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Robert Boyle and the early Royal Society: a reciprocal exchange in the making of Baconian science

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Abstract. This paper documents an important development in Robert Boyle's natural-philosophical method – his use from the 1660s onwards of 'heads' and 'inquiries' as a means of organizing his data, setting himself an agenda when studying a subject and soliciting information from others. Boyle acknowledged that he derived this approach from Francis Bacon, but he had not previously used it in his work, and the reason why it came to the fore when it did is not apparent from his printed and manuscript corpus. It is necessary to look beyond Boyle to his milieu for the cause, in this case to the influence on him of the Royal Society. Whereas the Royal Society in its early years is often seen as putting into practice a programme pioneered by Boyle, this crucial methodological change on his part seems rather to have been stimulated by the society's early concern for systematic data-collecting. In this connection, it is here shown that a key text, Boyle's influential 'General Heads for a *Natural History of a Country*, Great or small', published in *Philosophical Transactions* in 1666, represents more of a shared initiative between him and the society than has hitherto been appreciated.

Ever since Robert Boyle's own time, his close relationship with the Royal Society has been a commonplace. His name appears almost at the head of the list of the twelve men who inaugurated the society on 28 November 1660, second only to that of William, Viscount Brouncker, who was to become the society's first president. Equally important was Boyle's air-pump, the crucial piece of equipment which he had divulged earlier that year in his *New Experiments Physico-Mechanicall, Touching the Spring of the Air, and its Effects (Made for the most part, in a New Pneumatical Engine)*, and which became a kind of emblem of the society and its scientific programme in its formative period. Boyle presented a pump to the society in May 1661, and thereafter the demonstration and

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vindication of the findings of the 'pneumatical engine' became central to the society's early corporate life; as if symbolically, the modified version of the original device is depicted in the celebrated frontispiece to Thomas Sprat's promotional *History of the Royal Society* of 1667.[1]

Equally important was the way in which Boyle, more than anyone else, became the hero of the society's early protagonists. The *Philosophical Transactions* inaugurated by the first secretary, Henry Oldenburg, are ceaselessly complimentary about Boyle, invariably there described in such formulae as 'that Noble Searcher of Nature'; Oldenburg devoted much space to flattering reviews of each of Boyle's books as they appeared, as well as to articles by him.[2] As Boyle's protégé, Oldenburg had an obvious interest in this, but the result of his efforts was undoubtedly to publicize Boyle as the principal exemplar of the society's experimental policy. Boyle's iconic status for the society in its early years arguably reached its climax in Joseph Glanvill's *Plus Ultra* (1668), another work which had a major influence whatever its ulterior motives. In defending the Royal Society against its critics, Glanvill devoted nearly two whole chapters to the work of the '*Illustrious* Mr. *BOYLE*' as a means of illustrating the society's achievement

> by a Single Instance in one of its Members, who alone hath done enough to oblige all Mankind, and to erect an *eternal Monument* to his *Memory*. So that had this great Person lived in those days, when men *Godded* their *Benefactors*, he could not have miss'd one of the first places among their *deified Mortals*.[3]

This view of Boyle as the exemplar, and in many ways the inspiration, of the society's early activity has been echoed in recent scholarship, in which Boyle continues to occupy an almost emblematic role not dissimilar to that which he held for Oldenburg and Glanvill. In Paolo Rossi's *The Birth of Modern Science*, for instance, Boyle appears as 'one of the most influential members of the new institution', who was 'especially active' in its work, while a view of Boyle as the virtual archetype of the society is to be found in Steven Shapin's *A Social History of Truth*, in which we learn that Sprat's *History* 'was, in large part, the validation of pictures of the experimental philosopher and experimental social practices developed earlier by Robert Boyle'.[4]

Yet, considering the importance of Boyle for the Royal Society that such evaluations imply, it is perhaps slightly surprising to find that his links with the body were less continuous, and that he actually did less for it, than might have been expected. Thus, although Boyle acted as titular 'president' on one occasion before the society's

1 T. Birch, *The History of the Royal Society*, 4 vols., London, 1756–7, i, 3, 23 and *passim*; T. Sprat, *The History of the Royal Society of London, 1667* (ed. J. I. Cope and H. W. Jones), London, 1959, frontispiece; and S. Shapin and S. Schaffer, *Leviathan and the Air-Pump: Hobbes, Boyle and the Experimental Life*, Princeton, 1985.

2 *Philosophical Transactions* (1666), **1**, 153 and *passim*.

3 J. Glanvill, *Plus Ultra*, London, 1668, 92–3 and Chapters 13–14 *passim*. For Glanvill's ulterior motives see N. H. Steneck, '"The Ballad of Robert Crosse and Joseph Glanvill" and the background to *Plus Ultra*', *BHJS* (1981), **14**, 59–74.

4 P. Rossi, *The Birth of Modern Science*, English translation, Oxford, 2001, 199–200. S. Shapin, *A Social History of Truth*, Chicago, 1994, 185. See also ibid., 129, 143 and Chapter 4 *passim*, and Shapin and Schaffer, op. cit. (1), 78 and Chapter 2 *passim*.

incorporation in 1662, he thereafter failed ever to hold high office in the society, the most striking episode from this point of view occurring in 1680, when he was actually elected president but declined to serve.[5] Equally noteworthy is the fact that, in contrast to those stalwarts who regularly attended the meetings of the society through thick and thin, Boyle was distinctly haphazard in his attendance. This owed something to his peripatetic lifestyle for much of the 1660s, which meant that he was often out of London, but it is nevertheless significant, and if anything his attendance became more, rather than less, erratic after he domiciled himself more permanently in the capital in 1668. If one studies the Royal Society's minutes, Boyle repeatedly disappears for lengthy periods. Thus he vanishes from September 1661 to March 1662 and from October to December 1662. He was absent again from May to August 1663, from August 1664 for the remainder of the year and then again from May 1665 to April 1666 (though in this case the society itself intermitted its activity for part of this time because of the Great Plague). Further gaps occurred from July 1667 to April 1668, from August 1668 to January 1669 and from July 1669 to March 1670 – despite the fact that in 1668 Boyle moved into Lady Ranelagh's house in Pall Mall.[6] Then, in June 1670, Boyle had a stroke, and after this he attended less frequently, with a dozen or so appearances recorded between 1671 and 1674. Thereafter, he is only once recorded as being present, on 8 December 1680, during the debacle over his election to the presidency.[7]

If all members had been as erratic in their attendance, the society could hardly have survived. Moreover, though Boyle is frequently recorded as speaking at meetings at which he was present, drawing attention to topics which he thought might interest the society or reporting on the progress of his experimental work, he often seems to have been pursuing an agenda of his own which did not necessarily overlap with that of the society. It is revealing that on one occasion when he was requested to 'give the society his thoughts' on the subject of fire, flame and heat, his response was 'that four or five years before he had made the consideration of this subject a part of his business, but did not know, whether his present studies of other matters would give him leave to review what he had then written'.[8] Overall, we are left with what might seem a distinctly one-sided relationship.

If this is the state of affairs from the point of view of the Royal Society, however, it is worth considering the matter more carefully from the point of view of Boyle. Was it simply a case of the Royal Society being the grateful and essentially passive recipient of

5 Birch, op. cit. (1), i, 87; iv, 58. For a discussion of the latter episode see M. Hunter, *Robert Boyle (1627–91): Scrupulosity and Science*, Woodbridge, 2000, 64–8.

6 For the principal gaps see Birch, op. cit. (1), i, 45–77, 115–67, 248–93, 455–511; ii, 50–83, 184–273, 312–40, 392–427.

7 Birch, op. cit. (1), ii, 500–1; iii, 21, 48, 50–1, 61, 63, 73–4, 76, 84, 88–9, 91–2, 114, 115–16, 131–2; iv, 60. For ambiguous references which could imply Boyle's presence, but probably do not, see ibid., iii, 311, 510; iv, 252–3, 522. For Boyle's stroke see R. E. W. Maddison, *The Life of the Hon. Robert Boyle*, London, 1969, 145–7.

8 Birch, op. cit. (1), ii, 8. There were, however, moments of real synergy between Boyle's interests and the society's, for instance in connection with transfusion experiments in 1666 and 1667. See 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*, forthcoming.

the reflected glory of Boyle's role as a natural philosopher, happy to humour him when he deigned to take part in the society's activities? Or is there any evidence that, on the contrary, Boyle learned things from the Royal Society? For the biographer of Boyle, the great challenge is to ascertain when and why his ideas developed in the way they did. Obviously, conclusions on such issues will be based to a large extent on the profuse materials that Boyle has left us, in the form of his voluminous published writings, his correspondence and his extensive papers. But herein lies a problem, because in these circumstances it is easy to succumb to 'navel-gazing' – to an exclusive focus on sources emanating from Boyle himself, failing to give sufficient attention to external factors unless they are actually referred to there. Yet this sometimes leaves explanatory lacunae, making one prone to underestimate the impact of significant stimuli that are only indirectly apparent from Boyle's own corpus. Indeed, in certain instances, Boyle seems to have been deliberately vague about what his sources actually were, hence providing a challenge to his interpreters to set the record straight. A case in point is his relationship with the German natural philosopher Daniel Sennert, where William Newman has illustrated how Boyle was less honest about the extent of his debt to the earlier author than many commentators have presumed.[9]

Arguably, a further case of such an underestimated stimulus may be represented by the influence on Boyle of the early Royal Society, in this case in relation to a key aspect of his natural philosophical method, his use of 'heads' and 'inquiries' as a means of eliciting and structuring data. This was a genre that, as we will see, went back to Francis Bacon. The most famous exemplar of it was Boyle's article, 'General Heads for a *Natural History of a Country*, Great or small', published in *Philosophical Transactions* in 1666, with its sequel in the form of his 'Articles of Inquiries touching *Mines*', but these belong to a larger corpus of such material that Boyle started to produce just at the time when these were published.[10] Thereafter, such 'heads' continued to play a significant role in his work for the rest of his career, as will be indicated below. But there is no obvious explanation from within Boyle's papers as to why this striking change in his working methods should have occurred at this particular time. If one looks at the fledgling Royal Society, on the other hand, one finds an enthusiasm for such 'heads of inquiries' which could almost be seen as a leitmotif of the society's activity in its earliest years, inspired by the Baconian imperative to data-collecting that was central to the society's rationale.[11] Here, it will be claimed that it was almost certainly due to the

9 See W. R. Newman, 'The alchemical sources of Robert Boyle's corpuscular philosophy', *Annals of Science* (1996), **53**, 567–85, and the more general consideration in Hunter, op. cit. (5), 144ff.

