitality in both humanism and the study of nature' in the English universities, a claim certainly consonant with the lively circle from which the Royal Society sprang, and which we have seen above in correspondence, publication and experiment. Extending Levitin's argument, the influence of the *via lucis* of Jan Comenius' imagination, (stretching into the republic of letters in Europe and its colonies) on the thought, observation, experiment and commentary generated in the scholarly community was also of importance in stimulating that liveliness.

Boyle's *Christian Virtuoso* sought to place 'right reason' in its context, informed not only by observation but also by revelation.<sup>86</sup> In this, he ran somewhat counter to the late sixteenth-century divine, Richard Hooker, whose *Laws of Ecclesiastical Politeia* (1595) had provided a basis for the Anglican discussion of natural law and natural religion.<sup>87</sup> Boyle was convinced that

Another thing, that disposes an Experimental Philosopher to embrace Religion, is, That his Genius and Course of Studies accustoms him to value and delight in abstracted Truths; by which Term, I here mean such Truths,

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<sup>85</sup> Levitin, *Ancient Wisdom*: the book's argument develops this assertion, first made in the introduction.

<sup>86</sup> Boyle, *Works*, 12, 'Occasional Thoughts', 423. 'Right reason may be looked upon as a catholick principle, of which philosophy is but an application, and the dictates of particular philosophies, such as the Peripatetick, the Platonick, the Epicurean, &c. are but particular corollaries, which are not always truly drawn, and on that account may always be questioned or examined, and may, I fear, oftentimes be justly rejected; and this holds, especially, when, in the examen, he that makes it is assisted by the discoveries made by revelation, from whose heavenly light, in reference to divers subjects, the intellect may receive such a benefit, as the air does in a clear day from the beams of the sun, by which it is both enlightened and expanded.'

<sup>87</sup> Richard Hooker, *The Works of Mr Richard Hooker* (London, 1666), 16: 'The works of nature are all behoveful, beautiful, without superfluity or defect; even so theirs [who keep them], if they be framed according to that which the law of reason teacheth. Secondly, these laws are investigable by reason, without the help of revelation supernatural or divine. Finally, in such sort they are investigable, that the knowledge of them is general, the world hath always been acquainted with them'.

as do not at all, or do but very little, gratifie Mens Ambition, Sensuality, or other Inferiour Passions and Appetites.<sup>88</sup>

That experiment itself could occasionally be laid aside is seen in the preface to Boyle's *Disquisition on Final Causes*:

Those that Relish no Books in Natural Philosophy but such as abound in Experiments, are seasonably Advertis'd, that I do not Invite Them to Read this Treatise; wherein I thought it much more Suitable to the Nature of my Subject and Design, to declare the Works of God, than of Men; and consequently to Deliver rather Observations, than Artificial Experiments.<sup>89</sup>

It is notable that Boyle employed a rather variant use of the concept of observations (here, perhaps, sharing the meaning of 'remarks'), which he contrasted in this context with experiments made by artifice.

When natural philosophers in Ireland collected formed stones and wondered about their various origins, observed the heavens, urged the improvement of instrumentation, exchanged information with their peers, and received commentary on the text of the Bible, they were acting in concert with the philosophical community further afield, and linking the books of nature and scripture in the rational pursuit of knowledge. Introducing a collection of essays on the interactions of nature and scripture, Van der Meer and Mandelbrote noted that both the history of science and the history of biblical interpretation are incomplete without an account of the conceptual exchanges between the interpretative practices in each discipline.<sup>90</sup> In the same collection, James J. Bono instanced how the natural history of the English naturalist Edward Topsell read the book of nature as part of an instruction in God's redemptive processes.<sup>91</sup> The reading of the book of history and the book of

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<sup>88</sup> Boyle *Works* 11, '304.

<sup>89</sup> Boyle *Works* 11, 82.

<sup>90</sup> J.M. Van Der Meer and S.H. Mandelbrote, eds, *Nature and Scripture in the Abrahamic Religions: Up to 1700* (Leiden, 2008).

<sup>91</sup> James J. Bono, 'The Two Books And Adamic Knowledge: Reading The Book Of Nature And Early Modern Strategies For Repairing The Effects Of The Fall And Of Babel' in J.M. Van Der Meer and S.H. Mandelbrote, eds, *Nature and Scripture in the Abrahamic Religions: Up to 1700*, 299–340.

languages were justified by a similar argument: all held in their essences the remains of the prelapsarian state of humankind and the created environment.

For many in the circle of influence of the DPS, and in particular for the highly influential Robert Boyle, the studies of natural philosophers were ideally to be underpinned by religious motives. Those most concerned in these matters, including both Narcissus Marsh and William Molyneux, couched their investigations and interpretations of the cosmos in terms of their religion, Marsh being explicit in considering the ‘true end of all our studies’ to be the glory of God. In personal contacts and correspondence, and in reading and publishing of their observations and interpretations, the circle of the curious collaborated, debated and argued in the pursuit of ‘matters of fact’ relating to the created world, whether in observatory, library, or laboratory.

## CHAPTER 5

### WITNESSING THE LABORATORY

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*And when, in a word, by the help of Anatomical Knives, and the light of Chymicall Furnaces, I study the Book of Nature, and consult the Glosses of Aristotle, Epicurus, Paracelsus, Harvey, Helmont, and other learn'd Expositors of that instructive Volumne; I find my self oftentimes reduc'd to exclaim with the Psalmist, How manifold are thy works, O Lord? in wisdom hast thou made them all!<sup>1</sup>*

*Our Society has built a laboratory, by Dr. Mullen's directions, in the same house where we have taken a large room for our meeting, and a small repository.<sup>2</sup>*

Robert Boyle's view of Ireland's atmosphere as unconducive to chymical trials and 'hermetick thoughts' was not reflected in the activities of the DPS.<sup>3</sup> An explicit interest in a chymical topic is recorded as early as the second meeting.<sup>4</sup> The general area of chymical experiment and comment continued to feature in more than thirty of the meetings of the society, with some aspects being pursued in more than one meeting. This chapter discusses the spheres of interest into which these chymically oriented contributions fell, and the performance and consideration of laboratory experiments in the circle of the DPS. These experiments and discussions took place in the context of the 'trials' of the Royal Society, the Oxford Society and others within these islands, and the various academies active in continental Europe. Concepts of repetition and of independent witness were combined in an accumulation of successful experiments, and in an understanding of the unsuccessful as also capable of revealing information. The requests for additional

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<sup>1</sup> Boyle, *Works* 1, 85–6.

<sup>2</sup> William Molyneux to Thomas Molyneux, 14 June 1684. *DUM*, 483.

<sup>3</sup>'I live here in a barbarous country, where chemical spirits are so misunderstood, and chemical instruments so unprocurable, that it is hard to have any hermetick thoughts in it, and impossible to bring them to experiment.' Robert Boyle to Frederick Clodius: between April and May 1654, Boyle *Correspondence* I, 165–168 (quote from 166).

<sup>4</sup> *DPS Papers* no. 2.

laboratory trials, and accounts of trials, which emerged in a general sense from the investigation of the texts of the correspondence and minutes in Chapter 2, are discussed further in this chapter, giving details of the exchanges which passed between the societies, and between individual members.

The varied membership of the society, ranging from bishops to physicians and including merchants among their number, has been described in Chapter 1. From the beginning, some members emerged as having a particular competence and interest in chymical matters. These included William Petty, who had been influenced by an earlier generation of Leiden and Oxford chymistry; the Molyneux brothers, William and Thomas, also with Leiden connections; St George Ashe, mathematician and experimentalist; the physician Allen Mullen, who was the designer of the society's laboratory; and another physician, Daniel Huolaghan, who interested himself in colour tests for acid and alkali. Reconstruction of the physical space of Mullen's laboratory is not possible except in the broadest terms but the intellectual space occupied by these Dublin chymists and their wider circle is evident from their reports. They discussed laboratory investigations of the nature of acid and alkali; the effects of cold; interactions of various substances with blood *in vitro* and *in vivo*; and the dissolution of hard bodies in menstrua, among other chymical topics. As we shall see, the Molyneux brothers, who carried on a personal correspondence which included chymical topics, also saw their exchange of views on the behaviour of solutes into print, in the emerging journals of the period.

Striking parallels with the investigative aims and methods recorded in Boyle's histories of blood, of mineral waters, of colours, of fluidity and firmness, and of cold, emerge in the proceedings of the DPS meetings and in correspondence between the members and their circle. It is clear that similar projects were carried out in other learned societies, both in these islands and further afield. Contemporary publications and practices in the experimental investigation of natural substances and their interactions also stimulated mutual interest and comment. In common with the output of the Royal Society, theoretical explanations of phenomena are relatively seldom explored, being deliberately eschewed as part

of the rejection of ‘speculation’. Rather than being explicitly cited, the competing views of matter and mechanism (e.g. Cartesianism, corpuscularianism) emerged as influences on queries, and on methods of experimental fact-gathering. Reconstructing patterns of adoption and understanding of these underlying concepts thus becomes a matter of gleaning implications and influences from the language of the surviving texts, particularly from discussion recorded in the minutes, and from the more personal elements of correspondence, which could be free from the conventions adopted in more formal or public exchanges.

In the early life of the DPS, we find a chymical topic of great contemporary interest discussed at the second meeting. The context of the discussion linked the wide interests included in the newly-established society’s discussion of natural philosophy. As we have seen in Chapter 4, the physician, anatomist and chymist Allen Mullen gave an account ‘*de alkali et acido*’, while Dudley Loftus presented Richard Simon’s critique of the received texts of the Bible, a topic which brought humanist tools of philology to bear on the chronology of the texts and the cosmos.<sup>5</sup> The following six meetings found the society favouring mathematical, anatomical and political topics rather than chymical. The next meeting to see a return to the chymical *inter alia* took place on the 4<sup>th</sup> of February 1683/4, when the members heard an account of St George Ashe’s experiments on freezing.<sup>6</sup>

By the 14<sup>th</sup> of April 1684, the meetings were taking place in the house known as Crows Nest, which was off Dame Street, close to the original meeting place in the provost’s lodgings in Trinity College. The rooms were let from the apothecary Robert Witherall, who was to lead the guild of Barber Surgeons in 1693.<sup>7</sup> In taking

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<sup>5</sup> For Loftus see Elizabethanne Boran, ‘Loftus, Dudley (1618–1695)’, *ODNB*. Also see the biographical note in the *DPS Papers II*: 952. For Allan Mullen, also known as Molin/Molines/Moulin/Moulins: see Ian Lyle, ‘Mullin, Allen (1653/4–1690)’, *ODNB*; also biographical note, *DPS Papers II*: 959. Much of the information in all sources appears to derive from Walter Harris, *The Whole Works of James Ware concerning Ireland* (Dublin, 1745), 206.

<sup>6</sup> Ashe’s full paper is at no. 119 in the *DPS Papers*.

<sup>7</sup> K.T. Hoppen, *The Common Scientist in the Seventeenth Century: a study of the Dublin Philosophical Society* (London, 1970), 93; J.T. Gilbert, *A History of the city of Dublin* (Dublin, 1859) II, 178 give an account of the history of the house and its uses and records that ‘nothing more is heard of Crow’s Nest after Witherall’s death in 1730.’

rooms in an apothecary's premises, the Dublin society was following the practice of an earlier English group, which had included many of the founders of the Royal Society. As recalled by John Wallis in his memoir of his life, this earlier group had begun its meetings in London. When some of the members moved to Oxford they 'brought those Studies into fashion there; meeting first at *Dr. Petties Lodgings*, (in an Apothecaries house) because of the convenience of inspecting Drugs, and the like, as there was occasion'.<sup>8</sup> William Petty also had a connection with the previous use of Crows Nest, which had served as the offices of the Down Survey in the latter half of the 1650s. In these rooms, the DPS established a laboratory, along with those other requisites of 'philosophical' activity, a 'fair garden for plants' and a repository where the specimens acquired by the society could be kept for inspection.<sup>9</sup>

### Laboratory practice

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As with much of seventeenth century laboratory practice, the chymical endeavours of the DPS employed substances related to the production of *materia medica*. At the time, there was competition between the older and more traditional remedies attributed to the practice of the Greek writer Galen and the relatively new iatrocchemical remedies, in which medically active substances were produced in the laboratory. These chymically produced substances were largely derived from the works of Paracelsus as developed by the chymist Jan Baptist van Helmont (1580–1644).<sup>10</sup> Galenic and chymical remedies were conceptually separate but intersected in many aspects of the substances involved and in some of their production

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<sup>8</sup> Domenico Bertoloni Meli, 'Wallis, John (1616–1703)', *ODNB*; Christoph J. Scriba, 'The Autobiography of John Wallis, F.R.S.', *Notes and Records of the Royal Society of London* 25 (1970), 17–46; 39–41.

<sup>9</sup> William Molyneux to Thomas Molyneux, 14 June 1684. *DUM*, 483. First reference to the establishment of a laboratory, *ibid.*, 10 May 1684.

<sup>10</sup> The system of medicine developed by Jan Baptist van Helmont, based on the earlier systems of Paracelsus (Theophrastus von Hohenheim, 1493–1541). Van Helmont's approach considered the functions of the human body as chymical (fermentation and putrefaction being fundamental examples). Paracelsus considered that poisons such as heavy metals could be applied to cure as well as cause disease and constructed an alchemical approach to the preparation of remedies. Van Helmont found some applications of Paracelsus' understanding of the fundamental tria prima (salt, sulphur and mercury) but both criticised and extended it. For an English version of van Helmont's approach, see Jan Baptist van Helmont, *Oriatrike, or, Physick Refined. The common errors therein refuted, and the whole art reformed* (London, 1662).

processes (distillation, calcination, and other laboratory methods). All these are likely to have been integral to Witherall's business and to have been familiar to the practising physicians of the DPS, who included Charles Willoughby, Jacobus Sylvius and Allan Mullen: Hoppen gives a total of 12 members belonging to the profession.<sup>11</sup> The preparation of remedies, their theoretical backgrounds, and their efficacy, were subjects of extensive discussion among the virtuosi and physicians of early modern Europe, in coffee-houses, correspondence and print.

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### Queries and desiderata

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William Petty's standing in the philosophical world has attracted mixed comments. He was described by one writer as 'not a natural philosopher of great penetration', seemingly more interested in the practical applications of experimental results than in the theories lying beneath them.<sup>12</sup> In contrast, he was commended by another writer for his theoretical synthesis in the application of Baconian empiricism and a mechanical and corpuscular outlook. Petty's 'political arithmetic' proposed to convert the Irish to the more desirable English condition, a process he described by the alchemical language of 'transmutation'. Writing on this proposal, McCormick commented that Petty may have been influenced by Hobbes' political interpretations of corpuscular approaches to natural philosophy.<sup>13</sup>

As noted in the introduction to this thesis, Petty's long and varied career included time spent in Paris during the 1640s, where he met 'Mersennus, Gassendy, Mr Hobs, Monsieur Des Cartes, Monsieur Roberval, Monsieur Mydorge and other famous men'.<sup>14</sup> He recalled these encounters thirty years later in the dedication of *The DISCOURSE... concerning the use of DUPLICATE PROPORTION* (London, 1674) addressed to his patron, the wealthy royalist, William Cavendish, Duke of

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<sup>11</sup> *DPS Papers*, Preface, xxii.

<sup>12</sup> See Hoppen's biographical note on Petty, *DPS Papers* II, 962.

<sup>13</sup> For an alternative interpretation of Petty's views and their origins see T. McCormick, *William Petty and the Ambitions of Political Arithmetic*, ch. 3, 5.

<sup>14</sup> Petty's attitude to Descartes was severely practical. In his correspondence with More, Petty asked: 'who, that hath followed [Descartes'] principles, hath drawne any new usefull or pleasant art or reall conclusion from them?' cited in McCormick, *William Petty and the Ambitions of Political Arithmetic*, 63.

Newcastle, who had been in contact with this influential intellectual circle while exiled in Paris during the political upheavals of the 1640s.<sup>15</sup> The dedication to Cavendish also contains an apology for Petty's lack of philosophical progress in the intervening period, which was very far from being the truth. Petty had matriculated at Leiden in 1644 and while there spent '7 monthes practice in a Chymicall Laboratory': his later time in Oxford as physician and chymist reinforced that experience.<sup>16</sup> McCormick asserts that he 'was taken seriously as an alchemical innovator, and his improvements and his alchemy were intimately connected'.<sup>17</sup> The views of the Molyneux brothers on Petty's chymical abilities were less complimentary, Thomas Molyneux going so far as to say that he 'never took Sir Wm. Petty for a chymist'.<sup>18</sup>

For the DPS, Petty contributed lists of queries on mineral waters, a list of necessary equipment, and a list of 'mean, vulgar, cheap and simple' experiments. His attention to mathematical expression is seen even in the 'vulgar, cheap and simple' where many of the queries relate to weights and measures.<sup>19</sup> As Allen Debus has shown, a general trend towards quantification, which found a very full application in astronomy and the investigation of physical motion, was expressed in the chymical world in the proper use of weight and measure in the laboratory.<sup>20</sup> As mentioned in Chapter 1, William Molyneux's biblical reference recalled that the creator had 'made all things in number, weight and measure': this was an additional facet of the mindset brought to bear on these simple properties of created matter.<sup>21</sup>

Petty's queries on mineral waters are closely related to queries previously collated by Boyle, whose work on mineral waters, like much else in his evolving works, was

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<sup>15</sup> Lynn Hulse, 'Cavendish, William, first duke of Newcastle upon Tyne (bap. 1593, d. 1676).' *ODNB*.

