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University of Kent at Canterbury

Faculty of Social Sciences

Unit for the History, Philosophy, and Social Relations of Science

Guy Stuart Kitteringham

Studies in the Popularisation of Science in England, 1800-30

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Abstract

The ideas of ordinary people about the nature and value of science have a profound effect upon both the practice and the reception of science. Despite this, little work has been done by historians on the development and characteristics of such ideas. One important process affecting this development was the popularisation of science, which is studied in this thesis in England during the first three decades of the nineteenth century.

The major subdivisions of the thesis are based upon the various media of popularisation. After an introductory chapter which discusses the place of science in society, the nature of popularisation, and eighteenth-century popularisation, chapters two and three analyse popular science books. The coverage of science is related to contemporary social groupings and four representative sciences (natural history, geology, chemistry and astronomy) are examined in detail. Chapter four discusses science coverage in both scientific and general periodicals. The subsequent three chapters examine the roles of societies and institutions in the popularisation of science. The local variations in these activities are taken into account by analysing London and provincial societies separately, but the common characteristics of many mechanics' institutions are recognised and the institutes are considered together in chapter seven. Chapter eight restates and discusses the major conclusions of the study.

Popularisation is shown to have been not merely the simple dissemination of scientific truths. The means of popularisation and even the very content of popular science are shown to have varied with the desires and beliefs of the popularisers about both the natural and the social worlds. Similarly, the audiences for popular science displayed varying degrees of receptivity to these ideas, dependent upon their social positions and interests.

Contents

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Chapter One: Introduction

A. Science and Society

In recent years historians of science have increasingly been considering not only the economic but also the cultural implications of science in society. Work in this field has stressed not only that science had a role in the culture of past times, but also that science itself could be treated as a part of culture.[1] Such studies have been associated with researches in the philosophy and sociology of science which have concluded that there is no generally acceptable rational criterion with which to mark science off from other activities.[2] Scientific truth, it is claimed, comes about by social negotiation of truth claims by scientists whose beliefs depend, at least in part, upon their instrumental and social interests.[3]

Science, therefore, cannot be considered in isolation from the social milieu in which it is carried on, for, indeed, it is itself a part of that milieu and one which inevitably interconnects with many other parts. As David Knight has written, there "seems no reason why the historian of science, or anyone who wants to know 'what is this thing called science', should confine himself to problems on the frontiers of physics rather than to practices in museums, schools, or scientific societies, or to relations between science and other intellectual disciplines from which it is not delimited by any natural frontier".[4] Indeed, once it is accepted that the image of science in a society is not merely important to science but actually a part of it, then it is clear that such historical work is essential to a full understanding of the history of science.

One of the clearest and most important developments in Western society in the recent past is the increasing monopoly of scientific criteria of rationality as the only such criteria which are valid. If it can no longer be accepted that this occurred simply because these criteria are the 'correct' ones, then explaining this development becomes a considerable historical problem.[5] Yet indications that such an analysis was required already existed. As Michel Foucault has pointed out, if one tries to assert that, for instance, Marxism is a science, one is not attempting to prove it to be rational and verifiable, but rather to give it the power associated in the west with scientific discourse.[6] In other words there is a (perhaps unconscious) recognition that the power and authority of the historical construct called 'science' lies not in its methodology but in the perception of its technical and intellectual success. A study of the popularisation of science, i.e. of the flow of scientific ideas and associated ideas about science, is thus a contribution to the understanding of 'science' as a whole.

The period discussed in this thesis saw many significant events, but in political and social terms the most important was the French Revolution (even though it of course actually occurred in the last years of the eighteenth century). Its after-effects swamped other social and political trends for many years. Counter-revolutionary feeling in Britain halted middle-class reform efforts in their tracks and produced a consensus amongst the wealthier classes in which "Loyalty, conservatism, [and] Christianity, became identical".[7] Reform movements amongst the working people were repressed. Gradually, however, these opinions resurfaced, reaching an initial peak at the time of the 1832 Reform Act.

Before this, however, a new morality was forged in an alliance between evangelism and utilitarianism. Feelings were equated with moral laxity,[8] and the latter, of whatever kind, was believed to be anti-social: "Every act that sanctions cruelty to animals must tend to destroy the morals of a people, and consequently every social duty", claimed the Manchester Mercury in 1800.[9] Consistency in morality was encouraged, not mere public virtue. It is "when we follow men into their retirements we are most likely to see them in their true state, and may judge of their natural dispositions", wrote Joseph Shuth.[10]

The evangelical revival of the eighteenth century continued to make gains; unscriptural natural theology, like that of Paley, began to attract critics, (although the work itself was only published in 1802). Amongst the general populace millenarian religion increased in popularity, most notably with Joanna Southcott and her followers in the 1810s. Significantly, this was an early example of literate popular religion, Southcott insisting that all followers had at least one copy of her writings.[11] Political unrest amongst the lower classes increased, and E.P. Thompson has claimed that it was in this period that a working-class consciousness, and an associated radical culture, was formed.[12]

Popular behaviour, particularly leisure activity, was certainly changing,[13] yet much remained constant. One middle-class writer found this reassuring, finding "something... very pleasing in the periodical return of Festive Days, and the various Rites and Ceremonies connected with them".[14] Many other members of the same social group were less sanguine. This period saw many attempts to reform popular behaviour. The National and Lancastrian schools, societies to suppress vice, and societies to prevent cruelty to animals, were just some of the moral reform institutions active at this time.

Institutionalisation did indeed proceed apace in these years not only in moral reform and education but in culture generally (e.g. literary and philosophical societies) and in science (e.g. the Geological, Astronomical and Zoological Societies). Science also underwent many intellectual changes and many historians have considered this a crucial period in its development. Chemistry had attained, in Kuhnian terms, a paradigm, with Lavoisier's work, while geology was 'made', in its modern form, in the early years of the century.[15] Increasingly, specialisation was occurring amongst practitioners of the sciences and in many areas a descriptive ideal was giving way to one which emphasised the formation of historical laws. In natural history, in particular, more note was taken of the geographical distribution of specimens collected.

According to Foucault, the years at the end of the eighteenth and beginning of the nineteenth centuries were a time of rapid transformation of the sciences; a methodology based on description and classification by external features gave way to modern science, with its emphasis on historical laws and the organic structure of organisms.[16] Such a change may be well illustrated by two definitions of natural history given respectively in the 1770s and the 1830s. The first edition of the Encyclopaedia Britannica defined natural history as: "that science which not only gives complete descriptions of natural productions in general, but also teaches the method of arranging them into classes, orders, genera, and species".

