Replacing Victoria's Scientific Culture

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Contemporary cultural history of science is notably suspicious of grand narrative.[1] Following Thomas Kuhn's invitation to allow society into science and the consequent development of social constructivist accounts of scientific practice, traditional accounts of science's progress started looking increasingly threadbare.[2] This was most clearly the case with what used to be called internal history of science. Triumphalist accounts of scientific progress and the inexorable rise of the scientific method simply failed to survive detailed sociological scrutiny and the new emphasis on microsocial analysis. The divorce between history and philosophy of science that followed in the wake of the new sociology of science meant that historians now cared more for detailed accounts of scientific practice in particular local contexts than for tracing the genealogies of abstract ideas across centuries. Scientific history was no longer treated as a testing ground for competing theories of scientific method. Unexpectedly, perhaps, another consequence of this redrawing of the historian of science's map of what did and did not matter for their discipline was a renewed attention to the nineteenth century. With the fragmenting of the scientific method, the period we used to call the Scientific Revolution was displaced as the main focus of historical inquiry.[3] Instead, the nineteenth century has come to be regarded by many historians of science as a particularly valuable testing ground for new ways of thinking about the relationship between science and the rise of modernity.

The nineteenth century already loomed large in what used to be called the external history of science – the study of science's institutions and its social relations.[4] The traditional story of nineteenth-century science and its place in culture was relatively straightforward and nicely complemented the role played by the Scientific Revolution in so-called internal accounts.[5] Thirty years ago the nineteenth century would still have been hailed as the age of scientific institutional consolidation. This was the century when Darwin and Huxley helped science finally and decisively part company from religion. It was the age when science

became professionalized and specialized. It was a second – and institutional – Scientific Revolution to finish the task left undone by the first. Science during the nineteenth century became industrial and took its place in forging British economic supremacy. This was a global big picture of institutional progress to match the intellectual march of mind. This story of nineteenth-century science as largely pragmatic consolidation and institutionalization now rings no more true than does the old view of the Scientific Revolution. Institutions certainly mattered a great deal to nineteenth-century protagonists, but there was nothing consensual or inevitable about the way they emerged. Far from it. There was probably as much blood spilt during the nineteenth century over the reform of the Royal Society or the proprieties of scientific education as there was over natural selection or the existence or otherwise of the luminferous ether.

Surveying the debates raging around the Royal Society and its constitution from the 1820s to the end of the 1840s allows us to cast a revealing light on the perils of over-easy generalization. The consensus until relatively recently has been that fairly straightforward homologies could be drawn between science, professionalization and reform. It seemed unproblematic that battles to reform the Royal Society could be read off as the campaign of the properly scientific Fellows to turn the society into a professional body.[6] Whig historians on the one hand have seemed to regard the eventual shape of a reformed Royal Society as a self-evident goal, its structures mirroring those of modern, professionalized science. Tory historians, on the other hand, have described the reform battles in terms of the practical efforts of pragmatic men to respond to particular local circumstances. Whilst certainly rather more sophisticated than its Whig counterpart, the Tory approach still takes as uncontentious the parallel linkage of science, professionalization and reform.[7] By overlooking the nuances that defined competing positions, both sides in the debate lost sight of the ideological battle lines that divided the warring parties. Rather than regarding professionalization (or science, for that matter) as defining particular positions, historians are now more inclined to treat them as the contingent outcomes of debate.

The old categories of professionalization and disciplinary formation no longer cut much ice. Rather than regarding nineteenth-century scientists as professionals in the making, historians of scientific culture are now more interested in asking questions about the different ways in which scientific practitioners sought to carve out a variety of cultural spaces within which they might forge careers for themselves. Detailed studies of particular debates have certainly made it clear that there was no nineteenth-century consensus around professionalization. Far from it, there was bloody debate over the proprieties of treating science like a trade. Gentlemen of science squabbled with each other over just what kind of individual could legitimately be regarded as a man of science at all and what counted as appropriate scientific demeanour. William Robert Grove, *éminence grise* of the 1840s reform movement, spluttered that it "would scarcely add to the dignity of philosophy, or to the reverence due to its votaries, to see them running with their various inventions to the patent office […] If parties look to money as their reward, they have no right to look for fame."[8] Instrument-makers, popular lecturers, consulting chemists, engineers, doctors, inventive artisans, working-class radical philosophers all jostled with each other for a claim to the mantle of science. Even within the relatively insulated coteries of the Fellows of the Royal Society or leading members of the British Association for the Advancement of Science (sometimes, but not always, the same people) there was precious little agreement and a great deal of debate about where their institutions should go, who should be in them and – just as importantly – who should be out. Throughout the nineteenth century it was never quite unambiguously clear what kind of person the scientist was.

