Natural Knowledge in Cultural Context: The Manchester Model

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> "We are *cultural beings,* endowed with the capacity and the will to take a deliberate attitude toward the world and to lend it *significance.*"[1]
>
> "Science, essentially, is the form of cognition of industrial society."[2]

FEW QUESTIONS ARE MORE fundamental to the modern world than the relationships of science, technology, and society. Whole areas of argument and action depend on one's manner of apperceiving those relationships. This is so whether society is viewed in terms of its physical well-being, political stability, social contentment, demographic profile, medical systems, economic growth, military preparedness, or cognitive and cultural orientations. That much is banal. It is almost as banal to point to an associated, partially reflexive historical concern with the interactions of science, technology, and society. This concern has fed on a burgeoning interest in the origins and adolescence of what have come to be seen as the fully matured or even postindustrial societies of the West. Further sustenance has been provided by recent analyses of the possible futures as well as the present nature of industrialized society. A whole division of Marxist literature comes within, but does not exhaust, this category. And, to a degree as yet incipient rather than actual, historical inquiry draws on the experience of improvers

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[1] *Max Weber on the Methodology of the Social Sciences* (Glencoe, 1949), 81.

[2] Ernest Gellner, *Thought and Change* (London, 1964), 72.

attempting to lead the nations of the third world through the supposedly unique gateway of modernization.[3]

Among historians, one question has been fastened on as critical and has become the center of an intensifying debate. The issue at stake is the connection between the European Scientific Revolution of the seventeenth century and the British Industrial Revolution of the late eighteenth and early nineteenth centuries.[4] In a much-quoted passage Sir Herbert Butterfield has argued that the European Scientific Revolution marks the real origin of the modern world and the modern mentality, thus outshining everything since the rise of Christianity and reducing events such as the Renaissance and Reformation to the rank of mere episodes in the local history of the West. Butterfield's claim, first put forward in 1948, is characteristically modern. Protagonists of the wider cultural significance of the British Industrial Revolution can draw on a longer historiographical tradition. A vigorous but not untypical recent statement is E. J. Hobsbawm's that the Industrial Revolution "marks the most fundamental transformation in the history of the world recorded in written documents." The geographic conjunction and close temporal sequence of two such remarkable revolutions obviously offers a strategic research site to the historical analyst. The problem is whether we are dealing with an interesting coincidence, a causal connection, or some less direct though intimate relationship. To rephrase the macrocosmic question on a microcosmic level, the need is to investigate the possible meanings of Benjamin Disraeli's remark that "what Art was to the ancient world, Science is to the modern. . . . Rightly understood, Manchester is as great a human exploit as Athens."[5]

Such an undertaking lies at the intersection of general history with three specialist disciplines: economic history, the history of science, and the history of technology. Within the traditional canons of economic history the British Industrial Revolution is a well-articulated subject of discussion. I have no wish to quarrel with the truths of the great tradition or to begin discussion of interest rates, capital formation, labor supply, entrepreneur-

[3] Entry to appropriate literature may be made via Bruce R. Williams, ed., *Science and Technology in Economic Growth* (London, 1973); Cyril E. Black, *The Dynamics of Modernization: A Study in Comparative History* (New York, 1966); John A. Moore, *Science for Society: A Bibliography* (Washington, 1971); and Schmuel N. Eisenstadt, *Tradition, Change and Modernity* (New York, 1973).

[4] See A. E. Musson and Eric Robinson, *Science and Technology in the Industrial Revolution* (Toronto, 1969); A. E. Musson, ed., *Science, Technology and Economic Growth in the Eighteenth Century* (London, 1972); David Landes, *The Unbound Prometheus* (Cambridge, 1969); Peter Mathias, "Who Unbound Prometheus?" in Mathias, ed., *Science and Society, 1600–1900* (Cambridge, 1973), 54–80; and Neil McKendrick, "The Role of Science in the Industrial Revolution," in M. Teich and R. M. Young, eds., *Changing Perspectives in the History of Science* (London, 1973), 274–319.

[5] Herbert Butterfield made the claim in a series of Cambridge lectures published as *The Origins of Modern Science* (London, 1949). See also E. J. Hobsbawm, *Industry and Empire* (Harmondsworth, 1969), 13; and Benjamin Disraeli, *Coningsby, Or the New Generation* (London, 1844). The Disraeli quotation is taken from p. 148 of the 1948 London edition.

ship, or the aerodynamics of "take off." Nor do I wish to dwell on the unprecedented technological changes of the period, since they are generally and clearly recognized. In transportation the transition from horse to canal to railroad was associated with dramatic alterations in traveling, bridging, and building. In power the development was from the Newcomen to the improved Watt steam engine, able to perform ten times as much work for an equal consumption of fuel. There was a shift in textiles from cottage industry to factory discipline; in tools from shop craft to machine precision; in chemicals from hand-batch operation to alkali works able to defoliate acres at a time with acid fumes.

My concern here is rather to explore the functions, meanings, and cultural geography of science within the British Industrial Revolution. By detailed attention to one location I shall endeavor to reveal some dimensions of the profound, little-recognized "second revolution" in English science which took place in that period. This "second revolution" was much different from but in its own way as consequential as the more familiar Scientific Revolution of the seventeenth century. One indication of its scope is that until 1781 the Royal Society of London enjoyed a lonely splendor as the sole institutionalized, enduring English organization devoted to the pursuit and publication of natural knowledge. Sixty years later the scene was crowded beyond recognition, with sixteen metropolitan disciplinary societies (for example, the Linnean, 1788; the Geological, 1807; the Astronomical, 1820; and the Botanical, 1839), at least sixteen provincial societies covering the whole of science, and over two dozen provincial disciplinary societies, some of considerable significance (notably the Manchester Statistical Society, Britain's first society for social statistics).

The proliferation of institutions points to fundamental qualitative shifts in the meaning of science as a cultural activity. The transformation in the number, nature, and orientation of its devotees was fittingly underlined by the creation of the British Association for the Advancement of Science (1831) and of the associated neologism "scientist."[6] Little attention has been given to the motor forces in this social and cognitive transformation of natural knowledge. The necessary preconditions for a given technical invention—or more perceptively, innovation—have too often been at the center in discussions of science in the Industrial Revolution. But this is to adopt a limited, historically unhelpful focus, for science has more to do with minds than with machines, as those familiar with problems

[6] The figures on societies were derived from *The Yearbook of Scientific and Learned Societies of Great Britain and Ireland,* 1 (London, 1844). There is no adequate survey of these developments, but see A. Ferguson, ed., *Natural Philosophy through the Eighteenth Century* (London, 1948); J. B. Morrell, "Individualism and the Structure of British Science in 1830," *Historical Studies in the Physical Sciences,* 3 (1971): 183–204; and Sydney Ross, "Scientist: The Story of a Word," *Annals of Science,* 18 (1962): 65–86. My argument would be enriched but greatly lengthened by reference to developments in Scotland and Ireland. An analytic focus on England rather than Britain serves to delineate the issues more sharply, even at the cost of some distortion.

of modernization in other cultures are beginning to perceive. That science might be an integral part of the British Industrial Revolution and yet have no direct bearing on processes of invention and innovation is a hypothesis that has not been discussed. Rather, its importance has yet to be grasped.

THE IMPORTANCE of Manchester as the major nexus of the first phase of the Industrial Revolution has long been recognized. Academic studies abound on such subjects as the growth of the British cotton trade, Manchester merchants and foreign trade, and the Manchester school of economics. Individual entrepreneurs have been closely studied, and broader inquiries essayed on the subject of social change in the Industrial Revolution. More recently these economic and occasional sociological inquiries have been joined by a trickle of works specifically concerned with technological developments in Manchester.[7] But the cultural meanings of scientific activity within the city are still unexamined. Those meanings can best be approached through attention to one crucial, little-studied group, the Literary and Philosophical Society. I hope that such a focus will cast at least a partial light on wider questions.

Apart from the Royal Society itself, the Manchester Literary and Philosophical Society is the oldest enduring English society given to scientific discourse and publication. Between its foundation in 1781 and the opening of Owens College (now the University of Manchester) in 1851, the "Lit & Phil" was central to the achievement of a succession of major scientific figures. They range from Thomas Percival, through Thomas Henry, John Dalton, and William Henry, to William Sturgeon and James Prescott Joule. The society was also the haunt of such formidable technologists and engineers as Richard Roberts, Eaton Hodgkinson, William Fairbairn, and James Nasmyth. Manufacturers and merchant princes like Robert Owen, John Kennedy, the Gregs, the Heywoods, the McConnels, and the Philipses were active in its affairs. Other men of note as varied as Charles White, P. M. Roget, James Kay Shuttleworth, the first Sir Robert Peel, Richard Cobden, and Lyon Playfair graced its membership rolls, while fathers solicitous for their sons' experience saw Joseph Priestley, Thomas Henry, and James Watt, juniors, duly enrolled.[8]

[7] See, for example, Richard Hills, *Power in the Industrial Revolution* (Manchester, 1970); D. S. L. Cardwell, *From Watt to Clausius* (New York, 1971); Neil Smelser, *Social Change in the Industrial Revolution* (London, 1959); Francois Vigier, *Change and Apathy: Liverpool and Manchester during the Industrial Revolution* (Cambridge, Mass., 1971); C. H. Lee, *A Cotton Spinning Enterprise, 1785–1940: A History of McConnel and Kennedy, Fine Cotton Spinners* (Manchester, 1972); and John Butt, ed., *Robert Owen: Prince of Cotton Spinners* (Newton Abbott, 1971).

[8] Here and throughout this article no further identification is given for individuals appearing in the *Dictionary of National Biography*. For the McConnels see Lee, *Cotton Spinning Enterprise;* for the Philipses see F. J. Faraday, "Selections from the Correspondence of J. L. Philips," *Manchester Memoirs,* 33 (1890): 13–56; *ibid.,* 44, no. 14 (1900); and *ibid.,* 45, no. 8 (1901).

The society has not lacked for historical notice, whether direct or oblique. As with so many other matters of interpretation in English history, we may trace discussion back to Elie Halévy. It was Halévy who created the "standard mythology" concerning the "Lit & Phil" and its significance: the idea that new technological (industrial, manufacturing) problems led to the organization of the society and determined the cognitive thrust of its scientific investigations. This view derived from and in turn provided evidence for a more general thesis about relationship of science, technology, and the Industrial Revolution: science proliferated in the nineteenth century in direct response to technical problems created by the new production processes of the period. In *England in 1815* Halevy stated that "the manufactures which were now coming into existence and spreading so rapidly needed engineers and scientific experts." He argued that

> it is in Nonconformist England, the England excluded from the national Universities, in industrial England with its new centres of population and civilization, that we must seek the institutions which gave birth to the utilitarian and scientific culture of the new era. . . . At Manchester first, centre of the cotton industry, a species of local academy, a literary and scientific club was founded.

In time "other provincial towns followed the example of Manchester." Halévy, though no enthusiast for Marxist doctrine, felt that the undeniable facts made it necessary to admit how "the thesis of historical materialism, questionable when applied universally, is to this extent true of England at the opening of the nineteenth century. Scientific theory was the offspring of industrial practice."[9]

As Halévy emphasized, the interpretation he applied to events in Manchester was but an instance of a broader proposition, expressed most tersely by Friedrich Engels: "If society has a technical need, that helps science forward more than ten universities." This Marxian position is logically distinct from, though reconcilable with, the belief that the innovations of the Industrial Revolution were dependent on scientific expertise. Either, both, or neither position may be correct. Marxian orthodoxy has favored the first and ignored the second. Less doctrinaire writers, like T. S. Ashton, have sometimes seemed to hold both views, without distinguishing clearly between them.

The belief that science flourished in response to the technical problems of the Industrial Revolution was given new prominence in the Marxist climate of the 1930s. In his *Social Function of Science* J. D. Bernal argued that "it was in Leeds, Manchester, Birmingham, Glasgow and Philadelphia, rather than Oxford, Cambridge and London, that the science of the Industrial Revolution took root." The reason was partly that science was necessary "for directors of industry," partly that some knowledge of scientific principles "was also becoming increasingly desirable for leading operatives."

[9] E. Halévy, *England in 1815* (Paris, 1912). The quotation is taken from the revised English edition (London, 1949), pp. 524–25, 559–63.

S. F. Mason later reiterated the claim with more explicit local detail: "The men of the industrial regions with their scientific education . . . and their technical interest forwarded institutions to promote the arts and sciences in their own localities. . . . The Manchester Literary and Philosophical Society arose from the meetings of scientists and industrialists."[10]

It is not only the Marxist-oriented who have seen the society in this way. T. S. Ashton was remote from any left-wing scientists. Yet he argued that

there were in many towns institutions which . . . were devoted to the improvement of methods of production. Informal groups of scientists and manufacturers came into being in Lancashire and the Midlands, as well as at Edinburgh and Glasgow. Who can say how much the master cotton spinners gained from their contact with Thomas Percival and John Dalton in the Literary and Philosophical Society of Manchester?

Similar judgments may be found in more recent writings. We might summarize the general consensus in the urbane prose of J. H. Plumb:

By 1815 every provincial town of importance had its [society on the model of Manchester's], supported by both the local aristocracy and the local manufacturers. . . . No other aspect of English cultural life had such whole-hearted middle-class support, because the intention was completely and avowedly utilitarian—the search for useful knowledge which would maintain England's industrial supremacy.[11]

These judgments are remarkable for two things. Despite variations of shading and emphasis, they show an almost unnerving scholarly unanimity. They agree that Manchester science was significant, that it was rooted in industry, that it derived its essential support from manufacturing men, that the ambition of the "Lit & Phil" was production of engineers and scientific experts, and that the aim of its science was useful knowledge which would maintain England's industrial supremacy. If such unanimity of interpretation is worth remark so is such enduring ignorance of sources. The only historical studies of the "Lit & Phil" are a fifty-two page antiquarian ramble of the 1920s and a hasty book compiled out of the society's published *Memoirs* by a dying man, when the committee set up to prepare a centennial history proved unequal to its task.[12] Slim reeds on which to build such a confident tradition of interpretation, even did they offer support for the "standard mythology."