Defining natural history as the science of observation was, to William Swainson, wrong:

> "The error... [is] not that it is untrue, but it is partial and insufficient... All branches of natural science, however varied may be their materials, or however diversified their nature, have but one and the same object in view - the discovery of the primary laws of nature... the question resolves itself into this. Are there any fixed and universal laws by which the variations of the forms of nature are regulated?"[17]

Whether such a change occurred in all the sciences or not, there can be no doubt that, as Thackray has put it, there was a distinct social change in science centred in the century after 1760, leading to "a new relevance and a new role" by the mid-nineteenth century.[18]

The greater prominence of science in society was noted by many contemporaries, although reactions were not always favourable. A 'science fiction' horror story, illustrating the dreadful results "of any human endeavour to mock the stupendous mechanism of the Creator of the world",[19] with its anti-hero Dr. Frankenstein, was, after all, published in 1818. In 1830 J.L. Knapp sarcastically remarked:

> "I do not comprehend what general practical benefit can arise from chemical analysis of soils; but as eminent persons maintain the great advantages of it, I suppose they are right, and regret my ignorance".[20]

Even if sometimes unfavoured, however, an awareness of science existed amongst large sections of the population. The concept of 'science' as the whole of knowledge had largely disappeared by this time, and even if no alternative concept of science was fully developed, 'the sciences' were taken as those studies which covered roughly the same subject areas as those of our modern natural sciences. As William Buckland put it in 1820:

> "rapid improvements in Physics... during the last half century have dignified with the name Sciences many subjects, which had perhaps too long been considered only as Experimental Arts: and information on these and similar sciences of modern growth ... has now been ...generally diffused, even amongst the imperfectly educated classes of society."[21]

B. The Popularisation of Science

"This word, popularisation, is one of that kind that do unintentional harm even in their most innocuous uses", writes Martin Green.[22] It has associations of superficiality and of distortion. Yet these connotations are not implicit in the word. It implies only the making popular of a subject and, unlike 'education', it has no association of possible compulsion. The concepts are being fitted to the audience, not vice versa. Unlike the 'dissemination of ideas' there seems to be no inevitability about the process. It is a word peculiarly appropriate to the way ideas spread in the early nineteenth century, for there was no educational system, in the modern sense, which taught science, nor, as will be shown, an inevitable spread of ideas on science. The word itself is indeed an invention of roughly this period, being apparently first used in the 1830s.[23]

Before this process even had its modern name, however, people were looking down upon it. As Robert Bakewell wrote in 1813, he "who attempts to make a scientific subject familiar runs the risque [sic] in this country of being deemed superficial: a plentiful shade of dullness, combined with a certain degree of technical precision, are regarded as essential proofs of profundity".[24] One must avoid taking a patronizing view of popularisation, however, not least because of the danger of distortion. If one believes popularised science is superficial, one is liable only to find superficiality. In particular one must not consider the 'truth' or otherwise of the ideas (either by comparison with modern or contemporary science), for scientific truth is only agreement among the scientific elite. Indeed, one of the major functions of popularisation may have been the dissemination of new standards of verifiability and falsifiability (the installation of a new "regime of truth", as Foucault would say)[25] which would be completely overlooked if modern standards of truth were used to judge the worth of popularisation.

Popularisation is a process, and this study is concerned with that process itself. In this way it sidesteps problems of definition, e.g. of orthodox and popular science, and where the boundary lies in the "uneasy territory", as Knight calls it,[26] between them. Neither does popularisation assume the social status of the originators of scientific ideas; the flow of such notions does not by any means have to be downwards only, but can be up or across social groups. Indeed those who were the targets and the receivers of popularised science are not to be assumed to be devoid of ideas about the natural world. Keith Thomas has explored in depth those beliefs about animals and the heavens which were common in the sixteenth and seventeenth centuries and many peristed into this period.[27] New ideas could be judged against these and, if necessary, rejected.

The popularisation of science has not generally been very well treated by historians of science. Charles Gillispie discussed popular geological works, but tended to measure them against his own standard of what was 'scientific'.[28] Recent work has shown more sensitivity, but the most informative work is still to be found in the context of the history of education with different (and usually very Whiggish) preoccupations.[29]

This study will attempt to answer, or point towards answers to, many questions. Not least is the question of why popularisation occurred at all. The relative popularities of different subject areas, the conception of science amongst popularisers and audience, the relation of popularity to deeper beliefs, the relationship of specialization to popularisation, and perhaps even some idea of why modern science developed in the way it did, may all, it is hoped, receive clarification from this study.

There are many media by which ideas on science can flow, some of which have been listed by Roy Porter: "folio picture books, encyclopaedias, prints, museums, collections, landscape painting, itinerant lecturers, topographical poetry, maps, children's books,... [books about] voyages and travels"; all contributed to the popularisation of knowledge of the earth.[30] All these are public media, yet private ones must also have effected some dissemination of ideas. Hinton divides the media of popularisation into 'direct' and 'indirect' media. The latter, defined as "sources of information and opinion not seen as part of the overt popularisation of science, but nonetheless [doing]... much to diffuse associations about science", include personal contact, the spread of scientific terminology, attitudes to health, etc.[31]

The characteristics of such essentially private processes are much harder to determine than those of direct media, and this study concentrates on the latter. It must be remembered, however, that ideas can spread rapidly by personal contact to diffuse a wider general conception of science than might be expected from limited circulation of books or limited audiences at lectures. This was, after all, a period of both industrial and agricultural revolution and yet, certainly in the lives of farmers, printed works played very little part.[32]

Some media, such as religious sermons, novels, poetry, and even newspapers, could well have had some effect on the popularisation of scientific notions, and yet they have not been systematically used in this thesis. This is for essentially methodological reasons, simply because relevant information would be too diffuse. Effective use of newspapers, in particular, is the realm of the local historian. The analysis of general periodicals in chapter four will, however, compensate by giving examples of coverage of science by works whose primary aim was cultural, religious, reformist, etc., rather than scientific.

Even when using a major library, such as the British Library, occasional problems with sources are inevitable, e.g. lack of extant copies of popular books, the selective preservation of institutional records etc. Such distortion has been minimised by the wide sampling of books in chapters two and three, of periodicals in chapter four, and of both London and provincial institutions in chapters five to seven.

The study has been limited to England because of the inevitable scale of any comparative project between England and, for instance, France. Such work would be interesting and useful, and it is to be hoped that the present study may prove helpful in any future comparative project.[33] Even Scotland has had to be excluded because of its different system of education, both elementary and advanced, different levels of scientific appreciation in the universities and amongst the social elite, and different social conditions. Nevertheless the influence of Scotland and the Continent, in terms of immigrants and publications (translations in the case of European countries), have been fully considered.

Unlike popular science books or the popular science content of periodicals, on which little historical work has been done, mechanics' institutes and provincial societies have been fairly extensively discussed. The relevant chapters in this work, while drawing upon this previous research, attempt to synthesise and extend the understanding of the provincial societies and the mechanics' institutes in this period. The latter are also related more closely than has usually been done to the activities of the Society for the Diffusion of Useful Knowledge.[34] Knowledge of the former was in great need of broadening and this has been attempted.