Since nineteenth-century practitioners – to recent historians' eyes at least – seem to have been less than entirely sure who the scientists were, historians have become rather more circumspect about the matter too. It no longer seems clear that we can point to a relatively small number of big names and say without hesitation that they were the nineteenth-century British scientific community. Traditional categories – like Fellowship of the Royal Society or the new specialist scientific societies, membership of the BAAS and so forth – no longer

seem to capture the full variety of groups and individuals who insisted that what they were doing was science. It is worth remembering that not only was the word 'scientist' itself invented in this period (coined by William Whewell in 1833) but that for most of the nineteenth century it was a polemic, disputed and occasionally derogatory term.[9] Certainly it was a term that many of those whom modern expectations might regard as being most appropriately labelled by it (such as Michael Faraday) quite actively abhorred. If the label is difficult to apply to individuals, it is difficult to apply to activities and practices too. Increasingly, science starts to look to nineteenth-century historians like something that can only be established after the fact. What in the end counted as nineteenth-century science was the outcome of a whole series of local debates about the locus of institutional and intellectual authority in a variety of contexts.

Thinking about nineteenth-century science like this has focussed particular attention on the issue of space – both geographical and cultural. Science itself, most historians of science would now agree, is contested space.[10] Throughout the nineteenth century, groups and individuals tried to carve out spaces for themselves where what they did counted as science. Where one went to encounter science – as an interested audience, a dilettante seeking amusement or even a neophyte seeking entry into the hallowed halls – largely defined the kind of practice one thought science was (as well, incidentally, as the person one was, or aspired to be). By looking at science's spaces historians of nineteenth-century scientific culture have tried to make sense of science by paying attention to the place different kinds of practices occupied in social networks. They have looked at how different spaces played their roles in scientific self-fashioning as competing practitioners jostled for legitimacy. The outcome has been a decentering of our view of just where scientific authority lay during the nineteenth century.[11] The big picture of Victorian science as leisured, progressive institutional consolidation is certainly now decisively broken. The view we now have of nineteenth-century science may be considerably more nuanced than it was a few decades ago, but it is

also considerably more fractured. The focus of inquiry, moreover, remains overwhelmingly the Victorian period. Here, by surveying what I regard as the most promising trends and directions of current research, I want to consider the 'long nineteenth century' alternative and what it might promise in terms of reassembling a coherent narrative about science's place in culture.

I

Diffusion and its Discontents

One important consequence of this fracturing of our understanding of the location of nineteenth-century scientific authority has been a re-evaluation of the old, diffusionist account of the movement of scientific knowledge through society and, as a result, a reassessment of the notion of popular science.[12] In the diffusionist account, scientific knowledge was produced and owned by a trained, disciplined elite. Popular science was a watered-down affair, repackaged and made comprehensible to the masses. As a result, it was of little interest to respectable historians of science, being regarded as little more than post facto vulgarization for the hoi polloi. Nowadays, on the contrary, nineteenth-century institutions aimed at bringing scientific knowledge to different and broader audiences are regarded as being active, knowledge-producing centres in their own right rather than being anodyne purveyors of codified and settled knowledge for the uninitiated. They are regarded instead as being at the heart of the nineteenth-century science wars where rival notions of how and by whom knowledge should be produced were hashed out and promulgated. Looking at institutions of popular science, from the Royal Institution to the Royal Polytechnic, has led to an important decentering in our understanding of the locus of scientific authority in nineteenth-century Britain. It was both everywhere and nowhere.

The gentlemen of science themselves were certainly keen to overcome the fragmentation of scientific authority that characterized the first half of the nineteenth century. Many of the institutions they either established or attempted to co-opt for their own purposes, were designed to promote their own meritocratic vision of science as the province of a

cultured, disciplined and vocationally-minded elite. In many respects, John Herschel's *Preliminary Discourse on the Study of Natural Philosophy*, was an effort to define just who nature's legitimate spokesmen were. It laid out the training and the disciplined set of mind that a true philosopher needed.[13] The British Association for the Advancement of Science has been widely interpreted as an instrument to impose gentlemanly hegemony on a broader scientific public.[14] Concerted efforts were made to define its remit, to police what could and could not be discussed on its platforms and to impose gentlemanly standards of behaviour. Repeated efforts to reform the Royal Society may be understood as attempts to wrest power in that crucial scientific institution from an old guard that meritocratic young Turks such as Herschel or Charles Babbage and their acolytes regarded as terminally tainted by old corruption and into the hands of a new disciplined elite.[15] The squabbles amongst the gentlemen of science themselves, over just what they thought reforming the Royal Society meant, is an important reminder as well of just how fragile and contested even that powerful alliance might be.

