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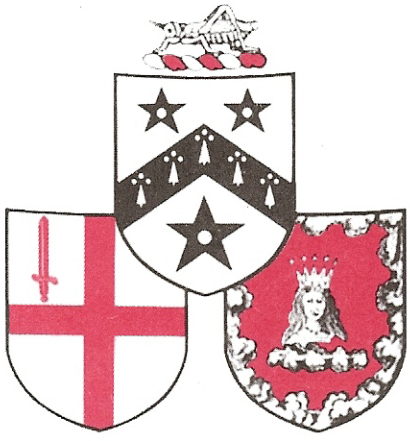

ROBERT HOOKE, LONDON'S LEONARDO

Lecture 4

HOOKE AS SPECULATIVE PHILOSOPHER

by

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Hooke as Speculative Philosopher

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I take up where the previous lecturers have left off, to discuss Hooke's achievement as a thinker - a theoretician of science as much as a practitioner of it. Of course, this overlaps with what Jim Bennett said last week, since, as Jim made clear, the use of instruments was central to Hooke's science. It also has resonances with Mike Cooper's theme of Hooke as an employee, in ways that will soon become apparent. But I want to complement their presentations by trying to do justice to Hooke as a natural philosopher in the fullest sense of that word, a man who produced endless speculations about the nature of the universe, and who also theorized in an interesting way about the method of science.

My starting point is the unpublished manuscript text of a Cutlerian lecture that Hooke delivered on 26 June 1689. In it, Hooke demonstrated and commented on a strange phenomenon, the effect that resulted when two liquids – water and concentrated sulphuric acid - were mixed, 'which immediately produced a considerable Degree of Heat'.

The lecture has three characteristics to which I wish to draw attention. Firstly, having outlined the phenomenon, Hooke went on to complain that his initial discovery of it many years previously had been plagiarised, in this case by the physiologist, John Mayow. This formed part of a more general gripe on his part about how his ideas 'have had the misfortune either not to be understood by some <who have asserted I have done nothing> or to be misunderstood or misconstrued (for what ends I <now> inquire not) by others... And though many of those things I here first Discovered could not find acceptance. Yet I finde there are not wanting some who pride themselves in the arrogating of them <for> their own'.Comparable complaints recur in many such lectures, not least concerning Hooke's arch-enemy, Newton, and 'those proprietys of Gravity, which I myself first Discovered and shewed to this Society many years since, which of late Mr Newton has done me the favour to print and Publish as his own Inventions'.[1] Indeed, it is impossible to avoid the issues of intellectual personality that arise in an acute form in a figure like Hooke, as epitomised by such complaints, and I will therefore end with some broad reflections on the dispute with Newton which has had such a blighting effect on Hooke's reputation.

The second striking characteristic of the lecture is its opening, which gives a memorable general account of Hooke's and the Royal Society's intellectual agenda in seven numbered points. The first was 'to define and Reduce to a <geometricall> certainty the Powers and effects <of naturall bodys> already in part known, by stating and limiting them And their proper extents according to

Number Weight and Measure. Or Els Secondly to Discover some new proprietys Qualifications or powers of Bodys not before taken notice of, by meanes whereof there might be Administred to an inquiring Naturalist A new medium or meanes to Discover the true essence and nature of that body Or third to invent and Exhibit some new artificiall ways and Instruments to inable such as should think fitt to use them, to make more curious and deeper searches into the nature of Bodys and their Operations'.

This illustrates Hooke's central role in the Royal Society in its formative years, that seminal institution founded in 1660 to champion the reform of natural philosophy by collaborative empirical enquiry. Arguably, as Curator of Experiments to the Society, Hooke did as much as anyone else to define the Society's scientific programme, and it was therefore appropriate that he should use his lectures to set out a systematic method for science. Yet there is a paradox here, since, for all the enthusiasm that Hooke showed for reforming knowledge by providing a solid basis of empirical data carefully collected and systematized, he was also endlessly fertile in coming up with explanations of how the world worked, often of quite a speculative nature, and the urge to explain sometimes outran its empirical basis.