[10] J. D. Bernal, *The Social Function of Science* (London, 1939), 25; and S. F. Mason, *A History of the Sciences: Main Currents of Scientific Thought* (London, 1953), 229. See also Neal Wood, *Communism and British Intellectuals* (New York, 1959), especially ch. 5.

[11] T. S. Ashton, *The Industrial Revolution* (London, 1948), 16, 21; J. H. Plumb, *England in the Eighteenth Century* (Harmondsworth, 1950), 167.

[12] See F. Nicholson, "The Literary and Philosophical Society, 1781–1851," *Manchester Memoirs*, 68 (1924): 97–148; and R. A. Smith, *A Centenary of Science in Manchester: In a Series of Notes* (London, 1883). Smith was quite explicit (p. v.) that "I could not give time to write a history." However, "no one seemed inclined to take up the subject," hence his "sketch" largely "made up of quotations" from published sources.

Because the society's archives were destroyed in a bombing raid in 1940, certain questions about its history can no longer be answered. Nonetheless there is much still to be learned, not least through the versatile if sometimes barbarous art of prosopography. The analysis that follows draws on the results of a continuing prosopographical examination of the 588 men who joined the society between its beginning in 1781 and the foundation of Owens College, seventy years later. From this analysis it will appear that an adequate understanding of the society hinges on the question of the social legitimation of marginal men, on the adoption of science as the mode of cultural self-expression by a new social class, and on generational patterning in intellectual life. It turns out that the legitimation, the institutionalization, and the growth of science itself was more nearly a by-product of the society rather than the reason for it. And finally it becomes evident that the interaction between science and technology within the society's walls has assumed for historian commentators a degree and kind of importance it never possessed for contemporaries, whether manufacturers or men of science.[13]

A key to understanding may lie in the social legitimation of marginal men. Such legitimation is itself a complex, subtle thing. The adoption of science as a mode of cultural self-expression also depends on a particular affinity between progressivist, rationalist images of scientific knowledge and the alternative value system espoused by a group peripheral to English society. Natural knowledge had of course been an accepted component in the central value system of the English elite from at least Stuart times, as the existence and membership of the Royal Society of London eloquently testify. But such knowledge was at best a minor component in that value system and, in the decades immediately prior to 1780, a diminishing one. The quiescent mood of the Royal Society itself and the peripheral status of natural knowledge within the hierarchy of norms and expectations then characterizing Oxbridge life sustain the picture. Natural knowledge thus seemed an appropriate, suitably distinct center around which a new, marginal group could build its own separate and progressivist philosophy and cultural system. The alliance between science, peripheral status, and progressivist philosophy was itself transmuted as the larger culture within which that alliance had formed experienced its own shifts and changes. By the 1830s and 1840s the descendants of Manchester manufacturers were active in the consolidation of science within the central value system of English life and, in response to the challenges they now faced from a new urban lower class, in finding deeper conservative mean-

[13] See Lawrence Stone, "Prosopography," *Daedalus*, 100 (1971): 46–79; Steven Shapin and Arnold Thackray, "Prosopography as a Research Tool in the History of Science," *History of Science*, 12 (1974): 321–49; E. V. Stonequist, *The Marginal Man: A Study in Personality and Culture Conflict* (New York, 1937); and E. Shils, "Centre and Periphery," in Marjorie Grene, ed., *The Logic of Personal Knowledge: Essays Presented to Michael Polanyi* (London, 1961), 275–94.

ings in the very structure of natural knowledge. These shifts offer important clues to the little-explored influence of generational patterning on the cultural geography of, and the recruitment patterns to, scientific activity. The transformations are nicely mirrored in the way the second Sir Robert Peel—whose father and grandfather had belonged to the Manchester Society—was a Tory, in time a Fellow of the Royal Society, and the most enthusiastic supporter of science among all Victorian prime ministers.

The efflorescence of scientific activity in Manchester and the varied cultural meanings that activity came to possess must be set against several salient facts about the town. Five points about the cultural context are important for present purposes:

The first is population growth. Manchester's population increased from perhaps fifteen thousand in 1760 to a quarter of a million in 1831, becoming by then second only to London's and growing more than twice as fast. The social institutions of a small provincial town had to change, and the demand for new social modes was obligatory, not optional.[14]

A second factor is the growth of new riches—among manufacturers like the Drinkwaters, the Kennedys, and Robert Owen, among merchants like the Lees and the Philipses, among bankers such as the Heywoods and the Brookeses, or among medical men like Thomas Percival and Edward Holme. While the number of fortunes made was probably greatest in the first half of the nineteenth century, the process began much earlier and was initially more startling because unprecedented and unfamiliar within provincial culture. Indicative of the opportunities is the way Nathan Meyer Rothschild journeyed to Manchester in the 1790s and there enjoyed those first successes upon which the English house of Rothschild was to be built. Perhaps the most extreme example of self-accumulated wealth among members of the "Lit & Phil" was Samuel Reeves Brookes, son of a modest manufacturer, who left a personal fortune of £21½ million.[15]

Isolation, social as well as physical, is the third fact to set alongside growing population and wealth. London remained more than twenty hours' journey away until the 1840s. Nearer spiritually, Edinburgh was physically more remote. Socially, the newly prosperous merchants, manufacturers, and tradesmen remained cut off from the acceptance and prestige rewards of English landed society by their occupations and their tendency to adopt Dissenting—especially Quaker and Unitarian—religious modes. In a pattern repeated time and again, it was to be the third generation that finally took its place at the center of English society and fully con-

[14] Great Britain, *Parliamentary Papers,* vol. 18 (Accounts and Papers, vol. 5, 1831), pp. 12–13. See also W. H. Chaloner, "Manchester in the Latter Half of the Eighteenth Century," *Bulletin of the John Rylands Library,* 42 (1959–60): 40–60; and Valentine A. C. Gatrell, "The Commercial Middle Class in Manchester, c. 1820–1857" (Ph.D. dissertation, Cambridge University, 1972). I am indebted to Dr. Gatrell for access to this dissertation and for helpful discussions.

[15] See Leo H. Grindon, *Manchester Banks and Bankers* (Manchester, 1877), especially p. 214.

formed to the central value system. Ultimate examples are found in the manufacturing families of the Peels and the Bannermans—each could count a prime minister in the third generation. More typical are the Henrys and the Heywoods, who in three generations went from self-made Unitarians with strong scientific interests to liberal Anglicans with far different concerns: the Henrys as Herefordshire gentry, the Heywoods as men of affairs in Manchester and London. But for the second generation, and pre-eminently for the first, social legitimation, cultural stimulus, and intellectual reward had to be sought within the local context.[16]

Social isolation found its mirror in political impotence. Manchester had no M.P.'s until 1832, no elected local government until 1838. The lord of the manor selected the annually appointed borough reeve, and the nominee had to serve or face a substantial fine. The J.P.'s—a more meaningful because more enduring appointment—were likewise selected from above, with conforming background and independent fortune essential prerequisites. Political reform, a possible hope in the 1780s, was out of the question for thirty years after 1791. When political power finally arrived, it was members of the "Lit & Phil" who, as the local elite, naturally exercised it.[17] This change was itself to affect radically the society's view of the significance and function of natural knowledge.

Finally, there was the social peril of Manchester life—food riots in 1757, 1762, 1795, and 1812; political riots in 1792, 1809, 1812, and 1819, culminating in the tragedy of Peterloo. The accepted norms also included endemic drunkenness, gambling, cockfighting, and prostitution (estimates claim one public house and one prostitute per 200 inhabitants). Almost as a matter of course John Dalton records being mugged while on his evening walk in 1817. At least until the end of the hungry forties it was a violent society,

[16] Cf. F. M. L. Thompson, *English Landed Society in the Nineteenth Century* (London, 1963), 63: "The steps of the social ladder had long been clearly marked. They were trade, a fortune, the acquisition of an estate, a baronetry, a membership of Parliament, and finally a peerage. In the late eighteenth century the process had usually taken at least two generations, and there is no sign that the nineteenth century easily permitted any greater speed. . . . Fortunes *directly derived* from industry were not represented [by new peerages] until . . . 1873." The only Manchester family to make the full transition in two generations was that of the Unitarian banker John Jones: his son-in-law built up the family fortune to an estimated £5 million, becoming "one of the wealthiest subjects in the world" and the first Lord Overstone. See *ibid.*, 39; and D. P. O'Brien, ed., *The Correspondence of Lord Overstone* (Cambridge, 1971).

[17] See A. Redford, *The History of Local Government in Manchester* (London, 1939–40); and S. D. Simon, *A Century of City Government: Manchester 1838–1938* (London, 1938). By the end of the nineteenth century, some 21 members of the society (including 10 out of the 588 in this study) had become M.P.'s. The dates of their election to Parliament reveal the changing situation of the Manchester elite. Having been without M.P.'s before 1829, the society was continuously represented for the rest of the nineteenth century; after 1859 there were only four years in which the society had less than three members simultaneously in Parliament. On the qualification of earlier Manchester J.P.'s see, for example, the Earl of Liverpool to Thomas Butterworth Bayley, Jan. 16, 1795: "I have always been unwilling to appoint any merchant to be a justice of the peace previous to his having left off business," in Add. MSS 38,310 f 132, British Museum; and Bayley to Liverpool, Dec. 15, 1789, recommending a physician who does not practice but is "a gentleman of independent property" and a merchant who has "a very large fortune" and is thus "entirely out of business," Add. MSS 38,446 f 343, *ibid.*

which bred official counterviolence (fourteen executed in one day in the aftermath of the 1812 food riots).[18] It was a culture in which the illiterate mob perpetually menaced the fragile social veneer maintained by the higher orders of the explosively growing town.

Given their social isolation, political emasculation, and tumultuous surroundings, Manchester's new and increasingly wealthy elite understandably sought cultural means through which to define and express themselves. The question remains why the main vehicle of that culture was initially to be natural knowledge and before long "science" in the modern sense of the world. Music, drama, the classics, and modern literature were all, at least in theory, possible alternatives. The first and most significant of Manchester's scientific institutions was the Literary and Philosophical Society. Its very name indicates that natural knowledge was not intended as the dominating mode it soon became. Indeed the visitor to Manchester in 1760 would have seen little to indicate the town's imminent meteoric rise either in population or scientific stature. The visitor in 1840 would find not only Britain's second city but also one in which scientific institutions were dominant, though past their peak of influence. *Manchester As It Is,* a guidebook published in 1839, lists ten major societies of scientific orientation among the cultural institutions of the city. They range from the Athenaeum, through the Geological, and Literary and Philosophical Societies, to the Natural History Society, the Royal Manchester Institution, and the Statistical and Zoological Societies. There were in addition such varied ephemeral groups as the Royal Victoria Gallery of Practical Science, the Phrenological Gallery, and the Owenite Halls of Science.[19]

In examining why science became the predominant mode of cultural expression in Manchester, we shall inevitably be led to consider Robert Merton's thesis of the congruence of science with certain religious values.[20] The disproportionate influence of Unitarians and to a lesser extent Quakers in the first fifty years of the "Lit & Phil" would seem clear confirming

[18] See, for example, Arthur G. Rose, "Early Cotton Riots in Lancashire, 1769–1779," *Transactions of the Lancashire and Chesire Antiquarian Society,* 73 (1963–64): 60–100; Pauline Handforth, "Manchester Radical Politics, 1789–1794," *ibid.,* 66 (1956): 87–106; F. Nicholson and E. Axon, "The Hatfield Family of Manchester and the Food Riots of 1757 and 1812," *ibid.,* 28 (1910): 82–114; John B. Smith, "Reminiscences of Manchester, 1812–1832" (typescript in Manchester Central Library, Manchester, England); and A. Prentice, *Historical Sketches and Personal Recollections of Manchester* (London, 1851). On the rapid increase in crime, see also Bayley to Liverpool, Dec. 15, 1789.

[19] Manchester at this time had only two theaters and no purely literary or artistic societies. In contrast the plethora of scientific institutions was ranged in an informal hierarchy. Ordinary members of the "Lit & Phil" served as officers of the lesser institutions while, in a system of "interlocking directorships," their presidents were chosen from among "Lit & Phil" officers. [Benjamin Love], *Manchester As It Is, or Notices . . . of the Metropolis of Manufacturers* (Manchester, 1839).

[20] For entrée to the literature on science and religious values, see the new introduction and bibliography in Robert K. Merton, *Science, Technology and Society in Seventeenth Century England* (New York, 1970).

evidence of that thesis. Yet matters are by no means simple. There is reason to believe that the success and endurance of the society also depended on certain generational patterns and on the desire of marginal men (the "manufacturers") to achieve social legitimation. Their espousal of the progressivist values of Unitarianism and a progressivist interpretation of science can then be seen as deriving from their need to justify themselves, and to do so in terms of belief systems that simultaneously affirmed their commitment to high culture, announced their distance from the traditional value systems of English society, and offered a coherent explanatory scheme for the unprecedented, change-oriented society in which they found themselves unavoidably if willingly cast in leading roles.[21]

By the early nineteenth century science was established as the cultural mode of the Manchester elite. At the same time that elite, more secure and self-aware in its commercial and incipient political power, was inevitably attracted toward conservative beliefs, beliefs which would emphasize the rightness of its dominance as also its connection with and claims on the central value system of English culture. Within these changing perspectives the potentialities of science to explain the existing order in mundane rather than prophetic modes took on greater importance. (The forms, metaphors, and subjects of scientific inquiry seem to have mirrored that transmutation, in ways that still await analysis.) Shifts in the social texture of science also set in. Some new societies appeared to serve narrower specialist ends, while others strove for implicit control of the lower orders through inculcation of right thinking on unemotional topics like geology and thus, by extension, on social issues. These developments gave science both plebian and professional aspects uncongenial to men bent on assimilation to the national high culture. The attachment to science of the Manchester elite was but little better able to survive these reorientations of perspective than was their religious commitment—a fact that highlights the relevance while indicating the limitations of a direct Puritanism-progressivism-science connection. The ramified ambiguities that necessarily attach to any such general interpretation can best be illustrated by detailed attention to events.