10 Boyle, *Works* (ed. M. Hunter and E. B. Davis), 14 vols., London, 1999–2000, v, 508–11, 529–40. See further below.

11 On the early Royal Society's Baconianism see M. Hunter, *Establishing the New Science: The Experience of the Royal Society*, Woodbridge, 1989, especially Chapters 1, 3 and 6; and W. T. Lynch, *Solomon's Child: Method in the Early Royal Society of London*, Stanford, 2001; and *idem*, 'A society of Baconians? The collective development of Bacon's method in the Royal Society of London', in *Francis Bacon and the Refiguring of Early Modern Thought* (ed. J. R. Solomon and C. G. Martin), Aldershot, 2005, 173–202. (Lynch's views and my own are more compatible than he implies.) On the use of enquiries see D. Carey, 'Compiling nature's history: travellers and travel narratives in the early Royal Society', *Annals of Science* (1997), **54**, 269–92, and below.

society's stimulus that Boyle came to see the methodological value of such 'heads'. Indeed, as we will see, it even appears that a committee of the society produced a set of 'General Heads' preceding Boyle's, though this is now lost.

To set the scene, it is necessary briefly to survey Boyle's writings on natural philosophy, in which there is a fairly clear pattern of development from the point when he first discovered science around 1650. There is thus continuity from the largely apologetic writings that comprise his earliest extant natural philosophical works to such published books as *The Usefulness of Natural Philosophy*, largely compiled in the late 1650s and published in 1663 and 1671.[12] Then in his 'Oxford' period from 1656 onwards, Boyle developed an influential programme to which the classic 'Essay on Nitre' which formed the core of his *Certain Physiological Essays* (1661) was central. This led to a whole series of discursive essays in which he sought to use experimental evidence to vindicate the mechanical hypothesis. Some of these were published in the 1660s, including his famous *Origin of Forms and Qualities*; others came out in extended form at a much later date.[13] All these writings take the form of ruminative essays, in which experimental data was adduced, but in a far from systematic way, and this was a style of writing that Boyle continued to use in much of his scientific work for the rest of his life. Even *Spring of the Air*, though presenting a series of numbered experiments, takes a comparably discursive form.

In 1665, however, Boyle published a book of a rather different kind, his *New Experiments and Observations Touching Cold*. In contrast to the writings already noted, the experiments that are reported in the main part of this massive work are divided up into thematic 'Titles', dealing successively and systematically with experiments on such topics as 'Bodies capable of Freezing others', 'Bodies disposed [or indisposed] to be Frozen', 'the degrees of Cold in several Bodies', 'the Tendency of Cold, upwards or downwards' and so on.[14] This was the first of Boyle's books to be promoted in the newly founded *Philosophical Transactions*, and, if anything, the synopsis of the work published there brought out its structure all the more clearly in summarizing Boyle's main findings under its various heads.[15] In his preface, Boyle refers to 'the Scheme of heads of Inquiry, that I drew up to give myself a general Prospect of the subject I was to handle'; this provided him with a 'method' for his material which could at the same time accommodate 'future discoveries and hints' that he or others might add. As Boyle put it, 'being unwilling to huddle my Experiments confusedly together, I thought it an expedient … to draw up a company of comprehensive Titles, under which might commodiously be rang'd most of the Particulars I had observ'd'.[16] In this work, for the first

12 Boyle, op. cit. (10), xiii, pp. xxxvii–xlii and *passim*; and iii, pp. xix–xxiv; vi, pp. li–liv.

13 Boyle, op. cit. (10), i, 33–4, especially 33n.

14 Boyle, op. cit. (10), iv, 210–11, 226–7 and 213ff. *passim*. It is perhaps worth noting that the prolegomena concerning the thermometers and other equipment used and the authors cited, and the appendages discussing alternative theories concerning cold, could be seen to exemplify the proper structure for a natural history expounded in Boyle's 1666 letter to Oldenburg; see below.

15 *Philosophical Transactions* (1666), **1**, 8–9, 46–52, and especially the latter, though it peters out at title 13, due to want of space.

16 Boyle, op. cit. (10), iv, 210.

time, Boyle imposed a clear and orderly structure on his profuse experimental investigations of a whole class of phenomena concerning the natural world.

What was his source? The clue is provided by the title page, which has on it a quotation from Francis Bacon, though, oddly enough, his inspiration was not otherwise very explicitly acknowledged in *Cold* itself.[17] It was in a later work with a comparable structure, Boyle's *Memoirs for the Natural History of Human Blood* (1684), that he clarified the origin of his new format. There, he explained the various 'heads' he used to subdivide his subject: 'I thought fit to comprize all these sorts of particular Topicks, or Articles of Inquiry (to use our illustrious *Verulam*'s phrase) under the general and comprehensive name of *Titles*'.[18] Bacon had indeed opened the two principal specimens of the natural histories which he saw as crucial for 'the foundation of philosophy' in his *Instauratio magna* with just such lists of 'topica particularia': these were his 'History of winds' and his 'History of life and death', published in his *Historia naturalis et experimentalis ad condendam philosophiam* of 1622. As he explained at the outset, in 'the rule of the present history', 'In each Title, after an Introduction or Preface, Particular Topics or Articles of Inquiry are immediately proposed, as well to give light in the present, as to stimulate further inquiry'.[19] Though these lists and their role in Bacon's thought have not been much studied by Bacon scholars, in both cases they do indeed seem to have played a crucial role in structuring the work, being cited at the start of each section, and evidently providing an agenda both for the accumulation of relevant information and for the content of the text. A handful of other such lists survives, dealing with such topics as magnetism, light, metals and minerals, the transmutation of bodies and the commixture of liquors.[20] In addition, the idea of compiling such lists was divulged by Bacon in his influential *Parasceve* or 'Preparative for a Natural and Experimental History', where he listed over a hundred such topics, explaining how, 'as soon as we have the leisure for the task, we plan to give detailed instructions by putting the questions that most need to be investigated and written up in

17 Boyle, op. cit. (10), iv, 203. The quotation is from Bacon, *Novum organon*, 2, 10.

18 Boyle, op. cit. (10), x, 9. The discussion of his sources here supersedes the note given there.

19 Bacon, *Works* (ed. J. Spedding, R. L. Ellis and D. D. Heath), 14 vols., London, 1857–74, ii, 17, 20–5, 108–10; v, 135, 140–5, 220–2. The issue of Bacon's possible sources cannot be addressed here, but among precedents it is worth noting (1) the Aristotelian 'problem literature' which Bacon saw as worthy of emulation in his *De augmentis scientarum* (B. Lawn, *The Salernitan Questions*, Oxford, 1963, 141 and *passim*); for the scholastic background to the genre see also P. Anstey, 'The methodological origins of Newton's queries', *Studies in History and Philosophy of Science* (2004), **35**, 247–69, especially 248–9, 252–3; (2) the genre of ecclesiastical visitation articles (see W. H. Frere (ed.), *Visitation Articles and Injunctions of the Period of the Reformation*, 3 vols. (Alcuin Club, vols. 14–16), London, 1910); and (3) the questionnaires addressed to the Spanish possessions in the New World in the late sixteenth century (see e.g. H. F. Cline, 'The *Relaciones Geográficas* of the Spanish Indies, 1577–86', *Hispanic American Historical Review* (1964), **44**, 341–74). The possible influence of Bacon's legal background has not been explored.

20 These were published in the posthumous *Scripta*, edited by J. Gruter in 1653; in the *Opuscula*, edited by W. Rawley in 1658; and in *Baconiana*, edited by T. Tenison in 1679 (the latter too late, incidentally, to have influenced Boyle). See Bacon, op. cit. (19), ii, 307–22; iii, 799–826; v, 401–14. For a definitive edition for the two former, see F. Bacon, *The Instauratio magna: Last Writings* (ed. G. Rees), Oxford, 2000, 237–57.

each history because they help to fulfil our purpose, like certain particular *Topics*'.[21] Bacon thus provided a clear model for Boyle.

