THE BUSINESS OF INDUCTION: INDUSTRY AND GENIUS IN THE LANGUAGE OF BRITISH SCIENTIFIC REFORM, 1820–1840

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INTRODUCTION

Scientific reformers in early Victorian England spoke in two overlapping languages, one for organizing nature and one for organizing themselves. In constructing each language they drew heavily on classical political economy, the most fashionable and contentious system of thought going at the time, and one that was uniquely suited to the project of describing and creating new forms of natural and social organization. Historians who have discussed the place of political economy in British science have focused primarily on the first of these organizational tasks assisted by economic language: the scientists’ use of social metaphors to describe nature. This line of inquiry has turned up, among other things, Malthusian population theory in Darwin’s biology, George Poulett Scrope’s monetary ideas in Lyell’s actualism, and the economics of the steam engine in the new thermodynamics of William Thomson. Such discoveries have also helped answer the further question of why economic language was able to do so much work in natural knowledge at the time. As Norton Wise has argued, it was because society was itself conceived as a “natural system”, and because “[e]veryone read political economy, while only some read astronomy, or geology”, that writings about population, rent and division of labour found so much currency in attempts to describe the working of natural economies in any number of scientific fields.

Yet while historians of science have grown increasingly sensitive in recent years to how contemporaries’ understanding of political economy shaped the way they organized nature, they have not treated the second project of self-organization with the same sensitivity to the participants’ economic language. The many studies of the social organization of early Victorian science that have emerged in the past two decades have either imposed modern sociological or economic categories on the actors, or focused on actors’ categories that only indirectly related to the market. An early example of the first approach, demonstrating its strengths as well as weaknesses, was Arnold Thackray’s groundbreaking article on the ‘Manchester Model’ of natural knowledge that
appeared in 1974. By marshalling the then-novel tools of prosopography, Thackray plausibly depicted science as a social response to industrialisation instead of following such historians as T. S. Ashton, S. F. Mason, and J. D. Bernal in assuming that science acted unidirectionally as a spur to economic growth. Focusing on a cohort of industrialists and middle-class professionals at the Manchester Literary and Philosophical Society, he related their new-found enthusiasm for science to their social insecurity as an emergent class of *nouveaux riches*; and subsequent studies by Morris Berman, Robert Kargon, and others have added breadth and detail to Thackray’s depiction of science as “an appropriate, suitably distinct center around which a new, marginal group could build its own separate and progressivist philosophy and cultural system”. Another of Thackray’s accomplishments was to stress the sociological importance of geography in the shaping of scientific communities. He claimed that Manchester men, because they were remote from both the cultural centre of Edinburgh and the political centre of London, made do with science as a unique form of self-expression. Berman’s study of London men of science at the Royal Institution, Kargon’s history of the Manchester Lit. and Phil., and a number of shorter works have since similarly shown how local circumstances can distinctly shape the values and practice of science.

Interpreting early nineteenth-century British science in this way, however, had the tendency of depriving the agents who appeared in the narratives from speaking about social organization in their own words. To address this problem, historians have more recently started to study how contemporary patterns of language shaped the culture (as opposed to the content) of early Victorian science. Lorraine Daston has located the emergence of modern scientific objectivity in the ‘de-skilling’ of science at this time, while Simon Schaffer has traced to the 1820s the first appearance of ‘genius’ and ‘discipline’ as important components of how people described scientific discovery. In the same vein Richard Yeo, writing in the tradition of earlier historians like Robert Young and S. F. Cannon, has more recently placed William Whewell’s ‘metascience’ in the context of early Victorian debates between ‘progressives’ and ‘conservatives’ on history, education and religion. These accounts, while adding much to our knowledge of how men of science fashioned their community, still have not turned up the language of political economy with the same frequency that one might expect, given its prevalence in the natural systems these people were describing. Concepts of skill and genius, which were primary intellectual components of political economy, are central in these discussions, but they have seldom been connected to the prominence of such ideas in contemporary economic thought. The primary contexts that appear in these cases are moral and natural philosophy, and rightly so: this was the main language people used when they wrote their philosophies of induction and Bridgewater treatises. But scientists also used other sorts of language, and engaged in other practices, that had more to do with power looms than with postulates.
To recover a sense of how economic language shaped the cultural practices of early Victorian natural philosophers, it is important first to understand what they gained from using such language. The best way to do this is to refer to what we already know about their use of political economy in constructing natural explanations. As Norton Wise and Martin Rudwick have shown in different ways, one of the most important contributions of political economy to the new thinking about nature was its departure from cramped or static conceptions of time. Rudwick has discussed how Lyell felt justified in making ‘drafts’ on geological time after reading Scrope’s banking-informed work on French volcanoes, and Wise has mapped a transition in mechanics from static ‘balancing’ models to progressive thermodynamic systems onto a parallel transition from Smithian political economy to the economy of the steam engine as articulated by such diverse writers as Charles Babbage and William Whewell. A second important contribution concerned the claim of fecundity or productivity that appeared originally in Adam Smith’s political economy, then later re-emerged in the anti-Malthusian economics of such writers as Scrope and Babbage. Gillian Beer has discussed how Darwin converted Malthus’s dire economic conclusions about human reproduction into a celebration of natural fecundity, while Wise, following Schaffer, tells of Babbage articulating “an insidious thesis within British scientific culture: the capacity for designed transformations could be built into natural law.”

Political economy assisted men of science in the normative task of organizing themselves because its own subject of social relations blurred the boundary between the descriptive and the normative. Economists both described social organization and told people how they should organize themselves. The problems of dynamics and productivity in nature that men of science solved by appealing to political economy’s descriptive organizational models resurfaced when they actively set out to change their own organizations like the Royal Society. In this latter task they could build on political economy’s capacity for describing natural systems in order to solve the normative problem of how best to inject a torpid community with ‘progress’. Older models of social organization, in particular Bacon’s blueprint for the division of scientific labour in *New Atlantis*, failed to provide the scientists with a language that worked both as ‘progressive’ natural description and as a mechanism for reform. To the extent that the goal of ‘Baconianism’ — a well-organized and productive scientific community — converged with the progressive aims of early Victorian scientific reformers, such language remained popular in Britain. Herschel cited the *Novum organum*, not *The wealth of nations*, on the frontispiece to his *Preliminary discourse on the study of natural philosophy*, William Vernon Harcourt depicted the early British Association as the New Atlantis made manifest, and Babbage never tired in reminding his readers that “knowledge is power”. But these celebrations of Bacon in the 1830s, apart perhaps from Harcourt’s, were usually blunted by a number of modifications which demonstrate that Bacon’s legacy in early Victorian science
was decidedly problematic. Where Bacon’s static (and statist) Utopian model for science ceased to be relevant to the political and rhetorical needs of ‘progressive’ early Victorians, economic language often replaced the programmatic norms of New Atlantis as the organizational model of choice. And just as men of science proved to be quite willing and able to select out from Bacon only those precepts that suited their purpose, with the consequence that Baconianism provided a general context within which debate occurred, they were similarly selective when it came to importing strategies from political economy.

My argument in this article is that scientific reformers in London and Cambridge between 1820 and 1840 viewed the social side of their task in terms of the paradoxical legacy of Adam Smith, who had attributed to the de-skilling mechanism of the division of labour the perfect apportionment of skill. When Smith argued in The wealth of nations that the division of labour allowed “the most dissimilar geniuses” to be “of use to one another”, this formula for productivity struck many members of the British scientific community as uniquely suited to the task of stimulating the advancement of knowledge. In the eyes of reformers like Charles Babbage, John Herschel and William Whewell, British science appeared to be suffering from inadequate employment opportunities. The problem as they saw it was not a lack of native genius but a failure of the country’s varied geniuses to be organized effectively. It was with this in mind that Herschel proclaimed in 1830 that induction “employs, as an engine, the division of labour”; and that Whewell, in a review of Herschel, fretted that “a spirit of gratuitous theorizing” would “misemploy the cultivators of science”. Such concerns about misemployment were part of a wider perception among younger philosophers that British scientific production in the 1820s was threatened on two fronts. On one side, aristocratic dilettantes had monopolized the nation’s traditional seats of learning, leading to a restriction of opportunity for research and publication. On the other, scientific charlatans were taking advantage of the unclear status of knowledge to pass off their own meagre contributions as important discoveries. Although most scientific reformers agreed that dilettantes and charlatans were both problems, their specific targets of reform varied depending on which they feared more. Babbage focused on the first threat when he supported Herschel’s unsuccessful campaign against the Duke of Sussex for the presidency of the Royal Society in 1830, in an effort to supplant what he called “the aristocracy of rank and of power” with “the prouder aristocracy of science”. Whewell, whose primary concern about the Royal Society was its inability to put down the claims of lower-brow science, guarded against the latter threat when he tried to use the newly-formed British Association as a proving ground for would-be geniuses to test their mettle.