<sup>16</sup> *The Petty Papers* (1927; London, 1997) II, 261 gives a list of Petty's writings, including 'A history of 7 monthes practise in a Chymicall Laboratory' (1645). This paper is unfortunately listed as lost at sea.

<sup>17</sup> McCormick, *William Petty and the Ambitions of Political Arithmetic*, 52.

<sup>18</sup> Thomas Molyneux to William Molyneux, undated. *DUM*, 484, footnote.

<sup>19</sup> *DPS Papers* no. 194 lists Petty's 'mean, vulgar, cheap and simple experiments'.

<sup>20</sup> A. G. Debus, 'Mathematics and nature in the chemical texts of the renaissance', *AMBIX* 15 (1968), 1-28.

<sup>21</sup> See Chapter 1, 8, fn 4.

not formally disseminated for many years. It was presented at the Royal Society in 1664 but only appeared in print in 1685.<sup>22</sup> Boyle paid particular attention to the influence of the rocks surrounding the spring on the solutes in the water.<sup>23</sup> The Baconian structure of Boyle's treatise, as a set of heads and queries, has been noted by Hunter.<sup>24</sup> Given Petty's association with the Royal Society, and his direct relationship with Boyle as shown by three surviving letters and mentions by other correspondents, Petty is likely to have been aware of Boyle's views before the emergence into print of the treatise. Boyle's unpublished material was not the only source of commentary on the properties of mineral waters available to the DPS. Some twenty years before the establishment of the DPS, Boyle had described the usefulness of natural philosophy in medicine. He divided physick into parts under the headings of physiology, pathology, semiotics (signs and symptoms), hygeinal [sic], and therapeutical. In the preface to the section on therapeutics, Boyle ridiculed those physicians who could give 'languid' medicines and simultaneously predict the demise of their patients 'per artem', averring

I had much rather, that the Physitian of any Friend of mine, should keep his Patient by powerful Medicines from dying, then tell me punctually when he shall die, or shew me in the opened Carcase why it may be supposed he lived no longer.<sup>25</sup>

He advocated, among other recommendations for the improvement of the tolerability of the remedies, that the chymists might seek a more detailed understanding of the operation of the components of mineral waters

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<sup>22</sup> In *Boyle: between God and science*, Hunter describes the influence that the publication of the DuClos volume and Petty's paper may have had on Boyle's somewhat tardy decision to publish his work on mineral waters (118–9).

<sup>23</sup> N.G. Coley, "'Cures without Care': Chymical Physicians and Mineral Waters in Seventeenth-century English Medicine', *Medical History* 23 (1979), 191–214. This paper gives a general background including a survey of the methods in general use for chymical analysis of the waters (206–7); see also Anna Marie Roos, *The Salt of the Earth: Natural Philosophy, Medicine and Chymistry in England 1650–1730* (Leiden, 2007) (ch. 4, 5) who examines both the science and the quackery associated with drinking the waters.

<sup>24</sup> Petty's queries are at no. 193 of the *DPS Papers*.

<sup>25</sup> Boyle, *Works* 3, 365.

The skilful Naturalist, especially if a good Chymist, may much assist the Physitian to discover the Qualities of Medicines ... divers Mineral Waters are of the nobler sort of Medicines... 'tis known too, that the Industry of Chymists hath produced some good directions towards the discovery of the Minerals predominant in divers Medicinal Springs.<sup>26</sup>

These preoccupations and recommendations, as we have seen, were being taken up by the DPS some two decades later, and were the subject of interest in the wider learned community.

A treatise on mineral waters by the York physician Martin Lister appeared in 1682 and was reissued in 1684, the same year as the queries presented to the DPS on the same subject by Petty were printed in the *Philosophical Transactions*.<sup>27</sup> Boyle's material was almost certainly influenced by a publication issued in 1675 by the *Académie Royale* in Paris. Their principal chemist Samuel DuClos described various mineral waters and their effects, attempting to determine the chemical constituents which conferred the properties on the waters. This book was reviewed at length in the *Philosophical Transactions* in 1676.

In 1684, Pierre Bellon published a short book called *The Irish Spaw* which was clearly influenced by DuClos in describing some of the effects of mineral waters – whether purgative, inciting to physical or sexual appetite, inducing lethargy or liveliness – and included a list of queries very similar to that provided to the DPS by Petty.<sup>28</sup> Bellon may have made an appearance in person at the meeting of the DPS on 23 November 1685, where a Dr Belon is recorded as having made a response to a reading of a paper by Boyle on 'self-moving liquor', promising to try the experiments described in it.<sup>29</sup>

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<sup>26</sup> Boyle, *Works*, 3, 368.

<sup>27</sup> William Petty, 'Some queries whereby to examine mineral waters by the Learned Sir William Petty Knight', *Philisophical Transactions* XIV (1684), 802-3.

<sup>28</sup> P. Bellon, *The Irish spaw, being a short discourse on mineral waters... with a way of improving by art weakly impregnated mineral waters* (Dublin, 1684). Anon., 'An Accompt of some Books', *Philosophical Transactions* (1665-1678), XI (1676), 611-622, 612.

<sup>29</sup> *DPS Papers*, no. 77. Boyle's paper on self-moving liquors later appeared in *Philosophical Transactions* (1685), XV, 1188-92 as recorded in the *DPS Papers*, vol. 1, 73, n. 2.

Petty's list of experiments for mineral waters includes the testing of acid and alkali with indicator substances such as syrup of violets and gall.<sup>30</sup> William King, another member of the DPS, reported using these 'Experiments whereby to examine mineral waters' to test the water from Clonus, in which he was assisted by the physician Patrick Dun (1642–1713).<sup>31</sup> On the 21<sup>st</sup> of July 1684 the DPS members proposed that as the Clonus waters turned black with gall, they might find a use in dyeing cloth black, since to be able to dye cloth without the use of vitriol as a mordant (fixative substance) was seen as a great advantage.<sup>32</sup> Both DuClos and his reviewer in the *Philosophical Transactions* had mentioned this possibility, although Petty had not.

In his *Short memoirs for the natural experimental history of mineral waters*, Boyle also tested the water with gall. He noted that the waters did not preserve all their qualities for long after coming out of the ground, and so should be examined firstly in the spring or natural container, and then swiftly after collecting them. This is echoed by Bellon in his *Irish Spaw*. Bellon also proposed artificially adding salts to waters to make them more effective as a remedy.<sup>33</sup> The Molyneux brothers were scathing in their comments about Bellon, calling him an 'impudent chirurgeon' who had borrowed all his ideas from a French treatise. They also, as we have seen, had a similarly poor opinion of Petty's queries and abilities.<sup>34</sup>

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#### Repeating trials: the effects of cold

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Repetition of a set of experiments derived from earlier publications is evident in the account by St George Ashe of 'Experiments of freezing' in which he refers to 'Mr Boyl's book, Dr Merrett's and an Italian treatise of ice written by one Bartoli a Jesuit'.<sup>35</sup> Boyle's *New experiments and observations touching cold* (1665, with a second edition in 1683) documented his demonstrations that freezing could provide

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<sup>30</sup> *DPS Papers*, no. 193.

<sup>31</sup> William King was later Bishop of Derry and Archbishop of Dublin. See S. J. Connolly, 'King, William (1650–1729)', *ODNB*; Davis Coakley, 'Dun, Sir Patrick (1642–1713)', *ODNB*. King's first report is at no. 144 of the *DPS Papers*. Clonus is probably Clones, Co. Monaghan.

<sup>32</sup> *DPS Papers* no. 145: King's second report on Clonus water.

<sup>33</sup> Bellon, *Irish Spaw*, 32.

<sup>34</sup> Thomas Molyneux to William Molyneux, undated. *DUM484*, footnote.

<sup>35</sup> These books are identified by Hoppen. *DPS Papers* vol. I: 124, notes.

a means of separation of the constituent parts of substances and of determining the chemical qualities of bodies. As discussed by Christopoulou, Boyle observed that different types of liquids varied in their susceptibility to freezing: salts, oils, spirits, solutions and *lixiviums* all behaved differently. From this, he concluded that it was not possible to freeze substances which were not liquid or which had no aqueous or phlegmatic parts. In the case of such complex fluids, the act of freezing separated the spirituous part from the aqueous or phlegmatic. Boyle also observed that freezing seawater generated ice which, when melted, yielded water which tasted fresh, indicating to him that the salt had been removed.<sup>36</sup> The Aristotelian claim known as antiperistasis, which asserts that ‘warm water will freeze sooner than cold’, as Ashe put it, had been refuted by Boyle in his original publication.<sup>37</sup> Ashe referred to the original idea as demonstrably false, and also repeated another significant experiment from Boyle’s refutation of Aristotle, demonstrating that water expanded when frozen:

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.<sup>38</sup>

As well as the repetition of trials Boyle had carried out to refute Aristotle, Ashe also seems to have been attempting to repeat a group of similar observations to that reported in Merrett’s *Account of freezing made in December and January 1662*, which was appended to Boyle’s work on cold, and where instances of the behaviour of very varied substances when frozen are gathered without much comment.<sup>39</sup>

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<sup>36</sup> Boyle’s approach to the study of cold and the relationship of his findings to his evolving natural philosophy are discussed in Christiana Christopoulou, ‘Early Modern History of Cold: Robert Boyle and the Emergence of a New Experimental Field in Seventeenth Century Experimental Philosophy’, in Kostas Gavroglu, ed., *History of Artificial Cold, Scientific, Technological and Cultural Issues* (Dordrecht, 2014), 21–51.

<sup>37</sup> ‘An Examen of Antiperistasis’, Boyle, *Works*, vol. 4, 459–98. For the significance of these observations in prosecuting Boyle’s corpuscularian programme, see Michael Hunter, *Boyle: between God and Science*, 118–9 and Christopoulou, op. cit.

<sup>38</sup> *DPS Papers* no. 119, 125.

<sup>39</sup> Boyle appended Merrett’s work to ‘New Experiments...touching Cold’, adding a preface. See Boyle, *Works*, IV, 519–42.

Merrett, whose work Boyle describes as having been requested by the Royal Society at about the same time as his own experiments, refers to earlier work by Henshaw, which had been presented at a meeting of the Royal Society.<sup>40</sup> Merret also specifically comments that he has 'barely set down matters of fact' with respect to the notes he had gathered from various authors and did not intend to 'render a reason of the various phenomena φανώμενα [sic]... but shall leave that province to an Honourable person of this Society, who hath had much experience and reflections on this subject'.<sup>41</sup> The Royal Society's interest in freezing also continued into the 1681, when the behaviour of water surrounding a frozen egg or apple was mentioned. This gave rise to a debate about 'particles of cold' between Henshaw and Robert Hooke, and the 'spirituous' nature of the egg or apple, invoked by Nehemiah Grew and refuted by Hooke. Other than witnessing to his own repetition of the observations made by Boyle, Merrett and the authors cited by them, Ashe was reticent about providing an interpretation in his written paper. This reticence, reflecting the writing style of the Royal Society and their rejection of speculation, also echoed by Ashe, was less evident in the discussion at meetings than in written submissions. Debate and exchange of views on mechanism, giving rise to requests for further queries, and the stimulation of new trials, emerged more easily from the fluidity of an ongoing debate, in contrast to the relative fixity of a written account.

### Particles and petrification

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The Molyneux brothers' opinions on Petty's abilities as a chymist had a basis in experience and knowledge. Among the most detailed accounts of the laboratory practice and chymical thinking associated with the DPS are those recorded in the correspondence of William and Thomas Molyneux, some of which entered the more

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<sup>40</sup> For Henshaw's initial experiments on freezing, see Birch *History I*, 132.

'December 3. [1662] Mr. Henshaw read his experiments of freezing, and was desired to add more to them, and to bring them against the next meeting. Dr. Wilkins suggested an experiment of putting water freed from air into- Mr. Boyle's engine, and to let it freeze there, in order to see whether it will not- be a clear ice. Dr. Whistler suggested, that the freezing of salt-water renders it fresh; and Mr. Hill confirmed this, by alledging, that the people of Amsterdam use frozen sea- water for brewing.'

<sup>41</sup> Boyle, *Works*, 4, 519-42 (quote from 525). Stephen Pasmore, 'Thomas Henshaw, F.R.S. (1618-1700)', *Notes and Records of the Royal Society of London* 36:2 (1982), 177-88.

public sphere in learned journals. Many topics are covered in these letters, but the chief interest for the purpose of this chapter is in the accounts of chymistry, and the intersection between this private correspondence and publications by the brothers in the *Nouvelles de la République des Lettres* and in the *Philosophical Transactions* of the Royal Society.<sup>42</sup>

The correspondence of William Molyneux with the other learned societies in Oxford and London, as well as that with John Locke, and with the astronomers John Flamsteed and Edmond Halley, show a lively interest in many topics in natural philosophy, in particular in optics and astronomy, as we have seen in Chapter 4. His contributions to the meetings of the DPS on chymical topics are largely centred on the investigation of Lough Neagh stone. His younger brother Thomas had similarly wide interests, with his studies of the chymical basis of his medical profession taking their place beside notes on anatomy and antiquarianism. Travelling to Leiden to study medicine there after completing his studies at Trinity College Dublin, Thomas made his way through England, visiting Chester, Oxford, Cambridge and London. He carried with him letters of introduction from more senior members of the DPS, such as Narcissus Marsh and William Petty. These were addressed to notable natural philosophers in those cities, so that Thomas might make the most of his opportunity to meet and converse with them.

While in London, Thomas Molyneux was under the guidance of Theodore Haak, friend of the intelligencer Samuel Hartlib. Through him he was introduced to Frederick Slare, then beginning his rise to prominence as a chymist in the Royal Society. In a letter of 9 June 1683, Thomas refers to an experiment in which Slare could combine 'two liquors that mixed produce a strong flame'. Demonstrations of this somewhat spectacular type formed a part of public chemistry presentations

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<sup>42</sup> The publications by the Molyneux brothers appeared in the *Philosophical Transactions*. William Molyneux, 'A Discourse on This Problem; Why Bodies Dissolved in Menstrua Specifically Lighter Than Themselves Swim Therein By Mr. William Molyneux, of Dublin. Member of the Royal Society', *Philosophical Transactions XVI* (1686), 88–93; and in *Nouvelles de la République des Lettres* (cited from the second edition, Amsterdam, 1686): Article IV, August 1684, preface 579–81; article 581–85. Article VIII, Janvier 1685, 54–57.

over the following half-century: for example, Boyle Godfrey, the ne'er-do-well son of Robert Boyle's operator and maker of phosphorus, Ambrose Hanckwitz (the family changed its name) advertised just such an experiment among those to be performed 'for the entertainment of ladies as well as gentlemen' in Dublin in 1743 at the not-so-modest fee of a British half-crown.<sup>43</sup>

In a letter of 16 July 1683, Thomas described the courses in chymistry given by Robert Plot in Oxford:

In this place Plott reads lectures to all that goes thro' a course of chemistry with him, and to those only, till there a public salary be settled upon him for it.<sup>44</sup>

Chemistry had been an active topic of discussion and experiment at Oxford for some decades at that point but was not part of the quadrivium, so had no formal status within the curriculum. Plot was given the title of Professor of Chemistry in 1683, but this letter confirms that at this stage he had yet to be paid.<sup>45</sup> Discussing Plot's preparation of a menstruum he described as 'philosophical spirit of wine', Roos commented that Plot's need to make a living motivated him to keep his preparations and their potential secret, unlike both Boyle and Newton, whose alternative means of financial support meant that their interest in chrysopoeia (transmutational alchemy aimed at producing gold) could be a matter of experiment and philosophical curiosity.<sup>46</sup>

Once established in Leiden, Thomas wrote again on 30 November 1683, giving a detailed account of the university there, with the numbers of students, their nationalities and the focus of their studies. He discussed the approaches of the

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<sup>43</sup> Boyle Godfrey, 'List of Experiments for the Amusement and Entertainment of Ladies as Well as Gentlemen', [Dublin, 1743], Marsh's Library, Z1.1.13(87).

<sup>44</sup> Thomas Molyneux to William Molyneux, *DUM*, 324.

<sup>45</sup> Robert Joseph Paton Williams, Allan Chapman, and John Shipley Rowlinson, *Chemistry at Oxford: A History from 1600 to 2005* (London, 2009), 17.

<sup>46</sup> Anna Marie Roos, 'The Chymistry of "The Learned Dr Plot" (1640-96)', *Osiris* 29 (2014), 81–95. Roos cites Lawrence Principe, *Aspiring Adept* (cit. n. 2), 185. Her paper also describes in detail the contractual arrangements made by Plot for financial gain from his experiments.

professors, outlining their philosophical and political allegiances, and compared the university favourably to those at Paris, Montpellier and Padua for education in medicine.