Yet in his profuse writings prior to *Cold* Boyle had failed to follow Bacon's example, a fact which has been overlooked partly because it is so commonplace that Boyle was a Baconian that the actual trajectory of his Baconianism has been little studied.[22] In fact, Bacon does not play a particularly prominent role in Boyle's early natural philosophical writings. In Boyle's earliest discussions of scientific topics, Bacon is alluded to in a generalized way as a 'Free Philosopher' along with such authors as Telesio, Campanella, Sennert and Gassendi.[23] Even in *Usefulness* Bacon is only occasionally cited, usually on quite specific points.[24] In *Certain Physiological Essays* Boyle was ambivalent. In the 'Proemial Essay' he protested how he had refrained from reading Bacon's *Novum organum*, along with the natural philosophical writings of authors like Descartes and Gassendi, 'that I might not be prepossess'd with any Theory or Principles till I had spent some time in trying what Things themselves would incline me to think', a slightly gnomic statement the significance of which I have discussed elsewhere.[25] Later in the same essay, however, he expressed the ambition to continue Bacon's famous *Sylva sylvarum* in the form of a collection of 'Promiscuous Experiments', which is significant, if representing a rather unsophisticated ambition in comparison with the structured format used in *Cold*.[26] A similar transitional stage is represented by Boyle's *Experiments and Considerations Touching Colours*, published in 1664. After opening with a digressive account of the phenomena in hand addressed, like those in *Certain Physiological Essays* and *Usefulness*, to Pyrophilus, the name given by Boyle to his nephew, Richard Jones, later First Earl of Ranelagh, the rest of the book is quite different in format. It comprises a series of fifteen 'Experiments in Consort, Touching Whiteness & Blackness', and then a 'Third Part. Containing Promiscuous Experiments About Colours' to the number of fifty – in other words, the equivalent of half of one of the 'centuries' of experiments which *Sylva sylvarum* comprised, and hence possibly exemplifying the ambition to continue that work referred to in *Certain Physiological Essays*.[27]

21 Quoted from Bacon, *The New Organon* (ed. L. Jardine and M. Silverthorne), Cambridge, 2000, 232. See also ibid., 233–8, and *idem*, *The Instauratio magna: Part II Novum organum* (ed. G. Rees with M. Wakeley), Oxford, 2004, 472–3, 474–85. Bacon also proposed the use of '*Topica quædam inductiva, sive Articulos ad interrogandum*' in his *Descriptio globi intellectualis*; see *idem*, *Philosophical Studies c. 1611–c. 1619* (ed. G. Rees), Oxford, 1996, 114–15.

22 For an account of Boyle's Baconianism see R.-M. Sargent, *The Diffident Naturalist: Robert Boyle and the Philosophy of Experiment*, Chicago, 1995. However, she does not comment on the evolution of Boyle's Baconianism as outlined here, and she mentions the 'heads' and 'inquiries' only in passing on 175 and 297 n.70.

23 Boyle, op. cit. (10), xiii, 190, 197. Cf. the citation of *De augmentis scientarum* in ibid., 157.

24 Boyle, op. cit. (10), iii, 229, 271, 349, 364, 433–4, 477, 536; vi, 402, 409, 432–3; xiii, 351, 353. Note that in the last text, which is a fairly late addition, Boyle says of the *Novum organum* that he 'was not then vers'd' in it when he initially wrote this essay.

25 Boyle, op. cit. (10), ii, 12–13; Hunter, op. cit. (5), 145–6.

26 Boyle, op. cit. (10), ii, 17–18.

27 Boyle, op. cit. (10), iv, 3ff. *passim*. *Colours* had the same motto from Bacon on its title page as did *Cold*.

With *Cold*, however, the Baconian structure is much more overt, and this is also true of at least three other works by Boyle, all of them, significantly, with roots going back to the 1660s, though they were not published till much later. These are *Memoirs for the Natural History of Human Blood*, published in 1684; *Short Memoirs for the Natural Experimental History of Mineral Waters*, published in 1685; and *The General History of the Air*, posthumously published by John Locke in 1692.[28] The earliest version of the set of 'Titles' used in *Human Blood* survives in a notebook of Locke's dating from the 1660s, while both of the other works also seem to have their origins in that decade.[29] All of these present lists of 'topics' or (to use Boyle's preferred word) 'titles', while the remainder of their content comprises a collection of data categorized under one or other of the headings there laid out.

Equally significant is the fact that Boyle's papers contain a series of nearly twenty lists of such 'heads', though this is less well known because they have hitherto survived only in manuscript. These range in their descriptions from the almost directly Baconian 'Titles or Topica Particularia about the Natural History of Water' to the more general 'Enquirys and Experiments about Electricall Bodys'; others simply give a list of headings without an overall title.[30] There is some variety in the range and scale of such items. Some, such as 'Titles and Articles of Inquiry in Order to A Natural History of the Sea', effectively sketch out the contents of a planned book, in this case running systematically through every aspect of sea water, its nature and content, before dealing with storms, currents and other related phenomena. Others, on the other hand, are more specific lists of trials to be made, as with 'Experiments to be made in seald Receivers', which simply itemizes a series of substances to be tested thus. Either way, the document outlined the leading features of a phenomenon that seemed worthy of investigation, more often than not by experimental enquiry. An untitled series on elasticity, for instance, opens with the following:

> What Bodys are Naturally endowd with elasticity.
> What Bodys Naturally want Springs.

28 Boyle, op. cit. (10), x, 3ff., especially 12–13, 15–16, 40–1; 205ff., especially 220–4, 247–9; xii, 3ff., especially 7–9. See also the recently published 'Memoirs for the Natural History of Tin', in ibid., xiv, 133ff. In contrast to the rather scrappy nature of certain of these works, it is perhaps also worth noting here that the closest parallel to *Cold* among Boyle's later writings is his 'New Pneumatical Experiments about Respiration', published in *Philosophical Transactions* in 1670 (Boyle, op. cit. (10), vi, 213–57), which has twenty 'Titles', with a varying number of experiments under each; however, it does not have a list of the titles at the start.

29 Bodleian MS Locke f. 19, pp. 272–3, 302–3, the former (only) reproduced in K. Dewhurst, 'Locke's contribution to Boyle's researches on air and on human blood', *Notes and Records of the Royal Society* (1962), **17**, 198–206, Plate 12. For the text of this and the various revised versions of the list see M. Hunter and H. Knight (eds.), *Unpublished Material relating to Robert Boyle's 'Memoirs for the Natural History of Human Blood'*, Robert Boyle Project Occasional Papers, No. 2, 2005 (downloadable in the researchers' area of the Boyle website: www.bbk.ac.uk/boyle). For the link of this and other writings to the 1660s see Boyle, op. cit. (10), x, pp. xi–xii, pp. xxiv–xxx; xii, pp. xi–xiv.

30 See M. Hunter (ed.), *Robert Boyle's 'Heads' and 'Inquiries'*, Robert Boyle Project Occasional Papers, No. 1, 2005 (downloadable in the researchers' area of the Boyle website: www.bbk.ac.uk/boyle). This gives a complete text of the documents with a commentary. For a listing see note 32 below.

> What Bodys there are that have Springs under some Dimensions, & not under others, & but what measures as to length & thicknesse they appear to have, & not to have a Spring.
> What Bodys not Naturally or always elasticall are capable of being made soe.
> What Bodys Naturally Elasticall may be depriv'd of their Spring (to this belongs the Glasse of Lead & other Minerales per se, & the reductions of that Minerall).
> By what operations & meanes Elasticity may be introduc'd into Bodys, as fusion hammering, wire drawing &c.
> By what Operations & meanes the Elasticity of a Body may be destroyd, as nealing, melting &c.
> What are the cheif & most usuall Concomitants of Elasticitie, & of the absence or losse of it.[31]

What is particularly significant is that these lists survive to a disproportionate extent in the handwriting of amanuenses employed by Boyle in the 1660s. This is important because handwriting clues of this kind have proved crucial in identifying 'strata' within the Boyle Papers, and it is unusual to find such a high preponderance of 1660s hands in a group of material, as against handwritings from earlier or later in Boyle's career.[32] Revealingly, none at all are of earlier date, and, though a minority are in later hands, either because composed or recopied later, it is worth observing that the 1660s items are often clearly actual 'composition copies' – as shown by the fact that they contain various deletions and additions made in the hand of the amanuensis who wrote them in the first place – whereas this is true to a much lesser extent of the later ones.[33]

The link of such lists of titles with the 1660s is further documented by various references to these texts in Boyle's profuse correspondence with Henry Oldenburg in

31 Boyle Papers (hereafter BP) 10, fol. 132. This comprises the first third of the document only. For the remainder, see Hunter, op. cit. (30), 4–6.