These different priorities about where to commence the process of reform reappeared in divergent choices about how best to adapt the economic model of the division of labour to science. Fifty years of intermittent progress in economic thought presented the would-be reformers with a range of different models
from which to choose. In this article I discuss two different economic models for reorganizing British science that came to the fore in the 1820s and 1830s. One, which informed the social strategies of Babbage and Herschel, was a revised version of Smith’s conception of the division of labour, in which open competition allocated different forms of ‘genius’ in the organization of business. This model was especially useful as a critique of the reigning scientific élite, since it introduced the wild card of free trade into the Royal Society’s carefully stacked deck. It allowed reformers to apply Smith directly against the apparent efforts of Joseph Banks and others like him to obstruct the free circulation of all types of scientific genius, whether deriving from foreigner, artisan or aristocrat. Upon moving from this purely critical task to the more constructive problem of reorganizing science, however, they modified Smith’s original model in important ways. First, they introduced a new view of the relation between self-interest and the expansion of the ‘market’ for science. Unlike Smith, who had hoped that a suitably disinterested aristocracy could prevent combinations of capitalists or labourers from narrowing the market, scientific reformers suggested that with the help of machinery and publicity it would be possible to bury the negative effects of self-interest altogether, without sacrificing its ability to spur the growth of knowledge. In the process, they also relocated skill or ‘genius’ from the individual to the community. The fruits of genius, according to this view, would be apparent once labour had been properly organized, but impossible to trace in its component parts back to individual labourers.

William Whewell took a different approach to reform, claiming that genius could only be located at the individual level. He faulted the opposing theory of collective genius for wasting labour time on vain efforts by people who had no chance of stumbling on any new truths. He assumed that only certain heroes of scientific discovery possessed the sort of genius that allowed them to recognize truth when it came their way, and he inferred that the most efficient way to organize science was to allow this élite to apportion tasks to the rest of the community. Unlike Herschel, and especially unlike Babbage, Whewell arrived at this alternative organizational model without explicitly ‘choosing’ concepts from available economic discourse that would have suited his purpose. Although he was no economic neophyte, neither was he sufficiently confident in the capacity of political economy to effect social change to extend its principles to science. But his very response to Herschel and Babbage encompassed their economic logic, and as such it replicated parallel debates in the economic sphere. Hence his story about scientific genius unwittingly displayed notable similarities to contemporary revisions of the labour theory of value. Just as Whewell had devolved the task of organization on the hero-figure of the scientific genius, many apologists for capitalism in the 1830s constructed a similar hero in the entrepreneur, who deserved all the profits he got due to his unique combination of technical and organizational skill. Although Whewell would have bristled at the thought, his noble defence of scientific genius shared discursive space with
those less-than-noble economists like William Nassau Senior and J. R. McCulloch, who earned Marx’s rebuke of being capitalism’s “hired prize fighters”.

My readings of Herschel, Babbage and Whewell share certain assumptions with the social and linguistic approaches to the history of science mentioned above and depart from those approaches in other ways. One shared assumption is that the most useful way to formulate a context, whether social or linguistic, for a body of work is by starting at the local level. For that reason I have restricted my analysis to the scene in London and Cambridge: not to claim that this case exemplifies British scientific reform in general, but to provide a sense of the personal and local character of the organizational choices made in such reforms. Having said that, I do think there are good reasons for starting with a metropolitan case to illustrate my point. ‘Industrial’ descriptions of scientific activity that surfaced in the 1820s, like most descriptions of industrial society following the time of Smith, emanated more often than not from the traditional cultural centres of Edinburgh and London — despite (or, one might argue, owing to) the fact that these centres were most frequently targeted as responsible for scientific ‘decline’ and had little to do with industrialization. For political economy, a case has been made that City brokers like David Ricardo and Thomas Tooke originally developed the mythic language of laissez faire in order to subordinate the desires of ‘industry’ to their own interest in maintaining London as the centre of world trade; and that ‘Manchester men’, after first putting up a weak fight against such readings of their activity, eventually were satisfied to allow metropolitan journalists and politicians do much of the talking for them. A similar argument is worth taking seriously in application to the rhetoric of science in early Victorian Britain. Especially after the first wave of provincial scientists had established their presence as practitioners of an alternative form of natural knowledge, most were quite happy to let philosophers from London, Edinburgh or Cambridge theorize about their place in the social order. Those who chose to remain in the provinces, like John Dalton, gladly looked on as London men of science inserted their discoveries into metascientific treatises; others migrated from province to metropolis to speak on their own behalf, only now with the increased cultural authority that came from affiliation with the Royal Institution or Royal Society of Edinburgh. Those who resisted the cultural lure of metropolitan science, like mesmerists or provincial doctors, paid for their independence with marginalization — just as Birmingham’s leading merchants, who continued to support a paper currency system long after Ricardo and his London friends had convinced the rest of England to plump for the gold standard, earned universal derision that spread outward from London journals like the Times and Economist.

A further point where my interpretations overlap with recent studies of early Victorian scientific culture is in stressing the relevance of the scientists’ attempt to “escape from perspective”. This issue has appeared most prominently in discussions of the intellectual and moral foundations of objectivity in its ‘modern’
form. In their search for these foundations, historians of science like Daston and Ted Porter have turned to early nineteenth-century scientific texts and practices that attempted to minimize the role of the observer’s ‘subjective’ error in discerning natural ‘facts’. Examples of this tendency include Augustus De Morgan’s claim that a multiplication of observations, whether in astronomy or vital statistics, could not help but improve the certainty of one’s generalizations, and Babbage’s celebration of calculating engines or suitably-disciplined working-class calculators to show how the most practised observer could not compete with a large number of mechanical parts that had been arranged so as to perform a multitude of simple tasks. My readings of Babbage and Herschel, in particular, complement these insights by positing economic language and institutions as further sources for their attempts to ‘escape from perspective’. This can be stated at the level of a specific intellectual transfer, in the sense that ‘objectivity’ was the hoped-for outcome when scientific reformers tried to solve Adam Smith’s problem of how to promote productivity without planning in advance how to organize the labour force. The economic sources of scientific objectivity also appear, however, in models that found their way into science through channels that were more institutional than textual. With that in mind I go beyond a reading in which men of science sorted out problems left behind by Smith to one in which they tried to solve organizational problems by patterning the scientific community after institutions like joint-stock companies and voluntary associations, which claimed to minimize the significance of the perspective of any single participant.

An important difference, or at any rate a clarification, between my approach and that taken by some of the ‘first generation’ historians who analysed early Victorian science as a marginal social activity relates to the content of the natural philosophers’ reform strategies. An important claim in many of these studies is that science was an activity that was outside politics, in the same sense, for instance, that abolitionism was an apolitical issue around which marginalized industrialists could congregate. Assuming that ‘politics’ is defined narrowly as the high politics of the aristocracy in the 1820s, I do not challenge this view. But a focus on economic language reveals a further layer of political discourse that was available to reformers (in science and elsewhere) that was not caught in the web of party politics. It was, in fact, to the putative credit of ‘political economy’ as opposed to the ‘art of legislation’ that the former stood above all party strife. Hence when Herschel cautioned the Windsor and Eton Public Library in 1833 to exercise “an extreme scrupulousness ... with reference to works on Politics and Legislation”, he immediately followed this warning by enthusiastically supporting a well-stocked “assemblage of the best works on Political Economy, as a science, and a subject of rational enquiry entirely distinct from politics”. Unlike ‘politics’, political economy provided the perfect organizing metaphor for a reformed community of science precisely because of the rhetorical weight which its discourse placed on exemption from controversy. This insistence on exemption
was paradoxically expressed in the face of profound disagreement within political economy itself, as evidenced by the contrast between the often heated private debates at the Political Economy Club and the appearance of economic consensus in public. This could at times create problems for the economists themselves; but the very fact of dispute within political economy allowed men of science to co-opt organizational models more freely than they might have from a system of thought that was rigidly programmatic.

A final and related clarification that needs to be made is that the use of economic models for reforming the organization of science should not be confused with a defence of those models as descriptions of the economy. Certainly, as in Babbage’s case, it was possible for someone to move in a more or less unbroken line from openly proclaiming the social consequences of a version of political economy to proclaiming its relevance as a model for scientific reform. But political economy as a model for scientific reform also appealed to people who were considerably less confident about the wisdom of joining the goals of scientific and economic reform. If nothing else, a deep-seated ambivalence about the ‘economic’ realm is evident in Herschel’s warning that science should never be seen as “a mere appendage to and caterer for our pampered appetites” or in Whewell’s more profound suspicions of materialist interpretations of progress.