The gentlemanly vision of measured, meritocratic authority was by no means the only one doing the rounds. Historians now listen to plenty of alternative voices blowing in the wind and to the increasingly strident gentlemanly efforts to stifle those voices. Those efforts in themselves are a good measure of the extent to which alternative views of the locus of scientific authority were feared as real threats to attempted gentlemanly hegemony. Gleeful political radicals mischievously picked up on the latest discoveries in electricity and used them to turn the carefully measured and reformist world of gentlemanly science on its head.[16] Where the gents saw science as an agent of social order, the radicals saw it as a call to the barricades. Whilst the bombast generated by the likes of Richard Carlile or Eliza Sharples might be relatively easily dismissed, the same could not be said for the anonymous *Vestiges of the Natural History of Creation*. Authored, as it eventually turned out, by the publisher Robert Chambers, *Vestiges* made good use of gentlemanly authority to deeply subversive ends, offering its own view of who could or could not speak for nature.[17] In a similar vein,

mesmerists and phrenologists offered their own articulations of proper scientific practice, suggesting that groups distinctly marginal to gentlemanly expectations – such as women and the working classes – could have a legitimate voice.[18]

Far from being passive recipients or vulgarizers of received authority, historians now view these alternative voices as attempting to articulate their own claims to independent scientific legitimacy. One of the few things that opposing groups and constituencies during the first half of the nineteenth century appear to have had in common was a shared conception that being able to don the mantle of scientific authority mattered. As a result not only were the various attempts by vocationally-minded gentlemen to impose their own meliorist view strongly resisted, others put forward their own very different accounts of the sources of scientific authority. The fractures that soon surrounded the London Mechanics' Institution so shortly after its foundation in 1824, cast a revealing light on the fragility of the alliances that led to its inception and the heterogeneity of interests that might temporarily rally together under the banner of science. It soon became clear that the different groups that had banded together to establish the Mechanics' Institution had radically different conceptions of what such a body was for, how it ought to be organized and what sort of science should be heard there.[19] Any efforts to treat the Mechanics' Institution as a vehicle for diffusing sanitized knowledge to a cowed and grateful working class certainly came to nothing.[20] What becomes visible in the debates that surrounded the new institution is the clear availability of alternative and powerful accounts of scientific authority and proper scientific practice.[21]

Gentlemen of science were often painfully aware of just how tentative their grasp on the reins of power was. Even within their most hallowed institutions it was clearly all too easy for things to get away from them. The furore surrounding gentleman electrician Andrew Crosse right at the beginning of Victoria's reign is a case in point. Crosse, a Somerset landowner with distinctly radical political leanings was publicly lionized at the Bristol meeting of the BAAS in 1836 and held up to the audience as an exemplar of the humble, diffident (and well-behaved) investigator of nature.[22] All the more embarrassing, therefore,

for the gentlemen who had so lauded him, when Crosse announced a few months later that insects had spontaneously appeared in the apparatus during one of his electrical experiments. Political radicals jumped on the latest evidence that electricity was indeed the stuff of life. Reports appeared in the press that no less a figure than Michael Faraday, darling of elite metropolitan science, had repeated and endorsed Crosse's experiments. Despite Faraday's own disgusted assertions to the contrary, the reports were still circulating more than a decade later. An 'infidel lecturer' on Paddington Green during the 1850s, asserted that Faraday had demonstrated the electrical nature of life by producing animalcules and maggots by electrical agency. Faraday had allegedly underlined his experiments with the remark to his audience that: "Gentlemen, there is life, and, for ought I can tell, man was so created."[23]

What this suggests, at the very least, is that diffusionism had a politics. Different accounts of where science might legitimately be produced and how it might move around society carried with them their own political baggage. What was once bundled together dismissively under the heading of popular science is now recognized as a variety of efforts, more or less successful, to articulate different visions – with their own politics – of the ways in which scientific authority might be constructed, legitimized and circulated.[24] There was no trickle-down effect in nineteenth-century scientific culture and, insofar as a gentlemanly elite tried to realize one, they found their efforts strongly contested on all sides. When scientific claims and assertions of authority appeared in different contexts and places, rather than reading these as passive mediations from centre to periphery we should recognize them as active and artful appropriations of the mantle of science for a variety of purposes.[25] The different ways in which scientific claims were articulated and defended in a variety of contexts should alert us to just how flexible and indexical a term science was for much of the century. Different groups and individuals with their own axes to grind fashioned themselves and their sciences in a range of distinct ways.