One recent trend in the history of science has been the appropriation of methods of social anthropologists, in particular those of Mary Douglas, and their application to historical investigation of science.[35] The result has been the linking of scientific ideas held by various social groups in the past with their social interests in society, i.e. with their attempts to manipulate society to their own advantage. Models of the natural world are claimed to be derived from the social world (both as perceived and as desired) and then used to argue for the naturalness of required social institutions. Methodologically, such an approach has often relied on prosopographical (i.e. collective biography) analysis.[36] Such a methodology, with its emphasis upon the individual subject and his cosmology (i.e. his social, political, theological and philosophical attitudes), has recently been strenuously criticised by Simon Schaffer.[37] Using Foucaultian ideas, he has suggested that the object of historical investigation should be the discourse itself, rather than the constitutive subject. Without, it is to be hoped, demonstrating a soggy eclecticism, the present study attempts to follow a methodology somewhere between these alternatives. A wide range of books, periodicals and institutions have been analysed so as to make clear the nature of popularised science, without relating this directly to the subjective opinions of individual authors. Where significant differences emerge, however, explanatory reference has been made to social, economic, and intellectual factors.

Specifically this study concentrates on widely available media of popularisation, i.e. books 'in the trade',[38] periodicals, printed and manuscript lecture notes, library stocks, etc. Consequently, those sciences studied in detail are those which were considered orthodox sciences at the time, (allowing for the fact that with considerably less institutionalisation of science and a much smaller scientific elite, the division between orthodox and deviant sciences was much less clear cut than is the case today).[39] This is not to say that phrenology, mesmerism, etc. were 'wrong', but the scale of their public popularisation in this period, even of phrenology in the later 1820s, was far smaller than that of natural history, chemistry etc.

C. Popularisation of Science in Eighteenth-Century England

Before entering upon an examination of popularisation in the early nineteenth century, popularisation in the preceding years will be briefly considered.

The formal education system was very little concerned with science. The lower and upper classes, in their dame or charity schools, and their public schools, respectively, were very likely to go through formal education without any teaching in science. Only in a few middle-class schools, especially those associated with the dissenting sects of Quakers, Presbyterians etc., was practical or scientific education to be found.[40] This remained the case throughout the early nineteenth century. Indeed, where the Dissenting Academies had often taught some mathematics and natural philosophy in the later eighteenth century, even these facilities were generally withdrawn under the influence of growing evangelism and political conservatism. The English Universities took very little note of scientific subjects, any courses which were given being unexamined. Formal education in science was thus almost non-existent in both the eighteenth and early nineteenth centuries. In Scotland, however, the Universities took great interest in science, particulary in natural history and chemistry.

Informal societies, on the other hand, grew in number and often in size through the later eighteenth century. The Spitalfields Mathematical Society (founded 1717) and the Birmingham Sunday Society (of 1790) were two for the less well-off, while the better-off, particularly in the North, founded Literary and Philosophical Societies, beginning probably with Liverpool in 1780 and followed by Manchester (1781), Leeds (1783), Newcastle (1793), and others. The societies, which would discuss diverse subjects, would also sometimes host one of the many itinerant lecturers of the time.[41]

Greater wealth in the provinces, improvements in communications, and reduced travelling times, stimulated both supply and demand for such lectures. Early in the eighteenth century came John Desaguliers and James Ferguson; Benjamin Martin, John Warltire and Adam Walker were among their many successors. The lecturers were, above all, showmen and it is unsurprising that Martin reported being taken for a magician; the provost of Eton called Walker a conjuror, and in many ways that is just what he was.[42]

Reading became a widespread pastime amongst the wealthier classes in the eighteenth century and libraries, both circulating and proprietary, multiplied.[43] Works on natural philosophy took their place on the shelves and were available for perusal by those who were interested. The commercial production of children's books really commenced in mid-century with John Newbery, and some of his publications, such as Tom Telescope, were concerned with natural philosophy. One of the most important literary developments for the popularisation of science was the beginning of major encyclopaedias,[44] with John Harris' Lexicon Technicum (1704) and Chamber's Cyclopaedia (1728), while a widespread general periodical press may also be said to have commenced in this century. The Gentleman's Magazine, and other eighteenth-century miscellanies contained "feature articles on scientific subjects of interest to the curious".[45]

The popularisation of science clearly did not originate with the nineteenth century, but it did grow in these years, and to the study of popularisation in this period we will now proceed.

Notes to Chapter 1

N.B. Titles of works in the notes are occasionally short titles. Fuller titles may be found in the Bibliography.

1. See, for instance, the collection of essays illustrating such an approach in B. Barnes and S.Shapin (eds.), Natural Order, Historical Studies of Scientific Culture, London and Beverly Hills, 1979.
2. See the discussion of the problems of demarcation criteria in R.G.A. Dolby, 'Reflections on Deviant Science', in R. Wallis (ed.), On the Margins of Science: The Social Construction of Rejected Knowledge, Keele, 1979, pp.9-47 (esp. pp. 9-11).
3. On the social negotiation of truth claims see for instance the work of H.M. Collins, 'The Seven Sexes: A Study in the Sociology of a Phenomenon, or the Replication of Experiments in Physics', Sociology, 1975, 9, 205-24. For the dependence of such negotiations on perceived instrumental and social interests see for example B. Barnes and D. Mackenzie, 'On the Role of Interests in Scientific Change', in Wallis, op.cit. (2), pp.49-66.
4. D.M. Knight, [Review of A.F. Chalmers, What is this Thing Called Science?], British Journal for the History of Science, 1980, 13, 61-2.
5. Historians of non-scientific belief systems have naturally had a clearer understanding of the importance of this process. For an excellent attempt to describe the impact of science on religious belief in this period see J.D. Yule, 'The Impact of Science on British Religious Thought in the Second Quarter of the Nineteenth Century', University of Cambridge PhD thesis, 1976.
6. Michel Foucault, Power/Knowledge, Selected Interviews and Other Writings, 1972-1977, Brighton, 1980, pp.84-5.
7. V. Kiernan, 'Evangelism and the French Revolution', Past and Present, No.1,

February 1952, pp.44-56 (45).

8. J. Tompkins, The Popular Novel in England, 1770-1800, 1932; reprinted Lincoln (Nebr.), 1961, p.111.

9. Quoted in R. Malcolmson, Popular Recreations in English Society, 1700-1850, Cambridge, 1973, p.137.

10. Quoted in P. Bailey, Leisure and Class in Victorian England, London, and Toronto and Buffalo, 1978, p.169.

11. D. Valenze, 'Prophecy and Popular Literature in Eighteeth-Century England', Journal of Ecclesiastical History, 1978, 29, 75-92 (90n.44), points this out.

12. See E.P. Thompson, The Making of the English Working Class, 2nd edn., Harmondsworth, 1968, ch. XVI.

13. See Malcolmson, op.cit. (9) and Bailey, op.cit. (10).

14. Circle of the Seasons, and Perpetual Key to the Calendar and Almanack, London, 1828, p.vi.

15. See Roy Porter, The Making of Geology, Earth Science in Britain, 1660-1815, Cambridge, 1977.

16. M. Foucault, The Order of Things, An Archaeology of the Human Sciences, London, 1970.

17. Both quotations are from D.R. Baesel, 'Natural History and the British Periodical in the Eighteenth Century', Ohio State University PhD thesis, 1974, pp.118-9, 122-3.