Two members of the faculty were described as Cartesians: ‘the professor of institutions, Craanen, a mathematician and a great Chartisian’ and ‘the professor of chemistry, De Maets, a Chartisian too’. Carel de Maets (1640–90) was known for his attempt to make one of the most important alchemical reagents, sophic mercury.<sup>47</sup> This substance was intimately connected to the transmutational alchemy of previous generations and also to Helmontian approaches to iatrochemistry. Its role and nature had been an important topic in alchemical discussions between George Starkey and Robert Boyle.<sup>48</sup> De Maets did not treat his understanding of the recipe as something to be kept secret, but openly taught it in his lectures as an ordinary chymical process. This growing openness about the processes of the chymical art, moving the discussion into a professional sphere and the subject into a formal status in the university, whatever the interpretative level might imply for religion and the political sphere, was, it seems, well served at Leiden.<sup>49</sup>

From the surviving evidence of the letters between the two brothers, Thomas seems to have favoured a ‘private college’ for his chymical education over the officially appointed Carel de Maets:

There lives in the town an old experienced physician, a high German, that is allowed by the curators, although he is not a professor, to take private colleges. This man I was recommended to by Dr Slare, in England, and by

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<sup>47</sup> The mercury of the philosophers, or sophic mercury, is distinguished from the ‘common’ mercury, known as quicksilver, a metal which is liquid at room temperature. The sophic substance was thought of as acting analogously to the ordinary substance, but capable of imparting its flowing qualities to other substances. The preparation of sophic mercury was long, tedious, and generally kept secret. See Powers, *Inventing Chemistry*, 37–8 for De Maets’ preparations, and William Newman and Lawrence Principe, *Alchemy Tried in the Fire: Starkey, Boyle, and the Fate of Helmontian Chymistry* (Chicago, 2002), 120–5.

<sup>48</sup> For discussion of Boyle’s connections with Starkey, and in particular their common alchemical interests, see Newman and Principe, *Alchemy Tried in the Fire*.

<sup>49</sup> Gerhard Wiesenfeld, *Leerer Raum in Minervas Haus: Experimentelle Naturlehre an der Universität Leiden, 1675–1715* (Amsterdam, 2002).

most of the Englishmen here, as a better chemist than De Maets, the professor of it, so I have taken a college of him in chymistry and another de componendis medicamentis ... this old doctor, his name is Margrave, has a great kindness for me.<sup>50</sup>

This was Christian Margraaf (1626-87), elements of whose practical courses were recorded by Christopher Love Morley in a series of notebooks eventually published as *Collectanea chymica Leydensia* (1684).<sup>51</sup> On 27 December 1683, Thomas wrote that he had changed his lodgings from the house of the widow Van der Stein to a house belonging to Christiaan Margraaf:

I proposed to myself very great advantages in living where I do now in Dr Margrave's house ... here I shall have not only the advantages of his conversation and a free course to him, when any doubt shall arise in my private study, but also the use of his glasses and furnaces whenever I shall have a mind to do any thing in chymistry myself.<sup>52</sup>

Thomas also noted, among others, the 'anti-Chartesian' Wolfred Senguerd (1646-1724), whose book he has sent to William, and Burckerus de Volder, a 'strict Cartesian, and an experimental philosopher'. The nominally Aristotelian Wolfred Senguerd was something of a wolf in sheep's clothing, having adopted all the terminology of Aristotelian physics but infused the whole structure with ideas adapted from Democritean atomism.<sup>53</sup> Skilled in avoiding those concepts which generated theological and philosophical controversy, Senguerd discussed, but did not openly espouse, Cartesian cosmology. Instead, he supported the geocentric system of Tycho Brahe, which was by then almost discredited, although it had also been favoured by Jesuits such as Gianbattista Riccioli and Christoph Scheiner. It seems that Thomas Molyneux did not have a direct encounter with Senguerd's rival,

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<sup>50</sup> DUM, 473.

<sup>51</sup> This was a common practice. Hermann Boerhaave was particularly annoyed to find that his notes had been published without his permission and were full of errors. See John C. Powers, *Inventing Chemistry*, 144.

<sup>52</sup> DUM, 475.

<sup>53</sup> Powers, op. cit., 37-8.

Burckerus de Volder (1643-1709). De Volder was an influential teacher who was the principal mentor of the young Hermann Boerhaave (1668-1738), who was to become the most prominent chymist of his generation at Leiden. De Volder's emphasis on experimentation became even more pronounced after a visit to the Royal Society in London in 1674, where a demonstration of the air pump led him to employ the Leiden instrument maker, Samuel van Musschenbroek (active in the latter half of the seventeenth century), to construct just such an instrument for his own use in the Leiden *theatrum physicum*. As has been discussed by Wiesenfeld and by Otterspeer, the establishment of de Volder's *theatrum* in 1675 moved the new form of experimental practice into the formal space of the university, whereas before that, the new philosophies had existed outside the formal structures.<sup>54</sup> This experimental space provided an arena for the exposure of new philosophies which was less open to censorship and political intervention than the sphere of the formal lecture.

In the same letter, Thomas Molyneux described the political position of the 'Cartesian' faction and the influence of the Prince of Orange in choosing the Rector Magnificus of the university:

If one stand for it that is known to be no favourer of the Prince's faction, that is, a De Wittian or I may say, a Cartesian, for even that term is accounted synonymous with the rest, he is generally lay'd by, and the Prince makes choise of another, as he did this last year when De Maets, our chemical professor, stood for it; he chose Hultius, a divine.<sup>55</sup>

Both the experimental physics professors, de Volder and Senguerd, and the two practitioners of experimental chemistry, Jacob le Mort and Carel de Maets, found an increased freedom of expression in a medium which was less explicitly controversial than the formal reading of lectures. Who was to say exactly what the

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<sup>54</sup> Willem Otterspeer, 'The University of Leiden: An Eclectic Institution', *Early Science and Medicine*, 6:4 (2001), 324-333.

<sup>55</sup> DUM, 474. Johan De Witt (1625-1672) was the Grand Pensionary of Holland and the effective leader of the Dutch Republic during the First Stadholderless Era up till 1672.

meaning of an experimental demonstration was? It was open to interpretation in many subtly differing ways, as Senguerd and de Volder's coexistence demonstrated, and the philosophical and political inferences did not have to be discussed in the public forum of the theatrum.

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### Bodies in menstrua

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It may have been this environment of discussion, as well as his studies and chymical experiments, which emboldened Thomas to write to Pierre Bayle, compiler of the *Nouvelles de la Republique des Lettres*, in the following year. In a letter dated 27 July 1684, Thomas outlined his theory about the problem of dissolution of bodies in menstrua lighter than themselves:

There is scarce a more common operation in chemistry and that's oftner made use of then the dissolving of hard bodys by such and such menstruum; which for the most part if not constantly are lighter in equal quantitys then the body they dissolve; and yet the final subtile parts of thees heavy bodys when they have been minut[e]ly divided by the accute and penetrating parts of a far lighter menstruum freely float, tho not to be discern'd by sconce, and swim up and down in it which is quite contrary to the laws of hydrostaticks.<sup>56</sup>

Thomas went on to propose that the minute 'subtile parts' of the 'hard body' dissolved in the fluid were kept from sinking to the bottom of the vessel by the motion of the 'acute and penetrating parts' of the menstruum.

In another letter, Thomas described to William Molyneux how he had encouraged Bayle to publish more articles on natural philosophy in the *Nouvelles* than had hitherto been his practice, and commented on his own contribution:

to show him how willing I was to set forward the business, I adjoined a

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<sup>56</sup> This letter was transcribed into modern spelling in *DPS Papers* no. 240, where the response by William was also noted.

phansy of mine in the letter, concerning the dissolution and swimming of heavy bodies in Menstruum's far lighter than themselves, which he was pleased, after the French way, to commend with a great deal of compliment.<sup>57</sup>

Bayle published the article with a preface, indicating his approval of Molyneux's article as being approachable for those not versed in the chemical profession, and being conducive to the deepening of thought about the concepts and processes involved.

La Philosophie dont nous venons de parler est un peu abstraite. Passons à une autre qui soit plus sensible. On nous a communiqué l'explication d'un Phénomene, la cause est digne de la curiosité des honnêtes gens. Nous publions avec joye cette explication, tant parce qu'elle est extrêmement vraisemblable & intelligible à ceux-mêmes qui ne sont pas du metier, que parce qu'elle pourra exciter quelqu'un à méditer sur cette matiere, & l'approfondir d'avantage.<sup>58</sup>

Bayle's own idea of the mechanism producing the effect was that perhaps the solvent could surround the parts of the solute and cause them to float, much as small nails embedded in wax will float on water. Thomas answered this point in a further letter to Bayle (in Latin, dated 6 January 1685), reasoning that the nails in wax float because their combined density is less than that of water. He gave the results of experiments on the effects of heating the solvent (in modern terms) to promote the dissolution of greater quantities of solids, which then precipitated on cooling. This letter was translated and published in the January 1685 issues of the *Nouvelles*.<sup>59</sup>

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<sup>57</sup> DUM, 488.

<sup>58</sup> Bayle's initial contrast was with the previous article concerning disputes between Spanheim and Van der Weyen on ecclesiastical government. Pierre Bayle et al. *Nouvelles de la république des lettres*, Cited from the second edition, Amsterdam: Desbordes, 1686. Article IV, August 1684, Preface 579–81, article 581–85.

<sup>59</sup> *Nouvelles de la République des Lettres*, cited from the second edition, Amsterdam, 1686. Article VIII, Janvier 1685, 54.

The concept of the particles of a solute being prevented from sinking by the motion of the corpuscles of the solvent (aside from the consideration of the reaction of the metal with the acid) had already been the subject of discussion by Boyle in very similar terms. Describing his version of the Helmontian alkahest (a universal solvent) in the ‘History of fluidity and firmness’ (1662), Boyle wrote that ‘the most solid Body by being divided into parts small enough to be put into motion by the causes that keep those of water and other Liquors in agitation, may become fluid Bodies’.<sup>60</sup> It is likely that both brothers were aware of Boyle’s publications. Thomas was certainly sufficiently familiar with Boyle’s textual style to indicate that ‘he...speaks very slow and with many circumlocutions, just as he writes’ and to be sure that this would be understood and appreciated by William. Both could have been aware of this description of a corpuscular explanation of the observed behaviour of solvent and solute.

William’s response to the original concept appeared in the *Philosophical Transactions of the Royal Society* some time later, with a further couple of paragraphs appended by Thomas. William opened his paper by pointing out that they might disagree in print without occasioning a ‘breach of affection between two intirely Loving Brothers’ and goes on to discuss how the laws of hydrostatics, as cited by his brother, were themselves in need of amendment, and did not take into account the ‘Natural Congruity of the Parts of a Liquor, whereby they desire, as ‘twere, to unite and keep together’. <sup>61</sup> This concept of ‘Congruity’ had been utilised by Robert Hooke in similar terms some twenty years previously in his *Micrographia* (1665), where he discussed at length the properties of many different materials, observing behaviour in liquids due to what we now call surface tension. Hooke described the dissolution of materials in various solvents, making an analogy to the harmonies and sympathies among vibrating strings which he saw as paralleling the interactions of the particles of the substances in a liquid.<sup>62</sup>

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<sup>60</sup> Boyle, *Works*, 2, 128.

<sup>61</sup> William Molyneux, ‘A Discourse on This Problem; Why Bodies Dissolved in Menstrua Specifically Lighter Than Themselves Swim Therein’.

<sup>62</sup> Robert Hooke, *Micrographia* (London, 1665), 31.

On 14 June 1684, William Molyneux wrote to Thomas, telling him the news from Dublin and the DPS, and looking forward to the day ‘whenever [God] pleases to bring us together in our own country’. He proposed that he and his brother should be ‘the erecters and massers of as good a laboratory as can be desired for all chymical and philosophical operations, together with a place for dissection and astronomical operations’.<sup>63</sup> William’s desire for a laboratory was not merely a theoretical ambition: for example, there is evidence that he used laboratory methods to examine the nature of the controversial Lough Neagh stone in a search for the significance and process of petrification.

As we have seen, queries about the petrifying qualities of Lough Neagh water were among those raised by Samuel Hartlib in his 1654 letter to Boyle about the natural history of Ireland. Boyle’s own interest in petrification was developed in various papers, written mainly in the 1660s but published later.<sup>64</sup> It was expressed in published form in *An Essay about the Origin and Virtues of Gems* (1672) which again afforded an opportunity to reinforce the coherence of his corpuscularian philosophy, seeing the forms of the fundamental corpuscles of the mineral substances reflected in their crystalline geometry.<sup>65</sup> The petrifying properties of some waters had been known to the ancients: Pliny described waters that turned material immersed in them into stone but did not distinguish between those waters that formed stones (such as those in limestone caves which form stalagmites or stalactites) and those which appeared to transform other materials. In common with Nehemiah Grew, who investigated a material said to be petrified wood, the Dublin group interested themselves in the ‘fables’ of the action of the water of Lough Neagh on particular timbers immersed in the lake, or in the neighbouring soil.<sup>66</sup>

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<sup>63</sup> William Molyneux to Thomas Molyneux, 14 June 1684. *DUM*, 483. First reference to the establishment of a laboratory, *ibid.*, 10 May 1684.

<sup>64</sup> Boyle, *Works*, vol. 13, 363ff.

<sup>65</sup> Boyle, *Works*, vol. 7, 3-72.

<sup>66</sup> Nehemiah Grew, *Musaeum Regalis Societatis* (London, 1681), 262, 265, 270.

William Molyneux, in response to the discussions and query of the Oxford Society, gave a detailed account of what he had found or could ascertain about the ‘petrifying quality’ of Lough Neagh.<sup>67</sup> On the authority of a gentleman of good reputation, he asserted that when a quantity of mixed building timber was left on the banks of the lough during the ‘miserable time of the war’ (the 1641 rebellion), only holly was petrified. Molyneux tested the substance that ‘we call Lough Neagh stone’ and gave his opinion that it was probable that it had once been wood.<sup>68</sup> He found that it ‘will not stir with acids, which is a property observed by Dr Grew on some petrified woods’ (although this property had been used by Grew to argue that his items were actually stone) and that the Lough Neagh substance would burn, with a flame and smoke which smelt like that of wood.<sup>69</sup> On the suggestion of Edmond Halley, Molyneux tested the Lough Neagh stone for magnetic properties, with negative results even after calcination. Later, he retracted this part of his finding in a letter to Aston, writing that ‘the occasion of my former error being that I did not calcine it long enough’.<sup>70</sup> Stones were known to vary in composition, and so in behaviour under various laboratory conditions such as calcination (heating in a furnace until reduced to dust); subjection to acid or alkali; or response to magnets. As wood was never magnetic, a substance showing response to the magnet could not be wood: however, as occluded properties could be revealed by calcination, it seemed possible to Halley that magnetic properties might be revealed in this substance. Repetition of the experiment with longer calcination appeared to Molyneux to give a different result: this ‘unsucceeding experiment’ was as much part of the effort to understand the qualities of the stony substance as any of the other trials applied to it.

When this topic was discussed at the meeting of the Royal Society on 13 February 1683/4, Martin Lister commented on the diverse nature of the material sent to them by William Molyneux:

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<sup>67</sup> *DPS Papers* no. 166.

<sup>68</sup> *Ibid.*, 346.

<sup>69</sup> *Ibid.*

<sup>70</sup> *Philosophical Transactions* XIV (1684), 820. See *DPS Papers* vol. I, 347, note 4.

Dr. Lister conceived, that he had two sorts of these Lough Neagh stones, one from holly, and another from ash; one a lime-stone, and another an ironstone. He added, that holly might turn suddenly by reason of its viscousness and tenacity. Dr. Lister shewed a piece of this stone in the Museum, which was stone, iron, and wood.<sup>71</sup>

Martin Lister's influences on philosophical thought have received less attention than those of Robert Boyle, but were considerable, particularly in the area of those vital forces which could influence form, or generate an animated body. Lister had already interested himself in Lough Neagh independently of the RS and DPS, having received a letter from Thomas Kirke in 1677 containing 'a bottle and two stones'. Kirke, who appears to have extended a tour of Scotland into Ireland and was writing from Dublin, had obtained the specimens from one Dr Wilkins, parson of Lisburne. Kirke told Lister in a postscript that he had struck fire from sugar with the petrified wood, 'the first time ever I saw it experimented'.<sup>72</sup> The investigation of the Lough Neagh wood by the Royal Society continued with chymical experiments carried out by Dr Papin using various reagents including gall, processes including calcination, and the investigation of 'application to the magnet'.<sup>73</sup> Molyneux's own experiments, published in the *Philosophical Transactions*, used comparable methods.