As I will discuss below, even Babbage was not always immune to fearing that his market-oriented solutions might stain the dignity of science. While it is important to recognize the presence of ambivalence, however, it is also crucial to recognize what the actors themselves assumed: namely that political economy as a system of thought and practice solved certain problems of social organization within the scientific community more effectively than other available models. Just as Charles Lyell could indirectly relate his ideas about geological time to contemporary assumptions about paper money without taking sides in debates on the Bank of England, Whewell or Herschel could locate their scientific reform strategies within the context of economic language without extending their commitment to that language into the arena in which it originally appeared.

**REVISING SMITH: AN ESCAPE FROM PERSPECTIVE?**

For Adam Smith, the division of labour in its most efficient form was “not originally the effect of any human wisdom”, but rather the natural outcome of man’s “propensity to truck, barter, and exchange one thing for another”. Higgling, not the potentially errant plan of the factory boss or state official, was the only way to be sure that individual genius would be best adapted to the production of wealth. This premise, however, contained two paradoxes, which Smith needed to resolve in order to make free markets work in practice as well as in theory, and which people like Babbage and Herschel similarly needed to resolve if they were to succeed in applying Smith to scientific reform. The first was that people’s natural propensity to trade, besides leading them to seek out that sector of
the market where their individual skills would be the most productive, also led them to do whatever they could to reduce the opportunity for anyone else to compete with them for the same business. The ‘natural price’, which for Smith signified the ideal level of competition, was never fully reached owing to artificial obstructions to the free circulation of labour and capital. “People of the same trade seldom meet together”, he warned, “but the conversation ends in a conspiracy against the publick, or in some contrivance to raise prices”: a problem especially true with capitalists, but also evident in combinations among skilled workers. The second paradox was the famous conundrum that the division of labour appeared to deprive workers of ingenuity, even while it was allocating tasks most suited to their ‘dissimilar geniuses’. Hence, while Smith claimed in Book One of The wealth of nations that most machines had been “originally the inventions of common workmen” who thought about nothing but their specialized task all day long, he conceded in Book Four that the most trades were “generally so simple and uniform as to give little exercise to the understanding”, and too time-consuming to allow workers to pick up new skills in their spare hours.

To resolve the first contradiction, in which the same propensity that was responsible for efficient economic growth also restricted its extent, Smith appealed to an idealized ‘natural aristocracy’ of virtual representatives whose moral virtue of disinterestedness rendered them oblivious to the higglings proclivities of the middle order of society. Assuming he could shake enough landlords free of that “indolence” which rendered them “incapable of that application of mind which is necessary in order to foresee and understand the consequences of any publick regulation”, Smith hoped this class would be able to restrain the tendency of capital to combine. Only by resisting the clamour of public opinion, which past MPs had failed to do when they had supported mercantilist policies, could the legislator transcend his misguided sympathy with certain sections of the country. In Theory of moral sentiments Smith held out hope for a few modern incarnations of the “Academical or Peripatetic sage”, who possessed “the best head joined to the best heart”; although elsewhere in The wealth of nations he was less confident that “the freedom of trade should ever be entirely restored in Great Britain”, as both “the prejudices of the publick” and “the private interests of many individuals, irresistibly oppose it”. He was similarly pessimistic, although less regretful, about the possibility of solving the problem of de-skilling that seemed to accompany the division of labour. To meet this he offered little more than a weak suggestion that basic levels of education might be provided to working-class children, provided their parents paid for it and that it kept children out of the labour force as little as possible.

When scientific reformers adopted Smith’s model of a spontaneously-emerging division of labour in the 1820s they inherited its internal contradictions. Herschel, for instance, found cause to complain in his Preliminary discourse about self-interested “practical men” who had closely guarded their discoveries as
“mysteries known only to adepts”, with “their own languages and their own conventions”. The division of scientific labour, like its industrial equivalent, appeared to be limited by the extent of the market, in this case the market for communicable knowledge. But if scientific reformers shared Smith’s recognition that individual self-interest might lead to obstructive combinations, they shied away from his suggestion that the problem be laid at the door of a disinterested parliament of aristocrats — a suggestion which he in fact had explicitly related to the uniquely disinterested quality of eighteenth-century science. In their eyes, Smith’s virtue of disinterestedness represented everything that was wrong about the Royal Society, where aristocratic aloofness had prevented science from keeping pace with more active efforts across the Channel. In particular, his appeal to the philosopher’s privileged perch above the economic fray precluded any application of his model of the division of labour to science, despite his own assertion that speculation, “[l]ike every other employment”, was “sub-divided into a great number of different branches”. Herschel, for one, detected an inconsistency at this point in Smith’s argument. If the best form of division of labour required higgling, how were men of science, whose “trade” Smith described as “not to do any thing, but to observe everything”, to organize themselves in anything approaching an efficient manner? Rejecting Smith’s “homely definition” of the philosopher’s vocation, Herschel argued in his Preliminary discourse that it was precisely by making contact with the bustling tradesman that the man of science learned how to sort out true from false speculations. It was only in discovering a “practical application” of general principles, he concluded, that the natural philosopher could achieve “the readiest and completest verifications of his theories”. He might have supported this claim with an appeal to Bacon; but instead he chose to drop a footnote to an economist, Malthus, who had updated Smith in his recently-published Principles of political economy.

Once scientific reformers had rejected Smith’s praise of the disinterested aristocrat, they still needed to find a mechanism to prevent narrow combinations of ‘practical men’ from keeping the price of scientific discovery above its ‘natural’ level. The solution many arrived at in the 1820s was to appeal to a different third party, the ‘public’ — whose identity was vague enough not to personify any existing target of reform, yet specific enough to offer procedures for enabling its supervision over scientific discussion. Appealing to the ‘public’ allowed reformers to compete with combinations of ‘practical men’ on their own communitarian terms without apparently sacrificing the advantage of openness. A scientific society that was fully accountable to outside observers (encompassing, in theory, a much wider audience of ‘witnesses’ than exclusive institutions like the Royal Society permitted) could hardly be accused of leading to a “conspiracy against the public”, the outcome Smith had earlier predicted for all such combinations. Furthermore, argued Babbage and Herschel, such a society would be a special sort of combination, whose rules only dictated that all scientific discoveries be reported, without imposing any strictures on the method by which original discoveries were
reached. Hence scientists could retain the open-endedness of Smith’s original model for the division of labour without seeing that model degenerate into a cluster of closed shops that produced high-priced, low-quality goods.

Introducing an observant public into the equation promised to blur Smith’s boundary between pure self-interest and ideal disinterestedness. By moving knowledge from private to public combinations, they moved interest, and (as Daston would have it) perspective, from the individual breast or closed shopfloor to a potentially universal community of scholars. Herschel argued that such a scientific community would allow “the collective wisdom of mankind to bear down those obstacles which individual short-sightedness, selfishness, and passion, oppose to all improvements” — a social goal that he described as “a far more difficult conquest” than past success of “reason” in subduing “all nature to our purposes”. Babbage similarly held out hope that the recently-formed BAAS, “a new combination, differing entirely from the older societies”, would “give additional steadiness to the future march of science”. This steady progress was what Herschel called “the business of induction”, whereby “every new addition to our stock of causes becomes a means of fresh attack with new vantage ground upon all those unexplained parts of former phenomena which have resisted previous efforts”. Yet, as with Smith’s capitalist, there remained the possibility that any individual, spurred by the desire to compete successfully with his peers, could turn a profit with this improved “stock of causes”. As Herschel concluded: “we must not ... be scrupulous as to how we reach to a knowledge of such general facts: provided only we verify them carefully when once detected”.

The reformers’ newly-forged connection between publicity and competition, both in its strictly financial and wider epistemological senses, was the leading theme in Babbage’s critical discussion of scientific societies that occupied centre stage in his Reflections on the decline of science in England. “Full publicity, printed statements of accounts, and occasional discussions and enquiries at general meetings”, he remarked of the various London organizations, “are the only safeguards; and a due degree of vigilance should be exercised on those who discourage these principles”. More specifically, he faulted the Geological Society for insufficiently public accounts; charged that the Zoological Society’s large budget was “too tempting as the subject for jobs, and ... too fluctuating and uncertain in its amount”; and found the Horticultural Society guilty of “auditing the accounts without examining every item”. His exposé culminated with the short-lived Medico-Botanical Society, which “speedily became distinguished, not by its publications or discoveries, but by the number of princes it enrolled in its list”; and an enormous chapter recounting the various flaws of the Royal Society served as a sort of tumorous appendix to his more general critique of the newer organizations. Only the Astronomical Society, by attending to Babbage’s maxims for scientific success, managed to avoid his censure.