II

Reframing the Boundaries

As historians have become more aware of the heterogeneity of nineteenth-century scientific culture, more attention has been paid to its spatiality as well. It has become clear that if we want to understand who scientific practitioners and audiences were, we need to understand where they went to practice or encounter science. Spatiality matters on a number of different levels. Scientific activity throughout the nineteenth-century was certainly not evenly distributed across the British Isles.[26] Thinking about science's geographical distribution, between metropolis and province and between the islands' nationalities, is essential to making sense of who its practitioners and audiences were. In the metropolis, for example, looking at scientific networks of production and consumption should be central to understanding its cultural as well as its physical geography. Placing science in relation to the world that went on around it can help historians recognize the ways it was understood by participants and audiences alike. When audiences moved around scientific institutions the way that they made sense of the artefacts and performances around them was, in part at least, a product of the ways those things were spatially located and what else was going on in juxtaposition to them. Successful training regimes throughout the century depended in part on the careful control and manipulation of pedagogical spaces.

Scientific activities of one kind or another clearly took place all over the British Isles. Much of what historians have said about public science in nineteenth-century Britain is, nevertheless, still largely based on the English example. Relatively little work has been done on Scotland, less on Ireland and virtually none on Wales.[27] Outside London, scientific societies were being established in particular locales from the late eighteenth century onwards, the Manchester Literary & Philosophical Institution being the first, in 1781.[28] Looking at just where these kinds of societies were established tells us a great deal about science's cultural connections. It also tells us something about the kinds of people who turned to science as an element of self-fashioning. Looking at the links such institutions maintained with each other

and the place they occupied in local networks of mutual interest and patronage also tells a great deal about science's cultural place. Particular groups in specific locations clearly fostered scientific activity and participation in networks of scientific exchange. Both knowledge and personnel moved around between metropolis and province along the lines of such networks of exchange as well. Locations and their cultural connotations played a key role in defining what science was for different audiences. Clearly, as the century progressed, having a scientific institution, preferably in its own architecturally distinctive building, was an important feature of local civic pride.

In London itself, just where a particular institution was spoke volumes for its cultural place. It clearly mattered that the Royal Institution was on Albemarle Street and the Royal Polytechnic Institution was on Regent Street. Spatial location mattered because where an institution was told people something important about where it belonged on the cultural map as well. The Polytechnic on Regent Street, the Adelaide Gallery on the Strand, or the Royal Panopticon in Leicester Square, were in locations that had an already well-established reputation for providing entertainment, rational or otherwise, to their visitors.[29] Albemarle Street with its polite middle class and aristocratic clientele, on the other hand, signified a completely different kind of fashionable London.[30] It seems evident that different scientific institutions were embedded in their own particular networks of consumption. Their location placed them in the world of London entertainment and edification. They were also embedded in networks of production. None of these places could exist without the artisans' workshops and instrument-makers' shops that supported them. Networks of production provided scientific institutions of various kinds with the material and human resources they needed to mount their displays and performances.[31] Networks of consumption dictated, in part at least, how those displays and performances would be understood and contextualized by their audiences. What was going on around them helped decide how audiences made sense of what was going on inside.[32]

Pedagogical locations and spaces were both heterogeneous and increasingly circumscribed. Laboratories – certainly laboratories designed for teaching purposes – were relatively novel spaces at the beginning of the nineteenth century.[33] The movement of apparatus and information from laboratory to lecture theatre can be seen to mirror its transmission from public to private. As Michael Faraday, for example, moved between the basement laboratory at the Royal Institution and the lecture theatre upstairs, he was moving between private and public – and also between contingent and certain knowledge.[34] Teaching regimes and locations dictated particular forms of behaviour as well. As mathematics teaching and examination at Cambridge was reformed between the end of the eighteenth and the middle of the nineteenth centuries, moving from public disputation to paper examination, a reform of student manners took place as well. Students were encouraged to exercise their bodies as well as their minds to avoid breakdown.[35] Institutionalized teaching laboratories at Cambridge and elsewhere were accused of breaching boundaries between politeness and vulgarity. James Clerk Maxwell famously worried that if parents knew he was making their sons work with their hands in a laboratory they would be up in arms.[36] Laboratories appeared to breach what some at least took to be an inviolable barrier between factory and gentlemanly culture.