18. A. Thackray, 'The Industrial Revolution and the Image of Science', in A. Thackray and E. Mendelsohn (eds.), Science and Values, Patterns of Tradition and Change, New York, 1974, pp.3-18 (4,12).

19. Quoted in O.Handlin, 'Science and Technology in Popular Culture', Daedalus, 1965, 94, 156-70 (164).

20. [J.L. Knapp], The Journal of a Naturalist, 3rd edn., London, 1830, pp.17-18.

21. William Buckland, Vindiciae Geologicae, Oxford, 1820, p.3.

22. Martin Green, Science and the Shabby Curate of Poetry, Essays about the Two Cultures, London, 1964, p.32.

23. Ibid, p.33.

24. Robert Bakewell, An Introduction to Geology, illustrative of the General Structure of the Earth, London, 1813, pp.ix-x.

25. Foucault suggests that the discontinuity between natural philosophy and modern science came about not via a change in empirical content or theoretical beliefs but via a change in that which makes statements scientifically acceptable, i.e. capable of being verified or falsified by scientific procedures. This change occurs, in Colin Gordon's words, via the "effects of practices whose rationale is the installation of a regime of truth". Foucault, op.cit. (6), pp.112-3, 242.

26. D.M. Knight, 'The Physical Sciences and the Romantic Movement', History of Science, 1970, 9, 54-75 (62).

27. K. Thomas, Religion and the Decline of Magic, London, 1971.

28. C.C. Gillispie, Genesis and Geology, New York, 1959. See, for instance, p.250.

29. Popularisation of science in the early nineteenth century has been considered in the context of institutions such as the mechanics' institutes, literary and philosophical societies, and dissenting academies by a number of scholars. From a perspective of the development of technical education: M.D. Stephens and G.W. Roderick, Scientific and Technical Education in Nineteenth Century England, London, 1972; from more social perspectives mechanics' institutes have been discussed in Thomas Kelly, George Birkbeck, Pioneer of Adult Education, Liverpool, 1957 and M.Tylecote, The Mechanics' Institutes of Lancashire and Yorkshire before 1851, Manchester, 1957. Such institutions have been dealt with as parts of a wider educational system most effectively in B.

Simon, Studies in the History of Education 1780-1870, London, 1960 and J. Harrison, Learning and Living 1790-1960, A Study in the History of the Adult Education Movement, London, 1961. An overstated attempt to demonstrate widespread technical knowledge derived from science in this period is A.E. Musson and E. Robinson, Science and Technology in the Industrial Revolution, Manchester, 1969. An example of a modern social-interest approach to scientific education may be seen in S. Shapin and B. Barnes, 'Science, Nature and Control: Interpreting Mechanics' Institutes', Social Studies of Science, 1977, 7, 31-74.

30. Roy Porter, 'The Terraqueous Globe', in G.R. Rousseau and R. Porter (eds.), The Ferment of Knowledge, Studies in the Historiography of Eighteenth-Century Science, Cambridge, 1980, pp.285-324 (305).

31. D.A. Hinton, 'Popular Science in England, 1830-1870', University of Bath PhD thesis, 1979, pp.15, 341ff.

32. See Stuart MacDonald, 'The Diffusion of Knowledge among Northumberland Farmers, 1780-1815', Agricultural History Review, 1979, 27, 30-9 (esp.p.35).

33. Although see Susan Sheets-Pyenson, 'Low Scientific Culture in London and Paris 1820-1875', University of Pennsylvania PhD Thesis, 1976, for a comparison of popular scientific periodicals in London and Paris.

34. E.A. Storella, '"O What a World of Profit and Delight", The Society for the Diffusion of Useful Knowledge', Brandeis University PhD Thesis, 1969, contains a good discussion of the connections of the institutes and the society.

35. For a discussion of the application of such ideas see the article by Steven Shapin in Barnes and Shapin, op.cit.(1).

36. On this methodology see S.Shapin and A. Thackray, 'Prosopography as a Research Tool in History of Science: The British Scientific Community 1700-1900', History of Science, 1974, 12, 1-28.

37. Simon Schaffer, 'Natural Philosophy', in Rousseau and Porter, op.cit. (30), pp.55-91 (esp.pp. 86-91).

38. By 'in the trade' is meant those works which were on publishing house trade lists. Although other works could have circulated it is likely that those works which were on such lists (and, from them, via the London Catalogue of Books, reached the English Catalogue of Books, 1801-1836) were the most widely available. For full lists of primary source books see Bibliography.

39. See Dolby, op.cit. (2), pp.12-19, for a discussion of how scientific elites maintain orthodoxy in modern institutionalised science.

40. See, for example, the work on schools in J. Money, Experience and Identity. Birmingham and the West Midlands, 1760-1800, Manchester, 1977, pp. 134-6, and J.H. Plumb, 'The New World of Children in Eighteenth-Century England', Past and Present, No.67, May 1975, 64-95 (71-80).

41. For lecturers in the eighteenth century see esp. F.W. Gibbs, 'Itinerant Lecturers in Natural Philosophy', Ambix, 1960, 8, 111-17.

42. J. Millburn, Benjamin Martin,Author, Instrument-Maker, and 'Country-Showman', Leyden, 1976, p.41; The Galvanist, A Periodical Paper, No.1, 1804, p.2 and manuscript note.

43. See F. Beckwith, 'The Eighteenth-Century Proprietary Library in England', Journal of Documentation, 1947-8, 3, 81-98 and H. Hamlyn, 'Eighteenth-Century Circulating Libraries in England', The Library, 1946-7, 5th series, 1, 197-222.

44. See D. Layton, 'Diction and Dictionnaries in the Diffusion of Scientific Knowledge: An Aspect of the History of Popularization of Science in Great Britain', British Journal for the History of Science, 1964-5, 2, 221-34.

45. W.J. Graham, English Literary Periodicals, 1930; reprinted New York, 1966, p.145.

Chapter Two: The Popularisation of Science in Books

A. Books and their Availability in Early Nineteenth-Century England

For ideas to be communicated via the printed word, books and periodicals must be available both physically and financially to an audience, and that audience must also have the capacity to read and react to the ideas espoused. In the early nineteenth century both the literacy of the mass of the population and its purchasing power in relation to printed media was far less than it is today.