#### Acid, alkali and salt: Allan Mullen's chymistry

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The physician Allan Mullen proved to be one of the most prolific contributors to the DPS, on topics in chymistry, medicine and anatomy. Despite Petty's laboratory experience, Mullen was the acknowledged chymist of the society, being responsible, according to William Molyneux, for setting up the laboratory *ab initio*, and then for many contributions on the subject recorded in the minutes, as well as in papers and

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<sup>71</sup>Birch, *History of the RSIV*, 256.

<sup>72</sup>Anna Marie Roos, *The Correspondence of Dr. Martin Lister (1639-1712). Volume One: 1662-1677* (Leiden, 2015).

<sup>73</sup>Birch, *History of the RSIV*, 285.

correspondence.<sup>74</sup> The details of Mullen's life as they have come down to us are largely provided by Walter Harris in the *Writers of Ireland* section of his edition of *The whole works of Sir James Ware concerning Ireland*. Mullen received his education at Trinity College Dublin and established a successful medical practice, being particularly skilful in the curing of gout by a remedy of his own.<sup>75</sup> From Mullen's paper on the elephant, mentioned in Chapter 3, it appears that he was well up to date with the physiological writings of Sanctorius, Malpighi and others: he also commented on the salts in the elephant's blood and tissues.<sup>76</sup> Introduced into Boyle's circle in London by Marsh, as we have seen, Mullen was said to have frequented coffee-houses there in the company of members of the Royal Society.<sup>77</sup> Eventually, he left Dublin permanently, fleeing to London in the aftermath of a 'scandalous love affair'. From London he set off to Jamaica in the company of the Earl of Inchiquin, who was travelling to assess the potential of some mines there. On the journey, the ship put in at Barbados where Mullen 'met with some Friends who made him drink hard, which threw him into a Calenture of which he died'.<sup>78</sup>

Mullen's experiments varied in approach. In the examples preserved in the DPS papers, he can be seen to move between examination of the action of acids, salts, sulphur and mercury *in vitro* and their action *in vivo*, and to examine the nature of various waters and other substances by probing them with the standard laboratory methods he had to hand. Many of his experiments centred on the coagulation of milk or blood, and the effects of various substances which would inhibit or promote coagulation. 'Runnet or dissolved coagulum' (now usually 'rennet'), which is an enzymatic complex from the digestive tract of young calves, is still well known for its role in cheese-making through its coagulating effect on milk: it is now known to

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<sup>74</sup> William Molyneux to Thomas Molyneux, 14 June 1684. DUM, 483.

<sup>75</sup> Mullen refers to this remedy in his letter to Boyle of 1685/6, saying that Tichborne, who has had relief from the use of Mullen's remedy, will give Boyle a quantity of it for Boyle's own use. See Boyle Correspondence, vol. 6, p. 163–166 (reference on 166) (also *DPS Papers* no. 323, where the letter has a different date but the same text). William Molyneux described this remedy in a letter to his brother Thomas as 'a liquor given in brandy, which makes it as bitter as gall and to smell like garlick, but discolors it not at all [...] it works by sweat and that very moderate.' DUM, 478.

<sup>76</sup> Allen Mullen, *An Anatomical Account of the Elephant* (London, 1682).

<sup>77</sup> *DPS Papers*, no. 188.

<sup>78</sup> Walter Harris, *The Whole Works of James Ware concerning Ireland*, 206.

depend for its action on an acid pH. The meeting of 24 March 1683/4 heard of material which could inhibit the action of rennet: mixing spirit of hartshorn (a distilled aqueous solution of ammonia and ammonium carbonate) with the coagulum inhibited the ‘turning’ or curdling of the milk, unlike spirit of wine (a high concentration of alcohol).<sup>79</sup> Such experiments were related to a long series carried out by Boyle’s protégé Frederick Slare for the Royal Society, and to similar procedures at the Oxford Society.<sup>80</sup>

Mullen’s paper for the second meeting of the society is now lost but its topic, a discussion *de alkali et acido*, had potentially a very wide audience indeed. The acid-alkali theory, as it appeared to its most energetic adherents by the 1680s, was a contender for the crown of universal theory of matter, or, if failing there, at least for universal theory of disease. Earlier definitions of acid and alkali were functional to a greater or lesser degree: an acid was commonly characterised as having both a sourness to the taste and a corrosive action, both observed by Boyle, although he recorded instances in which this was not the case.<sup>81</sup> The sharp nature of acids was one of the factors which led the chymist Otto Tachenius (1610–80) to propose a specific corpuscular hypothesis of acids and alkalis, with the pointed, sharp nature of the acid particles slotting neatly into the corresponding pores of the alkali, even going so far as to find their theoretical parallels in the fruitful coition of male and female.<sup>82</sup> This, or a later formulation by the French chymist Nicolas Lémery (1645–1715), adapted from Tachenius with scant acknowledgement and published in 1680, could have formed the topic of Mullen’s discourse, although it is equally possible

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<sup>79</sup> Properly, ethanol.

<sup>80</sup> Experiments investigating this controversy carried out by members of the Oxford Philosophical Society are described in Birch, *Birch, History of the RS* IV, 349–50; Slare’s investigations of acids and alkali in ‘distinguishing the res medica’ are at 436–43 of the same volume. An article on Slare himself may be found at Marie Boas Hall, ‘Frederick Slare, F.R.S. (1648–1727)’, *Notes and Records of the Royal Society of London* 46:1 (1992), 23–41.

<sup>81</sup> For a discussion of the use of taste in distinguishing the nature of materials, and Boyle’s attitude to it in the context of acid and alkali, see Kleber Cecon, ‘Chemical translation: the case of Robert Boyle’s Experiments on Sensible Qualities’, *Annals of Science* 68:2 (2011), 179–98, in particular 184–5.

<sup>82</sup> In *Hippocrates chymicus* (1666). For an account of Tachenius’ concepts and the derivation by Lémery, see L.M. Principe, ‘A Revolution Nobody Noticed? Changes in Early Eighteenth-Century Chymistry’, in L.M. Principe (ed.), *New Narratives in Eighteenth-Century Chemistry: Contributions from the First Francis Bacon Workshop, 21–23 April 2005, California Institute of Technology, Pasadena, California* (Dordrecht, 2007), 1–22. Tachenius and Lémery are specifically discussed on p. 5.

that he referred to material from Boyle, Locke, or Willis, all of whom discussed the topic but remained unconvinced.

Boyle described the hypothesis in condemnatory terms as:

being in a sort subordinate to that of the *tria prima*, in ascribing to *two contrary saline Principles*, what vulgar Chymists do to their *Salt, Sulphur* and *Mercury*; most of the objections we have made against the vulgar Chymical Doctrine, may, as I lately intimated, be applied, by a little variation, to this.<sup>83</sup>

John Locke, in a letter to William Molyneux dated 15 June 1697, mirrored Boyle's less than enthusiastic comment when he referred to the medical efficacy of 'a little observation by a man not tyed up ... to the acid and alkali which has of late prevailed'.<sup>84</sup> Locke's views on the roles of alchemy, chymistry and theorising in medicine were further elaborated in correspondence with Thomas Molyneux, where he wrote that:

the Galenists four humors, or the chymists sal, sulphur, and mercury, or the late prevailing invention of acid and alkali, or whatever hereafter shall be substituted to these with new applause, will upon examination be found to be but so many learned empty sounds, with no precise determinate signification.<sup>85</sup>

In short, though the medical application of the acid-alkali hypothesis became rather fashionable, it did not meet with universal approbation. Mullen's discourse would,

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<sup>83</sup> Boyle, *Works*, 8, 409. For a discussion of the theories, their proponents and in particular their Helmontian roots see A.G. Debus, *Chemistry and Medical Debate: van Helmont to Boerhaave* (Canton, MA, 2001), ch. 4, and Anna Marie Roos, *The Salt of the Earth*, chs. 3, 4. Debus surveys the wider perspective while Roos, in addition, records some lesser-known figures from among the English practitioners.

<sup>84</sup> John Locke to William Molyneux, 15 June 1697. Locke, *Correspondence*, 6, 142–145 (Letter 2277).

<sup>85</sup> John Locke to Sir Thomas Molyneux, Friday, 20 January 1693. Locke, *Correspondence*, 4, 628–630 (Letter 1593). Locke was familiar with Boyle's hypothesis of acid and alkali: the differing mental approaches of the two men to the same material have been reviewed by Anstey: Peter R. Anstey, 'Locke on method in natural philosophy', in *The Philosophy of John Locke: New Perspectives* (London, 2003), 26–42.

however, have found an informed audience among the members of the DPS, the most prominent medical member being Charles Willoughby, then ‘Arbiter Conventionis’ of the DPS and professor of mathematics at Trinity. Willoughby’s own collection of chymical texts points to a nuanced view of the acid-alkali theory by at least this member of the DPS. While he owned works by Sylvius and Tachenius these were far outweighed by his collection of no less than thirteen works by Boyle.<sup>86</sup> Among the less chymically-inclined members of the DPS, Narcissus Marsh also took an interest in this topic: his books include a 1683 work in Dutch on acid and alkali by Cornelis Bontekoe (1644–85, known as the tea-doctor), as well as a treatise on salts by the German-Dutch chymist Johann Glauber (1604–70).<sup>87</sup>

Boyle’s experiments and opinions on salt, acid and alkali are found in many of his publications, from the *Usefulness of natural philosophy* (written in the 1650s although not published until 1663), through *History of fluidity and firmness*, which was first published in 1661, over twenty years before the first activities of the Dublin group, as well as his treatise of cold (1665) and his *Memoirs for natural history of human blood* (1684, although including much material from very much earlier), among others.<sup>88</sup> Taken together, these works reflect the continuing evolution of Boyle’s views on corpuscularian mechanisms, of alternative hypotheses for the explanation of observable effects, and of experiments proposed to answer the queries springing from those hypotheses. In the *History of Fluidity and Firmness*, Boyle reminds his readers that they are

assisted to judge of the Doctrine of the Chymists, who teach, that in all Bodies, Coagulation, Stability, Hardness and Brittleness depend upon Salt: for though what above has been said of Crudling [sic] of milk by saline

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<sup>86</sup> On the availability of chemical texts such as Sylvius, Tachenius, Lemery, Willis and Boyle, among the libraries of Irish medical men, including that of Charles Willoughby, see Elizabethanne Boran, ‘The sceptical collector: alchemy and chemistry in early modern Irish medical libraries’, in Danielle Westerhof, ed., *The Alchemy of Medicine and Print* (Dublin: Four Courts, 2010), 75–88.

<sup>87</sup> Bontekoe sarcastically referred to the book of nature as ‘the Book of Drivel’. See Jorink, *Reading the Book of Nature in the Dutch Golden Age*, 88, 107.

<sup>88</sup> H. Knight and M. Hunter, ‘Robert Boyle’s MEMOIRS FOR THE NATURAL HISTORY OF HUMAN BLOOD (1684), Print, Manuscript and the Impact of Baconianism in Seventeenth-Century Medical Science’, *Medical History* 51:2 (2007), 145–64.

Liquors, and the hardness and brittleness obvious in Salts themselves, may keep us from denying that the saline principle is very powerful in the coagulation of some bodies, and does produce much firmness or even brittleness in many or most of the concretes wherein it is predominant; yet this hardening power of Salt seems not to proceed from any peculiar and inexplicable property it has to coagulate other bodies, or make them compact, but from the shape and motion of its Corpuscles.<sup>89</sup>

Boyle's preoccupations here are mirrored in Mullen's brief report on 3 November 1684, which noted that 'a salt taken from a ground consisting of earth and sea-sand coagulated milk but could not be crystallized'.<sup>90</sup>

After Mullen's initial contribution, acids and alkalis and their interactions continued to attract the interest of the members of the DPS under various headings. At a meeting on 5 May 1684, Richard Bulkeley read a paper and demonstrated experiments on 'luctation of divers alkalis and acids in pursuance of Dr Grew's experiments of that kind'.<sup>91</sup> Bulkeley's paper, which has been lost, explored the diagnostic 'battle' between the acid and alkali, producing heat and effervescence, although it was becoming evident that other materials and interactions could produce similar effects. In another instance, Daniel Huologhan is recorded as seeking the best criterion for acidity at two meetings of the DPS in January 1684/5.<sup>92</sup> Initially, he proposed 'that it may be enquired what is the most nice way of discovering the acidity of liquors' to which William Petty responded with the suggestion of cochineal as an indicator dye.<sup>93</sup> This 'criterion' was pursued at the meeting of the 26<sup>th</sup> of January, when Huologhan 'showed some experiments of changing colours of liquors tinged with cochineal, syrup of violets etc. in order to

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<sup>89</sup> Boyle *Works* 2, 187.

<sup>90</sup> *DPS Papers* no. 38.

<sup>91</sup> *DPS Papers* no. 21. The paper is lost. Grew's paper on this effect is appended to his *Anatomy of Plants* (London, 1682).

<sup>92</sup> Biographical note, *DPS Papers*, vol. II, 950.

<sup>93</sup> *DPS Papers* no 46.

what he had formerly proposed concerning an accurate cri[terion] of acids'.<sup>94</sup>

Distinguishing with precision between the acid and the alkaline became critical to arguments concerning their use in analysis of other substances. As Marie Boas Hall records, Boyle's initial interest in the colour changes produced by the interaction of various reagents was centred on their entertainment value.<sup>95</sup> Both at the DPS meetings and more generally, indicative colour changes for the presence of acid or alkali, or the presence of a metal, were pursued in earnest for their analytical usefulness as well as their capacity to amaze the vulgar.

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### Colour, corpuscles, and spirit

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Boyle's experiments on colour and on the nature of the changes produced in indicator substances, developed in *Experiments and Considerations Touching Colours* (1664), have been interpreted as critical to Boyle's developing corpuscularian views.<sup>96</sup> He admitted the usefulness of tests for the presence of acid or alkali, although he thought them to be based on a false underlying hypothesis and subject to over-generalisation, a point also discussed by Locke.<sup>97</sup> In the twentieth experiment of *Experiments and Considerations Touching Colours*, he pointed out the general nature of the effect he observed, remarking that some had attributed the colour change generated by vitriol or lemon juice in syrup of violets (and in the much more expensive lignum nephriticum) to properties of those particular acidic substances. Boyle reported that he could obtain these colour changes with a wide range of substances which behaved as an acid or alkali under

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<sup>94</sup> DPS Papers no 48.

<sup>95</sup> Marie Boas Hall, *Robert Boyle and Seventeenth Century Chemistry* (first published 1958; Cambridge, 1976).

<sup>96</sup> See Antonio Clericuzio, 'A redefinition of Boyle's chemistry and corpuscular philosophy', *Annals of Science*, 47 (1990), 561–89. That others were engaging with the same concepts at the same period is emphasised in Anna Marie Roos, *The Salt of the Earth*, ch. 3, 4. Michael Hunter's integration of the development of the concepts in Boyle's published and unpublished works is set out in *Boyle: between God and Science* and elsewhere.

<sup>97</sup> Boyle, *Works* 8, 416–7. For Locke's views and the contrast with Boyle) see Peter R. Anstey, 'Locke on method in natural philosophy'.

other tests.<sup>98</sup> Mullen likewise found the topic absorbing, examining waters by chymical means on 20 July 1685. He found that

an equal quantity of river water mixed with spirit of wine caused a great many bubbles, which lasted long, was but milk-warm and pellucid. Pump water with spirit of wine made greater fermentation; the bubbles soon disappeared; 'twas warmer than the first and turned wheyish. Rainwater with spirit of wine caused a fermentation and heat like the first, with no alteration of colour: the like also happened in plantain water poured into spirit of wine but spirit of wine poured into the distilled water produced a greater fermentation.<sup>99</sup>

The minutes as given in the sources used by Hoppen omit the next part of the account which is given in Birch, which reads:

Sublimate sulphuris per campanam [dilute sulphuric acid] mixed with spirit of wine fermented more slowly, but became blood-warm, that is, much warmer than the rest. Syrup of violets with spirit of wine made small fermentation, with few bubbles: it turned of a greenish colour. Cornu cervi ustum [hartshorn] upon syrup of violets turned green, upon which sublimate sulphuris per campanam poured changed it to red with a very great fermentation. Milk dropped into spirit of wine presently coagulated.<sup>100</sup>

In common with Mullen, the Royal Society and the groups in Oxford and London all carried out experiments on the behaviour of spirit of wine, examining interaction with water (producing heat and effervescence) and with the colour indicator syrup of violets.<sup>101</sup> A controversy over the nature of the spirit of wine emerged in print

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<sup>98</sup> Boyle, *Works* 4, 124. For a recent discussion of this see Steven Turner and Rebecca Laroche, 'Robert Boyle, Hannah Woolley, and Syrup of Violets', *Notes and Queries* (2011) 58(3), 390-1.

<sup>99</sup> DPS Papers no. 68.

<sup>100</sup> Birch, *History of the RSIV*, 432.