32 See Boyle, op. cit. (10), i, 100–2, and M. Hunter *et al.*, *The Boyle Papers: Understanding the Manuscripts of Robert Boyle*, Aldershot, forthcoming, Chapter 1. The following items are in 1660s hands: BP 10, fols. 57 (magnetical trials; hand G; Hunter, op. cit. (30), 2–3), 118 (experiments in sealed receivers; hand E; Hunter, op. cit. (30), 3–4), 132 (elasticity; hand F; Hunter, op. cit. (30), 4–6), 133v–4 (tastes; hand F; Hunter, op. cit. (30), 6–7), 135v–6 (odours; hand F; Hunter, op. cit. (30), 7–8); BP 18, fols. 129–30 (anatomical experiments; hand F; Hunter, op. cit. (30), 9–12); BP 22, 197–200, continued in BP 38, fol. 120 (electrical bodies; hand F; Hunter, op. cit. (30), 12–15); BP 25, 392–3 (shining wood; hands E and F; Hunter, op. cit. (30), 16–17); BP 26, fols. 75–6 (lime; hand F; Hunter, op. cit. (30), 24–6), 90 (insects and 'Spontearta'; hand F; Hunter, op. cit. (30), 26–7); Boyle Letters 3, fols. 33–4 (Greatrakes; hand F; Hunter, op. cit. (30), 31–2). In addition, BP 10, fol. 5 (volatile salts; Hunter, op. cit. (30), 1–2), is in the hand of Frederic Slare, who started to work for Boyle around 1670. The following are in the hand of Boyle's amanuensis, Robin Bacon, who worked for Boyle from the mid-1670s onwards: BP 25, pp. 264–5, and BP 26, fols. 49–50 (natural history of water; two versions; Hunter, op. cit. (30), 17–19); BP 26, fols. 51v–2 (natural history of the sea; Hunter, op. cit. (30), 19–23); BP 26, fols. 62, 70 and BP 36, fols. 98–9 (light and luminosity; four copies; Hunter, op. cit. (30), 23–4); BP 36, fol. 80 (copper; Hunter, op. cit. (30), 30–1); British Library Sloane MS 2502, fols. 1v–2 (diseases; Hunter, op. cit. (30), 33–4). Documents in other hands: BP 27, 331–2 (gems; hand: Oldenburg; Hunter, op. cit. (30), 28–30); Bodleian Library MS Locke c. 42, fols. 266–7 (flame and fire; hand: Brownover; Hunter, op. cit. (30), 34–6); Bodleian MS Lister 34, fol. 35 (damps; hand: Oldenburg; Hunter, op. cit. (30), 36–7).

33 See Hunter, op. cit. (30), *passim*. For a later text showing evidence of revision see the two versions of the titles for the natural history of water, BP 25, 264–5, and BP 26, fols. 49–50 (Hunter, op. cit. (30), 17–19).

these years.[34] He also wrote discursively about such lists and their significance for natural history in a letter to Oldenburg dated 13 June 1666, from which he later extracted and extrapolated in the disquisition that opened *Human Blood*.[35] This letter is notable for its sophisticated treatment of natural history as a whole, both in its openness to the assessment of contrasting hypotheses and in its preparedness to emend Bacon's categories when appropriate, reflecting the fact that Boyle was by this time giving careful thought to Bacon's strictures on the writing of natural history and elaborating on these. He proposed a comprehensive, if provisional, categorization of the subject matter of natural history into various 'principal Parts', and the idea was evidently to subdivide these in a manner comparable to Bacon's *Parasceve*, though, if Boyle executed this, it has not survived other than in the form of the examples that he gave in the letter to illustrate each of his general categories, and the piecemeal sets of 'titles' that are extant.[36]

As is apparent from their proliferation among his literary remains at this point, Boyle clearly found such sets of 'heads' useful for various reasons. Most obviously, for him as for Bacon they acted as a means of setting himself an agenda and clarifying and structuring his ideas on his chosen subject. In *New Experiments Touching Cold*, as we have seen, he saw such 'titles' as providing 'a general Prospect of the subject I was to handle', while, in justifying the compilation of such lists of '*Topica particularia* or Articles of Inquiry' in a document that probably forms part of his 1666 letter to Oldenburg, he explained how 'tis highly useful for the discovery of the nature of a Body to consider how many wayes it may be examin'd, or (if you will) how many distinct *Phænomena* and representations of itself, it may be made to exhibit'.[37] An example of the way in which this might relate to his experimental work is provided by one of his manuscript lists, in this case headed 'Concerning shining Wood', with columns headed 'Observations to be made' and 'Tryalls to be made'.[38] This is apparently the document referred to in Boyle's account of his experiments on luminescent bodies published in *Philosophical Transactions* in 1668, where he explains how he had formerly collected observations on this topic, and 'had also proposed several Trials about them, to be made when I should have opportunity, and requisite Instruments to put them in practice'. In fact, as he goes on to explain, the experiment he tried was 'but one' of those 'in my List' (where it does indeed appear), but Boyle found it so engrossing that he went on to make a whole series of ancillary experiments, adding a series of reflections

34 See Boyle, *Correspondence* (ed. M. Hunter, A. Clericuzio and L. M. Principe), 6 vols., London, 1999–2000, iii, 80 (quoted in text below: probably a reference to BP 26, fol. 90; Hunter, op. cit. (30), 26–7), 251–2 (this refers to the queries published in *Philosophical Transactions*, but BP 26, fol. 51v–2 (Hunter, op. cit. (30), 19–23), may be linked to these), 373, 376, 380 (the former evidently referring to BP 10, fol. 118), (Hunter, op. cit. (30), 3–4), as well as BP 25, 392–3 (Hunter, op. cit. (30), 16–17), on which see further below. For references to the inquiries published in *Philosophical Transactions* see notes 68–9 below.

35 Boyle, op. cit. (34), iii, 170–5; Boyle, op. cit. (10), x, 9–12.

36 See Peter Anstey and Michael Hunter 'Robert Boyle's "Designe about Natural History"', forthcoming. See also P. Anstey, 'Locke, Bacon and natural history', *Early Science and Medicine* (2002), 7, 65–92.

37 Boyle, op. cit. (10), iv, 210; BP 9, fol. 71. For the link between the latter document and the 1666 Oldenburg letter see the forthcoming study referred to in the previous note. It has 'particularis' for 'particularia', an obvious mistranscription.

38 BP 25, 392–3; Hunter, op. cit. (30), 16–17.

'About the *Resemblances* and *Differences* between a *Burning Coal* and *Shining Wood*', which well illustrate his experimental virtuosity. On the other hand, this still left him with the original list as set out in his manuscript, from which he simply deleted this particular item, renumbering the remainder as an agenda for further investigation.[39]

Equally important, such lists could be used as a means of eliciting information relevant to a topic from others, and for classifying such data once it had been collected. Indeed, the extent to which they combined the provision of a structure for the study of a topic with an agenda of enquiry is apparent both from the Baconian precedent – in which 'topica particularia' were routinely combined with 'articles of inquiry' – and from Boyle's own adaptation of it. As he explained in *Human Blood*, his 'Titles' combined '*Queries* more properly So called, *Propositions* either Affirmative or Negative, and other Heads of Natural History'.[40] Indeed, in his descriptions of these documents, 'titles' or 'heads' overlapped seamlessly with 'queries' or 'inquiries' – often without this making much difference to the mode of presentation of the document in question, in which entries starting 'Whether' were interchangeable with others starting 'Of'. Thus, for instance, an untitled series relating to copper oscillates between entries such as 'Of the Fusiblenes of Copper' and 'Whether Copper be an Homogeneous Body?'[41]

That in Boyle's case he saw his 'titles' as an appropriate tool for eliciting information from others is shown most clearly by the fact that his 'Titles of the (Naturall and Experimental) History of the Air' – a typical list of topics mainly set out in a descriptive rather than an interrogatory tone – was apparently printed (though no copy survives); there is also evidence from Boyle's *Correspondence* that it was circulated, eliciting information on various of the matters that it covered.[42] Moreover, the overlap between 'titles' and 'queries' is illustrated perhaps most clearly by Boyle's best-known compositions of this kind, published, as already noted, in *Philosophical Transactions* in 1666 – his 'General Heads for a *Natural History of a Country*, Great or small' and his 'Articles of Inquiries touching *Mines*', which are then subdivided by 'Titles'.[43] This overlap between 'heads' and 'inquiries' is slightly strange to us, since we are prone to expect documents intended to elicit information to have an explicitly interrogatory tone, yet one should note how these grew out of the structured lists of topics with which, as we have seen here, they overlapped.

In addition to using these lists to interrogate others, Boyle also employed them to categorize data so accumulated. This has been revealed by Harriet Knight in her recent Ph.D. thesis on Boyle's methods of intellectual organization, in which she has analysed the content of a massive compilation entitled 'Promiscuous Experiments, Observations & Notes', the most extensive of a series of 'workdiaries' that Boyle drew up throughout

39 Boyle, op. cit. (10), vi, 1–25, especially 5, 20; BP 25, 393 (Hunter, op. cit. (30), 17).

40 Boyle, op. cit. (10), x, 9.

41 BP 36, fol. 80; Hunter, op. cit. (30), 30–1.

42 See Boyle, op. cit. (34), vi, 123, 132–3, 151–2, 180, 217–23. The set of 'titles' to which John Clayton was replying in the last reference differed slightly in its numeration from that in Boyle, op. cit. (10), xii, pp. xxiii–xxiv. On the printing of the 'Titles' see Boyle, op. cit. (10), pp. xi–xii.