The literacy of the population in general is hard to estimate with any accuracy, and would probably be fairly uninformative anyway. Contemporary accounts are of little use. Alexander Murray suggested in 1810 that three-quarters of the agricultural labourers were unable to read while John Freeman claimed in 1811 that around two-thirds of the adult population of England could read.[1] Do these estimates agree or disagree? What may be confidently stated is that the variation from area to area, and within areas, was immense. Middlesex and Lancashire had the lowest levels of school attendance in the country, and therefore, it has been assumed, the lowest literacy (although many learnt to read from relatives and neighbours rather than through formal education). West quotes figures from Lancashire of 48 per cent of men and 17 per cent of women able to sign their names on marriage registers in 1814-16 as the lowest level reached.[2] Yet it is not necessary to be able to write in order to read and much of the formal education given to children, particularly that in the Sunday Schools, emphasised reading (but not necessarily understanding) the Bible far more than writing. Hannah More assured worried patrons that she would "allow of no writing for the poor".[3] Those counties which maintained comparatively good basic education systems, such as the western, midland and northern counties, did so because of the strong popular protestantism of the areas; presumably they would have paid more attention to reading than writing.[4]

Better indication of the size of the reading public comes from other evidence. The pamphlet output of the 1790s, sale of the tens of thousands of Cobbett's Weekly Register, and other radical papers of the 1810s, and the sales of over 100,000 of the early editions of the Penny Magazine in the 1830s, all indicate sizable numbers who could read. In addition many would be in a position to have things read to them, even if they themselves could not read. Most impressive of all was the sale of almanacs, which could be measured exactly if they were sold legally, with the stamp duty paid. Every year of the 1820s saw around 500,000 of these publications sold, or one almanac for every twenty-five inhabitants of England and Wales. The probability must also be that many more were sold illegally, unstamped.[5]

Other factors tended to increase the size of the reading public. The political turmoil of the times, the coming of cheap 'respectable' literature from the 1820s via John Limbird's Mirror of Amusement and Instruction, the need for reading in lower jobs and possibly an increased social prestige in the ability to read, helped the literacy of the lower classes at this time. As E.P. Thompson has written, in "most artisan trades the journeymen and petty masters found some reading and work with figures an occupational necessity".[6] Increased leisure time - due to the more frequent use of servants - in combination with the decrease in morally acceptable amusements and recreations, meant that the middle classes also read more than in the previous century.

Altick has identified a new mass audience for the printed word in the first half of the nineteenth-century composed of skilled workers, small shopkeepers, clerks and better grade domestic servants.[7] It was not, however, only an urban phenomenon. Many rural areas had literacy rates as high as urban ones, and for every rural parish lacking a school there was probably an overcrowded urban one where the growth of population had swamped local educational provision.

Of course, even members of the lower classes who could read suffered from many difficulties. Altick lists: long hours at work, bad lighting in the homes, noise, dirt, lack of privacy, ridicule and overcrowding.[8] To these may be added the disapproval of much of the upper classes, particularly in the years of strong counter-revolution immediately following the French Revolution. In 1795, the Anti-Jacobin had even warned against the middle-class proprietary libraries of the northern towns, suggesting that they were dangerous to society.[9] The free communication of ideas amongst lower sections of the community was felt to be threatening. Hannah More reassured her patrons by informing them that: "My object has not been to teach dogmas and opinions, but to form the lower classes to habits of industry and virtue".[10]

In discussing the popularisation of scientific ideas, it is, of course, as important to know what people read as to know whether they read. Two types of works which are known to have been very widely available are chapbooks and almanacs. Both were hawked around the country by chapmen who carried them, along with Bibles, prayer books etc., in packs, which would be laid out for the inspection of potential purchasers at fairs, or on the doorstep. Almanacs were subject to very high stamp duty: eightpence in 1800; 1s. 3d. from 1816. The result was a price usually about double that of the stamp duty. Many of the publications were continuations of early eighteenth or even seventeenth-century publications, as for instance those "written" by Moore, Partridge and Old Robin. Although the official monopoly in their publication was removed in 1775 from the Company of Stationers and the two universities, most of the early nineteenth-century publications were still published by the Stationers. In 1821 528,254 stamped copies were sold; in 1830 481,690. This drop, small as it was, was interpreted by reformers who objected to the astrological and immoral content (as they saw it) of the works, as an indication of a decline in their popularity. Upon the removal of the stamp duty in 1835, however, twice as many copies of the oft-condemned Moore's Almanack were sold. The "believers in Moore's Almanack... comprise nearly all the rural population, and very many of the dwellers in towns", wrote Charles Knight.[11]

Belfast and Aberdeen seem to have been the main sources of unstamped almanacs, although many which claimed to have been printed in America were probably the pirate editions of English provincial presses. Freed from restrictions in 1693, the provincial printers had subsequently published mostly chapbooks, ballads, etc. Newcastle was the foremost source of such publications after London, but many others were important, and Weiss lists thirty-four provincial towns as places of origin of chapbook literature. London had at least eighty firms publishing such works in the years 1785-1830.[12]

Unlike almanacs, chapbook literature was very varied both in form and content . As in the previous two or three centuries "almanacs" really consisted of four parts: a calendar; an almanac of astronomical events of the year; 'prognostications' or astrological forecasts of notable events; and a section of miscellaneous information on the dates of fairs, taxes, postal rates, etc.[13] Chapbooks, on the other hand, could range from folk tales to conjuring books, from descriptions of animals to prognostications. In format they were anything from four to thirty-six pages (although usually twenty-four to thirty-six pages in this period). They could cost only a few farthings, or as much as a shilling, and could be as little as two inches by one inch, although these were usually for children, and most were approximately 5 inches by 3 inches.[14]

Some writers have seen chapbook literature as a survival of peasant culture tradition and as such opposed to the urban street ballads, etc., yet it seems that chapbooks, while often "nothing more than an embodiment of the legends, superstitions, ballads and songs which had been kept alive by oral tradition before the invention of printing",[15] were printed by the same firms as produced the new political ballads and pamphlets and execution ballads of the towns. The chapbooks were as 'urban' as any of this other literature and did not 'die out' but evolved into the publications of the later nineteenth century.

Chapbooks and almanacs were available to any who could read. This was not so for those books sold by the 'respectable' publishers in the early nineteenth century, which were very expensive and had consistently increased in price since around 1780.[16] By restricting the size of editions to usually 750-1,000, the publishers maintained the high prices to ensure both exclusivity and profitability, although the prices were also necessarily high because of the high costs of production. Paper prices in 1801 were double those of 1793, at 27s.-34s. a ream, depending on quality. Tax on paper of 5d. a pound in the same year, regardless of quality, penalised most those who wished to publish cheaply. The result was that the typical book size was octavo, costing between ten and fourteen shillings. Duodecimo works were priced at, typically, five to six shillings, while quartos could cost two guineas, although discounts of ten per cent for cash and fifteen per cent to schools were usually given on all sizes . The only cheap publications of the 'respectable' publishing houses were those where the copyright had expired, while remaindered works were often sold by the entrepreneurs of the trade, such as James Lackington and Thomas Tegg, with new title pages at a large discount. One other method of cheap publication was number publishing, i.e. issuing books in parts, usually priced at 6d. a part. This had been done in the eighteenth century and was especially important in the early nineteenth in the midlands and industrial parts of the north. Specifically exempted in the Stamp Act of 1819, which attempted to reduce the flow of political pamphlets, it was the method chosen by the Society for the Diffusion of Useful Knowledge when they issued their first publication, the Library of Useful Knowledge, from 1827.