As was the case with popular science, looking at science's spaces ultimately brings us back again to the politics of knowledge. Space had a great deal to do with defining the epistemological status of scientific knowledge and, as a result, it had a great deal to do with defining its political status too. If where knowledge was helped decide what kind of knowledge it was, then that had a great deal to do with the way that knowledge was understood by society. The place of knowledge conferred (or withheld) authority. The knowledge produced at the Adelaide Gallery or an Owenite Hall of Science was a very different beast from that emanating from the London Institution or the Royal School of Mines. It was understood differently and was recognized as embodying a different kind of authority. Battles about the legitimacy of various kinds of scientific activity throughout the

nineteenth century were, more often than not, disputes about what the appropriate place of science was. Place was also intimately bound up in individual self-fashioning. Being seen in a scientific setting was clearly becoming an increasingly marketable bit of personal cultural capital – in some contexts at least. Where one cared to be seen consuming (or producing) knowledge had important ramifications for the presentation of self.

III

Back to the Big Picture

So where does this leave the long nineteenth century? It is certainly clear that if we want to start panning back from the local and think again about trying to put together a more panoramic view of nineteenth-century scientific culture then we need to give our picture a temporal as a well as a spatial shape. The question, of course, is which timescale provides the best perspective. Much recent work in the history of science has focussed on the Victorian period as a way of giving shape to a broader sweep across scientific culture. This certainly has some advantages. Zooming in on the Victorian age does indeed allow us to capture some important features of the nineteenth-century scientific landscape. It coincides (particularly if interpreted with a degree of flexibility) with the emergence of a number of key institutions, such as the foundation of the British Association for the Advancement of Science in 1831. The period coincides as well with a number of important scientific debates such as those surrounding the beginnings of thermodynamics and the publication of the *Origin of Species*. The story of Victorian science can be smoothly topped and tailed, starting with natural philosophy as the property of a Liberal Anglican elite – a weapon in a war to confound both conservatism and radicalism in religion and politics by founding a new meliorist consensus around a reformed understanding of natural order – and ending with science firmly embedded in the workings of the late Victorian imperial state.[37]

Starting the story forty or fifty years earlier, around British intellectual responses to the French Revolution, works better, however. Looking back to the fractures of the 1780s and

1790s might allow us to understand much that happened in terms of attempted institutionalizations of British scientific culture in a broader historical context. To its critics at the end of the eighteenth century, the culture of natural philosophy looked deeply dangerous. Joseph Priestley, after all, had famously argued that "the English hierarchy (if there be anything unsound in its constitution) has equal reason to tremble, even at an air-pump or an electrical machine."[38] To his political enemies, like Edmund Burke, this was fighting talk. They were convinced that English natural philosophy was indeed dangerously politically heterodox and that new philosophical enthusiasms like electricity or mesmerism were a means to introduce the Revolution to England through the back door. The result was a fragmentation of established eighteenth century expectations of natural philosophy's social place. At the newly established Royal Institution, which would be a bulwark of elite science throughout the nineteenth century, plans to build a stairway so that the working classes could come in and mingle with their betters in the lecture theatre at least, if not in the lobby, were abruptly abandoned.[39]

The spectre of revolution still haunted those who would be England's elite gentlemen of science a generation and more later. The carefully measured utterances of the metropolitan scientific elite on the occasion of the centenary of Priestley's birth in 1833 show just how nervous some of them still were of the chemist's radical reputation. Any hint that celebrating his chemistry might mean endorsing his politics was to be rigorously avoided.[40] Henry Brougham prissily belittled the reputation of a man "who united in his own person the part of the experimental inquirer after physical truth with that of the angry polemic and the fiery politician."[41] There certainly seems to be a case to be made for the possibility that for some groups of natural philosophers in the aftermath of the Revolutionary and Napoleonic wars, the reordering of science and the establishment of new spaces of scientific activity was imperatively a way of disassociating themselves from past linkages that now appeared to have been disastrous. For these people, forging new spaces for science was a way of signalling a decisive break with the past.[42] For others, such as groups of radical artisans, who wanted to

attach the mantle of science to themselves, the imperatives were quite different. They wanted to find spaces where they could reassert natural philosophy's radical legacy and turn it into a political tool for new and further battles.[43] It seems not implausible that many of the rancorous manoeuvrings around the banner of scientific reform that occupied metropolitan elites in the Royal Society and elsewhere from the 1820s to the 1850s can be understood as attempts to refound a role for science in relation to the state.