43 Boyle, op. cit. (10), v, 508–11, 529–40. For their date, see below.

his intellectual career, in which he recorded both his own experimental and observational findings and information divulged to him by others. She has shown that the entries have been endorsed according a scheme which is clearly that of Boyle's 'General Heads', with material being allocated a number according to whether it was best placed under the heading 'Air', 'Water', 'Earth', 'Mines', 'Plants', 'Animals', 'Inhabitants' or human productions.[44] A similar rationale is expressed by a paper entitled 'Advertisements', which seems to have been intended to accompany such a collection of data and to clarify its relationship with the 'Naturall Historys' to which Boyle aspired. In it he states how 'the particulars that are here huddled together in the casuall order wherein they occurd to me, are to be rang'd according to the Intimations of the *Topica particularia* or Articles of Enquiry about each of these Historys', the histories in question being enumerated as 'Fermentation, Putrefaction, water, air, flame &c.' – in other words, categories of the sort that might have been predicted from his 1666 letter to Oldenburg.[45]

Hence the lists of 'heads' that Boyle evidently started to compile at this time almost immediately began to serve a crucial role in his intellectual agenda. But what had stimulated their inception? Within Boyle's manuscripts, there are no real clues to help answer this question – documents of this type simply appear for the first time in the handwriting of amanuenses whom he employed in the 1660s. But here we need to return to the Royal Society, because it is almost certainly not coincidental it was in the society's early years that Boyle first developed this enthusiasm for using such 'heads' – not least since, as we shall see, the institution was from its inception much preoccupied by the preparation of elaborate lists of queries, as the most effective way of organizing the data-collecting that was central to its ambitions. First, however, it is worth returning to *New Experiments and Observations Touching Cold* (1665), the first work by Boyle to be organized under 'titles', for this was very much a 'Royal Society' book, more so than almost any other publication by Boyle.[46] Though the material on which it was based seems to have been collected over a longer period, it was prepared for publication in the society's early years, and it was evidently at this stage that the book's structure originated. In his preface Boyle specifically linked the inception of the work to '*The Command of the Royal Society*', reiterating in a letter, which precedes the main text, to the president, Lord Brouncker, how its collection of experimental data was drawn up at the society's behest. He also apparently circulated copies of certain sections of the work to the Fellows of the society prior to publication, including the list of 'heads' under which the experiments were organized.[47]

44 H. Knight, 'Organising natural knowledge in the seventeenth century: the works of Robert Boyle', University of London Ph.D. thesis, 2003, 110–13. The workdiary in question is no. 21; see www.livesandletters.ac.uk/wd.

45 BP 10, 138, published in Hunter *et al.*, op. cit. (32), 184. This, too, has 'particularis' for 'particularia' (see note 37 above).

46 The main potential rival is *Hydrostatical Paradoxes* (1666).

47 Boyle, op. cit. (10), iv, 206, 210, 263–4. See also ibid., pp. xvii–xxi. It is odd that there is no reference in the minutes published by Birch to the explicit instruction to produce the work to which he there appears to refer. However, for the copies of the heads and so on see Birch, op. cit. (1), ii, 2, 5.

Also worth considering here is the case of Boyle's former employee, Robert Hooke, who had become the first curator of experiments to the Royal Society in November 1662. One of Hooke's earliest activities in this role, in February 1663, was to present the society with an elaborate 'scheme of inquiries concerning the air', which formed the basis of a systematic programme of experiments that he was subsequently to pursue at the society's meetings.[48] Thereafter the compilation of documents of this kind became a major preoccupation for Hooke, as seen particularly in his 'General Scheme, or Idea Of the Present State of Natural Philosophy, And How its Defects may be Remedied', a remarkable exposition of scientific method on essentially Baconian principles which dates from the late 1660s although it was not published until after Hooke's death. This was almost certainly based on presentations made to the Royal Society, and in it Hooke gave a series of such lists of queries.[49] Indeed, Hooke was implicitly as systematic in this regard as Bacon himself, seeing the examples that he gave (which related to astronomical phenomena and to various aspects of the air) as merely a 'few Instances' which 'may serve for a Specimen of what I mean by the Method of propounding Queries on any Subject, to be examined by accurate Observations and Tryals, before the Writing a Natural History of it'.[50]

Here it is significant that we specifically know that the 'scheme of inquiries concerning the air' that Hooke produced in February 1663 was compiled on the orders of the Fellows of the Royal Society as a collective body.[51] Without belittling Hooke in any way, this implies that, in drawing up this pioneering list, he was responding to a corporate initiative on the part of the society, which evidently had an effect on him comparable to that which it seems to have had on Boyle. We arguably tend to underestimate the extraordinary collective energy of the Royal Society as a body in its formative years, which transcended the role of individuals and in which the whole was truly more than the sum of its parts. Moreover, within it, whereas we are prone to be preoccupied by individual Fellows who are retrospectively famous, such as Hooke and Boyle, an equally important role was apparently played by less well-known figures, not least in formulating the society's programme. A case in point is Sir Robert Moray, whose memorandum on the society's 'business & designe' has often been seen to epitomize the institution's aims in its early years, and whose enthusiasm for structured data collection is seen, for instance, in his '*Patternes* of the *Tables* proposed to be made for *Observing of Tides*' published in *Philosophical Transactions* in 1666.[52] The first president, Lord Brouncker, may have played a similar role. Boyle's dedication to him

48 Birch, op. cit. (1), i, 202–4 and *passim*. See also Hunter, op. cit. (11), 23.

49 R. Hooke, *Posthumous Works* (ed. R. Waller), London, 1705, 1–70, 21–33. For an associated item, referred to there, see Hooke's 'Cometa', in his *Lectiones Cutlerianae*, London, 1679, 7–8, reprinted in *Early Science in Oxford* (ed. R. T. Gunther), 14 vols., Oxford, 1923–45, viii, 223–4. For the link to the Royal Society Cutlerian lectures see Hunter, op. cit. (11), 301–3. On these 'queries' see Anstey, op. cit. (19), 254–6.

50 Hooke, *Posthumous Works*, op. cit. (49), 33.

51 Birch, op. cit. (1), i, 198, 202.

52 For the attribution of the former to Moray see M. Hunter, *Science and the Shape of Orthodoxy*, Woodbridge, 1995, 172–4; for a commentary on it see Lynch, 'A society of Baconians?', op. cit. (11), 187–8 and *passim*. For the latter see *Philosophical Transactions* (1666), **1**, 311–13.

of *Cold* could reflect his particular significance in stimulating the way in which that work was presented, while, previous to this, it is interesting that he and Boyle had collaborated on what seems to be the earliest document of the kind under consideration here: this was 'some questions, in order to the tryal of the quicksilver experiment upon Teneriffe' which a group of five Fellows, including Brouncker and Boyle, was asked to compile at the first full meeting (on 5 December) of the society after its inauguration on 28 November 1660, and which Boyle and Brouncker produced at the meeting on 2 January 1661. This was the very first item to be entered in the society's Register Book, thus almost symbolizing the association of such texts with the nascent society.[53] It is perhaps significant that neither Brouncker nor Moray had been active in the 'Oxford group' with which Boyle had been associated in the late 1650s, hence helping to explain the distinctive character of the Royal Society's apparent institutional influence on him and others at this point.[54]

Above all, this corporate initiative is seen in an enthusiasm for the preparation of sets of 'inquiries' for those travelling to exotic places. Since this forms the background to arguably the most influential of all the compilations of this kind that emanated from the Royal Society in its early years, in the form of Boyle's 'General Heads for a *Natural History of a Country*, Great or small', this matter deserves detailed consideration. On 6 February 1661 a committee of sixteen Fellows was appointed 'for considering of proper questions to be inquired of in the remotest parts of the world', the list being led by Brouncker and Moray and again including Boyle along with a number of Fellows reflecting the metropolitan, governmental input into the society, including Thomas Povey, the eminent colonialist; William Petty, projector and courtier; Lawrence Rooke, Gresham Professor of Geometry; Henry Oldenburg, the future secretary of the society; the virtuosi John Evelyn and Thomas Henshaw; and the merchant Daniel Colwall.[55] Equally interesting is the fact that on 4 March 1661 – still within weeks of the society's inauguration, and representing its earliest documented public initiative – we find Thomas Povey sending a correspondent in Virginia, Edward Digges, a set of 'Enquiryes concerning those severall kind of things which are reported to be in Virginia & the

53 Birch, op. cit. (1), i, 5 (the other Fellows asked were Moray, William Petty and Christopher Wren), 8–10; Royal Society Copy Register Book (hereafter RBC), Vol. 1, 1–3. For Brouncker's pneumatic experiments see Boyle, op. cit. (10), iii, 62.

54 Brouncker was in epistolary communication with a key Oxford figure, John Wallis (see *Commercium epistolicum* (ed. J. Wallis), London, 1658, *passim*), but there is no evidence that he had any contact with Boyle at that point.

55 Birch, op. cit. (1), i, 15. Cf. ibid., 17. The other members were John Wilkins; William Coventry, courtier and politician; the doctors Jonathan Goddard, Daniel Whistler and Timothy Clarke; and John Austen, a somewhat shadowy figure. It is perhaps worth noting here that the papers of another member of this committee, Petty, include various documents similar to those discussed here; see *The Petty Papers* (ed. the Marquis of Lansdowne), 2 vols., London, 1927, e.g. i, 175–8, 187–9; ii, 109–10, 115–19. These are hard to date, but most probably date from Petty's later years, like the bulk of his extant manuscripts; see F. Harris, 'Ireland as a laboratory: the archive of Sir William Petty', in *Archives of the Scientific Revolution* (ed. M. Hunter), Woodbridge, 1998, 73–91. However, at least one is of much earlier date, 'Enquiries concerning Bathe Waters', evidently dating from *c.* 1650, British Library Add MS 72892, fol. 1; I am grateful to Adam Fox for drawing my attention to this item.