By the mid-eighteenth century Manchester's population was increasing significantly, and in 1767 there appeared the first of what was eventually to become a large group of societies devoted to social improvement through intellectual means. This first society—the Agricultural Society of Manchester—was progressive in its technical aims but conspicuously traditional

[21] I am indebted to Robert K. Webb for showing me the manuscript of an early version of his forthcoming study of the English Unitarians. Dr. Webb's work provides a broader framework for this present analysis. So in rather different ways do Raymond Williams's investigations of *Culture and Society 1780–1950* (London, 1958) and *The Country and the City* (New York, 1973). See also the novels of Elizabeth Gaskell, the wife of a Unitarian member of the "Lit & Phil."

in membership and cultural orientation. Its gentry members were active in awarding premiums, encouraging improvements, and corresponding with Arthur Young on such subjects as "the art and mystery of cutting and trussing hay." The society continued into the 1840s, though air and water pollution and urban preoccupations had long since sapped its vitality. Even so its early success serves as a reminder that new forms of manufacturing and trade were initially viewed as unprecedented intrusions on a familiar order.[22]

If the Agricultural Society displays facets of a progressive yet preindustrial Manchester, the infirmary presents an aspect more firmly associated with population growth and its contemporary correlates of industrialization, urbanization, and social change. A mid-eighteenth-century movement led to the founding of infirmaries in a number of emerging provincial towns, such as Manchester (1752), Birmingham (1765), and Leeds (1768). Rapid population growth reinforced the appeal of such towns to ambitious medical men like Thomas Percival, who arrived in Manchester in 1767, and Thomas Henry, who came some three years earlier. Older medical residents like the father-son surgeon teams of Thomas and Charles White or R. E. and Richard Hall found new companionship with the influx. Camaraderie and competition centered on the infirmary. Three positions there as honorary physician and three as honorary surgeon certified social standing and professional success within the medical fraternity.[23]

The infirmary buildings, erected in the 1750s and 1760s, dominated the town. As Thomas Henry later recalled,

> Such an institution was greatly to be desired at . . . the seat of a rising manufacture; and contiguous to . . . the West Riding of Yorkshire, as well as the mining part of Derbyshire. . . . The lead mines of Derbyshire, and the coal mines of our own district, of Cheshire, and the confines of Yorkshire, supplied many accidents and cases in which capital operations were required.

A later visitor to Manchester, after discoursing about the town's wonderful machinery, went on to describe the infirmary where "we saw feet torn off from legs and arms severed from bodies, and hands literally crushed, and heads laid open to the brain. But all was cleanliness, attention, order, neatness."[24]

By 1825 the Manchester Infirmary could claim "2,000 more [patients annually] than the largest hospital in London." The status claims, personal ambition, and public interest centered on the infirmary may be seen

[22] See, for example, the *Manchester Mercury*, Aug. 10, 1779; *Rules and Conditions of the Manchester Agricultural Society* (Manchester, 1804); and Bayley to Arthur Young, Mar. 2, 1771, Add. MSS 35,126 f 94; Mar. 2, 1772, f 129; Nov. 4, 1773, f 153, etc., all in the British Museum.

[23] See B. Abel-Smith, *The Hospitals, 1800–1948* (London, 1964); E. M. Brockbank, *Sketches of the Honorary Medical Staff of the Manchester Royal Infirmary* (Manchester, 1904); and W. Brockbank, *Portrait of a Hospital* (London, 1952).

[24] Thomas Henry, "Memoirs of the Late Charles White," *Manchester Memoirs*, 8 (1819): 33–51; and "A Week in Manchester," *Blackwood's Magazine*, 45 (1839): 481–96.

in its election campaigns: in 1835 the successful candidate for a post as physician found it necessary to spend £690 on canvassing and transporting the 870 participating electors.[25] The significance of provincial infirmaries within their local cultures has yet to be explored, even if readers of George Eliot's *Middlemarch* have long been provided with ample clues. Such hospitals not only offered a badge of rank and respectability to those able to be subscribers, but they also offered a means of social control, a forum for approved teaching, a testing ground for management ability, an opportunity for cooperative capitalism on a large scale (the infirmary was, after all, the factory of medicine, replacing cottage craft with standardized technique), and a meeting ground for the local elite.

It is thus not surprising to find a previously unremarked interplay between the personnel of the Manchester Infirmary and the Literary and Philosophical Society. Indeed in its first creation the society seems to have been very much the creature of such improving physicians as Thomas Percival. Of the twenty-four founding members of the society, one is unknown. Of the other twenty-three, there were six practicing physicians, six surgeons, and two apothecaries: professional medical men formed sixty per cent of the founding members. Actual or potential association with the infirmary was correspondingly crucial. Nine of the founders were allied with the infirmary when the "Lit & Phil" was inaugurated in 1781, and three others subsequently became honorary physicians there. More revealing is an analysis of the first officers of the society. Of the two founding presidents, one was president of the infirmary trustees, and the other was the senior honorary physician. Two of the four vice-presidents were infirmary physicians, while the secretaries were the visiting apothecary to the infirmary and an M.D. subsequently elected honorary physician. Absolute control was mitigated only by the presence of two vice-presidents from outside the medical world—a minister and a trustee of Cross Street (Unitarian) Chapel, itself the focus of "aristocratic" Dissent in the town, and as such not so remote from the medical world as one might at first suppose.[26]

The connection between medical status as certified by the infirmary and activity in the Literary and Philosophical Society continued for some time. All the presidents of the society for almost a quarter century were infirmary men as were nine of sixteen vice-presidents and six of fifteen

[25] T. Turner, *An Address to the Inhabitants of Lancashire . . .* (London, 1825), 19–20; and F. W. Jordan, *The Life of Joseph Jordan, Surgeon* (Manchester, 1904), 52–53.

[26] The founding members are listed in the *Complete List of the Members and Officers of the Manchester Literary and Philosophical Society* (Manchester, 1896). Their occupations, religious affiliations, social background, etc., have been identified from contemporary directories, obituary notices in newspapers and religious periodicals, histories of the town and of its varied institutions, contemporary correspondence, family and company histories, school and university registers, and other miscellaneous sources. For further details on technique see Shapin and Thackray, "Prosopography." The sections on T. Southwood Smith in Webb's study of the English Unitarians give revealing examples of Unitarian and medical concerns in a different context.

secretaries. "The search for useful knowledge which would maintain England's industrial supremacy" may or may not have become the purpose of the society. Concerns over relative status among medical men in a growing town, together with the vision of the medical profession as guardian of the politer virtues in an industrializing world, seem more important in explaining the genesis and growth of the society.

Medical men were of course favorably placed in regard to any organized intellectual endeavor. Their social background, training, and daily routine favored habits of exact organization, regulated intercourse, and polite interest. They enjoyed the particular advantage of an education that made them familiar with the intricacies of natural knowledge, while judicious publication in the field could advance their reputations and careers. Understandably enough, medical men played a critical role in English scientific organization as it developed in the later eighteenth and early nineteenth centuries. This is true for the apothecaries and surgeons, even though they were most often trained by local apprenticeship. It applies pre-eminently to the physicians, the true cosmopolitans in provincial English culture, who brought with them the standards of a wider world, together with an insistence on polite knowledge.

Late eighteenth-century commentators agreed that "the character of a physician ought to be that of a gentleman, which cannot be maintained with dignity but by a man of literature." Blunt realities dictated that "if a gentleman, engaged in the practice of physic, be destitute of that degree of preliminary and ornamental learning, which is requisite" then whenever he speaks "on any subject of history or philosophy" he will be immediately out of his depth, with consequent "real discredit to the profession."[27] That the new Manchester group was called the Literary and Philosophical Society most probably testifies to its origins among professional medical men and to their vision of the character of ornamental learning.

The medical component within the "Lit & Phil" continued well into the nineteenth century. Occasional "public" medical lectures and lecture courses for the faculty were given in the society's rooms as late as the 1820s. Not until 1834 was a separate Manchester Medical Society inaugurated. That the "Lit & Phil" did not expire in the turbulence of the 1790s and the early nineteenth century is at least in part because medical men gave it undivided loyalty and provided most of its officers. Anxious to establish their standing as gentlemen, they gave polite knowledge their approbation. They were also willing to see the form of that knowledge closest to their professional concerns—natural knowledge, or science—given a particular attention. Yet the presence of medical men is a condition, not a reason, for the choice of modes

[27] Quoted in Thomas Withers, *A Treatise on the Errors and Defects of Medical Education* (York, 1794). There were sixteen provincial hospitals in 1760 and sixty-two (plus at least thirty-six dispensaries) by 1820. This fact alone explains much about the growth in numbers of provincial scientific societies. See A. Chaplin, *Medicine in England during the Reign of George III* (London, 1919).

by which Manchester's new elite was so effulgently to express its special status—at once distant from, compatible with, and subtly superior to the culture prevailing at the center of English life.

A wider focus is needed when we turn to consider the aims, achievements, and place of the "Lit & Phil" in the lives of its members. Manifestoes of a type characteristic of the period, but remarkable in their number and energy, occupied much energy in the early years of the society. In 1783 Thomas Barnes and Thomas Henry provided rationales for a College of Arts and Sciences they envisaged as the educational division of the society; the same year the society composed a flyer on its aims, to be sent to interested parties, and a revised version was circulated the following year. In 1785 the first two volumes of the society's *Memoirs* were published with deliberate pomp and circumstance and an introductory explanation; in 1786 two of the society's influential members addressed the new Manchester Academy and analyzed the role of knowledge in society.[28] This formal discussion of aims and values represents the effort of a new social group to create a cultural space in which to express its own identity. The decision to publish a journal and the vigorous recruitment of an international elite of honorary members were part of the same cultural initiative.

In examining the aims of the society we may distinguish seven reasons why its members found natural knowledge especially rewarding as their chosen intellectual genre. Some of these reasons explain the new strength of social support for scientific activity, while others point toward the impact of the particular context upon the cognitive forms of scientific debate. Some of these reasons apply equally well to other cultural pursuits, but only for natural knowledge did they all act to reinforce one another. Thus natural knowledge, while never the exclusive pursuit, quickly became the dominant concern of the society. The reasons for the choice of science were its possibilities as polite knowledge, as rational entertainment, as theological instruction, as professional occupation, as technological agent, as value-transcendent pursuit, and as intellectual ratifier of a new world order. Each requires illustration, for each throws light on possible audiences for, as well as cultural functions of, the sustained inquiry into nature.

Most important, because it both determined that science would be the Manchester mode and also powerfully effected the definition of that mode, was the ability of natural knowledge to function as ratifier of a new world order. I have already noted how in the late eighteenth century a core group

[28] See Thomas Henry, "On the Advantages of Literature and Philosophy in General, and Especially on the Consistency of Literary and Philosophical, with Commercial Pursuits," *Manchester Memoirs*, 1 (1785): 7–28; Thomas Barnes, "On the Affinity Subsisting between the Arts," *ibid.*, 72–88; "Constitution and Regulations of the College of Arts and Sciences in Manchester," *ibid.*, 2 (1785): 42–46; *A Short Account of the Institution and Views of the Literary and Philosophical Society of Manchester* (Manchester, 1784); "Preface" in *Manchester Memoirs*, 1 (1785): v–ix; and *A Sermon Preached at the Dissenting Chapel in Cross Street, Manchester . . . by Ralph Harrison Together with a Discourse . . . at the Public Commencement of Manchester Academy, by Thomas Barnes* (Warrington, 1786).

of Manchester's physicians, manufacturers, and merchants found an ideology of progressive change peculiarly appropriate in explaining their present marginal status and their coming reign of power. "To truth. To liberty. To religion." was their motto, the hope that "the holy light of truth, of reason, and of righteousness, may shine over all the nations of the earth, with growing lustre, even to meridian day."[29] The new Manchester elite had little sympathy for honorable birth and hereditary wealth. The idea of a limited democracy of intellect and effort had greater appeal.

The members of this democracy were to rely on "good natural powers, a vigorous application of their talents, and the blessing of God on their endeavours."[30] And here, natural knowledge offered an opportunity quite foreign to the imaginative arts, for "in the sciences founded on observation and calculation, the more we increase the number of cultivators, the more we contribute to the progress of those sciences. . . . Every man may be a master, who to a just understanding, unites extensive knowledge." More than this, "they who have attained to the first honours of science and immortalized themselves in the annals of mankind, have generally excelled others, not more in the superiority of their natural genius and abilities, than in their patient, laborious and constant application." Nothing could be more appropriate to "men of the middle walk of life" than to imitate the great cultivators of natural knowledge whose lives, instead of being spent in luxury and debauchery, had aided all men by "correcting their vices, softening their distresses, adding to their comforts or curing their diseases."[31] As one master manufacturer bluntly put it to his son, "There is no magic in all this. Newton you know said that all he did was only by patient thinking." Determined expenditure of effort would thus put all who wished "in the ranks of those by whose powers of mind we have been so much elevated in the scale of being," for "there are to be sure degrees of sagacity, but anyone who will persevere cannot but sooner or later blunder upon something valuable." Manchester's greatest adopted man of science, John Dalton, showed how well he had assimilated to this ethos when, in old age, he reported to a cheering audience that "if I have succeeded better than many who surround me, it has been chiefly, nay, I say almost solely from unwearied assiduity."[32]

Natural knowledge offered a present field for democratic endeavor. In the eyes of progressive thinkers it also served to guarantee the future. To this group Joseph Priestley was culture-hero. As natural philosopher and chemist (discoverer of oxygen) and as ideologist of "rational" Christianity he exemplified the values they espoused. Despite opposition, the "Lit & Phil" sup-

[29] *A Sermon Preached*, 37.