Babbage’s call for financial accountability in the polity of science reappeared as a plea for epistemological accountability in the realm of observing nature.
Immediately following his long litany of sins committed by the heads of the Royal Society was a strategically-located chapter on observation, where he contrasted minute observations visible only to a few talented men with those that could be replicated or magnified for the benefit of a wider audience. The latter case marked true genius, “by placing nature in such circumstances, that she is forced to record her minutest variations on so magnified a scale, that an observer, possessing ordinary faculties, shall find them legibly written ... alike independent of testimony or of judgment”. The replacement of informal testimony with communal observation created the additional necessity of training book-keepers, so Babbage included a section on “the art of observing”, which promised to teach “any gentleman of liberal education” how to “ascertain the limits within which he may trust both his instrument and himself”; and another on departures from that art, namely “the frauds of observers”. Such strictures on observation paralleled Babbage’s strictures on scientific organization, with the implicit moral that the two were connected. After attempting to refute the arguments used to support the Royal Society’s system of management, which he characterised as “a party, or coterie” that was quick to repress “any symptoms of independence and enquiry”, he paused to observe: “In the same spirit I have heard errors of calculation or observation defended.”

Whether the goal was accurate balance sheets or verified experiments, the justification was phrased in terms of competitive advantage, and it marked out the territory that Babbage and Herschel still shared with Smith. The products of public science, in open competition with the secret arts of the merely practical man and the private conversations at the Royal Society, would invariably improve the scientific as well as economic wealth of nations. Herschel filled his Preliminary discourse with examples of public science conquering private, isolated knowledge in commercial combat. The laws of nature, he claimed, were “invincible opponents” of projects that had been designed without paying attention to the latest scientific news; while those same laws provided “irresistible auxiliaries” to those who were smart enough to depart from their trade secrets when a well-ascertained scientific discovery suggested a better way. As examples of speculators paying for their faith in private skill, Herschel pointed to the projector of a diving-bell who had underestimated the pressure of deep water and drowned, “an unhappy victim of his own ingenuity”. As an example of science suffering for want of publicity, he contrasted the age-old practice of vaccination by “a few farmers in a remote province” with the lucrative discovery of a reproducible smallpox vaccine by Jenner. Besides holding out an incentive for most members of society to pursue science in a public manner, the marriage between physical and economic laws acted as an important symbol of the superior efficiency of the scientific division of labour. Herschel was hopeful that even those at the Royal Society, who practised science with scant commercial motivation, would at least stop and notice when faced with his examples of public science’s economic impact.
SCIENCE AND THE PROPERTY OF SKILL

This mixture of competition with public association also addressed Smith’s second paradox: the de-skilling consequences of specialized labour. If the production of scientific knowledge found its match in economic productivity, what was to prevent men of science from taking on such highly specialized tasks that their skill diminished along the pattern of Smith’s “common workmen”? The ideal of public science resolved this dilemma by de-emphasizing the role of skill at an individual level and reintroducing it in collective scientific societies. Just as a vaguely-defined ‘public’ prevented the need for any single person or group to guard against combination, a definition of skill in which knowledge emerged from an undifferentiated community of scholars made the de-skilling of individual scientists seem less relevant. As with the anti-monopolistic component of the public science ideal, it was assumed that this strategy for dealing with overspecialization would demonstrate its merits by leading to successful economic competition with other forms of knowledge production. Defining skill in this way, however, created new contradictions that scientific reformers found difficult to resolve. The prevailing institutional model that was designed to allow skill to emerge at a public and collective level was the voluntary association, the commercial equivalent of which was the joint-stock company. Although such associations were often convenient means for members of the early Victorian middle class to respond to social crisis, and joint-stock companies were frequently if fitfully profitable, these successful outcomes of public association were not always compatible with the intellectual aims of scientific reform. Sometimes, as with the Society for the Diffusion of Useful Knowledge (SDUK), it turned out that the easiest road to economic gain favoured hack writers and entertaining lecturers over serious men of science; other times, as when Babbage participated in the early nineteenth-century company craze, the fluctuations of the share market proved too violent for his mental habits to bear. These contradictions would ultimately drive reformers like Babbage and Herschel back into the arms of Smith’s ideal of the disinterested aristocracy in their effort to sort things out, which in turn opened up space for Whewell’s competing model of scientific organization.

The idea that skill should be reconceived as insignificant among individual workers was common to a more general economic debate over the impact of machinery on skilled labour. The large-scale appearance of automated machines in the 1820s, together with the apparent ease (even superiority) with which such machines could be tended by uneducated women and children, led many defenders of the factory system to question the relevance of Smith’s doctrines to the present day. As Andrew Ure observed in his Philosophy of manufactures, “the scholastic dogma of the division of labour into degrees of skill has been exploded by our enlightened manufacturers”. A comment like this did not necessarily mark the last word on skill, even for such an extreme defender of self-automated machinery as Ure. What it did do was move the really important variety
of skill from the hands to the head. The chief target of factory apologists had always been the artisan’s “peculiar dexterity and steadiness of hand”, which resulted in higher wages and was “so fruitful of jealousies and strikes among workmen”. Although Ure could not resist the occasional jab at Babbage’s fixation with verification and accountability, he mainly left the role of skill in constructing and organizing machinery up in the air.37

For people like Babbage, who were more involved than Ure in the internecine struggles of British science, what happened to skill once its importance in manual labour had been “exploded” was a critical issue. The question was especially important since Whewell’s response to Smith’s dilemma was to retain skill as an individual trait but limit its denotation to certain mentally gifted ‘geniuses’. Babbage and Herschel defended their collective definition of mental skill against this competing model on two grounds. First, they claimed that Whewell’s definition was élitist and thereby potentially obstructive to the free circulation of knowledge: Herschel, at one point, warned Whewell that a scientific clergy such as he envisaged would produce “a democratic tyranny with all the vices of the narrowest oligarchy”.38 Second, they assumed their interpretation of skill to be better suited to their dual struggle against ‘practical men’ and aristocratic natural philosophers. Both of these groups, as they saw it, had always defined skill collectively, and as a result would be less likely to pay attention to a revised definition along Whewell’s lines. And on this score, if we accept the conclusions of historians who have investigated the ‘property of skill’ among natural philosophers and artisans at this time, Herschel and Babbage were largely correct. Simon Schaffer has shown how British natural philosophers before 1820 relied on collectively negotiated precepts, often hashed out after the fact, for what counted as a successful discovery, and John Rule has pointed to a similar process at work in British artisan culture where, he notes, skill “was not viewed as an individual property right, but as a collective one”. Even in trades that were passed down from father to son, “what was inherited was rather the use right to be exercised within the regulations and restraints imposed by the trade”.39 In both cases the property of skill, while collective, was also explicitly private.40

In this context, a reform ideology that retained the collective sense of skill but exposed its inner workings to public opinion appeared to be a sound proposition. The strength in numbers that produced large stocks of knowledge in closed trades and private scientific societies could be opposed by even larger numbers of scientists in public organizations. No longer would exclusion from a guild or failure to secure Royal Society patronage snuff out a bright idea. Meanwhile, the very fact of publicity in these new groups, as well as their embrace of new forms of machinery that transferred skill from the hand to the head, would diminish the value of skill possessed by private combinations. The same result was already underway in the competition between factory owners and artisans, in which the wages of the latter group plummeted as machines made them redundant. In moving from factory goods to science, Herschel and Babbage hoped
for a more far-reaching victory, which would both dethrone the exclusive knowledge at the Royal Society and devalue the secrets of the shopfloor. Attempts to achieve this reformation of scientific skill took two paths. One was to establish alternative scientific societies that followed Babbage's guidelines for accountability: "younger institutions ... to supply the deficiencies of the old", as he wrote, the very existence of which demonstrated that "the system of division of labour and of co-operation" was on its way to being applied to the pursuit of knowledge. Another, which Babbage was especially keen on pursuing in the 1820s, was for men of science to enter into association with non-scientific capitalists to show how their version of skill could lead directly to business success.