From this point of view then, the 1780s or 1790s form a rather convenient point from which to start tracing the reordering of natural philosophy around new spaces and the building of new cultural networks for science during the course of the nineteenth century. In particular it helps us understand the politics of that reordering by reminding us of why it mattered so much to the participants. Even as we keep on looking at nineteenth-century science as a local, particularized activity, we should see that thinking politically about science provides a way of seeing that the narratives we construct about intellectual and institutional empire-building can indeed provide a new overarching perspective that might hold our histories together. What nineteenth-century scientific practitioners wanted was legitimacy. They wanted the right to speak for nature, since being able to speak for nature conferred power. The only way in which such legitimacy could be achieved was through acting politically and finding ways of making ideas, institutions and power work together. The nature that emerged out of such struggles for cultural place was itself unavoidably political too. Nineteenth-century views of nature and of the technologies and practices that were needed to make that nature visible were both inevitably organized around the social distribution of authority and power.

Beginning with the French Revolution and British responses to it and stretching through to the opening decades of the twentieth century and the start of the Great War, we can see the bare contours of a new grand narrative about science's cultural place and its role in the origins of modernity emerging. Instead of viewing the long nineteenth century's science as a triumphal march onwards, with institutions and ideas tramping forwards together towards their destiny we can see it as a series of little local skirmishes as new claimants to the status of

science sought to carve out a patch for themselves and reorient what it meant to be a scientific practitioner.[44] These dogfights were contests about authority and the legitimacy conferred by being able to show who nature's spokesmen really were. By the beginning of the twentieth century, certain kinds of scientific spaces – the academic research laboratory for example – had come to characterize what it meant to be scientific. It was through their association with such spaces that groups and individuals could claim mastery over the natural world.[45] That those groups and places won the battle for legitimacy was a matter of contingency. Throughout the nineteenth century other groups fought to try and make other kinds of spaces scientific too.

Seeing these manoeuvrings against a broader canvas should be able to help us understand better how these battles fell out as they did. Extending the temporal focus to embrace both the French Revolution and the Great War may well turn out to be rather fruitful in terms of allowing us to make sense of our spatial preoccupations too. One particular advantage might be that rethinking temporality will, paradoxically enough, help us do a better job of getting under the skin of what we think of as Victorian science in particular. The Victorians institutionalized science. They built buildings, established societies, set up university departments, published books and journals, opened exhibitions. It may become a little easier to make sense of these heterogeneous spaces if we track their trajectories a little further back to give ourselves a clearer sense of just what this frenetic institutionalization was built upon in the first place. It might also help us understand how much sense the very notion of Victorian science made to its creators and participants. What extending our view may well show is that there were several Victorian sciences jostling for position, trying to rebuild a scientific culture out of the embers of the 1790s.

[1] For some musings on this issue see Steven Shapin, 'Hyperprofessionalism and the Crisis of Readership in the History of Science', *Isis*, 96 (2005), 238-43.

[2] T. S. Kuhn, *The Structure of Scientific Revolutions* (Chicago: University of Chicago Press, 1962); Barry Barnes, *T. S. Kuhn and Social Science* (London: Macmillan, 1982).

[3] Steven Shapin, *The Scientific Revolution* (Chicago: University of Chicago Press, 1996).

[4] For internal and external histories see Steven Shapin, 'Discipline and Bounding: The History and Sociology of Science as Seen through the Externalism-Internalism Debate', *History of Science*, 30 (1992), 333-369.

[5] The classic traditional account is, of course, Herbert Butterfield, *The Origins of Modern Science* (London: Bell & Sons, 1949). The most recent defence of the received account of nineteenth-century institutionalization is Jack Meadows, *The Victorian Scientist: The Growth of a Profession* (London: The British Library, 2004).

[6] Marie Boas-Hall, *All Scientists Now* (Cambridge: Cambridge University Press, 1984).