[30] Andrew Kippis, *A Sermon . . . on . . . a New Academical Institution* (London, 1786), 15.

[31] Thomas Henry, ed., *Memoirs of Albert de Haller* (Warrington, 1783), 100; and *A Sermon Preached*, 14.

[32] William Strutt to Edward Strutt, Apr. 8, 1818, quoted in R. S. Fitton, *The Strutts and the Arkwrights* (Manchester, 1958), 172. The Strutts were a family of Unitarian mill owners at Belper in Derbyshire. See also Arnold Thackray, *John Dalton: Critical Assessments of His Life and Science* (Cambridge, Mass., 1972), 175.

ported his scientific work, made him an honorary member, and almost adopted a formal motion of condolence after a drunken mob made his house and laboratory their principal targets in the Birmingham "Church and King" riots of 1791. His combination of scientific virtuosity, theological dedication, and progressivist philosophy was peculiarly compelling to many early members of the "Lit & Phil." The laws of nature found out by reason were to them the token of their hope. As Priestley expressed it,

> The social millennium will be brought about by the influence of the commercial spirit aided by Christianity and true philosophy. . . . Public money no longer wasted [on war] will be spent on . . . public buildings, public libraries and public laboratories. The empire of reason will ever be the reign of peace.[33]

Such optimistic views did not long survive the French Revolution, but the possibilities of the appeal to science were not exhausted by a progressivist interpretation. As the Manchester elite was slowly accommodated by the traditional structures of English life, its interest in science might gradually wane. While that interest lasted it proved eminently susceptible to a conservative construction. Thomas Henry found it natural to admire Priestley and believe in rapid progress toward the millennium. His son William—second only to Dalton in the Manchester scientific community—had a quite different perspective some forty years later. Commending the new Mechanics' Institution in 1824, he argued that by diffusing the knowledge of chemistry, mechanics, and geology among the lower orders, the institution would render them

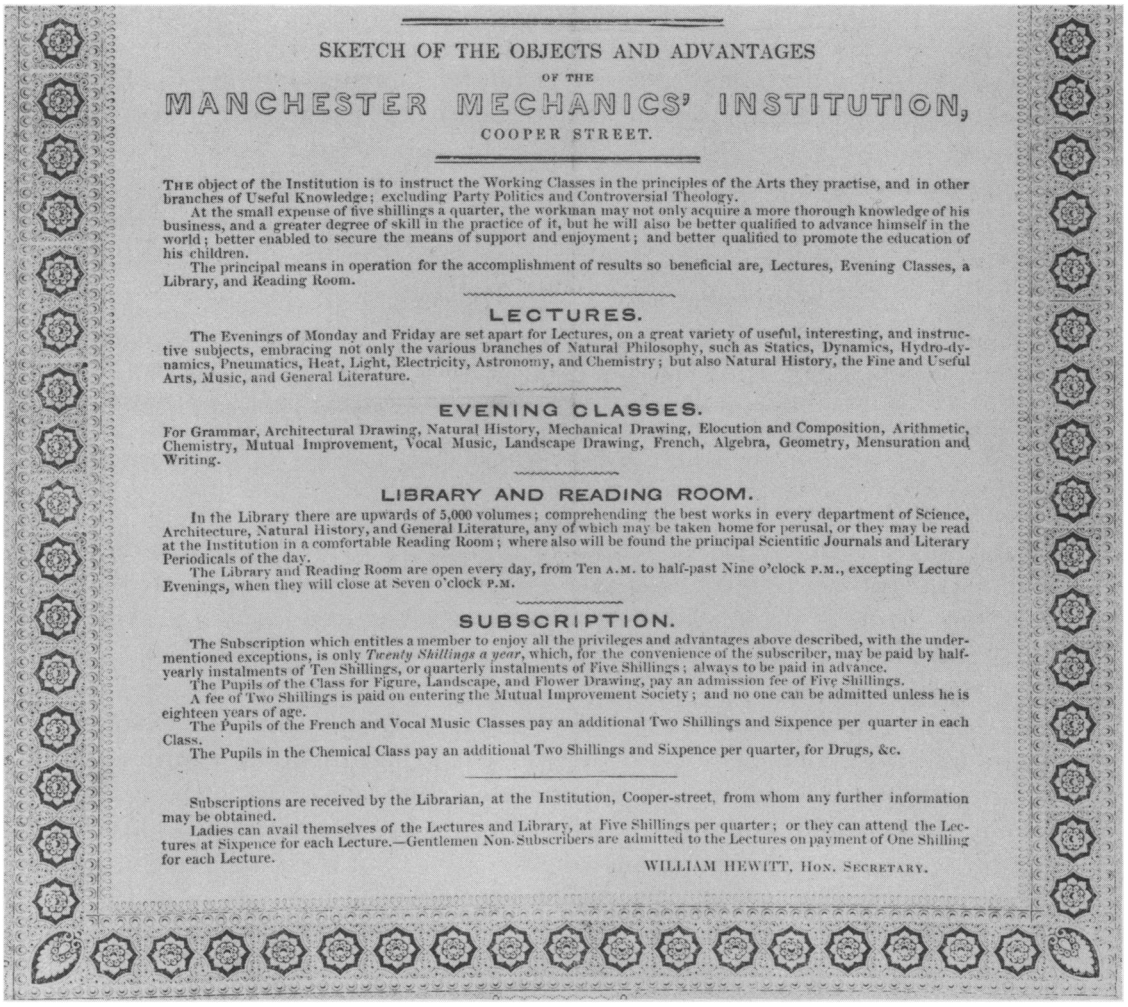
> more substantially happy, less the slaves of vicious habits, and not only better fitted but better disposed, to fulfill their several duties. . . . The habits of reasoning correctly, on subjects properly within its [the institution's] scope, will be beneficially extended to other subjects, and will tend indirectly but powerfully, to root out fanaticism in religion, and visionary and impracticable speculations in politics.

Henry expressed an unexceptional sentiment, but it had little in common with Priestley's belief that "the English hierarchy (if there be anything unsound in its constitution) has . . . reason to tremble even at an air pump or an electrical machine."[34] The shift in argument indicates how the Manchester aristocracy found science an appropriate agent through which to ratify their experience and exercise social control both within their own ranks and among the lower orders, even as their views changed concerning the meaning of that experience and the virtue of alterations in it.

On an altogether less strenuous level, science was an especially appealing form of polite knowledge. Thomas Henry voiced the prevailing belief of the "Lit & Phil" when he argued that "a taste for polite literature, and the

[33] Joseph Priestley, *A Letter to . . . Edmund Burke* (Birmingham, 1791), 239–43.

[34] "Minutes of the Manchester Mechanics' Institute," vol. 1, p. 5, in the Registrar's Dept., University of Manchester Institute of Science and Technology; and Joseph Priestley, *Experiments and Observations on Different Kinds of Air* (London, 1774), xiv.



SKETCH OF THE OBJECTS AND ADVANTAGES

OF THE

MANCHESTER MECHANICS' INSTITUTION,

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THE object of the Institution is to instruct the Working Classes in the principles of the Arts they practise, and in other branches of Useful Knowledge; excluding Party Politics and Controversial Theology.

At the small expense of five shillings a quarter, the workman may not only acquire a more thorough knowledge of his business, and a greater degree of skill in the practice of it, but he will also be better qualified to advance himself in the world; better enabled to secure the means of support and enjoyment; and better qualified to promote the education of his children.

The principal means in operation for the accomplishment of results so beneficial are, Lectures, Evening Classes, a Library, and Reading Room.

LECTURES.

The Evenings of Monday and Friday are set apart for Lectures, on a great variety of useful, interesting, and instructive subjects, embracing not only the various branches of Natural Philosophy, such as Statics, Dynamics, Hydro-dynamics, Pneumatics, Heat, Light, Electricity, Astronomy, and Chemistry; but also Natural History, the Fine and Useful Arts, Music, and General Literature.

EVENING CLASSES.

For Grammar, Architectural Drawing, Natural History, Mechanical Drawing, Elocution and Composition, Arithmetic, Chemistry, Mutual Improvement, Vocal Music, Landscape Drawing, French, Algebra, Geometry, Mensuration and Writing.

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In the Library there are upwards of 5,000 volumes; comprehending the best works in every department of Science, Architecture, Natural History, and General Literature, any of which may be taken home for perusal, or they may be read at the Institution in a comfortable Reading Room; where also will be found the principal Scientific Journals and Literary Periodicals of the day.

The Library and Reading Room are open every day, from Ten A.M. to half-past Nine o'clock P.M., excepting Lecture Evenings, when they will close at Seven o'clock P.M.

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The Subscription which entitles a member to enjoy all the privileges and advantages above described, with the undermentioned exceptions, is only *Twenty Shillings a year*, which, for the convenience of the subscriber, may be paid by half-yearly instalments of Ten Shillings, or quarterly instalments of Five Shillings; always to be paid in advance.

The Pupils of the Class for Figure, Landscape, and Flower Drawing, pay an admission fee of Five Shillings.

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Subscriptions are received by the Librarian, at the Institution, Cooper-street, from whom any further information may be obtained.

Ladies can avail themselves of the Lectures and Library, at Five Shillings per quarter; or they can attend the Lectures at Sixpence for each Lecture.—Gentlemen Non-Subscribers are admitted to the Lectures on payment of One Shilling for each Lecture.

WILLIAM HEWITT, HON. SECRETARY.

Fig. 1. **Poster for exhibition at the Mechanics' Institution, 1839. Courtesy Manchester Public Libraries, Manchester, England.**

works of nature and of art, is essentially necessary to form the gentleman." Such taste, not mere wealth, dress, or opulence would always distinguish a gentleman from one of the vulgar. The proposition was self-evident to the man of good education, the man of polite imagination, the "gentleman and professionalist" so adequately represented in the society by its medical supporters. For them the desire to emphasize status nicely complemented their desire to gain it in a pattern of mutual reinforcement that could only profit the new society. Matters were less straightforward when Henry's arguments were "extended to another wealthy class of men—the merchant and manufacturer."[35] Among these groups with their new-found wealth, attitudes were more ambivalent. Skepticism over the value of social certification through theoretical knowledge reinforced their hesitations about the utility of such knowledge in manufacturing practice.

[35] Henry, "On the Advantages of Literature and Philosophy," 9, 11.

Only two manufacturers were among the two dozen founding members of the society. Hence the urgency of such pleas as Henry's or of Thomas Barnes's statement that a taste for science "would afford a grateful recess from the bustle and attention of business . . . and give [a man] respectability and consequence." More than that, it was crucial to those tradesmen "whose fortunes and prospects destine them to move in the higher spheres of life." Scientific knowledge would enable such a man

> to appear in the world in that line, to which an honourable ambition should prompt him to aspire. His connections will be more advantageous. To his customers, to his friends, to his fellow citizens, to foreigners, to the world in general, he will appear with greater consequence and respectability. His advice, his example, his influence will have weight which mere fortune, without mental cultivation, can never, of itself command.[36]

Such arguments apparently carried weight. Whereas only two of the founders and twenty-two per cent of the men joining the "Lit & Phil" in its first year were merchants or manufacturers, the percentage rose steadily to a peak of fifty-six per cent in 1809–11.

Science was not only polite knowledge for the highest elite: it was rational entertainment for all cultivated souls. Because rational, it offered possibilities of instruction in self-control not present in less disciplined forms of culture. Thus it could also solve a recurrent problem of parvenu social groups, how best to educate their sons so as to profit from their fathers' wealth without succumbing to the traditional vices of the rich. Time and again in the late eighteenth century, Manchester manufacturers related to one another the disadvantages of education at Oxford and Cambridge, notably its expense, its encouragement to dissipation, and to alienation from their own norms. One alternative lay in the Scottish universities, especially Glasgow and Edinburgh. They were cheaper, more spartan, and more attuned to the alternative values of Dissent and science. But should sons not be sent away, then something must be done in Manchester. Thomas Barnes had no illusions:

> Amusement is necessary to young men. If this be not enjoyed at home and within themselves, they will fly abroad into company and seek it, in taverns, in conviviality, and dissipation. Hence they will form habits, of all others the most unfavourable to success in business, and against which a relish for manly science would have been next to religion, the noblest antidote.

Thomas Henry reiterated the same points, praising natural philosophy for its possibilities as alternative to "the tavern, the gaming table or the brothel." The College of Arts and Sciences, created as an adjunct to the "Lit & Phil" in 1783, had as its principal view "to supply the youth of this very wealthy, commercial town with rational amusement and instruction." The appropriate agents were thought to be natural philosophy, chemistry, mechanics,

[36] Thomas Barnes, "A Plan of Liberal Education," *Manchester Memoirs*, 2 (1785): 35.

INTERESTING LECTURES ON EXPERIMENTAL PHILOSOPHY.

The Nobility, Gentry, and others, of MANCHESTER and its Vicinity, are respectfully informed, that a COURSE of

LECTURES

WILL BE GIVEN ON

ELECTRICITY AND PNEUMATICS,

Including some pleasing Experiments in

Hydraulics, Hydrostatics, Magnetism, Optical Illusions, &c.

BY T. CLARKE,

Lecturer to the principal Seminaries in the United Kingdom.

THE COURSE WILL CONSIST OF THREE LECTURES, WHICH WILL BE DELIVERED

On MONDAY, January 13th, TUESDAY 14th, and WEDNESDAY 15th, 1823,

AT THE REPERTORY, N° 28, TOP OF KING-STREET.