Babbage's "younger institutions", in which men of science would join together to demonstrate the intellectual and commercial advantages of public co-operation, fell into two broad categories. Some, like the Astronomical Society, were directed mainly at the existing scientific élites. Others, like the SDUK and the various educational projects that grew up around it, directed the glare of public knowledge at artisanal trade secrets. In either case, though, the assumption was that the institution would achieve a competitive advantage over aristocrats and artisans alike, which in turn would signify the superior efficiency of the scientific reformers' strategy for organizing mental skill. Members of the Astronomical Society used commercial arguments to convince the Admiralty Office to hand superintendence of the *Nautical almanac* over to them, in the process depriving the Royal Society designate, Thomas Young, from a lucrative sinecure at the Board of Longitude. They also pointed to the advantage of replacing artisanal nautical practices, which according to a Board of Longitude memo of Herschel's placed naval calculations "in the light of a craft and a mystery", with computing methods that were "pursued in the observatory". Similarly, the scientists and mathematicians at the SDUK sought both to diffuse knowledge that would break down artisanal monopolies on manual skill and to communicate ideas cheaply enough to circumvent the more expensive and elitist system of publication promoted by the highbrow booksellers and the Royal Society. In hiring the bookseller Charles Knight, the SDUK found a capitalist who had learned how to use the steam press (which in itself cut back on the proportion of labour needed for printing) to expose thousands of artisans to pages upon pages of cheap and useful knowledge, while simultaneously weakening the power of the typographers' guilds. And in closely modelling themselves on the "subscriber democracy" pattern of contemporary voluntary associations, the SDUK attempted to supplant the traditional connotation of combination from a private, secretive body to a public body.

Yet while the commercial and intellectual goals of such associations overlapped at certain times, the overlap was far from complete. In the SDUK, for instance, the diffusers in question often set their sights on only one of these two goals, at the expense of the other. When the recent Cambridge graduates J. E. Drinkwater and J. W. Lubbock supplied the Society with a treatise on probability...
in 1830, their wish to make a mark in the scientific community grated against the Society’s marketing efforts. While negotiating with the SDUK, Drinkwater informed its secretary Thomas Coates that “with all our endeavours to treat it in a popular manner, we feel that some of the Analysis is still too intricate for the objects of your Society” — adding that as “[t]his Analysis is directed to the examination of some of the most interesting questions, ... we should not be disposed to omit it”.46 When the Society did attract writers who had a keener sense of what the market for useful knowledge would bear, these tended to be people with little sympathy for the lofty goal of public knowledge. The economist J. R. McCulloch, for instance, ceaselessly bargained with Coates over his fees; and suggested at one point that the Society might make “a small speculation” and pay him wholesale rates for a thousand remaindered copies of his Principles of political economy, which were “still ensconced in the warehouse at Edinburgh”. Augustus De Morgan concisely described the dilemma faced by many SDUK contributors when he rejected a request to include commercial examples in his proposed treatise on mathematics: “he that wanteth Commercial Arithmetic only will say Pooh! to the Algebra; while on the other hand, he who delighteth in the square of a–b will say pish! to the cuts and hogs”.47 Within fifteen years the “cuts and hogs” contingent had prevailed over the Society’s original goals. Declining sales led the Library of Useful Knowledge in 1842 to change its name to the Library of Entertaining Knowledge, while the provincial mechanics’ institutes that orbited the central SDUK office were forced to choose in the 1830s between closing up shop and diluting the scientific component of their curricula.48

The other strategy for producing commercially successful knowledge in a public setting, which called on men of science to enter into association with businessmen, led to disillusionment even more quickly. Not all reformers were so bold (or foolish) to take this prescription personally: certainly not Herschel, who possessed sufficient income to leave the motive of self-interest to others.49 A rude awakening awaited Babbage, for whom scientific ambition and economic opportunity seemed to be moving along the same path in the 1820s. Upon graduating from Cambridge, Babbage made the mistake of marrying before succeeding in business, which led to disinheritance at the hands of his father, the banker Benjamin Babbage. At the same time, his inventive mind was well on the way to figuring out how, in theory, it would be possible to rid science of the annoying problem of manual skill getting in the way of the pursuit of truth. His calculating engine, he assumed, would transform the rate of discovery in the same fashion that comparable engineering feats had transformed industrial growth. This vision led him to form two sorts of commercial association: a partnership with the engineer Joseph Clement, whose privately-practised manual skill at building engines Babbage hoped to yoke to the higher ideal of public knowledge; and an investment contract with the British government, which advanced money to Babbage and Clement on the basis of his promise that the engines would vastly improve and cheapen nautical calculations.50

Provided by the NASA Astrophysics Data System
It was typical of Babbage's state of mind at this time, and also revealing of the modes of thought that infected many of his friends, that he jokingly referred to his new machine's output in terms of its 'natural price'. Writing to Herschel in 1825, he reported that "in a few years we shall have new (but not patent) stereotype logarithmic tables as cheap as potatoes". Unfortunately for Babbage, necessity may have been the mother of invention, but the wayward market of the 1820s was no place to raise an offspring as fragile as a machine for calculating logarithms. Once he stopped drawing plans for his difference engine and actually started to build it in 1823, he quickly discovered the drawbacks of mixing too closely with the world of manufactures. He converted the top floor of his house into a workshop, complete with forge, and hired out work to a lathe-operator; after a break in the mid-1820s, the pace of construction picked up again in 1828. But machinery, it turned out, produced other consequences besides reducing costs: it also contributed to overproduction and temporary shortages of labour as workers moved from one job to another. As a result, Babbage later recalled, construction could not be carried on without great expenditure. The fluctuations in the demand and supply of skilled labour were considerable. The railroad mania withdrew from other pursuits the most intellectual and skilful draftsmen.51

The draftsman who stayed was Clement, an exceptionally ruthless man who kept the title to the parts Babbage had taught him how to construct, made exorbitant demands on the Treasury Office, and used his influence to dissuade other engineers from working with Babbage when relations between the two soured. For Clement, skill was very much private property, and no natural laws in the world were going to convince him otherwise.52

In 1824 Babbage moved from one poorly-chosen association to another when he signed on as an actuary with the recently-projected Protector Life Assurance Office. The Protector was a public joint-stock company, which featured an administrative structure that replicated the model for scientific reform that Babbage would later celebrate in his Reflections. Its directors promised the dual guarantee of a voting proprietary, which would ensure proper supervision over all management decisions, and the best mortality tables money could buy, which would base the society on the firm footing of scientific law.53 Under different circumstances such promises might have been valid; but this was 1824, the year before the biggest stock market crash in British history up to that point, and no amount of paper assurances could prevent the Protector from going down with hundreds of other similar projects. Heedless of these snares, Babbage jumped into the project headfirst. After convincing a family friend that the Protector was safely removed from the class of "mere jobbing catchpenny transactions", he persuaded the friend and several others to sign up for some £20,000 in shares. Throughout the summer of 1824 he "calculated some tables and uncalculated others to see what they were made of", and provided the directors with "books neatly ruled, and properly lettered with printed formulae and every requisite...". But then, for
reasons Babbage refused to disclose in writing but apparently involving an indiscretion on the part of two of the directors, “all was overthrown”. He recoiled, refusing all further offers from life offices, and retired in frustration and in possession of “some additional knowledge of the world which if I could employ it would render me more heartless and incredulous than I should wish to be...”.

Babbage’s response to this succession of business disappointments, both in the immediate aftermath and the longer term, revealed an important break from his earlier vision of scientific reform. His immediate response to the Protector disaster was to drown his sorrows on a geological tour of Devonshire, where he “derived a great quantity of information and saw much”, as he later reported to Herschel. Unfortunately for Babbage, his gentlemanly visit to freshwater formations in Devonshire drowned his luggage as well as his sorrows, when a boat carrying his notes and supplies upstream capsized. All the tables he had constructed for the Protector, with which he had been planning on writing a book about life assurance, went down with the boat. Beaten but unbowed, he returned to London where he proceeded “slowly and steadily” on recalculating the life tables for publication and on designing his difference engine. Babbage had possibly lost his innocence, but not his sense of humour. “I think my run of luck must now turn”, he wrote to Herschel with a straight face. “I have some ideas of trying a ticket in the next lottery.”

As Babbage well knew, and as any elementary textbook on probability could have told him, his bad luck in Devonshire could not have contributed to his future fortunes. His combination of commercial and nautical mishaps did, however, directly affect his strategies for reforming science. Upon returning to London, he wrote three books within a space of eight years, each of which reflected his changed views in a different way. In his Comparative view of the various institutions for the assurance of lives he exorcized the demon of the Protector by urging his readers to join only mutual life offices, which by excluding outside shareholders lessened the threat of insurance being caught up in a stock market crash; Benjamin Babbage so liked this book that he wrote Charles back into his will. In Economy of machinery and manufactures he presented the scientist as a clipboard-carrying consultant whose job was to make the rounds at factories and suggest new uses for grease and electrical wires. He also held out hope, at the end of this book, that other supporters of science would have the same family fortunes he had recently experienced: predicting that “the sons of our wealthy manufacturers” would combine their parents’ money with their practical upbringing and act as the natural élite in the next generation of science.

And in his Reflections on the decline of science he proposed that the scientific community would only be able to exhibit a proper level of “esprit de corps”, which “frequently overpowers the jealousy which exists between individuals”, if the government stepped in with generous funding.