<sup>101</sup> See for example Birch, *History of the RS*, 328-9 for experiments by Frederick Slare designed to test Kunckel's claims; and 436-43 for an account of acid and alkali in the res medica, also by Slare, including reference to Boyle's concepts.

elsewhere, when Johann Kunckel used the evidence of a colour test to claim that the spirit of wine [alcohol] was an alkali.<sup>102</sup> This dispute was closely tied to the claims of Tachenius concerning the role of acid and alkali in nature and in disease states. Classifying spirituous substances, such as spirit of wine, held implications for the role of those substances (seen in the previous section of this chapter in the discussion of mechanisms of freezing by Grew, Hooke and Henshaw). Oils and spirits raised further questions, as we shall see from Mullen's experiments on the extraction of oils from vegetable matter.

In August 1685 Mullen was to be found in the laboratory extracting oil from scurvy-grass, which he found did not meet his initial expectations. Having bruised the herb and kept it in brandy for a month, he

distilled it in an alembic and got a good quantity of a very pungent spirit, much insipid phlegm, and last of all, an oil as insipid as sallet oil, which he was surprised at, having expected the most pungent acrimonious oil that he knew any vegetable to yield.

He then repeated the fractional distillation and was

induced to believe that the volatile ethereal piperine oil in the first parcel of scurvy-grass was changed into a spirit, there being neither oil nor milkiness to be seen in what came over the helm.<sup>103</sup>

Scurvy-grass, *Cochlearia officinalis* (spoonwort) was a well-known remedy for the syndrome which conferred its name. Boyle's interest in this substance is recorded in his work-diaries, where the preparation of 'Mr Cl[odius] remedy' is described.<sup>104</sup>

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<sup>102</sup> A description of the controversy as it appeared to the members of the Royal Society can be found in 'An Account of a Book: The Chymical Touch-Stone of Mr John Kuncle, ... De Acido, et Urinoso Sale Calido et Frigido, contra Doctor: Voights spirit: Vini vindicatum ...', *Philosophical Transactions XV* (1685), 896-914. Kunckel claimed that as spirit of wine turned syrup of violets green, it must be an alkali.

<sup>103</sup> *DPS Papers* no. 71.

<sup>104</sup> Robert Boyle, Workdiary 12, entry 48.

[http://www.livesandletters.ac.uk/wd/view/text\\_ed/WD12\\_ed.html](http://www.livesandletters.ac.uk/wd/view/text_ed/WD12_ed.html), accessed 10.03.2013.

He also published recipes for the treatment of loose teeth (a common symptom of scurvy) in volume 2 of his *Medicinal Experiments, or A Collection of Choice and Safe Remedies*, posthumously published in 1693 from earlier material.<sup>105</sup> Mullen may well have been aware of a translation by Thomas Sherley of a comprehensive work by Valentin Moellenbrock on scurvy grass. Published in 1676, it was advertised in its lengthy subtitle as containing the 'best preparations of medicines, both Galenical and chymical' from the plant.<sup>106</sup> Nicolas Lémery also described preparation of 'esprit de cochlearia' in his *Cours de chymie*, first published in 1675. In other words, Mullen appears to have been attempting to repeat or extend what was already known of the fractional distillation of the oil from these relatively standard works, or perhaps from a communication of Clodius' preparation via Boyle.

An earlier generation of uses for oils distilled from plants, which would very probably have been known to Mullen as part of a Helmontian understanding of iatrochemistry, was connected to the alchemical vegetation of metals. The property of growth of branching crystals, common to both metals and salts, was understood to be an indication of a vital spirit in that form of the metal, which in its turn could lend its energy to the transformation of other substances. In discussing the chymistry of Robert Plot, Roos has shown that processes from the alchemical writer known as pseudo-Llull were familiar to the Oxford circle. A distillation process of the spirit of wine with vegetable matter containing oil was described by Johann Seger von Weidenfeld, a commentator on the Lullian corpus and a contemporary of Plot:

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<sup>105</sup> Boyle, *Works*, vol. 12, 254. The recipes are discussed and cited in Anthony J. Lorenz, 'Some Pre-Lind Writers on Scurvy', *Proceedings of the Nutrition Society* (1953) 12:3, 306–24. For Boyle's motivation in communicating these and other remedies see Michael Hunter, *Robert Boyle, 1627–91: Scruples and Science* (Woodbridge, 2000), ch. 9.

<sup>106</sup> Thomas Sherley, *Cochlearia curiosa: or The curiosities of scurvygrass... In which is exhibited to publick use the most and best preparations of medicines, both Galenical and chymical; either for internal or external use, in which that plant, or any part thereof is employed. Written in Latine by Dr. Andreas Valentinus Molimbrochius of Lipswick. Englished by Tho. Sherley, M.D. (London, 1676).* For a discussion of the disease and of Moellenbrock's book, see Kenneth J. Carpenter, *The History of Scurvy and Vitamin C* (Cambridge, 1986). For Sherley see Antonio Clericuzio, 'Sherley, Thomas (bap. 1638, d.1678)', *ODNB*[n. 64].

the Oyl drawn out of Oyly Vegetables is by distillation together with the Spirit of Philosophical Wine, circulated into a Magistery by which the Spirit of wine is multiplied.<sup>107</sup>

Mullen's disappointment with the 'insipid' oil he had derived from the scurvy grass may be explained by his expectation of something 'pungent and acrimonious', endowed with heat, which might have conveyed its virtues to the wine and thus helped in the making of the philosophical 'lunaria'.

The two surviving letters from Mullen to Boyle reveal some of Mullen's approaches to the application of chymistry in medicine and physiology.<sup>108</sup> They also imply that he expected that these approaches were understood and shared by Boyle. The first letter, of 12 December 1682, discusses the use of the *ens veneris*. This was a Helmontian remedy which had been prepared by Boyle using a method which he is said to have learned from the American chymist George Starkey.<sup>109</sup> The '*ens veneris saccharinum*' was mentioned in Boyle's 1654 letter to Clodius, as one of a group of Clodius' Helmontian preparations which Boyle admired. He made this comment while in Ireland and perceiving himself to be in 'a country, where I can scarce get time to think of chemistry, much less opportunities to improve it'.<sup>110</sup>

Another experiment carried out separately by Mullen and Boyle also has Helmontian overtones. On 29 November 1686, Mullen 'showed before the society a new fixed substance produced by the mixture of three volatiles, viz. spirit of sal-ammoniac, mercury, and powder of sulphur'.<sup>111</sup> A very similar combination (of a version of the Paracelsian *tria prima*, which cannot have escaped notice, although it

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<sup>107</sup> Roos, 'The Chymistry of "The Learned Dr Plot" (1640-96)'. The citation from Weidenfeld is on page 87.

<sup>108</sup> For Mullen's letters to Boyle see Boyle *Correspondence*, 5, 361-5; 6, 163-6.

<sup>109</sup> *Ens veneris* was a remedy of varying composition, frequently understood as sal ammoniac tinted blue by the presence of copper sulphate. However, some varieties of it were red, made with a ferric salt instead of copper. Boyle and Starkey made their own version of it, although Boyle seems to have been inclined to claim it for his own recipe and reduce Starkey to the role of an operator (laboratory assistant). See Newman and Principe, *Alchemy tried in the Fire*, 221-2, 270.

<sup>110</sup> Boyle to Clodius, Boyle, *Correspondence*, 1, 166. It is unclear whether '*ens veneris saccharinum*' as referred to here is identical to the Helmontian *ens veneris* (a preparation of sal ammoniac tinted blue by the presence of a copper salt).

<sup>111</sup> *DPS Papers* no. 108.

passed without comment) is also described by Boyle in his *Experimental notes of the mechanical origin or production of fixtness*. Boyle records that:

having put a mixture made of a certain proportion of two dry, as well as volatile bodies, (*viz.* Sal Armoniac and Flower or very fine powder of Sulphur,) to half its weight of common running Mercury, and elevated this mixture three or four times from it, (in a conveniently shaped, and not over-wide, glass) the Mercury, that lay in the bottom was ... so fixt that it long endured a strong fire, which at length was made so strong, that it melted the Glass.

Boyle saw the investigation of volatility as significant, including its description among his desiderata in the aims of *Chymia Philosophica*.<sup>112</sup>

The second letter, dated 26 February 1685/6, in which Mullen thanks Boyle for sending him the book *Of the reconcileableness of specifick medicines to the corpuscular philosophy* (1685), reveals Mullen's experience of those medicines discussed in the book. The wide variety of substances in common – and apparently effective – use in medicine was a topic of interest to both Boyle (as detailed in the book he had sent to Mullen) and to Mullen himself, who recorded in his letter instances which mirrored those recorded by Boyle, commenting on 'the great satisfaction I had to find some notions I had of my owne soe well made out by a person of soe great learning & authority as yourself'.<sup>113</sup> A sample of Mullen's own remedy for the gout was sent to Boyle by the hand of the bearer of this second letter, Sir William Tichborne, who was apparently a grateful patient treated with this remedy.<sup>114</sup>

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Blood *in vivo* and *in vitro*

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Boyle's influence on Mullen is also seen in the investigation of the effects of salts,

<sup>112</sup> Boyle, *Works* VIII, 453-4, 423.

<sup>113</sup> Boyle, *Correspondence* VI, 164.

<sup>114</sup> Sir William Tichborne, of Beaulieu in Co Louth. See *DPS Papers*, no. 323, n. 12 for a comment from William Molyneux on Tichborne's being cured by Mullen's remedy.

acid and alkali on blood *in vitro* and *in vivo*. This extension of experimental method is indicative of a generalising pattern of thought, in which effects found to be replicable *in vitro* might also be effective *in vivo*, thus yielding the possibility of utility in medical applications. In his second letter to Boyle, Mullen describes his experiments on dogs which had been killed by the injection of various salts which were known to coagulate blood *in vitro*. Mullen reported that he had demonstrated:

that not onely acids coagulat the blood but alsoe most salts even such as hinder coagulation in milk & one manifest enemy to acids is what I can assure you from experience.<sup>115</sup>

The pattern of experimentation by injection into the blood was of long standing: in a letter from Petty to Boyle written early in 1658, an experiment on the effects of chymical substances *in vivo* was recorded:

that infusio croci metal. has been injected into a live animal's blood, without any notable alteration. It were good to try the same with opiate liquors, and other of notable and sensible vertues.<sup>116</sup>

As Knight and Hunter have noted, Boyle outlined the motivations for moving from the study of human blood to that of 'Brutes' in a class of 'succedaneous' experiments discussed in the material Boyle prepared towards a second edition of his *Memoirs for the Natural History of Human Blood* (1684), which, however, was destined to remain unpublished. These experiments were to include:

Whether spirit of Salt injected immediately into the Blood of a live Animal, will coagulate it; and if it doe, whether the spirit of Blood, or Hartshorn, or other volatile Salts, seasonably injected or administred will prove a Remedy. ... Whether a strong Purge, or a strong vomit being given to a Dog, open'd whilst it is working, the mass of Blood will appear to be sensibly

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<sup>115</sup> Boyle, *Correspondence* 6, 164.

<sup>116</sup> William Petty to Robert Boyle, 27 February 1658, Boyle, *Correspondence* 1, 254-5 (quote from p. 255).

alter'd, and whether more in some vessels than in others.<sup>117</sup>

A further possible connection between Mullen's experiments and Boyle's draft queries is to be found in the 'Materials for the Scheme of Titles of the Second Classis of the Natural History of Human Blood':

Whether any (or if any) What difference, may be found by chymical analyses (& other wise) betwixt blood, & those other juices of the body, that are supposed to be either Further elaborations milk, sperm <Gall &c.,>...

in which a deleted note added

the pus of empostumes, the gleeting of ulcers, the water to be found in the abdomen of Hydropick persons &c'.<sup>118</sup>

At the meeting of 1 December 1684, Mullen reported harvesting the serum from a blister raised by a blistering plaster. The minutes record that the serum

ferments not with spirit of wine, nor with common spirit of sal ammoniac; but with a peculiar sort of salt of the Dr's own preparation, it ferments visibly. This serum turned syrup of violets green. It did not coagulate milk, but put over a fire,  $\frac{3}{4}$  of it evaporated, the residue remaining like a jelly.<sup>119</sup>

The strong influence of Robert Boyle is evident in the multiple series of experiments carried out by Mullen. Mullen's trials demonstrate a response to publications by Boyle, which explicitly set out to stimulate further trials. In the case of blood, as in the case of his works on mineral waters, Boyle revisited his notes and prepared material for publication decades after his original notes and investigations. Some of these revised notes emerged in published form; some although revisited by Boyle

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<sup>117</sup> Michael Hunter and Peter Anstey (eds), 'The Text of Robert Boyle's "Designe about Natural History"', Robert Boyle Project Occasional Papers, No. 3, Birkbeck, University of London, Robert Boyle Project (2008) (available at

[http://eprints.bbk.ac.uk/693/1/Hunter\\_Boyle\\_paper\\_3\\_pub\\_pdf.pdf](http://eprints.bbk.ac.uk/693/1/Hunter_Boyle_paper_3_pub_pdf.pdf), accessed 10.03.2013, 4.

<sup>118</sup> *Ibid*, 24.

<sup>119</sup> *DPS Papers*. no. 42.

himself in preparation for further publication, did not reach print during his lifetime.<sup>120</sup> These investigations, in their various stages of development, evidently stimulated related experiments carried out by the DPS and others at a remove of decades from Boyle's original investigations. These later investigations testify to the extent of continuing interest in the topics and of revived interest in experimental investigations as occasion allowed. In Mullen's case, the experiments he recorded as having been carried out in Boyle's premises took place about 1687/8, which is very close to the time that these preparatory notes for the unpublished second edition of the *Memoirs on human blood* were being drawn up. Whether Boyle had any direct involvement in the design of the trials made by Mullen is unclear but their association makes it likely that Boyle had exerted at least some influence on the younger Mullen.

Knowledge gained from animal experiments was applied to human findings, as when Mullen carried out a post-mortem on a person who had died of a condition of the lungs and extended his observation by a comparison to an earlier experiment on a dog. He described the blood in the heart of the dead man as

black, as if an acid were mixed with it, resembling that I formerly found in the left ventricle of a dog's heart killed by an injection of 3 ounces of vinegar. Whence we may guess that at least that kind of matter may be acid, and therefore obtunders of acids may be proper medicaments in ulcers of the lungs.<sup>121</sup>

Mullen's observation of the colour of the blood, particularly seen in his remarks on the difference in colour between arterial and venous blood, suggests knowledge of previous work on the colour of blood from (for example) Harvey's *De generatione*, where the putative action of the animating principle (the soul) on the colour of the arterial blood was refuted. To produce equivalent colour changes *in vitro* further refuted the necessity for any action of the soul in the process. Experiments to

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<sup>120</sup> H. Knight and M. Hunter, *Robert Boyle's MEMOIRS FOR THE NATURAL HISTORY OF HUMAN BLOOD* (1684).

<sup>121</sup> Allan Mullen, 'An account of one dying of a consumption', *DPS Papers* no. 184.

determine the cause and role of the coloured part of the blood and the inferences drawn from them by Malpighi, Harvey, Lower, Primrose and Riolan among others could have been known to the members of the DPS, although there is no explicit evidence of this.<sup>122</sup>

### Communication, reproducibility and extension: patterns of change

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Boyle's adoption of the system of enquiry put in place by Bacon has been discussed by Hunter in the context of Boyle's own heads and queries.<sup>123</sup> Hunter traced Boyle's use of this avowedly Baconian structure to the influence of the Royal Society on Boyle's concepts and practice. This is a reversal of a conventional position which traces Boyle's influence in the activities and investigative patterns within the Society. Boyle's 'General Heads for a *Natural History of a Country, Great or small*', published in the Society's journal, *Philosophical Transactions*, in 1666, is regarded by Hunter as a key text in this process of mutual influence. Hartlib's queries about Ireland, addressed to Boyle in his letter of May 1654, contains a similar pattern of queries, and the systematic taking of natural histories was a preliminary step in the evaluation of colonial territories.<sup>124</sup> In a recent article, Fox has commented upon the influences of Petty, Aubrey and Hooke on the questions included by Molyneux in his 'Quaeries', noting that similar systems of printed questionnaires became a general method of collecting information relating to features of the British Isles, also becoming a means of connecting 'ingenious and learned' men into a research network.<sup>125</sup> By the 1680s, this system of queries had established itself, and can

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<sup>122</sup> For a discussion of the many-layered meanings attached to the colour of blood see Domenico Bertoloni Meli, 'The Color of Blood: Between Sensory Experience and Epistemic Significance', in L. Daston and E. Lunbeck, eds, *Histories of Scientific Observation edited* (Chicago, 2011), 117-34.

<sup>123</sup> Michael Hunter, 'Robert Boyle and the early Royal Society: a reciprocal exchange in the making of Baconian science', *The British Journal for the History of Science* (2007). 40, 1-23. See also Michael Hunter (ed.), Robert Boyle's 'Heads' and 'Inquiries' (2005) [http://www.bbk.ac.uk/boyle/researchers/works/Occasional\\_Papers/BOYLE\\_Heads\\_Revise3.pdf](http://www.bbk.ac.uk/boyle/researchers/works/Occasional_Papers/BOYLE_Heads_Revise3.pdf) [Accessed 18 November 2011].