THE Electrical Machine is of the plate order, and of large dimensions; and the whole apparatus of the best workmanship, calculated to ensure success in every experiment. The design of this Course is to convey clear ideas of the general order of economy of nature, and the laws by which it is regulated; for Philosophy is an investigation of the first institutes, by which the God of Nature was pleased to create, govern and regulate the universe; and sets before the enquiring mind the progress made, by human discovery, in this sublime knowledge. The method by which this scrutiny will be prosecuted, is in the following order:—

Lecture the First.

THIS Lecture will commence with experiments on condensed Electricity by the Leyden Jar and Electrical Shooter, an entire new arrangement, much admired. A model of a house set on fire by a reel flash of lightning, the conductor passing through water.—The spiral rods shewing the cause of fire balls.—The illuminated leaf silver, which for brilliancy of light surpasses description.—The Franklinian bells.—The electrical fly.—The illuminated chain, on a grand scale.—The conducting powers of metals.—The pith balls in motion, a curious experiment.—The head with hair, a droll experiment.—The atmospheric cannon, a new thing, discharged by electricity, proving that no two fluids can be in the same space.—The experiment of caution, shewing the extreme danger of persons taking shelter under trees during thunder storms, by the model of a tree, and a male and female figure sitting under it; the one in the circuit of the lightning is struck down, while the other remains unhurt.—The cork balls, shewing the repulsive power of this agent.—The glass stool, and its wonderful properties, shewn in a variety of instances during this course of experiments, which will not only be rendered a pleasing source of amusement, but at the same time useful and instructive.—To conclude with the magic picture.

Lecture the Second,

WILL be introduced by some observations on that useful and elegant instrument the Air-Pump, with an explanation of its principles in a double and single capacity, as exhauster and condenser, with the various improvements from its first invention to the present time.—The nature of exhaustions and vacuums.—The causes of hurricanes and whirlwinds.—The air's elastic spring.—The bolthead and stand.—The hemispheres.—The hand-glass.—The bladder in vacuo.—A refutation of what is called suction.—The fountain in vacuo.—The candle in vacuo,—with other pleasing experiments in the department of science. To conclude with the following experiments in electricity:—The much-admired experiment of the dancing images, proving the action and re-action of atmospheric air; and experiments with other light substances.—The thunder-house, proving the great importance of conductors for every description of building, as houses, ships, &c.—The improved grain weight Electometer, a curious experiment.—The electrical Orrery.

Lecture the Third,

CONTAINS much useful information, and commences with a number of experiments in Electricity, shewing in what manner it may be applied medicinally to the human frame, and rendered beneficial to mankind; its wonderful stimulating properties shewn by the electrical pail in the electrical shower, general and local shocks, &c.; and the following Mechanical Experiments:—The double cone and inclined plane—the rolling cylinder and inclined plane. Numerous experiments on Magnetism.—The mariners' compass explained, and method of making magnets.—That important discovery of the Safety Lamp, by Sir Humphrey Davy, with explanations.—After which will be given the pleasing experiment of the fountain, by condensed air.—The cup of Tantalus, on a new plan, from the celebrated fable of Tantalus, who is represented by the ancients as suffering continual thirst, and though in the midst of water, is unable to assuage it.

" E'en in the circling flood refreshment craves, | " And when the water to his lips applies,
" And pines with thirst amidst a sea of waves; | " Back from his lips the treach'rous water flies."

The experiment relative to the ebbing and flowing wells.——The experiment of Aurora Borealis.—— The Diving-bell explained with suitable anecdotes.

These Lectures will be delivered in the most familiar manner, and as much as possible technical phrases avoided; so that persons who have not made these subjects their study, may not only be amused but instructed.

The candles on the Lecture Table will be lighted by Electricity, a pleasing experiment.

Seminaries attended, and private Parties at their own houses—Terms may be known by applying to MR CLARKE.

*** Persons unacquainted with experimental Philosophy can form no idea of the beauty of the numerous Experiments in this Course, as well in the singular appearance and elegance of the apparatus, not to mention the great advantages of obtaining much useful information, so highly prized in all civilized countries; for in proportion to our knowledge, such is the result of our happiness.—Philosophical Instruments repaired.

The Doors to be opened at Half-past SIX, and the Lecture to commence precisely at SEVEN o'Clock each Evening.

Admission to a single Lecture, 2s. 6d.—*To the Three Lectures,* 6s.—*Children,* 1s. 6d. *to each Lecture.*

Tickets may be had as above, from Ten till Four.

On THURSDAY Morning, Jan. 16th, at Eleven o'Clock precisely, the First Lecture will be repeated.

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Fig. 2. Advertisement for lectures on natural philosophy, 1823. Courtesy Manchester Public Libraries, Manchester, England.

and commercial history. Similar themes and motivations underlay the more formally constituted Manchester Academy, established in 1786.[37]

[37] *Ibid.*, 37; Henry, "On the Advantages of Literature and Philosophy," 14; and Henry to Benjamin Rush, May 10, 1784, Benjamin Rush Papers, Historical Society of Pennsylvania, Philadelphia, Pa. Neatly symbolizing the change in values, the academy still exists today as a theological seminary called Manchester College, Oxford. In the period 1786–98 it enrolled ninety-two students of "commerce" but only twenty students of "divinity." See *Roll of Students Entered at the Manchester Academy* (Manchester, 1868). The lower cost, higher moral tone, and greater opportunity for self-discipline offered by the academy are directly contrasted with the situation at the English universities in Edward Percival, ed., *The Works of Thomas Percival M.D.* (London, 1807), 1: lxxx.

Dissipation did not beckon only the young. William Turner, an honorary member of the "Lit & Phil," pointed out to his own Newcastle audience that those "who retire from the burdens of an active and laborious life" could find in natural philosophy "a fund of entertainment which will have the additional charm of novelty, and . . . this advantage, that [it] will produce none of those ill-effects on the body or the mind, which are the fruit of many expedients too frequently resorted to, of supposed amusement and relaxation." Air pumps, electrical machines, chemical apparatus, and natural-history collections offered more wholesome because more disciplined entertainment. The valuable accomplishments of science would "give dignity to the possession of wealth, lessen the snares and dangers with which it is surrounded [and] provide a constant source of rational and innocent enjoyments." Increasing numbers of manufacturers accordingly turned to this "sweet entertainment and consolation," which promised to render them "more amiable, more useful, more happy."[38]

Of theological edification it is scarcely necessary to speak. Those auditors who so readily agreed with the Reverend Ralph Harrison that the Deity had rendered knowledge of natural philosophy "an abundant source of pure, exquisite and lasting enjoyment" sincerely believed the pursuit of such philosophy could only lead the student of Nature back to Nature's God. For Quakers and Unitarians, with lives focused on their chapels and meetings, such a congruence was doubly welcome. Here as in other matters Joseph Priestley was the supreme exemplar, joining theological to scientific researches in sublime confidence that "as these different pursuits have never yet interfered with, but have promoted each other . . . this will continue to be the case."[39]

What theological edification encouraged, professional occupation may also have dictated. Though late eighteenth-century Britain possessed no institutionalized career structure for men of science, careers in science were beginning to emerge: in their different ways John Dalton, P. M. Roget, and William Henry may have felt this stimulus to the pursuit and publication of natural knowledge. In 1790 Dalton was still an obscure Kendal pedagogue, writing somewhat desperately to his friends that "very few people of middling genius" became schoolmasters and arguing that "my inclination would yet adapt itself to any business that promised to be of advantage." Ten years later he was secure in Manchester, with a rising scientific reputation and a growing role in the Literary and Philosophical Society, as setter of intellectual standards and as trusted administrator of scientific affairs.[40]

Technological enthusiasm also played a role in the life of the society. Particularly when it came to encouraging manufacturers to pay their admis-

[38] William Turner, *A General Introductory Discourse* . . . (Newcastle-on-Tyne, 1802), 15; *A Sermon Preached*, 10, 24.

[39] *A Sermon Preached*, 8; Joseph Priestley in *Derby Mercury*, Sept. 29, 1791. See also Webb on the English Unitarians.

[40] Thackray, *Dalton*, especially ch. 4.

sion fees, the hope of industrial advance through scientific research was a serviceable rhetorical theme: "The misfortune is, that few dyers are chemists, and few chemists dyers," declared Thomas Henry to the applause of his audience.[41] Some visionaries—including Henry himself—took the possibilities very seriously, invested much effort, and lost significant sums of money. But that many manufacturers hoped for or found technological advance and personal profit through the promotion of science goes against the grain of the evidence discussed below.

Science was probably more important in its role as value-transcendent pursuit. Natural knowledge was inevitably espoused with particular motives, for particular ends, by particular means. It was no more free of conscious and unconscious values than any other activity of man. Yet because the area of discourse was the natural rather than the moral world and because all participants agreed that there existed impersonal and timeless laws of nature, appeal to which must prove decisive, science was felt to offer a neutral means of communication between often hostile groups. "Bigotry and party rage" did lead to mass resignations from the society on several occasions. The strain induced in the society in 1785 by the apparently innocuous proposal to raise a subscription for Joseph Priestley's epoch-making researches into the chemistry of gases indicates how hard it was to divorce natural philosophy from politics or religion. This strain, however, should be set against scenes such as that at a 1788 meeting of the town's fustian and calico manufacturers, where the opposing leaders Thomas Walker and Robert Peel "collared each other, and all was violence."[42] In contrast to such alternatives, science was an activity that enabled different elements of the town's aristocracy to come together and to express their cultural solidarity and social cohesion in face of both the local *lumpenproletariat* and more traditional English elites.

Other cultural modes—music, painting, literature—also offered possibilities as polite knowledge and value-transcendent pursuit. To a lesser extent they could be a professional occupation or rational entertainment. But as theological instruction, as technological agent, and especially as intellectual ratifier of a new world order, natural knowledge commanded cognitive domains closed off from these other forms. These genres were also more integral to the central value system of eighteenth-century England, and for that reason less suitable as expressions of alternative values. Thus by adaptation and default natural knowledge became the cultural mode of Manchester, as of those other industrial towns adumbrated by Bernal.

[41] Henry, "On the Advantages of Literature and Philosophy," 27.

[42] The first resignations came with the formation of the College of Arts and Sciences in 1783, and further unease arose with the grant to Priestley in 1785. See Henry to Rush, May 10, 1784, Rush Papers; and J. T. Rutt, *Theological and Miscellaneous Works of Joseph Priestley*, 1 (London, 1831): 423–24. The formation of the Manchester Academy in 1786 led to further strains, while the failure of the society to adopt the formal motion of condolence to Priestley in 1791 was the occasion of still more resignations. For the 1788 altercations among Manchester manufacturers, see W. Bowden, *Industrial Society in England Toward the End of the Eighteenth Century* (New York, 1925), 168.

IT REMAINS to discuss the scientific work undertaken by members of the Literary and Philosophical Society, how that work reflects the place of science in their lives, and its relationships to the Industrial Revolution then transforming the whole of their environment. To do this I shall examine the characteristics of new groups joining the society at ten-year intervals and also explore the activities of particular individuals and families.

Table 1 shows that the founding group of twenty-four included fourteen medical men, four gentlemen (one the president of the infirmary), one Unitarian minister, one captain in the army, one tutor to a nobleman's son, and two manufacturers: altogether an eminently polite group. The entry of manufacturers and Anglican ministers during the rest of 1781 is particularly evident. All but one of the Anglican ministers were to resign only two years later in protest against the progressive aims and ambitions of the College of Arts and Sciences. It is remarkable that these guardians of traditional order joined the society at all. The fact testifies to the reality and the limitations of natural knowledge as a value-transcendent pursuit. It also points to the local influence of *arriviste* manufacturers, merchants, and medical men. Such men found their natural gathering place in the socially, politically, and intellectually exclusive meetings of the Unitarian Church. Manchester was and is the national center of this group, Cross Street Chapel its cathedral. It is nicely symbolic that the chapel was considerably extended in 1780 as manufacturing converts joined its progressive ranks.

Though only four of the "Lit & Phil's" twenty-four founders were Unitarians, they included its three prime activists—Thomas Percival (vice-president in 1781 and president for 1782–86 and 1789–1804), Thomas Henry (secretary for 1781–87, then successively vice-president and president until his death in 1816), and Thomas Barnes (Unitarian minister and vice-president for 1781–84). Further identification of the society with rational ends is provided by its home in rooms attached to the Unitarian Chapel, from a few months after the society's inauguration until December 1799, and by the fact that the ministers at Cross Street from 1781 to 1851 were not only members of the society but also active in its affairs.[43] Shifts in

[43] As a creed and as a denomination Unitarianism underwent a slow, complicated evolution in the half century following 1760; for instance, it was legally proscribed until 1813. Divisions among Unitarians rarely led to schism, and that exaltation of the rational and progressive personified by Joseph Priestley was characteristic of all parties to Unitarian doctrine. See Sir Thomas Baker, *Memorials of a Dissenting Chapel . . . Being a Sketch of the Rise of Nonconformity in Manchester . . .* (London, 1884); E. L. H. Thomas, *Illustrations of Cross Street Chapel . . .* (Manchester, 1917); H. McLachlan, *The Unitarian Movement in the Religious Life of England* (London, 1934); J. D. Gay, *The Geography of Religion in England* (London, 1971), especially 181–83; and Webb on the Unitarians. At the height of their prosperity the Unitarians had only five chapels in Manchester, but an influence far beyond their numbers. On the society's meeting place, see Nicholson, "Literary and Philosophical Society," 119–20. The only minister not to join the society had a correspondingly brief stay at Cross Street (1825–27). All the others (the chapel had two ministers at any one time) joined the society and most served on its council. Similar Unitarian coteries, with similar cultural orientations, existed in other provincial centers of commerce and manufacture: for Derby see J. Y. D. Peel, *Herbert Spencer* (London, 1971),

TABLE 1

Period of Joining the "Lit & Phil"[a]	Size of Group	Clergy			Medical Men[b]			Lawyers	Manufacturers and Merchants[c]	Engineers	Bankers	Teachers		Other[d]
		Gentlemen	Unitarian	Anglican	Physicians	Surgeons	Apothecaries					Secondary Education	Higher Education	
Founder members	24	17%[e]	4%	0%	25%	25%	8%	0%	8%	0%	0%	0%	0%	12%
Rest of 1781	22	0%	5%	32%	5%	0%	9%	5%	36%	0%	0%	0%	0%	9%
Total of above	46	9%	4%	15%	combined percentage: 37%			2%	22%	0%	0%	0%	0%	11%
1789–92	30	3%	3%	0%	9%	13%	6%	5%	43%	0%	3%	0%	0%	10%
1799–1803	26	4%	8%	4%	0%	8%	0%	12%	46%	0%	4%	0%	0%	15%
1809–11	27	4%	7%	4%	0%	7%	0%	4%	56%	0%	0%	4%	0%	15%
1819–22	27	4%	4%	0%		26%		19%	26%	0%	4%	0%	4%	15%
1828–32	28	7%	0%	7%		21%		4%	32%	0%	7%	4%	4%	14%
1840–42	40	5%	5%	0%		17%		15%	22%	15%	2%	5%	5%	7%
1850–52	28	0%	4%	4%		8%		4%	36%	7%	0%	0%	14%	25%

[a] The "periods of joining" have been adjusted to yield groups of comparable size.