[7] I am hijacking the vocabulary of a 1960s historiographical difference of opinion here: Oliver MacDonagh, 'The Nineteenth-century Revolution in Government: A Reappraisal', *Historical Journal*, 1 (1957), 52-67; Jennifer Hart, 'Nineteenth-century Social Reform: A Tory Interpretation of History', *Past & Present*, 31 (1965), 39-61. See also Roy MacLeod, 'Whigs and Savants: Reflections on the Reform Movement in the Royal Society, 1830-48', *Metropolis & Province: Science in British Culture, 1780-1850*, ed. by Ian Inkster & Jack Morrell (London: Hutchinson, 1983), pp. 55-90.

[8] William Robert Grove, 'On Physical Science in England', *Blackwood's Magazine*, 54 (1843), 514-25, (p.521); Iwan Rhys Morus, 'Correlation and Control: William Robert Grove and the Construction of a New Philosophy of Scientific Reform', *Studies in History & Philosophy of Science*, 22 (1991), 589-621.

[9] Sidney Ross, 'Scientist: The Story of a Word', *Annals of Science*, 18 (1962), 65-85.

[10] David Livingstone, *Putting Science in its Place: Geographies of Scientific Knowledge* (Chicago: University of Chicago Press, 2003) summarizes much of this literature.

[11] *Victorian Science in Context* ed. by Bernard Lightman (Chicago: University of Chicago Press, 1997).

[12] Roger Cooter & Stephen Pumfrey, 'Separate Spheres and Public Places: Reflections on the History of Science Popularization and Science in Popular Culture', *History of Science*, 32 (1994), 237-67.

[13] Walter F. Cannon, 'John Herschel and the Idea of Science', *Journal of the History of ideas*, 22 (1961), 215-39.

[14] Jack Morrell & Arnold Thackray, *Gentlemen of Science: The early Years of the British Association for the Advancement of Science* (Oxford: Clarendon Press, 1982)

[15] David P. Miller, 'Between Hostile Camps: Sir Humphry Davy's Presidency of the Royal Society, 1820-1827', *British Journal for the History of Science*, 16 (1983), 1-47; William J. Ashworth, 'The Calculating Eye: Baily, Herschel, Babbage and the Business of Astronomy', *British Journal for the History of Science*, 27 (1994), 409-41; William J. Ashworth, 'John Herschel, George Airy and the Roaming Eye of the State', *History of Science*, 36 (1998), 151-78.

[16] Iwan Rhys Morus, *Frankenstein's Children: Electricity, Exhibition and Experiment in early Nineteenth-century London* (Princeton: Princeton University Press, 1998); Iwan Rhys Morus, 'Galvanic Cultures: Electricity and Life in the early Nineteenth Century', *Endeavour*, 22 (1998), 7-11.

[17] James Secord, *Victorian Sensation: The Extraordinary Publication, Reception and Secret Authorship of Vestiges of the Natural History of Creation* (Chicago: University of Chicago Press, 2001).

[18] Roger Cooter, *The Cultural Meaning of Popular Science: Phrenology and the Organization of Consent in Nineteenth-century Britain* (Cambridge: Cambridge University Press, 1984); Alison Winter, *Mesmerized* (Chicago: University of Chicago Press, 1998).

[19] Maxine Berg, *The Machinery Question and the Making of Political Economy* (Cambridge: Cambridge University Press, 1980), pp.145-78; Iwan Rhys Morus, 'Manufacturing Nature: Science, Technology and Victorian Consumer Culture', *British Journal for the History of Science*, 29 (1996), 403-34.

[20] Steven Shapin & Barry Barnes, 'Science, Nature and Control: Interpreting Mechanics' Institutes', *Social Studies of Science*, 7 (1977), 31-74.

[21] In this respect historians of science can learn a great deal from historians of radical and labour culture, for example Clive Behagg, *Politics and Production in the early Nineteenth Century* (London: Routledge, 1990); Patrick Joyce, *Visions of the People: Industrial England and the Question of Class, 1848-1914* (Cambridge: Cambridge University Press, 1993) and Iain McCalman, *Radical Underworld: Prophets, Revolutionaries and Pornographers in London, 1795-1840* (Oxford: Clarendon Press, 1993).

[22] James Secord, 'Extraordinary Experiment: Electricity and the Creation of Life in Victorian England', *The Uses of Experiment* ed. by David Gooding, Trevor Pinch & Simon Schaffer (Cambridge: Cambridge University Press, 1989), pp.337-83; Morus, *Frankenstein's Children*, pp.139-43.

[23] Morus, *Frankenstein's Children*, p.143.