The third point about this lecture is that Hooke's manuscript of it survives. This introduces an important point to be made about the material on which I will be basing my talk, which also has implications for Hooke's intellectual personality. It may sound paradoxical to say this, since Hooke has some famous books to his credit, notably Micrographia, but a case can be made for seeing Hooke as a rather reluctant author, who never produced a book unless he had a good reason for doing so. There is no case of his spontaneously tossing off a book almost for the sake of it, as might seem to be the case with his mentor, Robert Boyle, who brought out over forty books in the course of his career, with no 'career' incentives to do so. Neither did Hooke ever produce a systematic treatise on natural philosophy as found in authors like Descartes or Newton; even Hook's most systematic work, Micrographia, represents something of a rag bag by comparison, and the rest of his writings are more haphazard still.

In fact, virtually all Hooke's writings relate to his contractual obligations, as Curator of Experiments to the Royal Society, as Gresham Professor of Geometry and as Cutlerian Lecturer, in other words, the post he held from 1664 until his death, paid for by the endowment of Sir John Cutler. Micrographia was commissioned by the Royal Society to show-case the approach to science that the new society championed, and it is doubtful whether, without this stimulus, Hooke would ever have published it. The series of Lectiones Cutlerianae, published in the 1670s and collected together under this title in 1679, was almost certainly intended to shame his patron, Sir John Cutler, into paying the arrears in his salary. After he had succeeded in that aim, Hooke never again published a book. On the other hand, his contractual obligations did lead him to leave a lot of writings in manuscript, in that he seems to have kept large numbers of lectures written out as delivered, often endorsed with a note of the the date on which they were delivered and the names of those who were in attendance on that occasion. It was because of this that Richard Waller was able to publish large numbers of these lectures in his edition of Hooke's Posthumous Works; to a lesser extent, the same applies to

Derham's collection of Hooke's Philosophical Experiments and Observations.

In the period of his life prior to his entering into these obligations, virtually no writings by Hooke survive, either in manuscript or printed form: the only exception to this is his Attempt for the Explication Of the Phænomena, Observable in an Experiment Published by the Honourable Robert Boyle Esq. of 1661, which in a sense proves the rule because of its obviously career-advancing role. Otherwise, we are much in the dark about the formative periods of Hooke's intellectual evolution, frustratingly dependent on the little scraps of information in retrospective biographies of him by Aubrey and Waller.

Reverting to the unpublished lecture with which I started, the statement of general principles with which it opens is typical of the Cutlerian lectures, reflecting one of the purposes to which Hooke put them. Initially, Cutler seems to have wanted them to be about the History of Trades, in other words, the description of craft practices which was central to the early ambitions of the Royal Society, and it seems that Hooke did actually give a couple of lectures on the history of trades, one dealing with salt-making in Hampshire, the other with the felt-maker's trade. But thereafter, the lectures reflected the rather different rubric of 'the history of nature and art' which the Royal Society gave them, and this enabled Hooke either to talk on all sorts of aspects of the natural world, or on instruments which would enhance our accurate understanding of nature. But Hooke also seems to have felt it appropriate to talk about the proper procedures for conducting scientific research, and it seems that Hooke's seminal work on this topic, A General Scheme, or Idea Of the Present State of Natural Philosophy, published in Waller's edition of the Posthumous Works, can be traced to his lectures on the Cutlerian foundation.