<sup>124</sup> Hartlib to Boyle 18 May 1654, Boyle *Correspondence* 1, 169-70. The unusual alphabetic arrangement of this 'Interrogatory' has led Hunter to question the influence of this set of queries on later questionnaires designed to collect similar information. M. Hunter, 'Robert Boyle and the early Royal Society: a reciprocal exchange in the making of Baconian science', 16, n. 59.

<sup>125</sup> Adam Fox, 'Printed Questionnaires, Research Networks and the Discovery of the British Isles, 1650-1800', *Historical Journal*, 53 (2010), 593-621.

perhaps be seen as underlying the operation of ‘useful’ natural philosophy such as that advocated by Boyle and conducted by the DPS and other similar societies. As mentioned in Chapter 4, the operation of such lists of queries, and of the construction of *desiderata*, has been characterised by Keller as developing an underlying pattern of research questions which were expected to stimulate both response and further query from the curious.<sup>126</sup>

And what of the results of these exchanges within a community such as the DPS, its models, such as Boyle and the Royal Society, and its correspondents beyond the Crow’s Nest? It is evident from these small narratives of experiment, month to month, that incremental discoveries and insights were generated by exchanges in the philosophical community. Recent historiography seeks to include a more complex account of the developments at this period, taking into account the building of consensus and the exchange of opinions. H.F Cohen’s concept of ‘transformations’ occurring in specific circumstances which yielded ‘genuine novelties’ in thinking was particularised for this period. He identified the developing corpuscularian approaches as a critical component, with Boyle’s notion of matter and motion as ‘catholick [universal] principles’ to be handled as the occasion required rather than as rigid dogma of the strictly Cartesian or Gassendist variety.<sup>127</sup> The evidence presented in this chapter tends to support the significance of Boyle’s influence in general, and of his corpuscularian views in particular.

As we have seen in the accounts of the Leiden chymists, the intersection of practical laboratory work with theoretical interpretation made chymistry unusual in eluding censorship. What did it mean, in 1680s Leiden, to say that someone held Cartesian views? And did that interpretation play out in laboratory implementations? Or did the mechanical and corpuscular interpretations of the world actually blend into each other? Descartes, like Bacon, may have been invoked, but perhaps not comprehended, or indeed easily applied to the practical. Sir William Petty, who became in a sense the grand old man of the DPS, had a severely practical attitude to

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<sup>126</sup> Vera Keller, ‘The New World of Sciences’.

<sup>127</sup> Cohen, *Modern Science*.

Cartesian philosophy, asking: ‘who, that hath followed [Descartes’] principles, hath drawne any new usefull or pleasant art or reall conclusion from them?’ And yet, Petty, in the appendix to *The Discourse... Concerning The Use Of Duplicate Proportion* (London, 1674) wrote about his aim to describe the vibration of atoms and their magnetic properties in simple terms.

Discussion of the ‘ancient and moderns’ debate was mentioned but was overshadowed by the practical.<sup>128</sup> Thomas Molyneux’s choice of old Dr Margrave as his mentor, and his focus on skills in iatrochemical preparations (which was to be part of his professional life, after all), seem to bring ‘usefull art’ to the fore --- and yet, as Pierre Bayle remarked in response to Thomas Molyneux’s ‘Phansy’ concerning solutes, the act of performing practical experiments provoked thought.

The repetition and reproducibility sought by trials in the learned societies, and the patterns of witness established by the philosophical community as a whole is useful when considering the significance of the activities of the members of the DPS in examining chymical processes. The relative lack of explicit commentary in the papers of the DPS makes it something of a challenge to label the conceptual standpoint of the members, although it is evident that their practices and interests owed much to Boyle and to their contemporaries in the Royal Society and beyond. It would be possible to conclude that they were simply men of their time, with proceedings which fell within the parameters accepted and understood by their community, in an echo of Kuhnian ‘normal science’—but perhaps it is that interaction with the community that becomes the most important point in understanding their place within the events producing the ‘new knowledge’. We have seen previously that Cohen described a significant component of the development in the seventeenth century as the emergence of ‘procedurally and institutionally established self-correction’. This could operate in an overlapping and

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<sup>128</sup> William Molyneux to Thomas Molyneux, 24 June 1684, *DUM*, 483. The Dutch physician Jan Almeloveen (c.1657–1712) claimed in his *Inventa nov-antiqua* (published in 1684) that many discoveries in medicine had been anticipated by ancient physicians such as Hippocrates and Galen. This contribution to the ‘ancients and moderns’ debate did not meet with the approval of William Molyneux, who called it a ‘foolish attempt’.

recursive fashion, with each succeeding generation building upon previous work, established by repetition.

In *Unsucceeding experiments*, Boyle was careful to point out that chymistry was not exact, giving several instances of ‘contingent experiments’ and of materials which varied, and noting that:

it need be no such wonder, if Philosophers and Chymists do sometime miss of the expected Event of an Experiment but once, or at least but seldom try’d, since we see Tradesmen themselves cannot do *always*, what, if they were not able to do *ordinarily*, they could not earn their bread.<sup>129</sup>

Reagents and processes, used similarly by honest and skilful investigators, might yield different results. To engage with this variation in results, Boyle advocated a gradual understanding emerging from repetition and consensus. Careful application of reasoning and evaluation of the sources of information was also important to Boyle’s ‘useful’ philosophy. The role of the ‘witness’ of the natural order, as described by Boyle in the *Christian Virtuoso* (1690) and earlier in his consideration of the *Usefulness of natural philosophy*, placed observers with personal experience of experimentally generated phenomena at the core of the process of the establishment of new knowledge.<sup>130</sup> The links between experiment and experience had been made in the religious sphere earlier in the century. Peter Harrison noted that the language of experiment and trial, common in the description of the making of ‘matters of fact’, was, if anything, more widely used in the religious sphere and, he argued, was *extended* to describe knowledge acquisition by natural philosophers.<sup>131</sup> Boyle, employing the language of experiment, drew upon the links with legal and faith-based argument. He also repurposed the argument, emphasising the value of experiment and experience

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<sup>129</sup> Boyle, *Works*, vol. I, 349.

<sup>130</sup> Consideration of these factors in Boyle’s philosophy has been central to Steven Shapin’s concept of the ‘modest witness’ as fundamental to the presentation of scientific process as objective: for discussions of these concepts and of the image of the scientific process generated from them see Steven Shapin, *Never Pure* (Baltimore, 2012).

<sup>131</sup> Peter Harrison, ‘Experimental Religion and Experimental Science in Early Modern England’, *Intellectual History Review* 21:4 (2012), 413–33.

over speculative philosophy. In common with others active in natural philosophy Boyle's religious framework combined both a moral motivation for continuing interest in and deepening study of workings of the natural world, and a potential epistemological role for the community of disinterested witnesses in establishing those 'matters of fact' which William Molyneux's preface to *Sciothericum* had emphasised so trenchantly.

The chymical investigations I have touched on here are largely from the first period of the society's existence, from 1683 until 1686. As Hoppen has noted, the activities of the DPS were disrupted on more than one occasion by the instability of the political situation in Ireland. The final revival of the society in the period 1707–09 under William Molyneux's son, Samuel, saw an initial correspondence with the instrument maker Francis Hauksbee about the purchase and use of an air pump, to complement the laboratory instruments inherited from Samuel's father. Whether because of a changing attitude to the purpose and practise of gentlemanly and professional science at the beginning of the eighteenth century, or simply because the critical mass of interested individuals changed, the surviving letters and papers testify to a move away from laboratory investigations towards the astronomical, antiquarian, geographical and agricultural interests which were to inform the genesis of the Royal Dublin Society and the Royal Irish Academy. It is in the earlier period of the DPS, looking out from the Crow's Nest, that chymical interests found their most ample expression in the Irish context.

Taken in this context, we can observe the members of the DPS applying the apparatus of Bacon and Boyle as they understood it to the investigation of their universe, performing trials suggested by others, developing queries, and seeking improvements. With luminaries such as Boyle, and with their less well-known correspondents in other like-minded societies, their experimental endeavours to set down 'matters of fact' enabled the survival, pursuit and development of some ideas raised by laboratory investigations of chymical materials, and the dwindling of others.

## CHAPTER 6

### THE TRUE END OF ALL OUR STUDIES

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*This day I found out the solution of the other two Cases of the Triangle  
... O Lord, thy holy name be for ever praised for thus enlightening my  
understanding & discovering to me hidden truths.<sup>1</sup>*

*Man in this life ... must therefore content himself with the Contemplation  
of plain matter of Fact, in which he cannot be deceived.<sup>2</sup>*

For Narcissus Marsh, the ‘true end of all our studies’ was the glory of God, who could enlighten the natural philosopher’s understanding of the ‘hidden truths’ of the universe. For William Molyneux, the contemplation of ‘plain matter of Fact’ was the core of natural philosophy, to be achieved by experiment. This thesis has examined the significance of the activities of the DPS, of which these two men were founder members. It has focussed on Marsh and Molyneux, as witnesses to matters of fact, as a way of setting the DPS in the wider context of the learned world. In this final chapter, I review what has been learned of the activities and culture of the society, setting the findings in the context of the historical and historiographical questions raised in the introduction. There, I argued that the DPS took part in a culture of experimentation, interacting with the learned world in the repetition and testing of their findings, contributing to the dissemination of new knowledge.

The process of intellectual change in which the members of the DPS were engaged had two main cultural contexts: firstly, that of the colonial situation in which they found themselves, which at once prompted them to seek improvement of their lot, gave them something of a sense of isolation, and involved them in the instability of war and flight; secondly, their spiritual context, within the developing attitudes of the established Anglican church to the emerging models of the created world, continually presented with new matters of fact which could inspire worship, or

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<sup>1</sup> Marsh, *Diary*, 28.

<sup>2</sup> Molyneux, *Dioptrica*, preface ‘To the Royal Society’, unnumbered.

doubt, or even atheism, challenging authority of church and state.

The combination of methodologies engaged in this thesis drew its inspiration from the work of Michael Hunter on processes of intellectual change. He sought to retrieve something of the mindset of individual protagonists of the period. Rather than imposing modern views upon the seventeenth-century actors, he described their individual responses to what he termed ‘themes and polarities’ as experienced in historic time. Adopting this approach, this thesis has combined case studies and anecdotes, largely in the language of the actors themselves, with an overview of their network, connections, and topics of interest as captured by a combination of digital tools and close reading.

Narcissus Marsh and William Molyneux, whose activities have received most attention across the thesis, were chosen as generally representative of similar but distinct views of natural philosophy. Marsh provides a link to the less well-known aspects of the study of creation in sacred chronology and biblical studies, while combining this with an interest in insects, a vivid and intelligent interest in comets and their origins, and an active life as a collector of books and manuscripts. Molyneux, as author of a wide range of papers in the *Philosophical Transactions*, and two books related to optics, was also engaged with chymistry and the understanding of matter. As we have seen, both were men of wide correspondence and reading, connected to the wider circle of the curious.

The network of the DPS, as examined in Chapter 2, reveals the spatial distribution of the wider community, the language of their correspondence, and the connections to their reading and engagement with print culture. A key feature of their activities, as seen through a combination of close reading and digital tools, was the exchange of accounts of trials, experiments and observations, which established a series of useful roles for those who found themselves on the periphery. The topics found by the analysis carried out in Chapter 2 influenced the choice of the individual case studies, which are presented under the headings of natural history, cosmology and chymistry in the succeeding chapters.

One of the principal recommendations in William Petty's list of desiderata prepared for the DPS was that the society should seek correspondence with those in similar societies beyond Ireland. What this thesis has demonstrated is the diversity of roles and experimental styles adopted by natural philosophers on the periphery of the Republic of Letters, such as members of the DPS, as seen in their own language and interactions. The nature of their activities varied according to the kind of enquiry in which they were engaged: in the case of natural history, their contributions were broadly descriptive, reporting on local specimens; for observations of astronomical events, reports were broadly collaborative; in the case of laboratory processes, experimenters sought reproducibility, or extension of findings, making occasional excursions to the realms of hypothesis. Within this overall pattern, the individuals making up the DPS pursued particular interests, bringing them to the attention of the society, and acting much as Francis Bacon's imagined Merchants of Light in collecting and exchanging matters of fact.

The sociable development of the DPS, with its 'prequel' in the meeting of what Narcissus Marsh described as a club, was also evident in the correspondence connecting the members with their peers. Every opportunity was taken for Thomas Molyneux, as a student setting off to Leiden in the early 1680s, to make personal contact with figures in the learned world. Here, letters of introduction drew on the personal within the network, in a pattern which bears out Anthony Grafton's description of the 'Lost Continent' of the Republic of Letters, mentioned in Chapter 1. While the DPS met in Dublin, it maintained connections with those in remoter regions of Ireland, seeking local information from them. It was notable that some of the society's informants appeared only by mention in the letters, where their credibility was emphasised. The nature of the networks also showed the close connections between the societies and drew out the roles of the secretaries as information brokers.

It is notable that those topics treated most extensively in the correspondence were also among those that eventually found expression in print, examples being the properties of Lough Neagh waters, or the supposedly venomous Connough worm. Although some sustained threads were not published, a level of sustained interest was evident in the choice of material for print, where correspondence was adapted as a basis for the emerging journals such as the *Philosophical Transactions* or the *Nouvelles de la Republique des Lettres*. Marsh and Molyneux, on the Anglican periphery in Ireland, and Edward Stillingfleet, influential in the Anglican response to new findings, shared an engagement with philosophical concepts disseminated in print, as seen through collection and citation. These shared interests and concerns tied periphery and centre.

The desire for improvement, particularly important in the colonial context, inspired enquiries into natural history of particular organisms. These were often found to include other local details, such as the ‘superstitious’ beliefs of the ‘native Irish’ concerning the origin of the swarms of beetles described by Thomas Molyneux, or the account of the Connough worm, which included a comparison of the English and Irish remedies against its reportedly poisonous qualities. Anecdotal collection of reports of strange cases in physick, unusual fauna and flora, and the ‘new and rare’ were transmitted with added commentary which included notes of the locality, and the antecedents of the people involved. These details served to add credibility but also emphasised similarities and differences between the Irish and English conditions, the Irish drawing adjectives such as ‘barbarous’, ‘poor’, and ‘superstitious’.

This thesis sought an explanation of the apparently excessive interest in the unusual which Hoppen had noted as a feature of the activities of the DPS.<sup>3</sup> Attention to the underlying discussions in the learned world demonstrated that the DPS was engaged in purposeful extension of queries which held implications for the study of the nature of creation. Among the local reports and specimens collected were

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<sup>3</sup> *DPS Papers*, Introduction, xxx.

'curious discoveries in earths, formed stones and minerals' as well as a number of instances of conjoined twins. Rather than simply demonstrating a prurient interest in the unusual, these apparently disparate specimens were connected through the ongoing questions as to the nature of matter and development. Processes of a similar nature in the generation of stony creatures as of living ones might plausibly be invoked, and the vitalist questions raised by Robert Plot's proposals for the production of fossils were linked to the formation of embryos, or the development of insects, which passed through several distinct embodiments before achieving their adult form. The governance of these forms raised questions which were related to the sources of forms and qualities in general. Similarly, chymical investigation of the petrifying waters of Lough Neagh was not undertaken merely on foot of interest in the unusual but was linked to the same set of underlying queries, which in turn extended to an interest in the behaviour of salts and solutes, and the generation of form in crystals. Stones within the body, while medically important, also raised question as to their chymical natures and were referred for laboratory investigation.

A further indication of the underlying implications of a repeated cluster of experiments was the demonstration of the circulation of the blood. As with the depreciation of spontaneous generation, which was reaching a general acceptance by the 1680s, the mechanism of the circulation of the blood was still a subject of debate (as seen in the attitude of Charles Allen in his *Operator for the Teeth*) when William Molyneux carried it out twice for the DPS. Demonstration 'ad oculum' was not enough to convince all, thus repetition was necessary to 'take off the heats of wanton Phansie' through witnessed matters of fact.<sup>4</sup> Molyneux was scathing about the ignorance of the Irish physicians, who would not accept his interpretation of what they had witnessed. Circulation powered by the heart's beating was incommensurable, in Kuhnian terms, with the Cartesian concept of fermentation in the blood being the cause of the motion, or with the older Galenic interpretation. Although the concept was resisted by some of the observers, such repeated

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<sup>4</sup> Joseph Glanvill, *Plus Ultra*, 89.

demonstrations of the operation of the heart served to spread conviction, ensuring the dissemination of locally witnessed matters of fact.

Experimental production of matters of fact found its fullest and most controllable expression in the laboratory. It was here that *materia medica* could be made, and here that their effects could be examined both *in vitro* and *in vivo*. Control over the universe was not in man's hands, and although the growth of a crop might be improved, or observations of an astronomical event might be carried out in different localities to observe similarities and differences, the opportunity to see small parts of a relatively controlled process was available only in the microcosm of the laboratory. This thesis has shown, by a return to the language and reports of the DPS themselves, and those who influenced them, such as Robert Boyle, that their 'endless and seemingly aimless' trials were purposeful and generated results of interest to their network. Successful experiments were communicated, and further trials requested through correspondence, sometimes inviting engagement with printed interpretations.