All these new social mechanisms for funding science and finding a place for expertise shared one thing in common: they had as little as possible to do with
the market economy that had burned Babbage so badly. His retreat from the market was of some consequence, since it accompanied a return to Smith’s model of the natural philosopher whose job was “not to do any thing, but to observe everything.” When Babbage made the rounds as a factory consultant, or went calling for state funding, he was not only pulling back from the confident assumption that science could hold its own in the market. He was also admitting that the “escape from perspective”, which was to help public science prevail against private skill, was not such an easy feat to pull off. This admission landed him back at Smith’s virtue of disinterestedness, and the related virtue of being financially independent and hence above the fray, as the best way to keep the division of scientific labour operating at a steady pace. A return to disinterestedness, in turn, raised a question that the reformers’ earlier strategies had allowed them to ignore: which men of science should qualify as suitably disinterested to direct the progress of inquiry?

This was a question people like Babbage and Herschel, as well as the many reformers who rallied around Babbage’s call for state-funded science, were ill-equipped to answer. Downplaying genius had led them to focus on the ‘division’ side of the division of labour, without worrying very much about who the labourers were. Simply calling for sufficient funding to keep men of science insulated from the market did not come close to determining who those men (or women) should be. As a result, the mantra of ‘state support’ evoked a different future for every scientist who asked the government for money. For Babbage government funding meant a national academy with competitive entrance standards. For the Scottish philosopher-of-all-trades David Brewster it meant a revival of the native British skill that Adam Smith had celebrated, by pumping state funds in the direction of deserving provincial professors like himself. And for the York naturalist William Vernon Harcourt it meant supplementing the aristocratic Royal Society élite with a New Atlantis of subsidized country gentlemen, who would transcend the narrow inquiries of specialized scientific societies. The argument over who should belong to the ‘prouder aristocracy’ of science — who should be elevated to the rank of being able to observe everything and do nothing — reintroduced the problem of competition narrowing the market for knowledge. Each new proposal for state assistance came with a different boundary between those who were capable of pursuing science in a disinterested manner and those who were consigned to sell their wares on the open market. This was a problem that Adam Smith, who had the luxury of appealing to a ready-made leisure class, had never needed to face.

WILLIAM WHEWELL: THE SCIENTIST AS ENTREPRENEUR

The failure of Babbage and Herschel to achieve full realization of their plan for reorganizing science left the ground open for a new reform scheme that took a more direct approach to defining scientific genius. Prominent among the
alternatives was William Whewell’s hierarchical vision of scientific discovery, in which ‘genius’ could be identified in certain individuals who were capable of combining many inductions in the same mind. Responding to Samuel Taylor Coleridge’s hint that a new line of demarcation would be useful to distinguish among motley ‘natural philosophers’, Whewell fashioned the neologism ‘scientist’ to fill the need. The job of the scientist would be to reconcile incoming discoveries, then use his privileged perspective to direct the future progress of science. In comparison to Babbage and Herschel, it is harder to maintain that Whewell came to this conception from a direct appreciation of similar reasoning in political economy. What can be maintained is that other scientific reformers presented Whewell with a set of economically-informed problems that invited a response that paralleled the direction taken by contemporary economists.

Around the same time that Whewell was fashioning the ‘scientist’ as the basis for forming a consensus about what counted as legitimate knowledge, economists like J. R. McCulloch and George Poullett Scrope were turning to the ‘entrepreneur’ as part of a new ideological basis for capitalism.

Unlike the scientist, the entrepreneur (at least as a concept) did not originate in England. The phrase, and the idea behind it, was first introduced by the French economist Jean Baptiste Say, who singled out the qualities of technical skill, risk-taking and supervision as essential ingredients of profit. He argued that Smith’s definition of profit, as returns from an investment, failed to account for these moral qualities. The mere capitalist, just by buying stock, could not count on turning a profit; while the entrepreneur, who possessed technical know-how and a strong will in addition to stock, was destined to earn rich dividends. Just as there had been people who fit Whewell’s definition of ‘scientist’ well before 1830 (Newton, for instance), Say discovered many examples of “wonderful practical skill” among past British factory bosses and merchants that clearly denoted entrepreneurship in action. The problem, for Say, was to introduce the same qualities into the French economy, which abounded in capital but lagged behind British profits. His solution, ironically, had less to do with Whewell than with Babbage: direct government support of science, both in terms of putting theorists on the state payroll and offering rewards and prizes to private inventors. Such support, he concluded, would “excite emulation and enlarge the general stock of knowledge without diverting industry and capital from its own most profitable channels”. The reason Say thought it was necessary to call on the French government to support entrepreneurship was similar to Babbage’s ultimate appeal to the state. Say assumed the best form of entrepreneurship had developed in the unprotected conditions of Britain. But in France, competition from the British had placed a heavier burden on the entrepreneurial component of profit. Once low import prices had forced down the rate of profit French capitalists could charge, it was unrealistic to expect them to make up for that loss with whatever individual technical skill they had managed to acquire. Hence the state entered the picture to inject the capitalist with enough extra ingenuity to
push his cost of production below that of his British competitors. Babbage, similarly, had only appealed to the state once it became clear to him that difference engines and scientific premium tables faced an uphill battle in the open market.

When the entrepreneur made his way across the Channel in the 1820s, his ideological function underwent important shifts in emphasis. Instead of being put forward as a fit subject for state funding, the chief rhetorical use of the entrepreneur was to justify the capitalist’s increasingly dominant place in society. For British economists after Ricardo, the problem was not to catch up with an economically powerful neighbour; it was to put down a socially threatening working class. As such, skill was not something to be injected into the entrepreneur by a protectionist government; it needed to be appropriated, at the conceptual level, from a class of restive artisans who protectively clutched onto it as their sole form of private property. Consequently, economists like Scrope and George Ramsay distinguished between the ‘mental qualities’ of the entrepreneur and the manual skill of the artisan, and drew attention to the former category as an important basis for profit.65 And unlike Babbage, who had made a similar distinction but had attributed ‘mental qualities’ to the public community of science, English theorists of entrepreneurship resolutely located those traits in the individual possessors of capital. In essence, they reasoned that since technical skill and capital almost always subsided in the same person, possession of capital was the surest sign of possession of skill. To do so they often referred back to Smith, who had never sorted out the issue of where skill came from but had, in any case, insisted on the superior efficiency of individual capitalists. This appeal to the individualist side of Smith was a common method for upholding the un-Smithian notion that skill and capital were most frequently joined in the same person.

It is, of course, still a long stretch between this example of capitalist apologetic and Whewell’s ‘scientist’. But given Whewell’s strategy for organizing the scientific division of labour, and taking into account both the sort of people he considered to be fit leaders of such a labour force and his own personal background, the parallels between Scrope’s entrepreneur and Whewell’s scientist are worth taking seriously. Most importantly, Whewell’s philosophy of science located genius and the accumulation of intellectual ‘capital’ (i.e., previously stored-up facts) in the same person. The entrepreneur’s profit, in this case, corresponded with the scientist’s “inductive inference”, which required “an idea from within, facts from without, and a coincidence of the two”.66 Just as a failed capitalist was someone who possessed a large stock but used it to produce an unprofitable commodity, the failed scientist turned his store of facts into an incorrect theory. And while Herschel, following Smith, had left it up to ‘market forces’ to weed out profitable from unprofitable theories, Whewell was more careful to trace the two back to the original theorists, so as to nip the unprofitable ones in the bud. He faulted Herschel for failing to condemn “the method of anticipation, as opposed to that of gradual induction”, as a road to discovery. This was the context in which he delivered his warning, cited in my introduction, that
an improper division of labour would “misemploy the cultivators of science”.\textsuperscript{67}

Alongside this formal similarity between the functions of the entrepreneur in contemporary economic language and that of the scientist in Whewell’s reform ideology, it is possible to point to specific economic ideas and experiences that informed his attitudes towards scientific organization. It has frequently been observed that Whewell was pessimistic about political economy’s capacity to achieve the level of certainty in its generalizations that its major advocates had claimed; this was the chief basis for his attacks on Ricardo and for his efforts to translate economics into a mathematical language, which he assumed would show how much distance separated its claims from those of mechanics or astronomy.\textsuperscript{68} But there was another, more private, side to Whewell’s interest in economics that suggests he at least took seriously its normative potential for social reorganization. In 1832, for instance, he confessed to Richard Jones that he had been “entirely charmed” upon reading the Exposition that Saint-Simon’s posthumous disciples had produced two years earlier. While writing off its “nonsensical blasphemy” as so much German metaphysics, which Say surely would have done as well, he had nothing but praise for the Saint-Simonians’ proposed mechanism for achieving progress. “It is only for the practical men of the English and French democratic states”, he concluded, “to make the first glimmerings of Political Economy a ground of legislation, and to preach a theory of the progress of man as a new religion”.\textsuperscript{69} A further case can be made that Whewell’s own personal progress, from being a master carpenter’s son on fellowship at Cambridge to being Master of Trinity College, reinforced the entrepreneurial contours of his language of scientific reform. His social struggle to conform as a Cambridge undergraduate imposed an immediate pressure to keep his artisanal heritage at arm’s length; and in marrying Cordelia Marshall, daughter-in-law of a Leeds flax merchant who had cashed in his entrepreneurial success for new membership in the landed gentry, Whewell acquired in a fell swoop the accumulated wealth of active capital and the newly-won status of aristocracy.\textsuperscript{70} Alongside the two very different meanings of ‘master’ associated with father and son stood a corresponding translation of the property of skill.