[b] The distinction of medical men into physicians, surgeons, and apothecaries is to some extent arbitrary and has been abandoned for post–1815 groups.

[c] Manufacturers and merchants are grouped together, as many members engaged in both roles.

[d] Included in this category are founder members: 1 captain, 1 tutor, and 1 unknown; rest of 1781: 2 unknown; 1789–92: 1 tax collector and 2 unknown; 1799–1803: 1 dockmaster and 2 unknown; 1809–11: 1 lecturer and 3 unknown; 1819–22: 1 journalist, 1 architect, and 2 unknown; 1828–32: 1 journalist and 3 unknown; 1840–42: 1 research chemist, 1 scientific-instrument maker, and 1 unknown; 1850–52: 1 architect, 1 accountant, 1 gas comptroller, and 4 unknown.

[e] The percentage figures are approximate and do not necessarily add up to 100.

this alliance between science and social values are illustrated by the changing percentages of Unitarians among different peer groups of recruits to the "Lit & Phil" (see table 2). The rise over the years to 1810 was interrupted only by the period of repression in the 1790s, when alliance with such a progressive denomination called for some temerity. The decline is equally precipitous. By 1850 the only Unitarian joining was a minister. Manchester's aristocracy of manufacturers, by now legitimated and secure, abandoned both science and advanced religion as appropriate cultural symbols. The great manufacturing families found social issues, practical politics, and the reform of Oxbridge to be matters more congenial to third-generation taste. The sharply lower percentage of manufacturers among those joining the society after the Napoleonic wars were men of more modest wealth and different type.

A significant development in the years after Waterloo was the steady rise of those with a "professional" interest in scientific research. By 1850, fourteen per cent of the peer group was directly in higher education, and the total was larger still if we include the diminishing, changing band of medical men. Neither of the medical men in 1850–52 had infirmary connections, but one was a lecturer in a proprietary medical school: of the seven in the 1840–42 group only three had infirmary connections, while three lectured in medical schools. Other shifts were also occurring. Most noticeable is the arrival of engineers as an explicit, self-confident group. Richard Roberts, in 1823, was the first to join the society, although he had already been in Manchester for seven years. By the 1840s the number and influence of the engineers were considerable. The character of the manufacturing group was also changing, with far fewer cotton spinners and a growing number of chemical manufacturers, metal workers, and others whose technical interests had a closer association with the possibilities offered by physical science. It may be that the social forms and images that characterized natural knowledge in the "consolidating" phase of the Industrial Revolution, say after 1850, gave rise to the tradition of interpretation through which Halévy and others misplaced by at least half a century whatever direct links existed between science and technology within the Manchester Literary and Philosophical Society. To search for such connections in the period 1780–1840 is to miss the deeper cultural meaning of the spectacular growth of science during the British Industrial Revolution.

The pattern of the earlier period is clear, at least if one takes the granting of patents as an indicator of concern with technical improvement. None of the founding members of the society took out a patent, while of those joining later in 1781 only two manufacturers did so. Neither have any publications to their names nor any detectable role within the scientific or administrative life of the society. On the other hand two gentlemen and eight

ch. 2; for Norwich see Robert K. Webb, *Harriet Martineau: A Radical Victorian* (New York 1960), chs. 2, 3.

medical men did publish scientific papers (there were, of course, also theological and antiquarian publications). The nearest the one publishing manufacturer came to any equation of science and technology is itself revealing. Thomas Kershaw, a calico printer, wrote on "The Comparative Merit of the Ancients and the Moderns with Respect to the Imitative Arts."[44]

The group who joined in 1789–92 show the society in a more settled state. A druggist took out two patents, and a cotton merchant had procured a patent twenty years before joining the society. Again, neither member published or played an active role within the society. Scientific publications were undertaken by four medical men (forty-four per cent of their group) and five manufacturers (thirty-nine per cent). The papers of this latter set scarcely provide strong evidence for any science-and-technology linkage. One manufacturer wrote "Observations on the Advantages of Planting Wastelands" while another examined "Spontaneous Generation" and "The Production

TABLE 2

Period of Joining the "Lit & Phil"	*Size of Group*	*Percentage Who Were Unitarians*
Founders	24	16%
Rest of 1781	22	18%
Total of above	46	17%
1789–92	30	23%
1799–1803	26	12%
1809–11	27	30%
1819–22	27	22%
1828–32	28	15%
1840–42	40	10%
1850–52	28	4%

of Air by the Freezing of Water." One investigated the "Weight Increase of Heated Bodies on Cooling." Only two composed on obviously technological themes. James Watt, Jr. gave "Some Account of a Mine in Which the Aerated Barytes is Found." Thomas Hoyle, a calico printer, wrote "On Oxygenated Muriate of Potash," thus providing a paper in which a subject of industrial importance received direct if not scientific attention.[45]

Of the group that joined between 1799 and 1803, one tape manufacturer eventually secured a patent, while one medical man wrote on physiological subjects. None of the manufacturers ventured any scientific publications. The high point of manufacturing involvement in the society was in

[44] *Manchester Memoirs,* 1 (1785): 405–12. The obtaining of a patent, as revealed by files at the Patent Office, London, has been taken as the measure of concern with advancing technology. See also B. Woodcroft, *Alphabetical Index of Patentees of Inventions, 1617–1852* (London, 1854).

[45] See Thomas Richardson, "Observations," *Manchester Memoirs,* 4 (1796): 345–68; Joseph Priestley, Jr., "Spontaneous Generation," *Transactions of the American Philosophical Society,* 6 (1809): 119–28, and "Production of Air," *ibid.,* 5 (1802): 36–41; Thomas Henry, Jr., "Weight Increase," *Manchester Memoirs,* 3 (1790): 174–77; James Watt, Jr., "Some Account," *ibid.,* 598–608; and Thomas Hoyle, "Oxygenated Muriate," *ibid.,* 5 (1798): 221–42.

1809–11, with some fifty-six per cent of the new members coming from this class. None took out patents or published any scientific papers. Of the manufacturers in the 1819–22 group, one procured a patent, published an obscure mythological paper, and otherwise played no part in the society. One manufacturing chemist published a brief note on "The Discovery of Selenium in the Sulphuric Acid Made from the Pyrites of Anglesey." Of the one other publishing merchant it was said that "the greater part of his ninety two years were devoted to the study of science." The *Royal Society Catalogue* lists sixty-four of his papers. Like his classic 1861 *Monograph of British Spiders,* all John Blackwell's publications were devoted to natural history.[46]

ENOUGH HAS BEEN said to illustrate the sterility of any simple thesis about the technological purposes of Manchester science in the Industrial Revolution. It remains to examine the broader cultural meaning of that science as revealed in the life-patterns of some leading local families over three or four generations. This analysis will point up the striking extent to which natural knowledge was the private cultural property of a closely knit, continually intermarrying, almost dynastic elite, and how that elite's ambition to move toward the center of affairs provided fuel for political reform movements and for changes in the nature of the nation's science. Six Unitarian families provided almost five per cent of the society's membership (28 out of 588 members). More strikingly, their members held office for a collective total of 144 years, or for 4.5 years each on average, occupying between them twenty-five per cent of the available offices. The families in question were the Gregs, the Heywoods, the Henrys, the McConnels, the Philipses, and the Robinsons.

The fortunes of the Greg family began in 1780 when Samuel Greg left Belfast to join uncles who were modest fustian manufacturers in Manchester. Samuel established mills at Quarry Bank, outside the town. He also took up Unitarianism and in 1790 joined the Literary and Philosophical Society. He never held office or published, but he did send his two sons to the "scientific" University of Edinburgh. Each married into the family of another Unitarian (Robert Hyde Greg chose a daughter of Robert Philips, the manufacturer, while his brother William Rathbone Greg espoused Lucy Henry, daughter of William Henry, the physician), each entered the Greg business, and each joined the "Lit & Phil." Robert was a model employer and a man of scientific and horticultural tastes. The Geological Society of London attracted his particular interest, and by his death in 1875 he had put together "the best private collection in England" in the field of mineralogy.

[46] Samuel Robinson, "Sketch of the Life and Writings of Ferdoosee," *Manchester Memoirs,* 9 (1824): 1–63; Edmund P. Thomson, "Discovery of Selenium," *Annals of Philosophy,* 9 (1825): 52; John Blackwall, *Monograph of British Spiders* (London, 1861); and see *Proceedings of the Manchester Literary and Philosophical Society,* 21 (1882): 141–42.

This eminently respectable interest was complemented by a taste for experimental farming, which he carried on in Hertfordshire. The polite science of the mill-owner mineralogist was allied with the reforming interests of the economist and liberal politician (M.P. for Manchester, 1839–41), and the concern for social order of a founder of the Mechanics' Institution.

William Rathbone Greg was the first secretary and later the president of the Manchester Statistical Society, thus aiding reformist endeavor. He also participated in the early years of the British Association for the Advancement of Science. Moving to London and the comptrollership of Her Majesty's Stationery Office, he was finally to become an elegant and apocalyptic prophet of doom. Perfectly expressing the changing values of Manchester's elite, he wrote W. E. Gladstone in 1852 that

> I am one of a considerable and daily increasing class who belong to the liberal party by early connection, long and active association, and by many surviving opinions also, who are yet decidedly conservative in all that relates to the further infusion of the democratic element into our Constitution. We still consider ourselves earnest reformers, but thorough anti-democrats.[47]

Scientific interest and connection with the "Lit & Phil" did just survive into the third generation in the person of Robert Philips Greg, eldest son of Robert Hyde Greg. Like his father he was educated at Edinburgh University and joined the Geological Society. He was also a founder of the London Mineralogical Society and its treasurer for a number of years. Before he was fifty, however, he had retired to the family estates in Hertfordshire, there to pursue "the peaceful and beneficient life of an active and useful country squire." At his death the mineralogical collection went to the British Museum, and the Gregs' connection with science, Manchester, and Unitarianism ended after three generations.[48]

The Gregs are atypical in that it was the second, not the third, generation which was caught up in political and meliorist social activity, though still turning toward science. The Henry family provides a more familiar pattern. Thomas Henry was the son of respectable Anglicans, who kept a boarding school in Wrexham. The expense involved deterred them from their plan of sending him to Oxford University and into the Church. Instead he was apprenticed to a succession of apothecaries including one in Oxford, where he literally spent time on the margin of established society. Henry settled in Manchester in 1764. His practice prospered. In 1778 he became visiting apothecary to the infirmary and began to be noted for his "medical attendance, for the most part on the more opulent inhabitants of the town and

[47] William R. Greg to W. E. Gladstone, Apr. 4, 1852, Add. MSS 44,371 f 283, British Museum.