[24] James Secord, 'Knowledge in Transit', *Isis*, 95 (2004), 654-72; Iwan Rhys Morus, '(Stop) Talking About Victorian Science', *Annals of Science*, forthcoming, 2006.

[25] See for example Anne Secord, 'Science in the Pub: Artisan Botanists in early Nineteenth-century Lancashire', *History of Science*, 32 (1994), 269-315.

[26] Ian Inkster & Jack Morrell (eds), *Metropolis and Province: Science and British Culture, 1780-1850* (London: Hutchinson, 1983), Introduction.

[27] But see Charles Withers, *Geography, Science and National Identity: Scotland since 1520* (Cambridge: Cambridge University Press, 2001); *Science and Irish Culture* ed. by David Attis & Charles Mollon (Dublin: Royal Dublin Society, 2004); Louise Miskell, 'The Making of a New Welsh Metropolis: Science, Leisure and Identity in early Nineteenth-century Swansea', *History*, 88 (2003), 32-52.

[28] Arnold Thackray, 'Natural Knowledge in Cultural Context: the Manchester Model', *American Historical Review*, 79 (1974), 672-709.

[29] Richard Altick, *The Shows of London* (Cambridge: Harvard University Press, 1978).

[30] Morris Berman, *Social Change and Scientific Organization: The Royal Institution, 1799-1844* (London: Heinemann, 1978).

[31] More attention needs to be devoted to scientific performances, their associated technologies and the material culture that sustained them. In this context, less talk about texts and more about things would be salutary. Asa Briggs, *Victorian Things* (Harmondsworth: Penguin, 1990) remains an interesting model. See Iwan Rhys Morus, 'Seeing and Believing Science', *Isis*, 97 (2006), 101-10.

[32] There are lessons to be learned here from histories of civic culture such as Patrick Joyce, *The Rule of Freedom: Liberalism and the Modern City* (London: Verso, 2003) and from histories of everyday life such as Leonore Davidoff & Catherine Hall, *Family Fortunes* (London: Routledge, 2002).

[33] Graeme Gooday, 'Precision Measurement and the Genesis of Physics Teaching Laboratories in Victorian Britain', *British Journal for the History of Science*, 23 (1990), 25-51.

[34] David Gooding, 'In Nature's School: Faraday as an Experimentalist', *Faraday Rediscovered* ed. by David Gooding & Frank James (London: Macmillan, 1985), pp.105-35.

[35] Andrew Warwick, *Masters of Theory* (Chicago: University of Chicago Press, 2003).

[36] Simon Schaffer, 'Metrology, Metrication and Victorian Values', *Victorian Science* ed. by Lightman, pp.438-74.

[37] Susan Faye Cannon, *Science in Culture* (New York: Science History Publications, 1978).

[38] Quoted in Jan Golinski, *Science as Public Culture* (Cambridge: Cambridge University Press, 1992), p.81.

[39] Berman, *Social Change.*

[40] 'Commemoration of the Centenary of the Birth of Dr. Priestley', *Philosophical Magazine*, 2 (1833), 382-402.

[41] Henry Brougham, *Lives of Men of Letters and Science, Who Flourished in the Reign of George III* 2 vols. (London, 1845-46), vol. i, p.402.

[42] William J. Ashworth, 'Memory, Efficiency and Symbolic Analysis: Charles Babbage, John Herschel and the Industrial Mind', *Isis*, 87 (1996), 629-53; Simon Schaffer, 'Babbage's Intelligence: Calculating Engines and the Factory System', *Critical Inquiry*, 21 (1994), 203-27.

[43] Adrian Desmond, 'Artisan Resistance and Evolution in Britain, 1819-1848', *Osiris*, 3 (1987), 77-110; Adrian Desmond, 'Lamarckism and Democracy: Corporations, Corruption and Comparative Anatomy in the 1830s', *History, Humanity and Evolution* ed. by James Moore (Cambridge: Cambridge University Press, 1989), pp.99-130; Adrian Desmond, *The Politics of Evolution* (Chicago: University of Chicago Press, 1989); Iorwerth Prothero, *Artisans and Politics in early Nineteenth-century London* (London: Methuen, 1981).

[44] Iwan Rhys Morus, *When Physics became King* (Chicago: University of Chicago Press, 2005).

[45] Simon Schaffer, 'Late Victorian Metrology and its Instrumentation: A Manufactory of Ohms', *Invisible Connections: Instruments, Institutions and Science* ed. by Robert Bud & Susan Cozzens (Bellingham: SPIE Optical Engineering Press, 1992), pp.23-56.