Whewell developed his precepts against misemployment out of the same concern to put down people whose methods of discovery threatened his vision of science in a manner that directly paralleled the threat posed to capitalists by artisanal methods of production. In this situation the prototypical ‘artisan’ philosopher was the provincial chemist John Dalton, whom Herschel had praised for announcing his discovery of the atomic theory “in its most general terms, on the contemplation of a few instances, without passing through subordinate stages of painful inductive ascent by the intermedium of subordinate laws”.\textsuperscript{71} Herschel could afford to be sanguine about Dalton’s discovery, since he assumed that once it had entered the public domain other chemists would sort out its true merit. Whewell, conversely, worried that Dalton’s approach to theory would devalue the precisely-defined quality of genius that he had attributed to the
scientist. As a result, he maligned Dalton for daring to propose a "method of molecular arrangement, of which we have no positive knowledge whatsoever" — to assert genius, in other words, without first possessing the 'capital' of collected facts. A more suitable method of pursuing truth, according to Whewell, was to act like the entrepreneur, who accumulated capital through stages of painful ascent until he finally possessed the 'mental qualities' which allowed him to collect profits while others performed the manual labour. Such a scientist was George Biddell Airy at the Royal Observatory, who imposed factory discipline on his star-seeking staff, or Michael Faraday at the Royal Institution, who set real-life artisans to work performing electrical experiments which prodded him on to ever greater feats of intuition. In the same vein, Whewell viewed the British Association less as a 'new combination' to add publicity or state support to a closed scientific shop, than as a sort of philosophical chamber of commerce where private men of science could disseminate propaganda on their own behalf.

Whewell's entrepreneurial fashioning of the man of science appeared in his choices about how to present the scientist to the public. As Richard Yeo has recently observed, biography was a favoured mode of presentation for Whewell. This genre conveyed the same moral message that chroniclers of Britain's great entrepreneurs carefully incorporated into their publications. Popular books like George Craik's *Pursuit of knowledge under difficulties* (1830), which inspired Samuel Smiles's even more successful self-help manuals a generation later, personalized material progress in the struggles experienced by individuals whose unique combination of intelligence, moral rectitude, and fortunate circumstances brought them wealth and social status. Whewell's only problem with such accounts was that they left out the parallel strides made in abstract science. His discussions of individual scientists in *The history of the inductive sciences* and in review articles betrayed an effort to de-centre more standard Victorian narratives that equated progress with political or material change, in order to emphasize the unique contributions to intellectual progress made by great scientists. Such was his depiction of Newton, whose "intense mental effort" in mechanics set him far above his eighteenth-century successors who "gave the subject over to the operation of algebraic reasoning, in which symbols think for us, without our dwelling constantly upon their meaning". No less than Smiles, Whewell intended comments like these to encourage mental discipline among his readers; but rather than keeping the strong-minded entrepreneur at his post overseeing hired hands, his language impressed the need for men of science to think their way through every discovery.

As ideology, Whewell's attempt to pin consensus on a carefully constructed 'scientist' produced mixed results, just as the 'entrepreneurial ideal' only went so far in achieving universal consent. A number of branches of the scientific community whom Whewell hoped to convert to his philosophy responded by stubbornly defining science on their own terms. Chemists jilted Whewell's efforts to get them to subordinate their subject beneath a rigid algebraic methodology.
in favour of the less mathematical and more lucrative direction of German organic chemistry; statisticians insisted on attaching their numbers to liberal social reform. And many other ‘marginal’ figures whom Whewell never even bothered to incorporate into the canon of inductive science, like the mesmerists and phrenologists, continued to challenge the legitimacy of a single scientific consensus long after the 1830s. But his ‘entrepreneurial’ model did succeed in another way, albeit at the expense of a more inclusive scientific community. In establishing putatively certain boundaries between what counted as science and what did not, Whewell pushed philosophers closer to embracing ‘genius’ (in the general sense implied by Adam Smith, if not in the more strictly defined sense intended by Whewell) as a legitimate defining trait of the scientist. And in contrast to Herschel and Babbage, he came much closer to showing other members of the scientific community how to recognize genius when they saw it.

Just as the ideal of entrepreneurship did useful ideological work at first, then receded when it had outlived its utility, so too, as Yeo has concluded, can Whewell be seen as largely successful in his efforts to “legitimate science as an intellectual and social activity in a particular context” — but not much further. For talented scientific administrators like Roderick Murchison, who had figured out how to win state support without losing too much intellectual independence, Whewell’s philosophy ultimately got in the way of their ambitions — leading Murchison to complain of him in 1843 as a “high priest” whose interests had diverged from those of the “men of science”. Others, like Charles Darwin, succeeded in setting up new informal networks of discovery without finding it necessary to appeal to the exclusive-sounding language of ‘genius’. Darwin, despite quoting Whewell’s Bridgewater treatise in his preface to the Origin of species, firmly departed from his methodological strictures both in theory and in practice. Whewell soon realized it was no longer possible or especially useful for an outside observer like himself to draw explicit attention to the unique traits of scientists. Consequently he emerged from the 1850s with a description of the scientific enterprise that sounded more Smithian than Herschel’s or Babbage’s ever had, claiming in 1857 that there was “a legislation of scientific discovery which is wiser than any legislator ... namely, men of science themselves, employed in making discoveries, according to their own intellectual impulse”. A victim of his own success, Whewell was all but silent on scientific topics in the last two decades of his life.

CONCLUSION

If the scientist replaced the natural philosopher in 1830, a different but related changing of the guard was transpiring in the neighbouring field of economic thought. As Ronald Meek has paraphrased Marx, 1830 marked “the end of ‘scientific’ economics.... From then on, the scientists were obliged to give way to the hired prize-fighters.” New theories of political economy appeared from the
pens of ‘vulgar’ apologists who abandoned Ricardo’s rigid (if contradictory) focus on the division of labour and instead paid attention to the special qualities of the capitalist that rendered him deserving of profits. In the process, apologetics replaced Ricardian ‘science’, which had threatened to decentre capitalists from the very theory that had been erected on their behalf. From a non-Marxian perspective, what these new economists did was supplement Ricardo with a theory of entrepreneurship, devoting less attention to the division of labour as a spontaneous process and more on the skill and savings that capitalists contributed to its efficient operation.

The problem Ricardo had introduced, and which required subsequent economists to make a theoretical choice between socialism and entrepreneurship, was functionally identical to the problem faced by scientific reformers once they had appealed to a Smithian conception of the division of labour. Just as Ricardo’s emphasis on labour removed the capitalist from his starring role in the story of economic growth, the same emphasis in science threatened to reduce the ‘true’ scientific genius to a supporting role in the advancement of knowledge. And just as ‘vulgar’ apologists quickly stepped in to develop a theory of economic production that would restore the capitalist to his original stature, men of science were waiting in the wings to discover special qualities that would place scientific genius at centre stage. Ironically, it was William Whewell and others like him who, at least in this functional sense, played vulgar economists to Babbage’s Ricardo. It was Whewell who decreed that only certain natural philosophers were capable of recognizing the eternal truths that would propel scientific discovery in a positive direction, and who argued that anyone who attempted to make a discovery without receiving direction from one of these philosophers was guilty of ‘misemployment’. It was Whewell who carefully distanced himself from those parts of Herschel that echoed the dicta of Adam Smith, and who brushed aside Babbage’s paens to the division of labour. Whewell’s invention of the ‘scientist’, in short, was only possible once ‘scientific’ economics no longer informed the organization of natural knowledge in England.

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REFERENCES

2. Wise, “Work and waste” (ref. 1), 263, 266.
5. Thackray, “Natural knowledge” (ref. 3), 679–80.
6. See in particular the contributions to Ian Inkster and Jack Morrell (eds), Metropolis and province: Science in British culture 1780–1850 (Philadelphia, 1983).
9. One historian who has observed this use of scientific language is Maxine Berg, in The machinery question and the making of political economy 1815–1848 (Cambridge, 1980), Part 3, although she mainly focuses on the impact of scientific language on the factory and not the reverse. See also Wise’s commentary on Berg in “Work and waste” (ref. 1), 393–4.
10. Rudwick, “Poulett Scrope on the volcanoes of Auvergne” (ref. 1), 236–42; Wise, “Work and waste” (ref. 1), Parts 1 and 2.
13. See in particular Bacon’s description of “the several employments and offices” of the fellows of Salomon’s House, in The advancement of learning and New Atlantis (1627; London, 1951), 296–7.