Such prices may be compared with wages of workers, which varied, in the 1820s, from over thirty shillings a week for a skilled London artisan down to perhaps 5s.6d. a week for one of the now impoverished hand-loom weavers. Clearly most books were out of the reach of all these workers; even 6d. a week to an artisan was a fairly large sum, especially when it might buy a pound of meat or half a pound of butter.[17]

From 1825 book prices fell, for a number of reasons. Technical developments increased printing speeds and reduced the cost of paper while simultaneously improving its quality; the recession of 1825 led to bankruptcies, even of established firms like Constable, and new methods of selling were experimented with; the success of John Limbird's Mirror of Amusement, which sold, it was said, 80,000 copies at 2d. a week,[18] showed the potential market that existed.

Chamber's Miscellany, at 3s.6d. a volume, and the Library of Entertaining Knowledge, at 4s.6d. a volume, were some of the many works published to exploit this market. The prices show, however, that this was still literature for the middle, rather than the lower, classes.

One other development of the early nineteenth century had major implications for the sale of popular books and periodicals: the change in illustration techniques. In the eighteenth century cheap works such as chapbooks relied on illustrations for much of their attractiveness to those who did not read easily. Old wood cuts were often used for many publications, and as they were originally frequently very crude, the imprints produced after many printings were of poor quality. More expensive works would use copper plates, but these engravings were very expensive and had to be printed on separate sheets of paper. Consequently they were often bound at the end of the book. In the late eighteenth century, Thomas Bewick pioneered a new method of wood cutting, using the end grain of a hardwood, rather than the side grain of a soft one. The result, while more expensive than the old wood cuts, was a much better quality design which could be printed in the text. The appeal of many of the works in the Library of Entertaining Knowledge lay in large part in the illustrations, for which the Society was said to pay 200 pounds or more per volume.[19] The Society's Penny Magazine, which also used Cowper's cylinder stereotype plate printer to speed production, was renowned for its illustration.

John Kitto recalled in the Penny Magazine of 1835 subscribing for one shilling to a history of the French Revolution more because of the coloured illustration in the first number than anything else. When subsequent parts had no illustrations, and "as the letter-press was in large type and loosely printed, [he] could not but think it a hard bargain to go on paying a shilling for it without the pictures".[20]

With most books expensive even for the middle classes, (particularly so after the success of Sir Walter Scott's novels at 31s. 6d. each), library provision was very important as a means of access to books for most sections of the community. Bookshops had always provided a place for discussion and perusal of works as well as mere purchase, and this tradition continued into the nineteenth century. Richard Carlile recognised the importance of the press and of discussion to working class efforts at reform and opened a bookshop himself. From the bookshops, in the eighteenth century, had developed the circulating libraries, booksellers lending out stock on payment of a fee. By 1720 119 towns in Britain had circulating libraries, and yet in 1750 there were only about 120 provincial booksellers, so nearly all must have also functioned as circulating libraries.[21]

The fees charged by circulating libraries, and the service given, varied enormously, and this probably accounts for the variations in estimated numbers of libraries that different authors give. One writer in the Iris magazine in 1825 complained that there were only two circulating libraries in London, and they were both expensive and of poor quality,[22] yet Maxted gives a figure of thirty circulating libraries in London in 1802; in 1838 three London parishes were said to have a total of thirty-eight (lower-class) circulating libraries.[23] Prices showed a commensurate variation. Tompkins gives figures of half a guinea per annum, and twopence a volume for circulating libraries of the later eighteenth century[24]; this seems to have been a fair price for a middle-class library, although the subscription had risen to perhaps one and a half guineas by the middle of the nineteenth century. For those which provided reading rooms or delivery into the country prices were often considerably more. Lane's library in London, which permitted eighteen books to be borrowed at once, charged three guineas per annum in 1798. Lower class libraries might charge from 1d. to 3d. a volume.[25]

The commercial circulating libraries of the time were more concerned with lending fiction than any other type of publication. Private citizens who wished to read other types of books often formed themselves into book-clubs, contributing to the cost of books, circulating them, and perhaps then selling the books off. A correspondent of the Monthly Magazine claimed at least 6,500 of these existed in 1821.[26] Wealthier members of the middle classes, particularly many in the dissenting communities in the north, formed proprietary libraries in the later eighteenth century. The Liverpool library of 1758 is generally considered the earliest of these institutions, which were usually run on democratic lines, each member having a share in the institution and a say in its government. Leeds, in 1768, was one of seven established in Yorkshire by 1801, and was also, together with Birmingham (1779), associated with the dissenting natural philosopher Joseph Priestley.[27]

At first such establishments had fairly low entrance fees - Leeds for instance charged one guinea in 1768 - but membership was deliberately restricted later so as to ensure social exclusivity. This was usually done by increasing fees.[28] Liverpool's annual subscription rose from six shillings in 1772 to one guinea in 1824, while Birmingham's admission fee increased from one guinea in 1779 to ten pounds in 1812.[29] By this time many of the libraries were established institutions with fairly large stocks. Liverpool, one of the largest, increased its possessions from 8,187 volumes in 1801 to 21,400 in 1830.[30]

Membership of such proprietary libraries was usually small. Liverpool, for instance, had roughly eight hundred members throughout this period.[31] For the majority of the population the options were much more restricted. The circulating libraries of the poorer classes in the towns were often run by small shopkeepers and might only consist of a few cheap novels.[32] Most of the other libraries were under the control of social superiors. Many parishes had libraries, but these were run by the clergy; often only religious works were allowed. A few isolated libraries existed, such as the Economical Library at Kendal in 1797, and the Artisan's Library at Birmingham in 1799. The latter had 1,500 volumes by 1825, with 182 subscribers who paid three shillings entrance fee and 1s.6d. subscription per quarter.[33] Other than these there seem to have been few libraries for the urban working classes before the mechanics' institutes of the 1820s. To some extent fore-runners of the institutes were the Liverpool and Sheffield Mechanics' and Apprentices' Libraries. The former was founded in 1823, stimulated by similar projects in America. After only six months it was claimed to have 800 volumes and 400 readers. By 1825 600 readers were paying 10s.6d. per annum or had given 2 guineas for life membership.[34] The founder, Egerton Smith, made sure that all "works of polemical theology and politics" were excluded, even refusing the offer of several volumes of his own newspaper, the Liverpool Mercury.[35] The object of the library was at least partly social and industrial discipline: "It will keep them at home, to the benefit, probably of others, as well as themselves; it will induce habits of order and regularity", said the 1830 report.[36]