This text is important, because it illustrates Hooke's position in the science of the day. As its full title illustrates, it sees the remedy to the 'defects' of the 'Present State of Natural Philosophy' as being 'to Compile a Natural History', and Hooke here echoes Francis Bacon, the early Stuart statesman and philosopher who had outlined a programme for the reform of knowledge in his book The Great Instauration. Basically, Bacon argued that existing ideas about the workings of nature suffered from a premature pursuit of generalisation on the basis of inadequate data, which resulted in 'disputes and scrappy controversies': he thus gave expression to the dissatisfaction with the science of the 'schools', of the universities dominated by the ideas of the ancient Greek philosopher, Aristotle, which was widespread in his period.

Bacon's remedy was to replace the scholastic use of deductive, syllogistic reasoning by the use of induction based on the compilation of factual 'natural histories'; it was on the basis of these that broader conclusions might be reached. Hooke reiterated this programme in reinvigorated form for his Restoration audience, echoing Bacon's famous metaphor of the four 'idols' of the human mind which needed to be eradicated, and going far beyond Bacon in his insistence that many of the shortcomings of the senses could be rectified by the use of instruments, for example instancing an instrument for measuring the velocity of falling bodies that he had demonstrated to the Royal Society in 1663. He also followed Bacon in advocating that it was imperative that data should be recorded

as systematically as possible, giving an elaborate tabulation of data about natural phenomena, comprising a very general classification of the visible world, both terrestrial and celestial, and then each component within that, of which 'Histories' needed to be compiled. Indeed, in this respect, he has claims to be considered one of the most systematic theorists of science of his age.

All this was intended as a template for data-collecting, which Hooke saw as a co-operative venture, well-suited to a body like the Royal Society. This is seen, for instance, in his scheme for compiling a History of the Weather that was published in Thomas Sprat's History of the Royal Society (1667). Yet, for all Hooke's stress on the importance of compiling accurate data in the form of a natural history, it is important to differentiate him from a tradition in interpretaing Bacon which was prevalent in the early Royal Society, which naively disavowed speculation 'before the Histories of Art and Nature are compleatly done'; this is seen not least in Sprat's book. Even as significant a figure as the philosopher, John Locke, took a strongly anti-hypotheticalist line in natural philosophy, believing that the compilation of descriptive natural histories was the highest appropriate goal and that speculation was out of order.

Hooke, on the other hand, disagreed, and in this he seems to have been a truer follower of Bacon than his rivals. He presumed that among 'the Requisites in a Natural Historian' was an alertness to hypotheses, which should be kept in mind while making enquiries, thus assisting 'in discovering and searching into the true causes of things'. In addition, Hooke seems to have gone beyond Bacon in attempting to formulate a systematic method for formulating hypotheses, which he described as his 'Philosophical Algebra', apparently a method of tabulating alternative explanations of a phenomenon which enabled alternatives to be eliminated until only one correct answer remained – though, since only hints survive of exactly what he had in mind, scholars have debated about exactly what was involved.

The tension between hypotheticalism and empiricism that I have sketched is important for understanding Micrographia. In many ways, although Hooke is named as the author of this work, it was perceived as a Royal Society venture, as was reinforced by its presentation. Thus the fact that Hooke was an FRS was stated both on the title-page and in the official (Royal Society) imprimatur that faced it, while the title-page prominently bore the Society's coat of arms, and after the Epistle Dedicatory to the King, Hooke included a second dedication 'To the Royal Society'. Moreover, the book did indeed show-case the work that Hooke had done at the Royal Society's behest. Apart from anything else, it show-cased instruments, as we have already heard from Jim Bennett: even within the preface, various instruments are described, and others are referred to thereafter, such as thermometers, hygroscopes or telescopes. And of course, among instruments, its whole raison d'etre was to illustrate the findings of the microscope. Clearly the background to this is the Royal Society's sense of defensiveness in its early years, its need to prove itself against those who said, 'What have they done?' The publication of the findings of the Society's Curator of Experiments might well have seemed a perfect way of vindicating the Society.