Unsuccessful experiments were also capable of revealing information, and corrections were communicated, as in the case of William Molyneux's trials of the magnetic qualities of Lough Neagh stone. Here again, the Baconian claims of the societies were vindicated in the distribution of roles, which extended to that of interpretation. In Bacon's imagined Salomon's House, the last stage of the philosophical process was assigned to those who

raise the former Discoveries by Experiments, into Greater Observations, Axiomes, and Ap[h]orismes. These we call Interpreters of Nature.<sup>5</sup>

The evidence presented in this thesis suggests that the DPS eschewed explicit consideration of possible concepts or mechanisms underlying their observations, which may (intentionally or otherwise) reflect such a division of roles. For example, the matters of fact reported in the case of cold (later repeated by St George Ashe)

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<sup>5</sup> Francis Bacon, *New Atlantis* (London, 1627), 32–3.

had been referred to ‘an Honourable person of this Society, who hath had much experience and reflections on this subject’.<sup>6</sup> An exception appeared in the case of the Molyneux brothers’ writings concerning the behaviour of solutes in menstrua, where their experiments and conceptualisation enhance our current understanding of the early modern apprehension of the interaction of particles (however those came to be defined).<sup>7</sup> The mechanistic interpretations discussed by the brothers were taken up by Pierre Bayle in his publication in the *Nouvelles*, with a comment that the results might stimulate others to consideration of the topics raised. As also noted in the case of Robert Boyle, publication could serve to encourage the repetition of experiments already carried out, and also to suggest those which had not yet been tried, as recommended to the DPS in the case of trials on blood.

In each facet of observation examined in this thesis, whether in laboratory, library or observatory, or in collection of specimens or anecdotes, a general pattern of testing sought to build on reproducible results, drawing together tested and attested matters of fact, with occasional excursions to hypothesis and prediction. Underlying and supporting all these processes, the network of individuals discussed, communicated and reacted to their newly made knowledge, disseminating their various levels of conviction.

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<sup>6</sup> See Chapter 5, 203.

<sup>7</sup> See Chapter 5, 207-8.

*I might excite all that hear me, to bend their thoughts towards the making of Experiments for the compleating this (yet very imperfect, though noble) Science.<sup>8</sup>*

*On such subjects as these I spent some of my thoughts, neither do I reckon them misspent, as far as they tend to illustrate the creation, and set forth the infinite power of the creator; as also to increase the conveniences of human life, and render our passage in this world more easy towards a better, for these are the great ends that all philosophical inquiries should tend to.<sup>9</sup>*

In seeking to place the community of natural philosophers in early modern Ireland in their conceptual context, I have described their practice in areas of natural history, cosmology and laboratory studies. The great ends of natural philosophy included the contemplation of the mechanical and corpuscular proposals for the structure of matter, and the understanding of the creator's action in the world. Lesser, more immediate ends, such as understanding the classification of a caterpillar, the nature of a particular stone or the extraction of an oil were the daily business of natural philosophy for the curious of early modern Ireland, and for their peers further afield.

The great ends were not neglected, however. We found William Petty, amidst his improvements, intending 'to improve and apply little small threds of Mathematicks to vast uses; and yet not to neglect, the finest Consideration, even of Atoms, where the same is necessary'.<sup>10</sup> Later, it was the Molyneux brothers who made excursions to more theoretical realms. Besides their work on the bodies in menstrua, William Molyneux's references to final causes, and the Leiden-educated Thomas Molyneux's comments on the political context of 'Chartisian' attitudes to chymical

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<sup>8</sup> Marsh, 'An Introductory Essay towards the Doctrine of Sounds', 486.

<sup>9</sup> Molyneux, *Life*, 67.

<sup>10</sup> Petty, *Duplicate Proportion*, preface.

investigations, both serve to indicate an awareness of the conceptual context.

A pattern of linkage between great and lesser ends of study recurred in the inquiries of the community of natural philosophers, both in Ireland and elsewhere. Samuel Foley may have provided a meeting with a ‘diversion’ by way of the anatomy of a large garden bean, as discussed in Chapter 3, but the investigation of the bean’s anatomy stimulated Foley to review Nehemiah Grew’s account of the same material, with the result that Foley considered Grew to be in error. The accumulation of such lesser matters of fact invited the consideration of greater matters, such as the connection between continents in prehistorical eras inferred by Thomas Molyneux from a broad view of his study of the giant deer and the linked study of plants occurring in Ireland and America, or, as referred to earlier, the issues of matter and motion arising from the study of bodies in menstrua by the Molyneux brothers.

Differing approaches were brought to bear by members with different backgrounds. It is evident from the proceedings of the DPS that the active physicians within the society carried out medically-based enquiry, accumulating case studies of disease and remedy, reflecting practice which was much older than Bacon’s system, and which informed many investigations into living things and their nature, and the underlying substances and processes which sustained vital forces. Similarly, the active clergy interested themselves in the pursuit of concepts and texts as well as ‘real-world’ trials and observations. For the theologically aware, the implications of the local collection of astronomical records, taken in conjunction with the implications of the chronologies with which astronomy was in dialogue, might invite greater conclusions, proposals, or debates. The results and conclusions of each class of investigation invited further thought, and further enquiry in turn.

In the case studies described in this thesis, a rather different view of the role of the witness, or the circle of witness, engages the discussion surrounding Shapin and Schaffer’s original proposals in *Leviathan and the Air Pump*, and the simpler role

as demonstrated by Principe in *Aspiring Adept*.<sup>11</sup> It was not necessary to invent a literary technology to engage virtual witnesses, as was claimed for Boyle, although he certainly engaged the existing technology of print. We have seen that patterns of repetition and extension of trials were common to all the societies, who designated individual members to investigate particular processes and to report back, and frequently met a report with a further query and a suggestion of further trials. The allocation of trials usually fell to those members of the societies with a demonstrated expertise: for example, as we have seen, chymical trials were assigned to Allan Mullen in the case of the DPS, and similarly to Frederick Slare and Denis Papin in the Royal Society. Some tasks demanded the physicians' iatrocymical and anatomical experience, although it was still possible for others without specific training, such as William Molyneux, to undertake laboratory investigations. Witnessing became a collective, if distributed, activity, in which matters of fact could be attested to as reliable. Even in this, an echo is found of the activities in Salomon's house, in which specific 'Inoculators' were directed to carry out experiments, and report on them to the whole body.<sup>12</sup>

The intellectual environment in which a culture of collective witness could emerge was one which allowed for an individual interpretation of text or experiment, without the dictates of a magisterium, in an atmosphere of relative intellectual freedom. One of the generalising hypotheses of the origins of the Scientific Revolution was Robert Merton's much-cited study which sought to emphasise the relationship between Puritanism and the emergence of the Royal Society's form of experimentalism in England.<sup>13</sup> This has since been extended by others who claimed that the relative intellectual freedom of some facets of Anglicanism provided a particularly suitable intellectual environment for these developments. Such narratives have been questioned more recently by Dmitri Levitin, who has re-

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<sup>11</sup> See *Aspiring Adept*, 32.

<sup>12</sup> Bacon, *New Atlantis*, 32–3.

<sup>13</sup> See discussion of the Merton thesis in H.F. Kearney, 'Merton revisited', *Science Studies* 3:1 (1973), 72–8; Charles Webster, *The Great Instauration: Science, Medicine and Reform 1626–1660* (London, 1975); I. Bernard Cohen, K. E. Duffin, and Stuart Strickland, *Puritanism and the Rise of Modern Science: The Merton Thesis*, (New Brunswick NJ, 1990); Stephen Shapin, 'Understanding the Merton thesis', *Isis* 79:4 (1988), 594–605.

evaluated and largely rejected the underlying linked concepts of ‘an English “early enlightenment”’ which commenced with Richard Hooker and was ‘anchored to ‘liberal’, whig divinity’.<sup>14</sup> The case of Marsh provides a counterpoint to such a narrative, illustrating in an individual a connection between a free, if cautious, enquiry into nature, and a relatively conservative view of the established order in church and state. His rejection of Toland’s destabilising churchmanship co-existed with his enquiry into biblical truths and the operation of nature in the form of comet or caterpillar. Marsh’s ‘true end’ of study appears to fit happily into a picture of ordered investigation by someone who saw the enhancement of his understanding as a God-given opportunity and a worthy use of time. Marsh’s approach was shared by others in his circle, with similar ideas to be found in the writings of William Molyneux, William Petty and William King, all members of the Anglican ruling class in Ireland. The members of the DPS adopted a balanced world-view as advocated by Boyle and Stillingfleet, to take but two of those who exercised influence both in the wider learned world, and within the Anglican confessional community. On a practical level, reassurance for the fearful Anglicans in Ireland was to be found in the philosophical basis for Edward Wetenhall’s firm and somewhat scornful rejection of the ominous prognostications of the ‘heroick poets’ in relation to the appearance of a comet.

The wider community was also drawn into an acceptance of new concepts by publication and by preaching. Not only did prominent churchmen such as Stillingfleet engage with the major concerns raised by Descartes and Newton, the scrupulous Boyle endowed sermons to be preached in the established church explaining the compatibility of the new patterns of thought with Christianity and, possibly as importantly, with the establishment of the state, not merely with its Church.<sup>15</sup> Sarah Hutton has noted that it may well be unnecessary to look to outward political polemic rather than internal attitudes to Providence for the

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<sup>14</sup> Levitin, *Ancient Wisdom*, 13.

<sup>15</sup> Hunter, *Science and the Shape of Orthodoxy*, 228.

adoption of Newtonianism in Anglican apologetics.<sup>16</sup> The political forces she and others have discussed, however, may indeed be internal to the church, given the identification of the established church with the state and vice versa, which even for Stillingfleet (commonly classed as a ‘Latitudinarian’) integrated the spiritual authority of Providence with the political authority of Monarchy.

The mutual influences of the Republic of Letters make proposals of the development of ideas in splendid Anglocentric isolation untenable, although the hero-myth of Newton was later embraced enthusiastically in France.<sup>17</sup> Parallel experimentalist developments, as well as major and *connected* publications, were emerging in continental Europe as well as in the motherland of Newton. Although not occupying the central position envisaged by Jacob and Jacob, Anglicanism has more recently been invoked as a cultural lens through which to examine the natural philosophy of Marsh and his circle of ‘establishment’ figures on the unstable fringe of the British colonial enterprise. Michael Brown, writing on the nature of the Irish Enlightenment, asserted that that attitudes towards the Enlightenment were shaped by the political positions of the confessional communities in early modern Ireland, and that a perception of supremacy on behalf of the Anglican communion influenced the empirical attitude of their philosophy. In assessing the Anglican community’s contribution to Enlightenment in Ireland, Brown’s views derived largely from a reading of rather later sources. He stressed a contrast between Swift’s ‘Scholastic’ views and a group of ‘clerics who made use of rationalist methods’, of whom George Berkeley is advanced as an example. The strong links between the Anglican establishment in Ireland and the peri-Enlightenment natural philosophers tend to support a connection, if not a causal connection. The links between Molyneux and Locke, and Marsh’s studies of chronology, take on a deeper potential in this context, and colour the possible interpretations of the activities of natural

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<sup>16</sup> Sarah Hutton, ‘Science, philosophy and atheism: Edward Stillingfleet’s defence of religion’, in Richard Popkin and Arie Vanderjagt, eds, *Scepticism and irreligion in the seventeenth and eighteenth centuries* (Leiden, 1993), 118, fn. 44.

<sup>17</sup> ‘Newton, à qui la route avait été préparée par Huyghens, parut enfin, et donna à la philosophie une forme qu’elle semble devoir conserver.’ Quotation from Jean Le Rond d’Alembert, *Discours préliminaire de l’encyclopédie* (Paris, 1894), 100. The first version of this work appeared in 1753.

philosophers in early modern Ireland, suggesting a potential avenue for further work.

It must be noted here that Enlightenment as a category has been debated as fiercely as the Scientific Revolution as a category. A recent account by Daniel Edelstein of what he terms the genealogy of the Enlightenment(s) argued that the Enlightenment is itself a series of constructs. In much the same way, the New Philosophy was something of a rhetorical device; the Scientific Revolution acquired its capitals; and the various labels beloved of much historiography (Cambridge Platonists, Latitudinarians) emerged and are now being questioned in their turn.<sup>18</sup>

It is arguable (as H.F. Cohen points out) that the ingredients in what he termed the 'Baconian brew' had a liberal dash of French intellectual yeast, imported to England by returning Royalists.<sup>19</sup> In an interesting glimpse of personal routes of communication of ideas, he gives as an example the Paris circle of the Cavendishes, whose household included both William Petty, afterwards active in the DPS, and Thomas Hobbes. The controversialist attitudes of Hobbes, whose vision of political authority was thoroughly integrated with his attitudes to knowledge and the establishment of 'fact', stood in opposition to the Royal Society's overt programme of progress through consensus. It is this aspect of his philosophy which was brought to bear on his refutation of Boyle's conclusions arising from experiments with the air-pump.

Far from being repeated by the 'gentlemanly' witnesses of the idealised process described by Shapin and Schaffer, where knowledge was made in a public sphere, or published having been repeated, or published in a repeatable way, Schuster and Taylor claimed that results were actively controlled by the Royal Society, who kept the less knowledgeable entertained but ignorant, and ensured that experiments were published only after testing by the society itself.<sup>20</sup> Although their claims were

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<sup>18</sup> Dan Edelstein, *The Enlightenment: A Genealogy* (Chicago, 2010).

<sup>19</sup> Cohen, *Modern Science*, 550.

<sup>20</sup> John A. Schuster and Alan B.H. Taylor, 'Blind Trust: The Gentlemanly Origins of Experimental Science', *Social Studies of Science* 27 (1997), 503–36. Anna Marie Roos, commenting on Shapin and

supported by the case studies they chose, it would appear from the present study that within the circle of the Royal Society and its network of knowledge exchange, the presentation of socially-engineered *faits accomplis* was not the case. The members of the DPS routinely repeated the repeatable, often at a remove of several decades, as in the case (for example) of experiments on the effects of cold and freezing. They were also capable (as members of the Royal Society were) of admitting errors and failures in repetition of their own experiments and investigations (an example is William Molyneux's testing of the magnetic properties of Lough Neagh stone). Within the Royal Society minutes themselves, there is ample evidence of requests for repetition and extension of findings, and while these proceedings took place within the meetings of the societies, so arguably in a less public sphere, the community was able to evaluate and discuss the results. The conviction of the witnesses 'ad oculum' was also not a given, hence Molyneux's repeated demonstration of blood circulation in the newt.

A further contrast between Schuster's view and the findings of this thesis is seen in the response of the DPS to Robert Boyle's publication of experiments with which he was not entirely satisfied. As discussed by Knight and Hunter, Boyle's intentions in circulating his 'heads and queries' was to provoke others to perform and to extend them. This stimulation of further trials could take place, as in the case of Allen Mullen of the DPS, by personal contact, as well as being more generally made available in print. Boyle's request for a process of repetition, as well as the ancillary processes of extension and correction, would appear to have found a ready implementation at hands of such experimenters in the DPS and other societies of the curious.

As to caution in inquiry, although the DPS was thought to have an excessive eye to

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Schaffer's work, stated that 'Boyle's development of the experimental enterprise was consciously designed to give its practitioners political and religious legitimacy and hegemony in the Restoration ... the detailed and modest presentation of matters of fact was originally in fact part of an ideological program.' Anna Marie Roos. Review of Shapin, Steven; Schaffer, Simon, *Leviathan and the Air Pump: Hobbes, Boyle and the Experimental Life, Including a Translation of Thomas Hobbes, Dialogus Physicus De Natura Aeris*. H-Ideas, H-Net Reviews (2000) <http://www.h-net.org/reviews/showrev.php?id=3996>, accessed 06.09.2018.

the bizarre in the evaluation of some topics, there is evidence that not every report or idea presented to them was accepted in its entirety. Many were referred for further investigation, an example being the ‘impertinent’ proposal of William Hearne concerning longitude and latitude which was passed to the society’s mathematician, George Tollet, for an answer. This was provided complete with a comprehensive list of citations from printed sources, which was explicitly invoked to support Tollet’s claims.<sup>21</sup> As seen here, the ‘self-correction’ (in H.F. Cohen’s terms) available within the community operated to test and evaluate propositions from diverse sources. The concept of a cautious curiosity may have informed the interpretation and adoption of the quantities of thought and experiment unleashed upon the intellectual world in the publications of the Royal Society and eagerly consumed, as we have seen, by those who purchased the copies of the *Philosophical Transactions* sent to Dublin. As far as possible, Marsh, Molyneux and their circle were also engaged in retesting and extending the findings disseminated to the learned world, with awareness of what they saw as a God-given opportunity to enlighten their understanding and discover truths hitherto hidden from human knowledge.