Sheffield Mechanics' and Apprentices' Library was similarly censored; no "novels, plays and works subversive of the Christian religion" were permitted. Despite this the library had 360 members in 1825 and charged 6s. a year in addition to the 5s. cost of the share.[37] Some of these libraries were absorbed into the libraries of the mechanics' institutes, and the latter often had similar restrictions. At first most institute libraries were fairly small (Leeds, for instance, had only 289 works in 1826) but they were usually heavily used. The 289 works at the Leeds institute were issued 3,823 times in 1826. The libraries also often grew quickly, Leeds having a fairly typical 2,000 volumes by 1841.[38]

The works discussed in this and the next chapter have been mainly located in the

English Catalogue of Books 1801-1836. As this was compiled from publishing trade lists of the time this should ensure that the works were actually available for people to buy.[39]

Output of books in this period was not constant. It has been estimated that the average yearly production for the first three decades of the nineteenth century was 874, 684 and 1144 titles respectively, including reprints.[40] Some idea of the relative proportions of works by subject may be gathered from the analysis that Charles Knight carried out on the content of the London Catalogue of Books of 1816-51.[41] Of the total number of titles of 45,260, the largest number (10,300) were on divinity. This may be compared with 2,450 (or approximately five per cent) on science.

The total output in the years 1801-30 was proportionately lower at approximately 27,000. Therefore, although the number of popular science works identified in this period is in the hundreds rather than the thousands, the number is not insignificant. The two hundred works discussed in detail in the next chapter alone probably numbered as many as ten per cent of the total output of fiction in the period.

B. Books for the Upper and Middle Classes

In the Britain of the early nineteenth century the aristocracy was probably at the height of its political and economic power, and its caste attitude at its greatest.[42] Below this level, however, the situation was very complicated. The middle ranks of society included, in roughly decreasing rank, country gentry, merchants, professional men, manufacturers, yeomen, tenant farmers, shopkeepers, schoolmasters and clerks.

Within each division there were, however, great economic differences. Merchants could be very wealthy, particularly if they belonged to an old-established international trading family. Domestic merchants, on the other hand, could be quite poor. Similarly, manufacturers could be factory owners or merely petty masters. The lower middle classes often worked just as long hours and for as little return as artisans.

Within the wealthier middle classes large differences existed between country and town dwellers, particularly those in the expanding towns of the north. The gentry, usually Tories and Anglicans, were very much country dwellers and would seldom visit London, the home of the fashionable Whig society of the aristocracy. In the towns the growing communities of manufacturers and merchants often had dissenting sympathies and were desirous of political reform both locally and nationally. Within these groups a middle-class consciousness was developing, helped by both the increased returns and the increased taxes of the war years.[43]

The aristocracy might despise the professional middle classes - witness the ridicule they poured on Prime Minister Henry Addington because he was only the son of a royal physician[44] - yet the middle classes often had only contempt for the behaviour of the aristocrats. The development of a provincial but urban middle-class culture, a characteristic Enlightenment phenomenon,[45] meant that alternative local leisure activities were developed as a substitute for the journey to London for the 'season'.

In 1788 Bolton and Manchester manufacturers, Liverpool merchants and Lancashire gentry were all to be found relaxing by the sea in Blackpool.[46] Such shared recreations must have promoted the development of a sense of shared interests.

In the later eighteenth and early nineteenth centuries 'respectability' became characteristic of the middle classes.[47] The lessons of the French Revolution, combined with the increased evangelism of the Protestant churches, led to the praise of 'sense' at the expense of 'sensibility'. Rather than judging by one's feelings, one based one's approach to all subjects on a considered evaluation of the morality of the situation. A strict moral code based upon a vital religion was the guarantee of social order, national greatness and individual salvation.[48] Above all it was a practical morality. This was crucial because it allowed the middle classes to combine utilitarian reformist ideals with those of evangelical origin, leading to the characteristic moral, pious and improving creed of the late-Georgian middle classes.

There arose a general feeling that it was these, essentially middle-class, moral qualities that gave England its position in the world. As the Manchester Chronicle wrote in 1815:

> "It is to the cultivation of the moral qualities that England is indebted for her power and influence. From the want of them France may be mischievous, but she will never be great".[49]

These attitudes had a profound effect upon the leisure activities of the middle classes. Their life-style was consciously separated from those of the other sections of the community. In London such separation occurred first in the eighteenth century when parks were fenced off, to ensure exclusivity, and characteristically middle-class retreats, such as coffee-houses, multiplied rapidly.[50] In the nineteenth century large scale suburban movements began, particularly in the industrial northern towns, such as Manchester. The desire for exclusivity was also shown by the sudden popularity of Southport with the middle classes when Blackpool became used by the local working people as a resort.[51] Amusements were now most acceptable if they were regular and private, preferably carried on in the family home. Jonathon Dymond, an evangelical minister, wrote in 1829 that:

> "the greatest sum of enjoyment is that which is quietly and constantly induced. No men understand the nature of pleasure so well or possess it so much as those who find it within their own doors".

"In estimating the propriety or rather lawfulness of a given amusement", he declared,

> "it may safely be laid down, that none is lawful of which the aggregate consequences are injurious to morals: nor if its effects upon the immediate agents, are, in general, morally bad: nor if it occasions needless pain and misery to men or to animals: nor, lastly, if it occupies much time or is attended with much expense".

Cruelty to animals had social implications, as all moral failings did. "Every act that sanctions cruelty to animals must tend to destroy the morals of a people, and consequently every social duty",[52] declared the Manchester Mercury in 1800.

Private, cheap, non-sensual and quiet amusements were limited. Obviously reading was one such pastime, provided that the reading matter was suitable, i.e. it had to be not only 'amusing' but improving. 'Rational recreation' was what was required, to distinguish it from the amusements of the idle rich as well as from those of the dissolute poor. Leisure had to 'recreate' i.e. it had to prepare one for the recommencement of productive work.[53]

In these circumstances it is unsurprising that reading became a major leisure activity of the middle classes. This process had begun in the eighteenth century when newspaper and novel reading first became widespread. Novels, however, came to be looked on with less favour as the century progressed. In contrast to those of

Fielding, Richardson and Smollett, those of the later part of the century were often inferior as literary works, being romantic novels or gothic horror stories too liable to 'inflame' the feelings and passions. Those which received good reviews were, like those of Jane Austen, inventive but also instructive and realistic. General hostility to novels was probably higher in the early nineteenth century than at any other time.[54] Utilitarians criticised their supposed uselessness; evangelicals criticised their 'immoral tendencies'. All such developments meant that works of 'fact', such as those of popular science, were well suited to the intellectual environment of the times.

Members of the wealthier classes had a wide range of popular science books to choose from. Introductions covering electricity, galvanism, phrenology, mathematics, natural history, geology, chemistry, astronomy, and many other subjects, were published in the early years of the century. Although the Quarterly Review argued that providing "the educated classes with a series of works on popular and practical sciences... illustrated by facts and experiments which are level to the capacity of ordinary minds" would reverse the supposed 'declining taste for science' in the 1820s,[55] such books did in fact already exist.