For these purposes, the ostensible subject-matter of Micrographia was ideal -

namely its detailed and surprising revelations about the intricacy of what might be called the micro-world that surrounds us. Indeed, this is precisely what Hooke made a point of at the start of the book, illustrating how the point of a needle was really blunt, and how a 'point' in typography was a great smudge. Thereafter, a good deal of the book, and the aspect of it that is most familiar to readers in retrospect, is its exposition of a series of microscopic observations illustrating the intricacy of nature. Thus we have Hooke's famous examination of the composition of Kettering stone and other stones; of cork and mould; of the stinging nettle; and, perhaps above all, of various insects, including the well-known large-scale plates of the flea and the louse. In each case, Hooke lays out precise observations which arguably were the quintessence of the empiricism which the Royal Society championed.

On the other hand, the part of the book devoted to relatively straightforward microscopic observations really starts only about halfway through, whereas the early part is dominated by a number of sustained passages in which Hooke set out theories about natural phenomena, while such disquisitions also recur at the end of the book. Indeed, for all its role as a manifesto for the careful empirical policy of the Royal Society, the book is far from restricted to a descriptive level. Hooke is constantly probing at why things are as they are. Thus he invoked 'the variety of reflection' as the reason 'why a small breez or gale of wind ruffling the surface of a smooth water, makes it appear black', offering as 'a very probable (at least, if not the true) cause or of the hardening or tempering of steel' the greater or lesser 'proportion of a vitrified Substance interspersed through the pores of the Steel'. Again and again he begins an excursus by explaining how 'The reason of which odd Phænomenon seems no other than this', elsewhere using the phrase, 'this seems also to be the reason why', to introduce a further, subsidiary line of speculation.

This raises some interesting questions as to what Hooke thought that he was doing in the book, and what his Royal Society masters thought he was doing. It does seem as if the book caused the Society some unease, since, when it was granted its imprimatur, Hooke was ordered to state 'that though they have licensed it, yet they own no theory, nor will be thought to do so: and that the several hypotheses and theories laid down by him therein, are not delivered as certainties, but as conjectures; and that he intends not at all to obtrude or expose them to the world as the opinion of the society. This reflects the tension between Hooke's sophisticated blend of natural history and hypotheticalism and the more naive strand of Baconianism in the Royal Society to which I have already alluded. Perhaps, since the book was published, one should see the imprimatur as a kind of 'health warning' to a book that many early Fellows nevertheless found as stimulating as we do.

So what was the philosophy of nature that Hooke here puts forward? It was the mechanical philosophy, the view that all phenomena could be explained in terms of the simple interaction of matter and motion, which was increasingly prevalent among natural philosophers of his day. It was a system which offered an exhilaratingly simple alternative to the complicated theories of Aristotle, yet which offered endless potential for explaining phenomena in the world. In particular, Hooke's rigorous mechanism was inspired by the French philosopher, René

Descartes, the author to whom Hooke most frequently refers, and especially his Principia philosophiæ of 1644. Many of his citations are implicitly approving, but elsewhere, Hooke shows himself critical of Descartes in a way that is typical of English scientists in his period; they found him too hypothetical, content with plausible explanations which were never tested or assessed. In a crucial passage in observation 8, Hooke criticised 'the most Acute Des Cartes' for not having 'applied himself experimentally' to a phenomenon; had he done so, 'he would certainly have a little altered his Hypothesis'.

In his recourse to 'experiment' as the ultimate authority, Hooke resembled his former employer, Robert Boyle, the father of the modern, controlled experiment, for whom he had constructed and operated his famous air-pump. It is therefore appropriate that Hooke's earliest publication, An Attempt at the Explication of the Phenomenon (1661), which was subsequently expanded as one of the chief speculative sections of Micrographia, stemmed from Boyle's findings, in the form of his theory of 'congruity', which Hooke linked with the effects of motion on particles, which made them 'vibrate together in a kind of Harmony or unison'. Later in Micrographia, Hooke offers a further digression stemming from the pneumatic work that he had done with Boyle, in this case setting out the findings concerning the relationship between the volume and pressure of air that the two men had studied together using the celebrated J-tube, which Hooke used to consider the effect of altitude on air, particularly in relation to the refraction of light.