Bermudas, not found in England'.[56] He explained how these emanated from the society, described as

> certaine Noble and Ingenuous Persons, who by his Majesties encouragement, doe sometimes meete together to enquire into and examine (as farr as Philosophie and experience may leade and Conduct them,) all such things as Art, or Nature have produced; that, by a more intimat knowledge and tryall thereof, they may bee able to improve what is allreadie donn, or discovered; or may at least raise by their Inquisition and Industrie some Observations to the benefitt of Mankind, and the advantage of the Commonwealth of Learning.

Povey continued, 'In order to which they have extracted out of such Authors as have writt concerning America a Paper containing some fewe Enquiries, to which a distinct account is desired.' The attached document asked quite specific questions, evidently based on the reading of those who had compiled it, presumably the committee set up in February, who had been instructed to do just this. Concerning earths, for instance, it noted, 'Tis said there is one kinde of a Gummy consistence, white & cleere. another white & so light that it swims uppon water: another red called Wapergh like terra Sigillata', while under fishes it singled out for inquiry 'very large Toadfish. St Georges Dragon. Sting ray with a poisonous preckle'.[57]

This was the first example of a whole genre of inquiries aimed at specific geographical areas, and thereafter similar documents, based on comparably careful scrutiny of appropriate sources, were produced for such places as the East Indies, Iceland, Turkey, Guinea, Egypt, Hungary and Greenland. These were initially enshrined in the society's Register Book and later printed in *Philosophical Transactions* after its inauguration; indeed, in the early months of 1667 two issues of the journal were almost exclusively devoted to such texts.[58] In addition, before his premature death, Lawrence Rooke produced a set of 'Directions for Sea-men, bound for far Voyages', while another important set of inquiries were those concerning agriculture which were prepared by the society's Georgical Committee, one of its most significant institutional initiatives in its early years; these were in fact the first set to be published in

56 Povey to [Digges], 4 March 1660[/1], British Library Egerton MS 2395, fol. 296, with the inquiries referred to in the letter following as fols. 297–8, endorsed (fol. 298v), 'The Paper of enquiries from Gresham College to Virginia sent [?] March 4th 1660'. I am extremely grateful to Tina Malcolmson for drawing my attention to this item. A copy of the same letter is to be found in Povey's letterbook, British Library Add MS 11411, fol. 24: this is endorsed 'Letter to Edward Diggs Esquire Concerning Present of Silke to the King from Virginia' (this refers to the first matter dealt with in the letter), thus identifying the addressee, who is not named in the Egerton MS version (it is dated 'Lincolnes Inne Feilds March the 2d 1660'); however, this copy lacks the accompanying inquiries. Copies of the inquiries survive in Royal Society Classified Papers (hereafter Cl. P.) 19, 65 (in Oldenburg's hand, entitled 'Enquiries of the things peculiar to Virginia and the Bermudas' and with slight differences of wording), and among Abraham Hill's papers in British Library Add MS 2903, fols. 112–13 (titled as in Egerton MS); a printed version derived from them appears in *Philosophical Transactions* (1667), **2**, 420–1. The letter in Egerton 2395 is referred to in J. R. Jacob, *Robert Boyle and the English Revolution*, New York, 1977, 146, but without referring to the attached inquiries; the Cl. P. and Sloane 2903 copies of the inquiries are referred to in R. P. Stearns, *Science in the British Colonies of America*, Urbana, IL, 1970, 694, but without reference to the Povey letter (ibid., 695–8, comprises a different, later set of inquiries for Virginia, again recommended to Edward Digges [1669]).

57 Egerton MS 2395, fol. 297; Birch, op. cit. (1), i, 17.

58 RBC, i, 216–21, 287–8; **2**, 24–5, 190–1; *Philosophical Transactions* (1667), **2**, 344–6, 360–2, 415–22, 467–72, 554–5; (1668), iii, 634–9. See also Cl. P. 19, *passim*.

Philosophical Transactions, and it is worth noting that the primary initiative in producing them seems to have been that of Sir Robert Moray.[59] Later, the production of such inquiries was given prominence in the account of the society's activities in Thomas Sprat's *History*, which also included a specimen of the responses that they elicited.[60]

Of more immediate relevance to Boyle's 'General Heads' there was evidently also a set of general queries for overseas countries. It is clear that such a questionnaire existed at least by January 1662, when 'four or five copies of the inquiries for foreign parts were ordered to be made and given to Mr Povey', while in April 1662 the society's amanuensis 'was ordered to write out the *Inquiries for foreign parts*, and to deliver them to Mr Boyle; and it was directed, that among these inquiries be inserted one, whether the rain-water varies in weight, trial thereof being made in divers places'.[61] Frustratingly, however, the document in question no longer survives. The only clue as to the possible nature of these inquiries is provided by the general agenda on which the queries sent by Povey to Virginia in March 1661 elaborated, in which case they may have comprised four general categories with more specific queries within them. If so, their content may be reconstructed by taking the 'general' part of each section of the Virginia document, and ignoring queries specific to the region:

1. Concerning the variety of earths.
2. What considerable mineralls, stones, Bitumens, Tinctures, Drugges, & a specimen of each.
   What hot Bathes, & of what medicinall use.
3. What variety of Plants are native there & not in England. what kind of peculiar herbs there are, considerable either for their flower, smell, Alimentary or medicinall use.
4. What kind of animalls, are peculiar to those places.
   1. Insects, flyes, ants, wormes, spiders. Some of each kind to be sent over either alive or dead.
   2. What strange fishes, Tortoises or Turtles.
   3. What Birds.
   4. What Beasts.[62]

59 *Philosophical Transactions* (1666), **1**, 91–4, 140–3 (Rooke's 'Directions'; see also Birch, op. cit. (1), i, 74, RBC, i, 153–5). On the agricultural inquiries see R. Lennard, 'English agriculture under Charles II: the evidence of the Royal Society's "Enquiries"', *Economic History Review* (1932–4), **4**, 23–45, and see the discussion in the minutes of the Georgical Committee in Hunter, op. cit. (11), 108–9. See also ibid., 85–6. Prior to Moray producing the inquiries which formed the basis of those circulated, Christopher Merrett had been asked to 'reduce all that belongs to Husbandry to certain comprehensive heads', and William Croone had been asked to extract enquiries from Samuel Hartlib's *Legacie*. The latter reference raises the possibility that the genre of 'heads' owed something to Hartlib, who had published an 'Interrogatory' concerning Ireland in the second edition of his *Legacie* (1652). However, this is arranged in an alphabetical order that none of the Royal Society questionnaires follow. On the 'Interrogatory' and its possible influence see A. G. MacGregor and A. J. Turner, 'The Ashmolean Museum', in *The History of the University of Oxford. Vol. 5: The Eighteenth Century* (ed. L. S. Sutherland and L. G. Mitchell), Oxford, 1986, 636–58, on 646n; D. Carey, op. cit. (11), 273n; and C. Webster, *The Great Instauration*, London, 1975, 431.

60 Sprat, op. cit. (1), 155–72.

61 Birch, op. cit. (1), i, 68, 79. Cf. 47.

62 Extracted from Egerton MS 2395, fol. 297.

However, the implication – not least of the instruction concerning the copy for Boyle – is that the document soon became much more elaborate than this, which makes its loss all the more regrettable. The matter arose again in the summer of 1664, when one of the series of committees that the society rather ambitiously set up at that time, that for 'Correspondence', chaired by Thomas Povey, was ordered to 'consider of drawing up both general and particular heads of inquiries for all the parts of the world'.[63] At its meeting on 19 August 1664, 'Some Generall inquiries, to be sent into all the parts of the world, being red, it was ordered, that the Secretary take care to have them transcribed, and reviewed by some of this Committee, as Sir R. Moray, Dr Wilkins.'[64] However, the Correspondence Committee ceased to meet after 23 September that year, and thereafter nothing further is heard of the matter.

What was Boyle's role in relation to all this? Though, as we have seen, he, with Brouncker, was responsible for the very first document of this kind, the inquiries for Teneriffe produced in January 1661, this was in response to a corporate initiative, and the impression one forms from the society's minutes in these early years is that Boyle's role was a passive rather than an active one in this regard, even concerning the 'general inquiries' whose conception prefigured the famous series with which his name was to be associated. Thus, even if the instruction that he should be given a copy of these in April 1662 was complied with, there is no sequel in the minutes implying that Boyle did anything about it. Similarly, when such matters arose again in the summer of 1664, Boyle was asked for suggestions for inquiries for Guinea but failed to produce any, while, although he was a member of the Correspondence Committee, he was absent from the meeting when the question of general 'inquiries' was discussed.[65] In a letter of 25 August Henry Oldenburg informed him,

> we were sorry to be without you, and without your Queries for Guiny. In the mean time, Generall inquiries were drawn up, serving for all the parts of the world; and Authors were distributed amongst the members of this Committee, to be perused for the collecting thence particular inquiries for particular countries.[66]

Boyle's response ignored the matter, while there is also no evidence of his interest in the agricultural inquiries produced at this time by the Georgical Committee, of which Oldenburg sent Boyle a copy in his letter of 1 September, again illustrating that Boyle was peripheral to such initiatives at this point.[67]

Yet within the next eighteen months, Boyle's interest in the genre seems to have been aroused, and it may not be coincidental that this was just the time when *Cold* was being prepared for publication and he evidently came to see the value of 'heads' for the various purposes that have already been itemized. The context in which he produced his 'General Heads' was the revival of the society's activities in the early months of 1666 after the intermission caused by the plague, when Oldenburg's letters to Boyle