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19. For London see Berman, *Social change and scientific organization* (ref. 4); for Edinburgh see Steven Shapin, “‘Nibbling at the teats of science’: Edinburgh and the diffusion of science in the 1830s”, in Inkster and Morrell (eds), *Metropolis and province* (ref. 6), 151–78. A parallel between the imperialist agenda of City economists and the language of empire within British science can be developed by comparing Ingham, *Capitalism divided?*, with Simon Schaffer, “The history and geography of the intellectual world: Whewell’s politics of language”, in Menachem Fisch and Simon Schaffer (eds), *William Whewell: A composite portrait* (Oxford, 1991), 201–31, pp. 203–7.


22. John Herschel, *Essays from the Edinburgh and Quarterly Reviews, with addresses and other pieces* (London, 1857), 19. See also his defence of political economy in *Preliminary discourse* (ref. 16), 73.


24. Herschel, *Preliminary discourse* (ref. 16), 10; see Yeo, “An idol of the market-place” (ref. 14), 258 and my discussion of Whewell below.


26. Ibid., 20, 785.


30. Daston observes in “Objectivity and the escape from perspective” (ref. 7), 605, that Smith looked up to natural philosophers as “paragons of the virtue of disinterestedness, both in the immediate sense of forsaking the motives of selfish gain, and in the more remote sense of remaining serene in the face of ... public contempt”. On the value of disinterestedness in Smith see also Mary Poovey, “The social constitution of ‘class’: Towards a history of classificatory thinking”, in W. C. Dimock and M. T. Gilmore (eds), *Rethinking class: Literary studies and social formations* (New York, 1994), 15–56, pp. 32–47.

31. Smith, *Wealth of nations* (ref. 15), 21; Herschel, *Preliminary discourse* (ref. 16), 12–13. Malthus’s *Principles* had appeared in 1820. As I suggested above, claims of this nature in Herschel can be found side-by-side with expressions of his contrary urge to recede from the ‘real world’. Hence his concern about science catering to “pampered appetites”, cited above, was followed immediately by a call for the natural philosopher “to descend from this high but fair ground” of theory “and justify himself, his pursuits, and his pleasures in the eyes of those around him”. And even in his chapter on “the higher degrees of inductive generalization” he reverted to examples such as “the boiler of the steam-engine” and the value of multiple observations that had as their ultimate source the factory floor or the insurance office (*ibid.*, 10–11, 194, 212–16).


34. *Ibid.*, 86–93, 71–72. See also his contrast between W. H. Wollaston and Humphry Davy in the conclusion to *Reflections*, where he praised Wollaston’s care “to avoid error”, to teach Babbage better techniques of observations, and to shun claiming to have made observations that others could not see (pp. 206, 208–12). Wollaston, and not Davy, was on a Committee with Babbage in 1827 to reform the Royal Society. See Zeno Swijtink, “The objectification of observation: Measurement and statistical methods in the nineteenth century”, in L. Krüger, L. J. Daston and M. Heidelberger (eds), *The probabilistic revolution* (Cambridge, Mass., 1987), i, 261–85, pp. 266–7.

35. Herschel, *Preliminary discourse* (ref. 16), 44–49, 114. The fact that Herschel’s reference to Jenner appeared in a paragraph that celebrated Bacon underscores the frequent overlap between Baconianism and what I am describing as Herschel’s ‘economic’ reform model.

36. The best summary of the politics of the voluntary association is R. J. Morris, “Voluntary societies and British urban élites 1780–1850: An analysis”, *Historical journal*, xxvi (1983), 95–118. Morris notes the formal connections between voluntary associations, most of which were non-profit, and joint-stock companies in *Class, sect and party: The making of the British middle class, Leeds 1820–1850* (Manchester, 1990), ch. 12.


38. Herschel to Whewell, 20 Sept. 1831, cited in S. F. Cannon, *Science in culture: The early Victorian period* (New York, 1978), 194. Herschel’s fear of democratic tyranny, as well as his concern elsewhere in this letter about preserving room for individual genius, demonstrates his ambivalent feelings about the possible consequences of minimizing the
role of individual discovery. But such feelings did not keep him from opposing Whewell's claim that the best discoverers could be selected out and encouraged ahead of time.


40. See also E. J. Hobsbawm, “Artisan or labour aristocrat?”, Economic history review, xxxvii (1984), 355–72, pp. 357–61 for the contemporary distinction between ‘being in a trade’ and ‘having a trade’.

41. Babbage, Economy of machinery (ref. 17), 263; Reflections on the decline of science (ref. 33), 21.

42. These categories correspond with R. J. Morris’s division of voluntary associations into “the membership society” and “the patronage society”: see Morris, Class, sect and party (ref. 36), 191.


47. Memo by J. R. McCulloch, 26 June 1830; McCulloch to Coates, 9 July 1831; De Morgan to Coates, 5 Jan. 1833, Nov. 1834, SDUK papers.


49. Herschel’s disinclination to practice what he preached (or even preach it very consistently) frustrated his scientific friends: see De Morgan, “Study of natural philosophy”, Quarterly journal of education, iii (1832), 70 (on Herschel’s failure to support including science in the undergraduate curriculum) and Cannon, Science in culture (ref. 37), 183–4, on his ambivalent response to Babbage’s Reflections.


51. Babbage to Herschel, 2 June 1825, HS 2.184, Royal Society papers; Babbage, Passages from the life of a philosopher (1864), in Works (ref. 17), xi, 86.

52. The best discussion of Babbage’s misbegotten partnership with Clement is in Simon Schaffer, “Babbage’s intelligence: Calculating engines and the factory system”, Critical inquiry,

54. Thomas Colby to Babbage, 22 Apr. 1824, BL add ms 37183.120; Babbage to Herschel, 28 May 1824, HP 2.196, Royal Society papers.

55. Babbage to Herschel, ibid.

56. Babbage, Comparative view of the various institutions for the assurance of lives (London, 1826); Hyman, Charles Babbage (ref. 50), 62–64.

57. Babbage, Economy of machinery (ref. 17), 264; and in general, see Berg, The machinery question (ref. 9), 182–9.

58. Babbage, Reflections (ref. 33), 4–5, 12–14.

59. Smith, Wealth of nations (ref. 15), 21.

60. Babbage, Reflections (ref. 33), ch. 1; for Brewster see his review of Babbage in Quarterly review, lxiii (1831), 305–42; for Harcourt see British Association report, 1831, 22–42, and Morrell and Thackray, Gentlemen of science (ref. 14).

61. See Schaffer, “The end of natural philosophy” (ref. 7) and “The history and geography of the intellectual world” (ref. 19); and Yeo, Defining science (ref. 7).

62. Wise makes a similar point about Whewell’s response to Babbage’s economics of steam power in “Work and waste” (ref. 1), Part 2.

63. As did other French economists at the time: see Margaret Bradley, “Charles Dupin’s study visits to the British Isles, 1816–1824”, Technology and culture, xxxii (1991), 47–69.

64. Cited in Berg, The machinery question (ref. 9), 91–93.


67. Whewell, “Modern science — inductive philosophy” (ref. 16), 399.


70. See Yeo, Defining science (ref. 7), 16.

71. Herschel, Preliminary discourse (ref. 16), 305–6; see also p. 300. I am here claiming only that Dalton occupied the same location with respect to Whewell that artisans occupied with respect to capitalists; not that Dalton himself was more like an artisan than a capitalist.


73. On Airy, see Schaffer, “Astronomers mark time” (ref. 8); on Royal Institution members as “entrepreneurial” men of science see Berman, Social change and scientific organization (ref. 4), ch. 5 (on Faraday) and p. xxi, where he credits the RI with “bending science to entrepreneurial and professional purposes”.

74. Although, as Adrian Desmond has shown in The politics of evolution: Morphology, medicine, and reform in radical London (Chicago, 1989), scientists whose views were closer to Whewell’s than to Babbage’s did not hesitate to play the ‘public combination’ card when it suited them. See Desmond’s discussion of P. M. Roget’s self-defence against charges
77. On the 'entrepreneurial ideal' see Perkin, The origins of modern English society (ref. 18), 221ff.


79. Yeo, Defining science (ref. 7), 14.

80. Cited in Morrell and Thackray, Gentlemen of science (ref. 14), 430.


82. Quoted in Yeo, Defining science (ref. 7), 254.