Hooke's speculations about heat and combustion in Micrographia similarly represented the development of ideas shared with Boyle, in this case more overtly critical of the ideas of Descartes. He argued that heat was a property of body arising from 'the motion or agitation of its parts' rather than from 'fire atoms', while later in the book, he presciently differentiated heat from combustion, which was 'made by a substance inherent, and mixt with the Air'. Indeed, here Hooke's ideas cross-fertilized mechanistic ideas with notions derived from the chemical tradition, ultimately stemming from the sixteenth-century iatrochemist, Paracelsus. This indicates the range of theories available at the time to those who were primarily empiricists, and who were dissatisfied with an unduly strict reading of the mechanical philosophy, not least in the circles at Oxford in which Hooke had moved in the 1650s. Paracelsus had postulated that there might be a nitrous substance in the air and Hooke took up this view, arguing that air was 'a kind of tincture or solution of terrestrial and aqueous particles', especially saline ones, and that it acted as a 'menstruum or dissolvent of all Sulphureous bodies' by virtue of 'a substance inherent, and mixt with the Air, that is like, if not the very same, with that which is fixt in Salt-Peter'.

There are also Hooke's speculations on light and colour, another topic on which, incidentally, his ideas resonated with Boyle's. In Hooke's case, his speculations stemmed from his observation of the irridescent colours seen in thin plates such as mother of pearl, the succession of colours in which he argued was produced by the combination of light reflected from the upper and lower surfaces. From this, he went on to attack Descartes' view of how white light was converted into coloured light, arguing that the primary colours were blue and red, of which the other colours are 'dilutions'. Ranging still more widely, Hooke put forward seminal

cosmological ideas, arguing that each primary planet and each satellite of a primary planet had its own gravitation, including the moon. Again, this was a significant critique of Descartes' views, in this case his vortex theory of heavenly motion, and particularly his view that the moon was embedded in the vortex of the earth and must draw its gravitation from that.

The last of the examples of the 'speculative' side of Micrographia that I want to instance comprises Hooke's views on petrifaction. In Observation 17, he argued against the view that fossils were 'Stones form'd by some extraordinary Plastick virtue latent in the Earth it self' on the basis of his microscopic observations of them. Instead, he asserted that they were 'the Shells of certain Shel-fishes, which, either by some Deluge, Inundation, Earthquake, or some such other means, came to be thrown to that place'. Here is the germ of the extensive geological writings that he was to produce later in his career.

Having used Micrographia at such length to illustrate the character of Hooke's science, I will pass very briefly over his later writings because, to a large extent, these further exemplify the themes to be found in Micrographia. For instance, in his De Potentia Restitutiva of 1678, not only did he divulge the law that bears his name, namely that 'the Power of any Spring is in the same proportion with the Tension thereof'; he also further developed the ideas about 'congruity' that had initially been set out in his 1661 tract and in Micrographia. As already noted, even Hooke's extensive geological writings, fascinating as they are, took up his speculations on such topics in Micrographia. Indeed, the series opens with a group of exquisite illustrations of fossils, analogous to the engravings in Micrographia, illustrating the intricacy and diversity of fossils by implicit analogy to the natural bodies illustrated in his earlier book. Essentially, as he had already stated in Micrographia, Hooke was reluctant to believe that fossils were artificial 'formed stones'. Instead, he argued that they were the remains of genuine natural bodies, often marine creatures which had been petrified and deposited deep in the earth by natural processes which it was possible to elucidate, notably earthquakes.