63 Birch, op. cit. (1), i, 456. For the committees see ibid., 397, 402–3, 406–7.
64 Hunter, op. cit. (11), 120. Cf. ibid. 93, 118–20.
65 Birch, op. cit. (1), i, 454; Hunter, op. cit. (11), 118–20.
66 Boyle, op. cit. (34), ii, 302.
67 Boyle, op. cit. (34), ii, 307–9, 313–14.

repeatedly badger him for material of this kind. In a letter of 27 January he asked for such guidance that he could publish, reiterating in a letter of 24 February how 'whatever Inquiries you can spare, whether about Insects, or other parts of Natural History, all will be exceeding welcome', and repeating on 6 March, 'what other Inquiries about Naturall things you have ready, and shall think fit to communicate to me for forrain parts, I shall take more than ordinary care to recommend'.[68] Suddenly, in a letter of 21 March, Boyle responded by sending the 'General Heads' to Oldenburg, explaining,

> It belongs to one of the essays of the unpublished part of the Usefulness, &c. and therefore possibly may not so much answer your expectation, as if it had been written entirely for your purpose. But perhaps too, it may serve your turn pretty well, especially with a little addition, which if you make use of it, I can afford it. I have somewhere some specimens of particular enquiries, subordinated to some of the more principal articles of inquisition, which I shall scarce take the pains to look out, till I know, whether the paper I now send may be of use to you. If you have occasion to take any publick notice of it, be pleased to intimate to what treatise it belongs.[69]

The 'General Heads' were published by Oldenburg in issue 11 of *Philosophical Transactions*, dated 2 April 1666.[70] Subsequently, they were followed in issues 18 and 19 in November that year by Boyle's 'Other Inquiries concerning the Sea' and his 'Articles of Inquiries touching *Mines*', which were evidently the 'specimens of particular enquiries' to which he referred in his covering letter to Oldenburg.[71] In publishing these items, Oldenburg capitalized on Boyle's illustrious name, explaining how they had been communicated by 'that lately named *Benefactour to Experimental Philosophy*', and hence drawing on the kudos associated with Boyle of which he and other protagonists of the society made so much. As he put it, alluding to their putative overseas audience in a letter to Boyle of 24 March 1666, 'I know, they will be much pleased and sett on by those comprehensive *Generall Queries*, you give me leave to enrich the next Transactions with.'[72]

But what can one say about their origins, particularly in the light of Boyle's statement in his covering letter about their belonging to a putative essay for *The Usefulness of Natural Philosophy*? This is not wholly implausible, in that we know that *Usefulness* was going to contain a number of essays that were never published, some of which no longer survive and are known only by lists of contents that Boyle drew up. It seems likely that the essay in question was one of these, namely the original sixth essay proposed for the second 'Tome' of the book in a synopsis dated 1666, 'That the Naturalist may much advantage Men by exciteing & assisting their Curiosity to discover, take notice, & make use of their homebred Riches & advantages of particular Countrys, & to increase their Number, (by transferring thither those of

68 Boyle, op. cit. (34), iii, 46, 80, 91. Oldenburg also wished Boyle to add his suggestions for the set of queries sent at this time to Hevelius. See also ibid., iii, 81, 108–9.

69 Boyle, op. cit. (34), iii, 118. He apologized that 'my haste' had made him forget to send it previously as intended. He also responded to the request for additions to the queries to Hevelius; ibid., iii, 117–8.

70 Boyle, op. cit. (10), v, 508–11. They were then read out at a meeting of the society on 9 May; Birch, op. cit. (1), ii, 89.

71 Boyle, op. cit. (10), v, 527–8, 529–40; see note 69 above.

72 Boyle, op. cit. (34), iii, 126.

others).'[73] Its date is unclear; much of *Usefulness* was written in the 1650s, but some parts dated from the 1660s. If Boyle's composition of this section did precede the Royal Society's initiatives in drawing up such queries, it seems strange that he had not offered this contribution earlier. On the other hand, it is equally likely that this development occurred in parallel with the Royal Society initiative, in connection with another activity in which Boyle was involved at this time, as a member of the Council for Foreign Plantations, to which he was appointed on 1 December 1660. In his autobiographical notes dictated to Gilbert Burnet around 1680, Boyle stated that 'He was of the Committee of forreigne Plantations and in that set himselfe much to know the Natural History of those Countries for which he drew a Paper of Queries'.[74] Since Thomas Povey was very much the guiding force behind the setting up of the council, it is interesting how closely the queries which he sent to Edward Digges in March 1661 echoed the ethos of Boyle's putative essay for *Usefulness*, in their stress on 'those severall kind of things which are reported to be in Virginia & the Bermudas, not found in England'.[75] Possibly Boyle was the mastermind behind both, but it is equally likely that – on this as on other occasions – he claimed the credit for an initiative which was really a shared one.

In fact, it may be argued that these sets of inquiries represent a kind of synergy between Boyle and the Royal Society. In their origins and conception, they unmistakably belong to the Baconian-inspired programme of information-gathering that was so central to the society's agenda in its earliest years. Yet Boyle's enthusiasm for the genre, once he had discovered it, is patent. Indeed, there are two pieces of evidence which suggest that, once he had developed his enthusiasm for 'heads', Boyle may have been less than fully frank about what had inspired it. One is a comment that he made when sending a copy of the sequel to the 'General Heads', in the form of his 'Articles of Inquiry touching *Mines*', to John Locke on 2 June 1666. In this letter he alluded to these 'Articles' by a vague formula not dissimilar to that used of the original series in his covering letter to Oldenburg, as a document 'which I once drew up, for the use of some freinds & partly for my owne'.[76] In fact, a heavily revised draft of the published text survives in the hand of an amanuensis who worked for Boyle in the 1660s, and it seems likely that the document in question was of relatively recent composition, notwithstanding the implication of this comment that this was an older text that he had serendipitously come across.[77] It is hard to avoid the suspicion that in this case, as on other occasions, Boyle was deliberately implying that he had long been interested in such things as a means to avoid admitting the extent to which he had been the subject of an external stimulus.

More significant still is an intriguing piece of evidence that Oldenburg did not see the 'General Heads' as so sacrosanct a work by Boyle that it was inappropriate for him to

73 Boyle, op. cit. (10), xiii, p. lxx.

74 M. Hunter (ed.), *Robert Boyle by Himself and His Friends*, London, 1994, 27.

75 See C. M. Andrews, *British Committees, Commissions and Councils of Trade and Plantations, 1622–75*, Baltimore, 1908; repr. New York, 1970, Chapter 4; Egerton MS 2395, fol. 297.

76 Boyle, op. cit. (34), iii, 164.

77 BP 38, fols. 1–5; see Boyle, op. cit. (10), x, pp. xxxiv–xxxv, 529–40.

tamper with it – thus implying a sense of ambivalence between the document's being a work by Boyle and the outcome of a more general Royal Society initiative. In 1669 Oldenburg accompanied 'Particular Inquiries for Turky' that he prepared for the English representative at Scanderoon (now Iskenderun) with a manuscript version of the 'General Heads' which is significantly reorganized and clarified compared with the printed version: various unnecessary complexities are omitted, while certain topics are moved from one heading to another where they fitted better.[78] In many respects its simpler and more logical structure represents an improvement on Boyle's slightly repetitious and digressive original, perhaps indicating the extent to which Oldenburg felt that he knew as well as Boyle what the content of the document should be.[79]

In general, however, it was Boyle's own version which was given wide circulation through its publication in print in *Philosophical Transactions* in 1666, and it achieved an extraordinary longevity. First, it was reprinted in 1692 in a volume comprising this and other questionnaires from the early volumes of *Philosophical Transactions* which was given an overall title echoing Boyle's, *General Heads for the Natural History of a Country, Great or Small*. Indeed, in this instance, the publisher attributed the whole book to Boyle on its title page, notwithstanding the fact that it really reflected the corporate activity of the Royal Society in this respect, including material by such authors as Lawrence Rooke, Thomas Henshaw, Sir John Hoskins, Charles Howard and Oldenburg.[80] Thereafter, versions of Boyle's 'General Heads' continued to appear in an almost emblematic position in collections of travel writings into the eighteenth century, for instance in Jean-François Bernard's *Receuil des voyages au nord* of 1715–27.[81] This has often and rightly been seen as a tribute to Boyle's influence on the development of natural history in the eighteenth century, but it is proper to acknowledge the extent to which Boyle might never have gone down this route but for the influence of the Royal Society.[82]

78 Cl. P. 19, 43 (1). See Appendix. In addition, questions concerning the tides were added to Section 2 from Rooke's 'Directions for Sea-men': see note 59 above. The attached 'Particular Inquiries for Turky' are endorsed: 'The Inquiries of this paper were recommended to Mr Martyn Lo, Consul (or Vice-Consul) of Scanderoon, who promised to give a fair account to them, Octob. 18. 1669. in London.' For the recipient, Martin Loe, see *HMC Finch I*, 238.

79 A further relevant piece of evidence has come to light in Robert Hooke's annotated transcript of the minutes of the Royal Society from 1661 to 1677, part of the 'Hooke Folio' sold to the Royal Society by Bonham's on 28 March 2006. Where the minutes record that Boyle's 'General Heads' were read out on 9 May 1666, Hooke has noted, 'Stoln from me.' In fact, no directly comparable text of Hooke's survives, though his 'General Scheme' does list topics for 'particular Histories of the several parts of the World' (Hooke, *Posthumous Works*, op. cit. (49), 22–3). Here we evidently see Hooke's notorious possessiveness at work in relation to ideas which were in fact widely shared in the early Royal Society.