[48] F. Collier, "Samuel Greg and Styal Mill," *Manchester Memoirs*, 85 (1943): 139–56; obituary of Robert Hyde Greg in *Manchester Guardian*, Feb. 23, 1785; William Henry to Charles Babbage, Aug. 7, 1835, Add. MSS 37,189 f 159, British Museum; information in biographical file, Manchester Local History Library, Manchester, England; and *Proceedings of the Geological Society*, 63 (1907): lxiii–lxiv. An exhaustive study of the dynastic patterns of intermarriage in the group is available in Gatrell, "Middle Class Manchester."

neighbourhood." About this time he became a Unitarian and a chemical manufacturer. He was a founding member of the "Lit & Phil" and held office continuously (with one two-month break) until his death in 1816. He translated Lavoisier's *Chemical Essays* and published in meteorology, medicine, chemistry, technology, and biography. His activities everywhere reveal the man of intellect and growing wealth, to whom science offered a means of self-expression not otherwise available.[49]

Thomas Henry, Jr., his eldest son, was a signal disappointment. Sent to attend the chemical lectures of Dr. Bryan Higgins in London, trained in James Potter's Manchester fustian manufactory, apprenticed to Dr. Lyon (a Liverpool surgeon and corresponding member of the "Lit & Phil"), and, in 1790, matriculated at Edinburgh, he settled to no pursuit. In 1794 he joined Joseph Priestley in his emigration to America but soon returned. He died in the Virgin Islands in 1798. William Henry, Thomas's second son, proved more rewarding. He was educated at Edinburgh University. He married Mary Bayley, the daughter of another wealthy Unitarian member of the "Lit & Phil," and became a physician at the Manchester Infirmary, a chemical manufacturer, and a leading citizen. He was vice-president of the "Lit & Phil" for twenty-seven years, a fellow of the Geological Society, an F.R.S. and Copley Medallist (1809), and one of the principals at the foundation meeting of the British Association for the Advancement of Science (characteristically, he spoke on Joseph Priestley). A succession of papers in chemistry, electricity, and medicine flowed from his pen. His central role in Manchester science was reinforced by his refinement of manner, his eloquence of speech, and "his wealth and habits of entertaining freely."[50]

His own son, William Charles Henry, was educated as a private pupil of John Dalton, who taught him "the great and leading doctrines of chemical philosophy," then at Edinburgh University, in Cambridge, and at the Paris hospitals. He also studied in Berlin and was one of the earliest English pupils of Justus Liebig at Giessen. By the time he returned home in 1836, he was the best trained and widest-traveled man of science of his generation. Elected F.R.S. and a fellow of the Geological Society, he was appointed as local secretary for the 1837 Liverpool meeting of the British Association, and at the same time elected a vice-president of the Manchester "Lit & Phil." He thus had every incentive and opportunity to devote his life to scientific research. As Leonard Horner noted when he dined with "the élite of the mercantile aristocracy of Manchester" in 1836, "Young Dr. Henry was there. . . . [He has worked] in the laboratories of Mitscherlich and Henry Rose, as scientific chemical research is his great occupation. His father is very rich, and he is an only son, so that he has no occasion to practise [medicine]."[51]

[49] See obituary notices for Thomas Henry in *Manchester Memoirs*, 8 (1819): 204–40, and *Monthly Repository*, 11 (1816): 435. I am indebted to Drs. W. and K. Farrar for letting me consult and draw on their extensive unpublished study of the Henry family.

[50] See obituary notices for William Henry in *Manchester Memoirs*, 11 (1842): 99–141, and *Christian Reformer* (1836), pp. 743–46.

[51] See obituary notices for William Charles Henry in *Manchester Memoirs*, 44 (1842): 178–79,

On his first visit to England Justus Liebig was to describe the Henry's house as "a kind of palace," and to be "rather taken aback by the massive elegance of a rich English household." He records how his room was provided with

four kinds of washbasin, one for the head and face, one for the teeth, one for the hands and a bidet. In the evening Henry had friends in for dinner, which was dreadfully boring for me; the servants came in black tail coats, kneebreeches and stockings, white gloves, *three* slaveys behind us, in short it was princely, but for me very dreary. I will say nothing about the food, still less of the dozen or so wines.[52]

If Liebig found all this irksome, W. C. Henry found it equally unconducive to the austere life of a research scientist. Shortly after Liebig's visit he abandoned Manchester, science, and Unitarianism for the life of an Anglican squire in the Herefordshire countryside. Natural knowledge as a means of cultural self-expression was thus found redundant in the third generation.

The Heywoods were a prosperous Liverpool family of Dissenters. Two brothers, Benjamin Arthur and Nathaniel, moved to Manchester as bankers in 1788. Within the century following the election of Benjamin Arthur Heywood in 1789, the family provided a further six members for the "Lit & Phil": Nathaniel (elected 1796) and three of his sons—the first Sir Benjamin (1815), Richard (1822), and James (1833). Two of Sir Benjamin's sons, Oliver (elected 1864) and Charles James (1889), followed family tradition. Benjamin Arthur, Nathaniel, and Sir Benjamin between them occupied the treasurer's office and thus enjoyed membership of the society's inner council continuously from 1791 to 1850. The two brothers of the first generation adhered to Unitarianism and to the society, without playing a particularly prominent part in either. Benjamin Arthur remained unmarried, while Nathaniel made a suitably advantageous match with Anne, only daughter of Thomas Percival (by 1790 president of the "Lit & Phil," senior physician in the town, and a figure of national stature). Sir Benjamin, their eldest son, was educated at Glasgow University, acquiring such a taste for science that he had a private laboratory fitted in his house on returning to Manchester and there "passed much of his time."[53]

No scientific paper ever came from Sir Benjamin Heywood's pen. He did, however, marry Sophia Anne Robinson, the daughter of Thomas Robinson, who was a merchant, a Unitarian, and a librarian to the "Lit & Phil." Sir Benjamin was essential to the success of the Mechanics' Institution, subscribing liberally and, as president from 1824 to 1841, enunciating and elaborating the possibilities of science for the social control of the lower orders.

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and *Manchester Guardian*, Jan. 9, 1892. See also William Henry to M. Napier, June 19, 1814, Add. MSS 34,611 f 81, British Museum; and K. M. Lyell, ed., *Memoir of Leonard Horner* (London, 1890), 1: 326–27.

[52] Justus Liebig to Mrs. Liebig, Aug. 9, 1837, Bayerische Staatsbibliothek, Munich, Germany, quoted by the Farrars.

[53] See T. Heywood, *A Memoir of Sir Benjamin Heywood* (Manchester, 1888), especially p. 24; and Baker, *Memorials of a Dissenting Chapel*, 108, 111, 115, *passim*.

Those same arguments which in the 1780s had been used to awaken the interest of a new elite were now recast for the benefit of those in more humble stations. By the 1820s it was otiose to stress the possibilities that natural knowledge held out for Manchester's rulers. They were too occupied with the prospects of national political power on the one hand and local social unrest on the other. For control of the latter natural knowledge was one of the means that came automatically to hand.

As Heywood put it to the assembled artisans in 1825, "the better knowledge of your business, and the qualification to make valuable improvements in it [which lectures in chemistry and mechanics will provide] . . . are the surest means of advancing yourselves and your families in the world." Should such advancement not be forthcoming

> it must also be remembered that the Mechanics' Institution will afford you entertainment as well as instruction. . . . To any who in search of amusement are accustomed to spend their evenings frequently in a public house, or indulge in other sensual gratifications, I can promise, if they will assert themselves a little at first, far more *amusement* from this institution.

Two years later, following a brief but severe recession in trade, Heywood was able to point out how "the patience with which the working classes have borne their severe sufferings is far beyond my praise. I delight to think of it as one result of those juster views which education necessarily implants in the mind."[54]

Sir Benjamin was a founder of the Royal Manchester Institution—a society designed to bring art and science before the petit bourgeoisie of the town. Like the lower ranking Mechanics' Institution the R.M.I. was an offspring of the "Lit & Phil," created and controlled by members of the more ancient body. In their proposal of 1823 its founders admitted their hope that the R.M.I. would "have the pleasing effect of removing prejudice, of softening the asperity of party feeling, and of fixing the public attention upon an object, with regard to which vehement differences of opinion can hardly be expected to arise." "The storms of religious or political animosity" would thus be avoided. It was intended to include in the institution a museum for the Natural History Society and to provide the commodious lecture room long lacking in "a town which, during half a century, has been honourably distinguished for its attachment to science." However, in a passage revealing of the changing priorities in Manchester culture, the prospectus argued that literature and the arts "tend, even more perhaps than the sciences themselves, to diffuse through the discordant elements of society a pervading emotion of friendly sympathy and mutual satisfac-

[54] Sir Benjamin Heywood, *Addresses Delivered at the Manchester Mechanics' Institution* (London, 1843), 13–17, 29–30. See also M. Tylecote, *The Mechanics' Institutes of Lancashire and Yorkshire before 1851* (Manchester, 1851); and Harold Silver, *The Concept of Popular Education* (London, 1965).

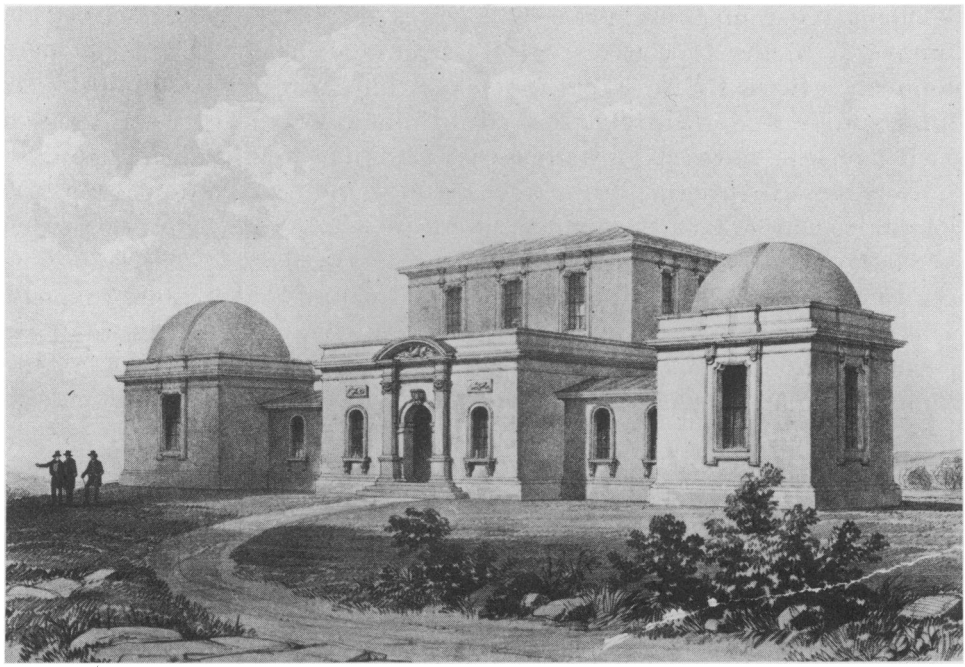

Fig. 3. Observatory proposed to be erected at Kersal Moor. Courtesy Manchester Public Libraries, Manchester, England.

tion."[55] Though science might still be appropriate food for the proletariat, art was increasingly to the taste of the commercial aristocracy, and permissible to the respectable middle class.

Heywood was also a trustee of Cross Street Chapel, a supporter of the Manchester Academy, and a moderate Whig. He served as an M.P. for Lancashire in the critical days of 1831. The London acquaintance then developed, led to a home in the capital, a baronetcy (1838), the sending of two sons to Eton and two to Harrow, a judicious change to Anglicanism (1842), and, with almost too symbolic a timing, his election as an F.R.S. soon afterwards. Two of his sons eventually joined the Manchester Society. Neither made any contribution or held any office. As liberal Anglicans their public spirit and charity were irreproachable—Oliver Heywood became the first honorary freeman of Manchester in 1888—but their interest in science was negligible.

Sir Benjamin illustrates a flowering of scientific and civic concern characteristic of the Manchester aristocracy in its second generation. That same tendency may be seen in his brothers Richard and especially James. James was educated at Edinburgh University and entered the family bank. The property he inherited on the death of Benjamin Arthur in 1828 enabled him to abandon this dull pursuit and go to Cambridge. Duly entered, with

[55] "Proposal of 1823" in packet B.4., Archives of the Royal Manchester Institution, Manchester Central Library.

William Whewell as his tutor, he graduated a senior optime 1833 and proceeded to the Inns of Court. He later married a daughter of John Kennedy, another "Lit & Phil" member and manufacturer, practiced a little, and became a Liberal M.P. for North Lancashire in 1847 and 1852. As such, he was to move the 1850 request for a Royal Commission on the ancient universities. He also found time to assist in founding the Manchester Geological Society (1838), to become an F.R.S. some time before his eldest brother, and to serve as president of the Statistical Society of London and chairman of the Royal Historical Society. He "maintained at his own expense a lecturer in Civil Engineering in connection with the secular side of the [Manchester] College." Such interest could not survive another generation, though the Heywoods continue to prosper to this day as suitably southern English gentry.[56]

Similar patterns may be seen in the cotton-spinning families of the McConnels and the Robinsons, and in the powerful Philips clan, who were active in silk manufacture, cotton spinning, and merchandizing. One strand of this last family may provide an illustration. John Philips was one of three cousins descended from an obscure merchant. By the 1780s all three were associated in various Manchester manufacturing enterprises. All were Unitarians, and all joined the "Lit & Phil" in the early 1780s, without taking any active part in its affairs. John Leigh Philips, son of John Philips, further built up the family business and created a sensation when he arranged for his mills to be lighted by gas in 1805. He was active in the "Lit & Phil," served on its publication committee, and developed a renowned natural-history collection. After his death the collection was bought at auction for over £5,000 by Thomas Henry Robinson. It then formed the basis around which the Manchester Natural History Society organized in 1821. John Leigh Philips's two sons both seem to have left Manchester, Unitarianism, and science—the one to become a landscape painter, the other a naval officer.[57] The Philipses thus provide a classic example of adhesion to the society by the money-making first generation, flowering of scientific talent in the second, and overt movement from these alternative values toward the cultural center in the third generation. The same patterning may be observed among the manufacturing elite of other provincial English towns. For instance Jedediah Strutt of Belper was a Unitarian manufacturer. His son William was noted as a man of science while his grandson became an Anglican, a liberal politician, and a peer. A contemporary observer of the Unitarian scene correctly noted the symbolic fact "that in opulent families the carriages

[56] See Heywood, *A Memoir,* especially 140–45; obituary notices in *Manchester Memoirs,* 42 (1898): lx–lxi, and 50 (1906): xxxii; and MSS D.4., notes by A. J. Naylor in Unitarian College, Manchester, England.