What should be clear even from this brief survey is the sheer range of Hooke's science, and the ingenuity that he brought to bear on every phenomenon that he studied. It will also be apparent that, in order to try to make sense of phenomena, he went beyond a strict interpretation of the mechanical philosophy to draw on the ideas of other traditions, including those of Paracelsus, which could be justified on the grounds that they made better sense of observed phenomena than did doctrinaire mechanism. Indeed, it has been argued that Hooke went so far beyond this that he challenges a strict definition of the mechanical philosophy, and that in fact he had much in common with the tradition of 'natural magic' that had flourished in the Middle Ages and in the Elizabethan period, dealing with phenomena that existed in nature but could not be explained according to the terms of reference of scholastic science. Indeed, the natural magical tradition has be seen as one of the sources of Hooke's combination of technical virtuosity, empiricism and eclecticism.

It is undoubtedly true that, for a mechanist, Hooke sometimes uses surprisingly non-mechanistic language - for instance, by using 'sympathy' and 'antipathy' as synonyms for 'congruity' and 'incongruity', or talking about the 'plastic virtue' of

nature, in both cases in Micrographia. Moreover, some of his notions had definite non-mechanical overtones, perhaps particularly the significance that he attached to 'harmony' in his views on the congruity of particles, his invocation of 'active principles' both in the animate and the inanimate creation, and his description of light and gravity as the 'Souls of the greater Bodies of the World'. To this extent the view of Hooke which has been put forward by John Henry and Penelope Gouk, is convincing. It certainly illustrates how we need a definition of the mechanical philosophy broad enough to encapsulate this, and suggests that an unduly strict demarcation between the mechanical and magical traditions in Hooke's period may be ill-advised.

Yet what needs to be emphasized in Hooke's case – and what is in danger of being obscured in the writings of such scholars – is that Hooke himself was consciously and explicitly anti-magical, associating magic with obfuscation and unintelligibility. Even when defending the reputation of the sixteenth-century natural magician, John Dee, in the rather unlikely setting of a Cutlerian lecture, he did so by arguing that the records of Dee's seances with angels were not the 'Rhapsody of incoherent and unintelligible Whimsies' that they seemed, but were written in code, on the grounds (in the words of the Royal Society's journal book) that Dee was 'a very extraordinary Knowing man of his time, and not to be supposed capable of such incoherent ridiculous fancies as are in appearance contained in that Book'. Equally revealing is an excursus in one of Hooke's Cutlerian Lectures of the 1670s, Lampas: or Descriptions of Some Mechanical Improvements of Lamps & Waterpoizes (1677), in which he took issue with the Cambridge Platonist, Henry More, criticising More's invocation of a so-called 'hylarchic spirit' to explain the hydraulic phenomena of which he had given an account, which he claimed were 'plainly and clearly performed by the common and known Rules of Mechanicks'. Mockingly noting that 'If it were a Spirit that Regulated the motion of the water in its running faster or slower, I am yet to learn by what Charm or Incantation I should be able to incite the Spirit to be less or more active', Hooke added: 'This Principle therefore at best tends to nothing but the discouraging Industry from searching into, and finding out the true causes of the Phenomena of nature: And incourages Ignorance and Superstition by perswading nothing more can be known, and that the Spirit will do what it pleases. He echoed this in his 'Discourse of the Nature of Comets', where he contrasted the kind of explanations that he furnished with supernaturalist ones in terms of the influence of angels or devils, which he condemned as 'the Subterfuge of Ignorance, and the want of Industry'. Hooke's stress was always on clarity and intelligibility.

Yet, despite Hooke's overt rejection of magic, I think that it is possible to see him as having something in common with the 'natural magical' tradition, and particularly its tantalising promise to be able to achieve the ostensibly impossible. It is almost as if Hooke had effected the transition from magician to modern physicist in the way in which he played on the partial revelation of amazing truths about nature to which he claimed that he was privy. A case in point is provided by the possibility of human flight, which had been a traditional ambition for natural magicians. Hooke claimed to have invented thirty ways of flying while still at Westminster, and he pursued this under the aegis of John Wilkins at Oxford: indeed, the possibility of flight was tantalisingly hinted at in Micrographia.