80 See Boyle, op. cit. (10), x, pp. xli–xlv. In this connection it is interesting that it was to Boyle that John Houghton attributed the society's agricultural inquiries when he reprinted them in *A Collection of Letters for the Improvement of Husbandry and Trade*, 2 vols., London, 1681–3, ii, 81–2 (alluding to *Collection*, i, 6–9).

81 J.-F. Bernard (ed.), *Receuil des voyages au nord*, 8 vols., Amsterdam, 1715–27, i, 2–5; iv, p. lxii.

82 See e.g. P. J. Marshall and G. Williams, *The Great Man of Mankind*, London, 1982, 45; A. Guerrini, *Natural History and the New World, 1524–1770*, Philadelphia, 1986, 5; C. Withers, 'Geography, science and national identity in early modern Britain: the case of Scotland and the work of Sir Robert Sibbald', *Annals of Science* (1996), **53**, 29–73, 63; R. Drayton, *Nature's Government: Science, Imperial Britain and the 'Improvement' of the World*, New Haven, CT, 2000, 17.

Once launched, the genre of 'inquiries' popularized as a result of these activities by Boyle and the Royal Society in the 1660s became more widespread. From the 1670s onwards we encounter a whole series of specially printed 'inquiries' issued as separate broadsheets which, as various scholars have noted, played a significant role in the natural philosophical (and antiquarian) enterprise of the period.[83] Thus the publisher John Ogilby issued *Queries in Order to the Description of Britannia* in 1673, and Robert Plot, first curator of the Ashmolean and author of *The Natural History of Oxfordshire* and of *Staffordshire*, brought out two such sets of printed inquiries in 1674 and 1679.[84] Plot was followed by his successor at the Ashmolean, Edward Lhwyd, whose *Parochial Queries* for Wales appeared in 1696, by which time the practice had spread to Ireland in the hands of William Molyneux and to Scotland in the hands first of Sir Robert Sibbald and then of Robert Wodrow.[85] Meanwhile, in England, we find such publications of a similar type as John Woodward's *Brief Instructions for Making Observations in All Parts of the World*, issued under the imprimatur of the Royal Society in 1696.[86] In some cases, we have sets of the responses which such queries elicited, and as a whole the genre cries out for a full study in its own right.[87]

In conclusion, however, it is appropriate to revert to Boyle. What I hope that I have established here is that the Baconian genre of 'heads', which was subsequently to prove so central to Boyle's natural-philosophical method, came into his corpus at a specific point, in the 1660s, and that by far the likeliest stimulus to this was the influence of the Royal Society, in whose early corporate activity the compilation of comparable documents played such a central role. This is symptomatic of a more general need to look beyond Boyle's own oeuvre in order properly to understand him. Another instance of this, also involving the Royal Society, is provided by Boyle's novel practice in the early 1670s of publishing his writings in the form of brief 'Tracts', which was almost certainly inspired by his experience of publishing in *Philosophical Transactions* in the 1660s.[88] Again, this is something that one can only divine by observing a shift in Boyle's behaviour and seeking a plausible explanation for it in his milieu. In the case of the

83 See, for instance, Withers, op. cit. (82); M. Hunter, *John Aubrey and the Realm of Learning*, London, 1975, 71–2; S. A. E. Mendyk, *Speculum Britanniae*, Toronto, 1989, Chapter 11; D. Woolf, *The Social Circulation of the Past*, Oxford, 2003, 159.

84 A copy of the earlier set of Plot's inquiries will be found in Cl. P. 19, 93, and of the revised set in ibid., 94; the latter is appended to P. Minet's 1972 reprint of Plot's *Natural History of Oxfordshire* (Chicheley, Bucks).

85 K. T. Hoppen, *The Common Scientist in the Seventeenth Century*, London, 1970, 21–3, 200–1; Withers, op. cit. (82), 66–73; M. Hunter, *The Occult Laboratory: Magic, Science and Second Sight in Late Seventeenth-Century Scotland*, Woodbridge, 2001, 23ff.

86 Reprinted, with intro. by V. A. Eyles, London, 1973.

87 See especially *Parochialia, Being a Summary of Answers to 'Parochial Queries … issued by Edward Lhwyd'* (ed. R. H. Morris), 3 supplementary volumes to *Archaeologia Cambrensis*, 1909–11. For the responses to Molyneux's enquiries see Hoppen, op. cit. (85), 234 n. 101; for Scotland, see the references cited in n. 85. For a valuable study of the genre see Adam Fox, 'Parochial queries: science, antiquarianism and ethnography in the British Isles, 1660–1700', forthcoming. I am grateful to Dr Fox for allowing me to read this prior to publication.

88 See Boyle, op. cit. (10), i, pp. xxxvi–xxxviii.

'heads' and 'inquiries' on which I have focused here, one sees a revealing reciprocity, which is all the more significant because of the influence enjoyed by the genre for which Boyle and the Royal Society were jointly responsible. But there is also a broader lesson concerning the relationship between biography and institutional history. No man is an island; even Boyle, for all his self-preoccupation, took lessons from his peers. The challenge is to integrate the subject with his setting, and the result is to enrich our understanding of both.

Appendix

Text of Oldenburg's version of Boyle's 'General Heads' (Classified Papers 19, 43 (1))[89]

General Heads of Inquiries For all Countries

1. Concerning the *Air*;
   What is the usual salubrity and insalubrity of the Air?
   What diseases the Country is most subject to?
   What are the Variations of the Weather, according to the Seasons of the year, and the times of the day? And what Duration the severerall [*sic*] kinds of Weather usually have?
   What Meteors it is most wont to breed; especially, what Winds it is subject to; whether any of them be stated and ordinary etc.?

2. About the *Water*;
   What is the Depth of the *Sea*, its degree of Saltnes,[90] Currents, Tydes? And, as to the Tydes, what is their precise Time of Ebbing and Flowing in Rivers, at Promontories or Capes; which way their Current runs; what Perpendicular distance there is between the highest Tyde and lowest Ebbe, during the Spring-Tides and Neap-Tides? What are the degrees of the Risings and Fallings of the Water in *Equal* spaces of time and the *Velocity* of its motion at several heights? What day of the Moons age, and what times of the year, the highest and lowest Tides fall out etc.?
   For *Rivers*; What is their bignes, Length, Course, Inundations, Goodnes, Levity of waters?
   For *Lakes, Ponds, Springs*, and especially Mineral waters, their kinds, Qualities, Vertues, and how examined?
   For all sorts of Waters; what kinds of *Fishes* they breed; their store, bignes, goodnes, seasons, haunts, peculiarities of any kind, and the ways of taking them?

3. About the *Earth*;
   [91]Whether <the Country be> plain, or mountanous, or both? If montanous, what is the height of the tallest mountains? Whether they lye scatter'd, or in

89 This is fol. 83 of the volume; the conjugate leaf, fol. 84, comprises 'Particular Inquiries for Turky': see note 78 above. The transcription follows the principles expounded in Hunter, op. cit. (30), p. xvi.

90 Followed by 'Tydes' deleted. Six words later, 'the' inserted between words after composition.

91 Preceded by 'As to its Figure' deleted.

ridges; and whether those run North and South, or East and West etc? What Promontories, /verso/ fiery or smoaking Hills the Contry has or hath not?
What the Magneticall Declination is in several places, and the Variation of that declination in the same place?
What the nature of the Soyle is, whether Clayie,[92] Sandy, etc. or good Mould? And what Grains, fruits and other vegetables doe the most naturally agree with it; and especially, what Fruit- and Timber-trees,[93] and what other Trees, whose wood is considerable, the Contry has or wants? By what particular Arts and Industries[94] the Inhabitants improve the advantages, and remedy the Inconveniences of their Soyle?
What *Animals* the Contry has or wants, both wild and tame? And as to the Inhabitants, Men and Woemen, What is their Stature, Shape, Colour, Features, Strength, Agility, Beauty, Dyet, Inclinations? What the Fruitfulnes or Barrenes, hard or easy Labour of the Woemen etc?
What Minerals the Contry is stored with? What Quarries it affords; and the particular conditions both of the Quarries and the Stones; as also, how the Beds of Stone lye, in reference to North and South etc? What Clays and Earths it affords, as Tobacco-pipe Clay, Marles, Fullers-earths, Earths for Potters-wares, Bolus's and other Medicated Earths? What other[95] Minerals it yields, as Coals, Salt-mines, or Salt-springs, Allom, Vitriol, Sulphur etc? What mettals[96] it affords; and a description of the Mines, their number, situation, depth, signs, waters, damps, quantities of ore, goodnes of ore, the ways of reducing their oares into mettals etc?

Adde hereunto the Names of the Men, excelling at the present in Philosophicall, Mathematicall, Mechanicall, Medicall and Chymicall knowledge, together with the Books, they have published or shall[97] publish from time to time.

92 Altered from 'Clays'. The next word, 'Sandy', is altered from 'Sands'.
93 Followed by '(esp' deleted.
94 Followed by 'impro' deleted.
95 Followed by 'What' deleted, evidently when 'What other' inserted at end of previous line.
96 Followed by 'the' deleted.
97 Altered from 'are' and followed by 'now' deleted. The next word, 'publish', is altered from 'publishing'. This paragraph was added to the text after composition in darker ink.