#### Epilogue: Witnessing matters of fact

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This thesis has sought to make a contribution to the history of intellectual change. We have seen that by involvement in exchange of observations and experiments, by repetition of earlier experiments, and by critical assessment of concepts promoted in the manuscript and printed communications of the self-proclaimed Republic of Letters, natural philosophers in early modern Ireland joined a circle of witnesses bearing testimony to their reception and production of what they termed ‘matters of fact’. In a sense, this study itself acts as a witness of a collection of the matters of fact thus produced, in much the same way as did the members of the DPS. As the ‘Interpreters of Nature’ did in Salomon’s House, we can attempt to proceed to ‘raise

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<sup>21</sup> The citations on longitude and latitude were referred to as follows: ‘This controversy being about the meaning of a definition, all that can be had or required to determine it is the authorities of the best writers.’ *DPS Papers* no. 295.

the former Discoveries by Experiments, into Greater Observations'.

The greater end, for the purposes of this thesis, is an enhanced understanding in the present day of the processes by which intellectual change occurred. Collation of the minutiae of day-to-day conduct of natural philosophy by the DPS into the present study brought larger influences and patterns to light. Firstly, the role of the local in the collaborative production of matters of fact, as instanced by the natural history and astronomical observations; secondly, in the culture of 'farther queries' and repetition, particularly seen in laboratory studies, and supporting H.F. Cohen's concept of a culture of self-correction; and thirdly, underpinning the whole, the spirit of reasonable enquiry into the works of the creator as shown in the books of nature and of scripture. The further ordering of those small matters of fact by the DPS and its network contributed to the greater ends, those of understanding underlying mechanisms in the functioning of organism and cosmos. The result from this study is, as H.F. Cohen considered in his much larger-scale study, a story of contingent transformations in understanding. Whether this can be said to be revolution, or evolution, is scarcely relevant. It was experienced by the people involved as a series of events, which were connected by threads of concept, not all of which were fully understood or assimilated by all of those individuals at the time. Much the same can be said of the process of science today – even if the 'instantia crucis' supports an interpretation, it is only in the larger scale of application of findings that they can be truly tested, and eventually something breaks, and has to be reconsidered.<sup>22</sup>

This thesis has offered a re-evaluation of the activities and culture of the DPS, and of their interactions with the wider circle of the curious. It has described their correspondence with each other and with the learned world, which, together with their engagement with print, sustained a culture of discussion and experiment, seeking reproducibility and extension of findings. Further, this thesis has shown that the rhetoric of the DPS was borne out in their activities, which demonstrated a

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<sup>22</sup> While this does resemble Kuhnian incommensurability, it is important to realise that conceptual change does not occur all at once, even in the minds of those most prepared to receive it.

level of systematic enquiry hitherto unrecognised. The case studies presented supported the argument that the circle of natural philosophers in early modern Dublin reacted to the concepts and commentary produced by the major figures of the learned world. A degree of mutuality in the exchanges between the Royal Society and its Dublin correspondents was also noted, with requests for further trials and inquiries being made of each society by the other. A similar mutuality existed between the Dublin and Oxford societies. The publication of material from the DPS emphasised the esteem with which the results of investigations by the Irish group were regarded by their London peers. This thesis has also demonstrated the influence of Robert Boyle's concepts of the nature and behaviour of matter and his promotion of systematic experiment, presenting a view of the chymical activities of the society which reveals an engagement with these concepts in such a way as to appropriate and develop them. A revised historiography of the importance of the DPS and their community in exchange, acceptance and dissemination of such concepts is a major outcome of this study, writing them back into history as significant contributors to the processes of intellectual change; as demonstrably systematic in enquiry; as involved in information exchange in specific ways arising from their context; and as making contributions which were valued by the wider philosophical community.

Through discussion of the debates on the nature of the created universe in which members of the DPS engaged, as well as detailed attention to individual mindsets, the thesis has offered a more rounded narrative of the processes of intellectual change. The roles and motivations of the members of the DPS were found to spring partly from their formation, location and political context, but importantly, were also shown to be rooted in confessional piety and the desire for understanding of the hidden truths of creation. Rejecting speculation and embracing matters of fact, Marsh, Molyneux and their fellow members of the DPS became a part of a process of collective witness to the reliability of findings in natural history, cosmology and chymistry, taking part in the process of intellectual change in their time.

## APPENDIX: TOOLS AND UTILITIES

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This thesis approached the texts and metadata associated with the DPS and its circle with a variety of digital tools, some derived from social network analysis and some from linguistic analysis. The intention was to explore connectedness of individuals and communities in time and space, and to attempt an approach to distant reading of the topics which engaged them. Scott Weingart's view on the application of digital humanities tools as useful in 'generative direction finding', was a helpful guide. This is more particularly the case when, as in this material examined in this thesis, the scale of the data is small and can be encompassed by close reading. Application of textual tools, such as those afforded by Voyant Tools and SketchEngine, enabled a return to the texts of the DPS with an altered set of perceptions.

As mentioned in the acknowledgements and in Chapter 2, the core text used was that of the DPS papers, which was supplied in both PDF and HTML formats by the generosity of the editor and publisher, and the kind offices of the Administrator of the Irish Manuscripts Commission, Cathy Hayes.

### **Access**

Microsoft, Database Software and Applications. <https://products.office.com/en-us/access>. Accessed 20 September 2018.

As a database to store and manipulate data, I used the relational database Access which is part of Microsoft Office 365 Premium. SQL queries were used to select and transform data for use in the other tools. I also designed a form to simplify and validate data entry for letters. The EMLO format for person records was used to simplify matching between datasets.

## Gephi

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Bastian M., Heymann S., Jacomy M. (2009). Gephi: an open source software for exploring and manipulating networks. International AAAI Conference on Weblogs and Social Media. <https://gephi.org>. Accessed 18 September 2018.

Gephi is a visualisation tool for networks which can also perform calculations of various properties arising from the structural properties of the network. It can accept input in the form of a spreadsheet of connections ('edges') and either infer the connected items ('nodes') from the edge list, or read them from a second, related table. For the purposes of this study, I exported tables of letters with senders and receivers (a directed network) and allowed the software to detect the nodes. Betweenness centrality was calculated within the software.

Gephi has been described as Photoshop for graphs, and allows manipulation of the appearance of the visualisation. I used the Fruchterman-Reingold layout algorithm, with parameters adjusted for optimal perception of the data. The resulting graphics (Chapter 2, Figures 3 and 4) display the betweenness centrality properties of the networks, but due to the incompleteness of the data should be considered as indicative rather than quantitative.

## MALLET

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McCallum, Andrew Kachites. MALLET: A Machine Learning for Language Toolkit.  
<http://mallet.cs.umass.edu>. Accessed 21 October 2016.

The topic modelling tool MALLET relies on the Latent Dirichlet Allocation algorithm, as described by David Blei and his colleagues.<sup>23</sup> MALLET was used as a tool which could approach the mapping of topic to file, and was combined with the previously used Access database to handle the mapping of people and timeline to file; and with Palladio for visualisation. MALLET was run from the command line,

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<sup>23</sup> David M. Blei, Andrew Y. Ng, and Michael I. Jordan, 'Latent Dirichlet Allocation', *Journal of Machine Learning Research* 3 (2003), 993–1022.

with the corpus split into numbered letter files rather than chunked in any other way. The aim of this was to preserve the association between the letter form, with its associated dates and correspondents, and the topics found. A stop list to exclude the common ‘dictaminals’ associated with the nature of the text as a correspondence corpus was derived from the processes applied in Voyant Tools. The ‘topics’ generated by this tools are lists of words which occur in statistical relationship to one another. For the purposes of visualisation, these were given meaningful labels, so although the purpose in subjecting the texts to this type of procedure was to remove the reader from the text, this was only partially possible.

The experiment proved useful in generating directions for further close reading. Although beyond the scope of this thesis, a detailed approach using Natural Language Processing and Named Entity Recognition tools, and the application of automatically derived ontologies and vocabularies may prove useful in future as one approach to the tracing of topic discussion in early modern philosophical texts.

### **Palladio**

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Stanford | HUMANITIES + DESIGN lab. <http://hdlab.stanford.edu/palladio>. Accessed 17 July 2018.

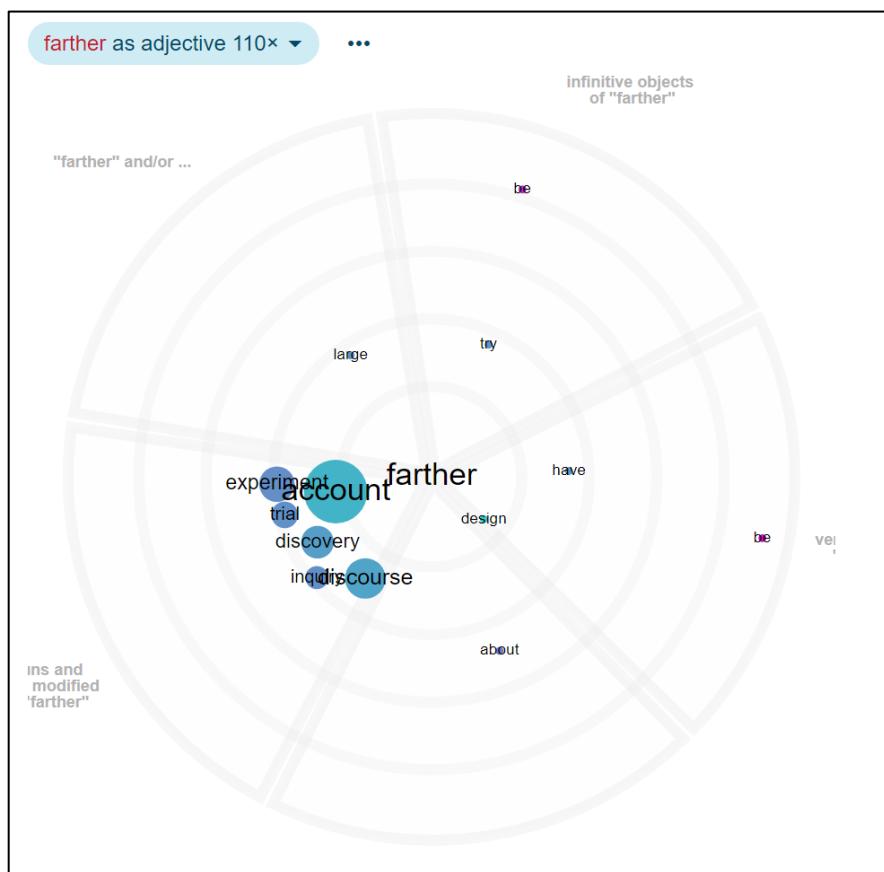
Palladio was derived from visualisation tools designed for the Stanford project ‘Mapping the Republic of Letters’. Data is uploaded as tables or in CommaSeparatedVariable format: tables are joined through simple relationships. In the case of correspondence networks presented, tables of letters were related to tables of people, places (with geolocation parameters) and topics, with human-generated labels.

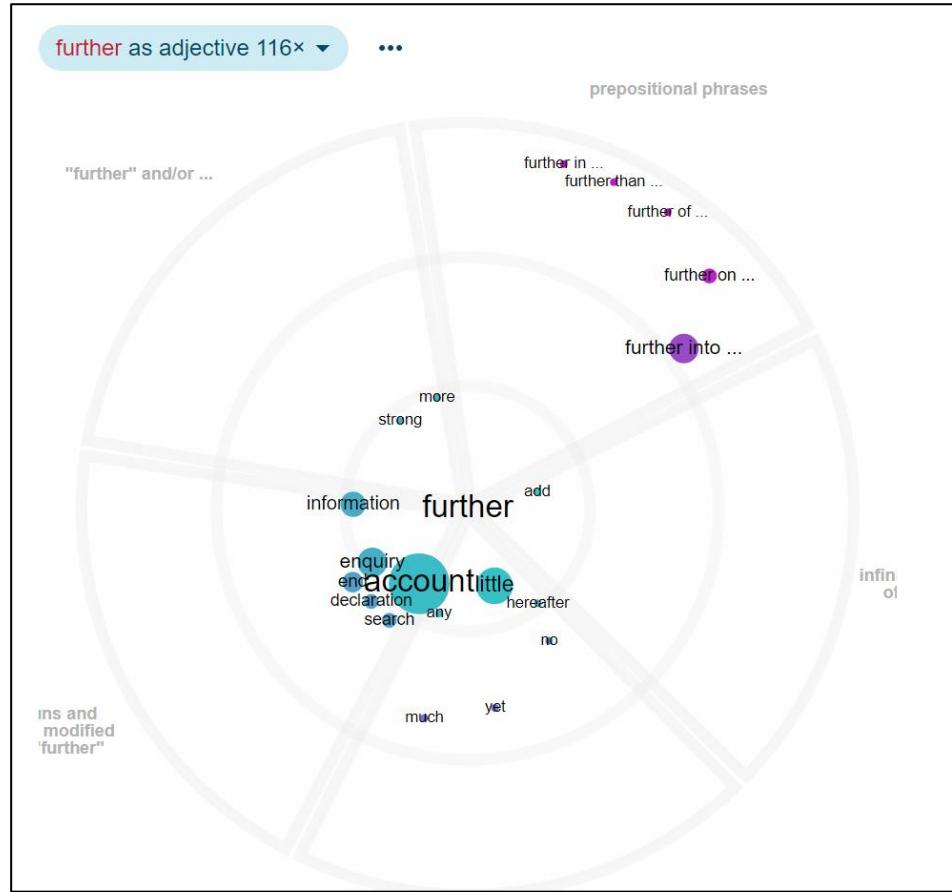
The tool can generate timeline and geographical representations of the data ingested, together with indications of the number of items and the pairing of links. Unlike Gephi, the tool does not have options for manipulation of the visualisation, and makes limited use of colour. However, for the purposes of this study, it allowed the generation of indicative visualisations.

<https://www.sketchengine.eu> Accessed 18 September 2018.

Sketch Engine describes itself as 'the ultimate tool to explore how language works'. It allows the uploading and processing online of user corpora, and applies corpus linguistics algorithms to detect the behaviour and environment of words within texts. The outputs can be tabular or visual, and both were applied in this study to explore the context of words surrounding the concept of experiment, trial or query.

For the purposes of this thesis, this tool, which combines concordance and listing into 'word sketches' gave another set of views of the texts. The most significant to emerge was that which suggested the concept of extension of enquiry as a possible avenue for exploration. Visual tools are included in Sketch Engine: the output below show the word associations of 'further' and 'farther' in the corpora explored.





DPS corpus

## Voyant Tools

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Stéfan Sinclair and Geoffrey Rockwell. <https://voyant-tools.org/>. Accessed 18 September 2018.

Voyant Tools is a highly developed suite of online tools developed by Stéfan Sinclair and Geoffrey Rockwell to provide text analysis and distant reading of corpora online. Although the Cirrus word-cloud tool began the exploration of the DPS texts, I also used the keyword-in-context tools and word frequencies to explore the texts and link to close reading. The interactivity offered by this suite is not easily captured by description but affords the type of 'generative direction finding' advocated by Scott Weingart in exploration of texts as 'bags of words'.

## Experimental tools

In exploring the texts, I also experimented with other tools, the results of which have been excluded from the main body of the study, either because they proved difficult to capture, or demanding to customise, or because their functions were duplicated by aspects of the tools described more fully above. I mention two here, as being of particular interest for potential further work.

I explore the use of TexTexture, which enabled the visualisation of any text as a network. This tool, which was developed by Nodus Labs, has now been superseded by Infranodus within their suite of tools. The developers

believe that various interfaces (software, visuals, and – especially – human body) offer a much more versatile way to communicate ideas than what we currently know. Our intent is to learn to evolve and to evolve the learning.<sup>24</sup>

Moving a little beyond the word cloud, the ICTA tool is embedded in the Netlytic suite, which is designed to analyse email corpora, with a particular facility for named entity recognition. Although it is possible to visualise word frequencies and associations, and to move from those to the texts themselves, this tool would require customisation to be more than suggestive. The same suite generated a network map of the active individuals in the correspondence and the names mentioned in their letters, which could also be an avenue worth pursuing to generate co-citation records from larger corpora.<sup>25</sup>

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<sup>24</sup> <https://noduslabs.com/>, accessed March 2019.

<sup>25</sup> <https://netlytic.org/> accessed March 2019.

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MS Eng. Letters c 28: Narcissus Marsh to Henry Dodwell (1 letter)

MS Eng. Letters c 29 St George Ashe to Henry Dodwell (32 letters); to Thomas Weaver (1 letter)

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MS Smith 16 Narcissus Marsh to Edward Bernard (1 letter)

MS Smith 45: Narcissus Marsh to Edward Bernard (8 letters)

MS Smith 52: Narcissus Marsh to Thomas Smith (39 letters)

MS Smith 54: John Wallis to Thomas Smith (1 letter)

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Marginalia in Toland, *Christianity not mysterious* (F3.5.13)

Marginalia in Keill, *A reflection on... the histories of the earth* (J3.4.9)

Marginalia in Newton, John, *Trigonometria Britanica or, the doctrine of triangles, in two books* (N3.2.7)

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Notes about loadstones headed 'History of the Royall Society' with references to page numbers matching Sprat, *History of the Royal Society* (1p.)

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