Thereafter, this trope recurs in his Diary, for instance on 8 October 1674, when he 'told Sir Robert Southwell that I could fly, not how', while on 11 February the following year there was a whole discussion on the topic at a meeting of the Royal Society, and Hooke 'intimated, that there was a way, which he knew, to produce strength, so as to give to one man the strength of ten or twenty men or more, and to contrive muscles for him of an equivalent strength to those of birds'. It is plain from such details as Hooke gave that he was thinking of a mechanical, naturalistic method of achieving human flight. Yet the very way in which he only partially divulged what he had in mind preserved something of the mystique which magicians had long enjoyed, leaving the whole thing titillating and vague.

In closing, and trying to assess Hooke's intellectual personality as a whole, flying presents a good example of one of Hooke's chief intellectual characteristics. For this is a topic on which he never wrote a treatise in which he worked out his ideas in full. Waller tells us that some papers of Hooke's on the subject survived in his time, 'but so imperfect, that I do not judge them fit for the Publick'. Evidently, nothing was ever worked out in full, and this failure to carry things through was typical of Hooke's work more generally. Of course, Hooke occasionally dealt with things systematically, thus exemplifying the exemplary method laid out in the General Scheme which I outlined earlier - a case in point would be his geology lectures, as studied by David Oldroyd. But more often he did not, instead taking an almost capricious line regarding what was possible or achieveable. Things were made worse by the extent to which Hooke's endless speculativeness made him slightly elusive about what he could explain or invent, intriguing his audience with tantalising ideas which he never fully worked out. Thus in Micrographia, he often writes'Which Explication I could easily prove had I time; but this is not a fit place for it', combining this with a grandiloquence about his claims to originality which was also potentially problematic, as where he states that from an experiment of his 'we may learn, that which has not, that I know of, been publish'd or hinted, nay, not so much as thought of, by any'.

In many respects Micrographia gives a portrait of Hooke in his heyday, revelling in his sheer fecundity of invention and his ability to come up with brilliant ideas at every turn, whether or not he ever had time to work them out. Moreover, it could be argued that this was a well suited to the kind of performative role that Hooke played at the Royal Society, where the premium was on titillation and the expectation of great things that might be achieved, and where, so long as the audience was satisfied, the systematic working-out of ideas could be postponed or delegated to collaborative effort of the kind advocated in his General Scheme. To have witnessed Hooke in action at meetings of the Royal Society must have been truly exciting, giving an exhilarating sense of being in the presence of genius ever on the verge of a break-through.

If Hooke had been happy simply to continue his stream of ingenious speculations, often leaving them to others to carry through, all might have been well. But unfortunately he was not. For he also partook of a strong possessiveness about his ideas, along with other natural philosophers of the day. Indeed, there was a paradoxical contradiction between the Baconian ethos of collaboration and co-operative endeavour to which these men paid lip-service, and their actual insistence on intellectual copyright. This was true not least of Boyle, who was

extremely prone to accuse others of plagiarising his ideas. Hooke, as he grew older, similarly expected a proper deference for his ingenuity and achievement, and here a problem was created by the habit of leaving investigations unfinished and unpublished – if not unrecorded – that had been encouraged by his role and intellectual style. Indeed, if it had not been for the contractual obligations already referred to, he would have written down even less still, and it is revealing how often, in his later priority disputes, he was to appeal to the Royal Society's records as the place where a written account of his achievements ought to be available.