[57] Faraday, "Philips Correspondence"; F. Nicholson, "The Old Manchester Natural History Society and Its Museum," *Manchester Memoirs,* 58 (1913): 1–13; and "Extracts from the Minute Book of the Manchester Society for the Promotion of Natural History," MS 378–42 M 60, Archives Dept., Manchester Central Library.

of the third generation always carried their possessors away to the national Church." Judicious marriage was central at each stage of this characteristic social trajectory. Daughters played correspondingly important roles. When Jeremiah Marshall of Leeds prospered as a merchant he moved to the Unitarian chapel earlier associated with Joseph Priestley. Marshall's son John—equally an outsider to the traditional elite of Leeds—pursued business, science, and the daughter of another Unitarian merchant. John Marshall's eldest son was called to the bar, elected to Parliament, and became an Anglican and a country gentleman. Two younger sons married daughters of the Chancellor of the Exchequer. One daughter married a peer (Lord Monteagle), while a second symbolized another aspect of these same transitions by her marriage to William Whewell, master of Trinity College and a leader of the new movement to serious science in Cambridge.[58]

The Manchester "Lit & Phil" was neither defined nor delimited by Unitarians and manufacturers, as table 1 has made clear. Other significant, dynastic groups within the society included the surgeons and some Anglican families. The surgeons, at least in the first two or three decades, tended to be local men, craft educated by apprenticeship, loyal members of the established church, and jealous of the liberal principles, cosmopolitan ideas, and higher status of the growing number of physicians in the town. Typical examples are to be found in the Hall and White families. Surgeons had obvious reasons to adhere to the "Lit & Phil" from its earliest days. Other Anglicans were more cautious. The mass entry and subsequent egress of Anglican ministers has been indicated. Such Church-oriented manufacturers as the Peel family chose to stand aloof from the society in its early days; the first Robert Peel joined only in 1799 when the initial radical thrust had been thoroughly blunted. It was the physicians and manufacturers congregated at Cross Street Chapel who gave the "Lit & Phil" its tone, its energy, and its orientation. Quakers, Anglicans, surgeons, barristers, and gentlemen might all add their contributions. Yet it was that particular combination of polite knowledge and progressivist philosophy also represented in Unitarianism which was best to express the allegiance of these new men and turn their zeal to scientific ends.

The polite, indeed ornamental, nature of the science most likely to be pursued by Manchester manufacturers in the Industrial Revolution has already been indicated: John Leigh Philips, mill owner and natural historian; Sir Benjamin Heywood, banker and chemical adept; Robert Hyde Greg, cotton spinner and mineralogist; such examples can be multiplied without effort. The second generation of the Hibbert family (linen merchants and Unitarians) gave rise to the geologist and antiquarian Samuel

[58] See W. G. Rimmer, *The Marshalls of Leeds: Flax Spinners* (Cambridge, 1960). The Unitarian elite features as a major strand of that "Intellectual Aristocracy" analyzed by Noel Annan in J. H. Plumb, ed., *Studies in Social History* (London, 1955), 243–87. Quotation cited by Webb from Lewis B. Bowring, ed., *Autobiographical Recollections of Sir John Bowring* (London, 1877), 388.

Hibbert-Ware; Joseph Evesleigh, hat manufacturer, was a significant botanist; John Moore, a Unitarian and retired merchant, was active as a zoologist, botanist, and horticulturalist; Eaton Hodgkinson, son of a respectable farmer, moved to Manchester in 1811 "to satisfy [his] thirst for scientific knowledge and society"; John Blackwell, retired linen importer, was a world authority on spiders; Thomas Glazebrook Rylands, cloth and wire manufacturer, was a noted astronomer and natural historian; and John Kennedy, machine maker and mule spinner, was a devoted friend of science over many years.[59] L. J. Henderson was certainly correct, though in ways he did not fully appreciate, when he argued that "science owes more to the steam engine, than the steam engine owes to science."

John Kennedy is worth further examination since he exemplifies much about the society. He had only the most rudimentary formal education, having been brought up in the remote mountains of Kirkcudbrightshire. In 1784, on route to his spectacular career in Manchester, he heard some lectures by John Banks, itinerant natural philosopher. These lectures "laid the foundation of his future tastes." As an obituarist noted,

> There were few disinguished men in the scientific world with whom [Mr. Kennedy] was not acquainted and on terms of friendly intercourse. . . . In private society Mr. Kennedy had the manners and conversation of a gentleman, acquired, not from his education, but from his subsequent intercourse with the best society. He had great discrimination, and would never associate with any but those of superior attainments . . . during a long period of years he was a regular attendant at the meetings [of the "Lit & Phil"].

The relationships between science, technology, and the Industrial Revolution find one of their classic expressions in the picture of John Kennedy, self-educated cotton spinner and Unitarian, sitting in Trinity College, Cambridge, deep in scientific conversation with William Whewell, the future master.[60]

Two of Kennedy's daughters were to marry within the dynastic elite of the "Lit & Phil": one to James Heywood, the other to Samuel Robinson. Robinson was a merchant, a Unitarian, and a promoter of the Manchester Statistical Society. Another daughter married Edwin Chadwick, the sanitary reformer. Kennedy's only son was to make the classic transition from the alternative value system to the central one. Despite his Unitarian background and early education John Lawson Kennedy was sent to Cambridge, where he subscribed to the Articles of Religion and graduated. He was called

[59] Mrs. Hibbert Ware, *Life and Correspondence of the Late Samuel Hibbert Ware* (Manchester, 1882); J. T. Slugg, *Reminiscences of Manchester Fifty Years Ago* (Manchester, 1881), 184. See obituaries for: John Moore in *Manchester Guardian,* May 18, 1857; Eaton Hodgkinson in *Manchester Memoirs,* 22 (1865): 145–204; John Blackwall in *The Entomologist,* 14 (1881): 145–50; and John Kennedy in *Manchester Memoirs,* 21 (1862): 147–57, and *Christian Reformer,* 11 (1855): 772–74. Also see R. D. Radcliffe, *A Memoir of Thomas Glazebrook Rylands* (Warrington, 1901).

[60] *Manchester Memoirs,* 21 (1862): 147–57; William Whewell to W. C. Henry, May 8, 1832, Houghton Library, Harvard University, Cambridge, Mass.

to the bar but did not practice. Instead he extended the family's manufacturing wealth. He did join the "Lit & Phil," but he plainly felt no need to express his separation from the central values of English society. Instead he was a great reader, an art fancier, and a good sportsman especially fond of hunting. The family estates, the family business, and his duties as a J.P. were the occupations of a wealthy man assimilated to, not alienated from, the wider society in which he lived.[61]

IF THE ENDURING impact of Manchester science within the Industrial Revolution is not to be found in its technical implications, that impact was none the less real. Further facets of it may be seen in the three areas of context, clientele, and concerns.

This account has taken for granted rather than emphasized the way that wider cultural valuations of natural knowledge and concern with it led to the creation of institutions and roles in which professional men of science could flourish. The ambitions expressed by Manchester spokesmen in the 1780s did not include this aim. But creation of the "Lit & Phil" and of a host of lesser institutions, with audiences, publications, occasional paid positions, libraries, apparatus, chemicals, mineral cabinets, biological collections, and prizes and legitimating titles, made scientific careers possible. Of major men of science within the society, only William Henry and James Prescott Joule grew up in Manchester. They both enjoyed second-generation wealth, and their devotion to science exemplifies the values of the city's new elite. In contrast John Dalton, William Sturgeon, and Lyon Playfair all came from outside and depended on Manchester institutions for employment—Dalton as a professor of natural philosophy at the Manchester Academy, Sturgeon as a lecturer in experimental philosophy at the Royal Victoria Gallery, and Playfair as a professor of chemistry at the Royal Manchester Institution. Other "outsider" professionals who made lesser contributions include M. L. Phillips, a professor of physical sciences at the Manchester Academy; R. A. Smith and F. Crace Calvert, both employed at the Royal Manchester Institution; and W. C. Williamson, the curator of the Natural History Society's museum. The heritage from this cultural context of concern for natural knowledge was later crucial to the mid-Victorian flowering of Owens College as a great scientific institution.[62]

The Industrial Revolution also created a wider clientele to swell the rank and file of metropolitan as well as local scientific endeavor. The most obvious illustration is that 31 of the 588 men in this analysis (5.3 per cent)

61 *Manchester Memoirs,* 40 (1896): 109–10.

62 As early as Nov. 9, 1836, James Heywood was writing a friend that "the present time [is] very suitable for the formation in Manchester of a college for the advancement of science." His plan was to model the college on the four sections of the British Association for the Advancement of Science and to overcome sectarian division "by placing a dignity of the Church of England at the head of the Institution." See *Letter Book of the College Commitee, 1836–1837,* p. 37, Special Collections, Manchester University Library.

became F.R.S.'s and by their interest, efforts, and attention helped feed the growth of knowledge. Others played significant parts in national societies as varied as the Geological, the Astronomical, the Mineralogical, the Chemical, the Linnaean, the Microscopical, and the Statistical, while local societies in their turn offered further outlets for national figures. The provincial origins and sustenance of the British Association for the Advancement of Science indicate how such urban centers as Manchester were important recruiting grounds for national scientific endeavor. The early correspondence of the prime movers in the British Association include such urgings as "pray let us arrange our next meeting in Manchester instead of Cambridge. . . . It is . . . a proper compliment to the manufacturing interest (which, depend upon it, is destined to become the great support of science)," together with much mutual concern about "the necessity of conciliating the manufacturing class to our objects."[63]

Manchester in the Industrial Revolution provided context and clientele for science. It also gradually gave birth to wider concerns. As manufacturing families in the second and third generation reached out to more traditional prizes, reform was a cry they found quite natural. They were concerned that science be more highly valued, whether in the Royal Society or in the teaching of Oxford and Cambridge. Using his obvious opportunity as member of Parliament James Heywood was to direct the 1850 movement for a Royal Commission to examine the teaching of the ancient universities, just as another member of the "Lit & Phil" had earlier led the campaign to abolish their religious tests. Reformist men of science within the metropolis drew on such provincial encouragement, while Whig professors like Adam Sedgwick numbered third-generation Manchester men among their students and supporters, as they sought to win a larger influence for their subjects within the Cambridge curriculum.[64]

Such facts point us toward a new awareness of the decisive shifts represented by the "second revolution" in English science, and the forces at work within it. Changes in science as a cognitive system—that is, in its conceptual

[63] Babbage to C. G. B. Daubeny, Apr. 28, 1832, Daubeny Papers, Magdalen College, Oxford, England; Lord Milton to W. V. Harcourt, Jan. 24, 1832 (in private possession). The 1831 foundation meeting of the British Association for the Advancement of Science was in York, the 1832 meeting in Cambridge. The Manchester philosophers declined to host the 1833 meeting on account of their lack of large lecture rooms, and the meeting went to Oxford by default. See William Henry to William Whewell, May 6, 1832, Whewell Papers, Trinity College, Cambridge, England; and Whewell to Henry, May 8, 1832, Houghton Library.

[64] See *Christian Reformer* (1843), pp. 726–30, for G. W. Wood's 1834 bill to abolish religious subscription in the national universities. A Unitarian and merchant, Wood was a fellow of the Linnaean and Geological Societies, one of ten founders of the Statistical Society of London, and a keen supporter of the British Association for the Advancement of Science. He was a vice-president of the "Lit & Phil" from 1822 until his death (in the society's rooms) in 1843. There are no scientific publications to his name, but he made major contributions to the scientific enterprise. See also John P. C. Roach, "The Age of Reforms," in *The Victoria History of the Counties of England, Cambridgeshire,* 3 (London, 1959): 235–65. For the links between, for example, the Heywood family of Manchester and the Marshalls of Leeds with such Cambridge men as Whewell and Sedgwick, see Isabelle M. Percival, *Reminiscences, Letters and Journals of T. P. Heywood* (Manchester, 1899), 16; and Rimmer, *Marshalls,* 225.

focuses, cultural aims, intellectual constructs, methodological affirmations, ontological claims, and investigatory techniques—are apparent if unanalyzed. These changes interdigitated with profound transformations in the broader culture. At one moment the progressivist orientations, metaphors, and analogies of a self-conscious rationalism then novel in English science served as the intellectual ratifier of a new, unfamiliar industrial world. Later, more cautious interpretations indicated shifting priorities in both scientific work and social life. A vastly expanded and newly self-conscious grouping of men of science faced an urban clientele that was both audience and patron. That same clientele also sought the role of active investigator. The novel business of creating and regulating the vastly expanded market in theories and information that resulted was a concern in which traditional metropolitan savants could make common cause with emergent provincial professionals. Systematic, factual investigations could safely be delegated to the swollen rank and file of scientific men, while the new scientific masters shaped the British Association and the metropolitan disciplinary societies toward the roles of arbitrators and entrepreneurs of scientific theory.[65] The launching of new journals, the flood of teaching manuals, the demand for encyclopedia articles and advanced texts, and the creation of private and proprietary laboratories are further aspects of that differentiation and specialization characteristic of an enterprise undergoing rapid evolutionary growth. Within this growth the form and texture of natural knowledge was itself transformed; through its second revolution, English natural knowledge became for the first time the "science" known by "scientists."

Context, clientele, and concern indicate three areas in which Manchester science had a permanent effect upon the wider enterprise. It also had a deeper significance within the Industrial Revolution proper. Natural knowledge was a crucial component in the cultural world the Manchester elite created for themselves, as they sought to come to terms with the unprecedented changes they lived through. Much in their effort was particular to their time and place. The ability to find in science a source of rational amusement, polite knowledge, self-discipline, or theological edification has inevitably decayed as science itself has evolved into ever more specialized forms. The use of science as a means of ordering experience, as a guarantor of rational belief in the possibilities of progress, and as a source of mental attitudes oriented toward change would seem to have wider significance. The receptivity of any culture toward such beliefs may be as significant in assessing its prospects of rapid industrialization as attention to narrower if necessary questions about the supply of financial capital and trained technicians.

Benjamin Disraeli's aphorism "what Art was to the ancient world, Science is to the modern" deserves reiteration, for, rightly understood, Manchester was indeed as great a human exploit as Athens.

[65] See the suggestive remarks in Roy Porter's "The Industrial Revolution and the Rise of the Science of Geology," in Teich and Young, *Changing Perspectives*, 320–43.