Things were made worse by another of Hooke's intellectual traits, his presumption of his undisputed brilliance, which made him ill-equipped to handle the arrival on the scene of someone equally, if not more, brilliant than him, in the form of Newton. The way in which this made him intolerant of others' ideas is clear from his initial exchange with Newton over his celebrated paper on colours, published in Philosophical Transactions in 1672. Though it did not help that (as Hooke was to complain retropectively) 'I had not above three or 4 hours time for the perusall of Mr Newtons paper and the writing my answer', it is nonetheless revealing that Hooke's instinctive reaction was very ungenerous to a promising young scholar, dismissing Newton's findings in a disastrously peremptory manner as perfectly explicable in terms of the hypothesis of colours outlined in Micrographia. Equally unfortunate – and equally characteristic - was his comment, even when trying to make things up somewhat in 1676, that he was 'extremely well pleased to see those notions promoted and improved which I long since begun, but had not time to compleat', presenting Newton's experiments as a working out of his own ideas in a manner calculated to enrage the younger man.

Matters were made worse by Hooke's imperfect sense of the difference between ideas that he had sketched on the back of an envelope, as it were, and ones that he had fully formulated. This problem became intense in his confrontation with Newton over the intellectual copyright of the idea of universal gravitation, which Hooke could claim to have sketchily indicated in his Attempt to Prove the Motion of the Earth from Observations of 1674, and which he claimed deserved acknowledgment when the Principia was being prepared for publication in 1686. It is to some extent a matter of opinion how justified he was: in many ways, the matter boils down to the question of whether the crucial step was to have had the brilliant idea - where Hooke believed the credit was legitimately his - or to have worked it out, a task that he claimed merely required the attentions of a mathematical drudge. The latter was, of course, a claim that was bound to rankle with Newton, who was cutting in his criticism of Hooke's 'excusing himself from that labour by reason of his other business: whereas he should rather have excused himself by reason of his inability', a telling remark in view of what I have already said about Hooke's style. Matters are here in any case complicated by the resonances of the long-running debate between mathematicians and natural philosophers which went back to the time of Galileo and beyond. They are further complicated by Newton's notorious reluctance to give credit to Hooke or anyone else for ideas that he felt were his – indeed, Newton offers a further extreme exemplification of the possessiveness that I have already instanced in Boyle, and Hooke was doubly unfortunate in being up against such an obsessive, scheming and ungenerous opponent. As Newton put it in a letter to Edmond Halley:

> Should a man who thinks himself knowing, & loves to shew it in correcting & instructing others, come to you when you are busy, & notwithstanding your excuse, press discourses upon you... & then make this use of it, to boast that he taught you all he spake & oblige you to acknowledge it & cry out injury & injustice if you do not, I believe you would think him a man of a strange unsociable temper.

Hooke did not help himself by making slightly absurd claims even in this connection – for instance, that Newton had obtained his ideas about the oval shape of the earth from Hooke, which was almost certainly not the case. It made matters worse that he was increasingly prone to accuse everyone of similar plagiarism, hence bringing us back to the tone of the passage with which I opened my paper

What was tragic about this from Hooke's point of view – apart from the extent to which the virtual deification of Newton in the eighteenth century meant that anyone who challenged his greatness must be in the wrong – is that it has meant that Hooke has had his claims, and his undoubted merits, taken less seriously than they deserve. In fact, it seems genuinely likely that the letters that Hooke and Newton exchanged in 1679-80 suggested to Newton a way of tackling the problem that he would otherwise have overlooked, whether or not Hooke had the mathematics to work it out in full. That would be grounds for celebrating Hooke in itself, and to it has to be added the variegated achievement across the whole range of natural philosophy that I have outlined in this paper. What more could a man ask?

NOTE

[1] In quotations from manuscripts, inserted passages are denoted by the use of angled brackets.

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- to continue the free public lectures which have been given for 400 years, and to reinterpret the 'new learning' of Sir Thomas Gresham's day in contemporary terms;

- to engage in study, teaching and research, particularly in those disciplines represented by the Gresham Professors;

- to foster academic consideration of contemporary problems;

- to challenge those who live or work in the City of London to engage in intellectual debate on those subjects in which the City has a proper concern; and to provide a window on the City for learned societies, both national and international..

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