Mathematical puzzles, astronomical information and other miscellaneous scientific information could be found in the almanacs produced for the wealthier classes. According to the London Magazine, White's Ephemeris and the Ladies' and Gentleman's Diaries were suited to the schoolmaster, Rider's British Merlin to the squire.[56] Herbals were sometimes published as leather bound quartos, a few astrological texts likewise.[57] If one judges from the works produced, there was a market for a wide range of scientific ideas across a wide social spectrum.

As described above, however, many of these works were expensive, even for the wealthy. The catalogues of libraries which are still in existence show that many of these books were present in the stock at the time, and could therefore have been borrowed by the proprietors. The Portico (Manchester) Library,[58] for instance, owned Nicholson's Introduction to Natural Philosophy (5th edition 1805), Lardner's Popular Lectures on the Steam Engine (1830), Cuthbertson's Practical Electricity (1807), Marcet's Conversations on Chemistry (10th edition, 1825), William Wood's Zoography, or the Beauties of Nature Displayed (1807), Bakewell's Introduction to Geology (1813), Guest's History of Cotton Manufacture (1823) and Lindley's Introduction to the Natural System of Botany, among other science works, both serious and popular. The library also received the Philosophical Magazine, the Annals of Philosophy, the Royal Institution Journal, the Zoological Journal and other scientific and technical periodicals.

The Leeds Library catalogue contains thirty chemistry works printed before 1831,[59] as well as twenty-five on natural history, seventeen on botany, twelve on electricity, twenty on geology and ten on mineralogy. Despite being a cloth manufacturing and trading centre, however, the library has only three works on dyeing, two on steam and steam engines, and none at all on bleaching, from this period.

A similar picture comes from analysis of the catalogues of the private Liverpool Library. The classification scheme used in the catalogues and the number and percentage of books in each class in the years 1801 and 1811 are given below:[60]

Class		1801 Volumes	1801 %	1811 Volumes	1811 %
A	Religion, Morality and Metaphysics	660	8.1	1,012	8.3
B	Natural Philosophy, Medicine, Mathematics, Chemistry	592	7.2	856	7.0
C	Natural History	226	2.8	338	2.8
D	History, Chronology, Antiquities, Topography	1,040	12.7	1,436	11.7
E	Biography	435	5.3	579	4.7
F	Astronomy, Geography, Voyages, Travels	630	7.7	889	7.3
G	Law, Politics and War	698	8.5	1,061	8.7
H	Trade and Commerce	91	1.1	132	1.1
I	Agriculture and Gardening	151	1.8	278	2.3
K	Education	102	1.2	135	1.1
L	Language, Grammar, Rhetoric, Criticism and Logic	536	6.5	729	5.6
M	Polite Literature	941	11.5	1,203	9.8
N	Polite Arts	82	1.0	121	1.0
O	Poetry	437	5.3	608	5.0
P	Novels and Romances	1,045	12.8	2,135	17.4
Q	Miscellanies	240	2.9	327	2.7
R	Drama	197	2.4	256	2.1
S	Miscellaneous Tracts	84	1.0	85	0.7
T	Latin and Greek Classics			68	0.6
	Total no. volumes	8,187		12,248	

The percentage of each class (with one exception) remained almost constant during the decade, despite the increase of fifty per cent in the total number of volumes. It may be fairly assumed, therefore, that the library was fulfilling its objective of "providing a fund of literary instruction and entertainment, adapted to the various tastes of the proprietors among whom the works are to circulate".[61] The number of books in those classes concerned with natural science, i.e. Classes B and C, make up a fairly high ten per cent of the totals, even with the exclusion of astronomy. Trade and commerce are surprisingly poorly represented, when one considers Liverpool's position as a port, while there is no technological classification at all.

In 1830 a new catalogue was produced, but because of changes in classification direct comparisons are not possible. The changes that were made, however, are informative in themselves. Astronomy was removed from its position next to geography, voyages and travels, and placed in an expanded 'class B' of "Natural Philosophy, Mathematics, Astronomy, Chemistry, Medicine, Cyclopaedias, Journals and Transactions". Clearly the changed status of astronomy as an independent physical science, rather than as the sister of geography (as it had very largely been in the eighteenth century) had been realised by the librarian in Liverpool. In addition "Political Economy" appeared for the first time, while "Agriculture and Gardening" was amalgamated with "Natural History". A section of "Useful and Fine Arts" was formed, perhaps indicating a swing away from agricultural or county interests, to urban manufacturing ones. Medicine, interestingly, was the largest group of works in 'Class B' in 1830, with 340 titles, although only ten proprietors listed themselves as "M.D". Most of these works are not popular medicine, and it must be assumed that by 1830 many students of medicine used the library as a reference source.

Apart from the medical works, and some of the chemistry books, such as the translations of Lavoisier and Fourcroy (which were probably used by medical men or students), most of the science was of a non-technical nature and may be considered 'popular'. In many senses it too was 'polite literature' in the sense well expressed by the Gentleman's Magazine in 1823: "It is highly important to gentlemen...who mix in society, that they should have a smattering of many sciences, which are frequently subjects of discussion in conversation".[62]

Science and art were not separate, but as the editor of the Artist, a short-lived journal of the early nineteenth century, wrote, "he regard [ed] every adept of Art or Science under the general description of an Artist, or the active student of Nature and Science".[63] In the Liverpool Library, therefore, science seems to have been functioning as part of a literary culture which could interest the whole of society, regardless of religious or political views.

The lower middle classes did not have much better access to libraries than the labouring population; and yet, sharing the ideals of self-improvement and quiet recreation, they were a market waiting to be exploited. Consequently they welcomed the flood of 'improving' and 'respectable' works of the 1820s. Limbird's Mirror, Constable's Miscellany and the publications of the Society for the Diffusion of Useful Knowledge, and other similar works, were all bought in large numbers. As Charles Knight reported from Leeds in 1828, 50 to 125 copies of the Society's Library of Useful Knowledge had been sold in the town, "some to the working classes, but principally to those of the middle and upper classes".[64]

Apart from works on individual sciences, works on the whole range of sciences and even on the whole of knowledge were published. In many ways this period could be said to be the beginning of mass encyclopaedia production.[65]

The form had been established in the eighteenth century with John Harris' Lexicon Technicum (1704), Chamber's Cyclopaedia (1728, revised and expanded by Abraham Rees, 1781-6), the first edition of the Encyclopaedia Britannica (1771) and, of course, the mammoth and very influential French Encyclopédie (1751-65). The first three decades of the nineteenth century, however, saw at least fifteen such works of which Rees' Cyclopedia (1802-19) and the Encyclopaedia Metropolitana (1817-45) were the most important new undertakings. The Encyclopaedia Britannica was also greatly expanded, and it achieved the status of a scholarly reference book in this period, in which a supplement to the third edition, the fourth, fifth and sixth editions and a general supplement to these were all published. More commercially successful were those encyclopaedias which were mainly works of compilation. The Unitarian, Jeremiah Joyce, compiled both the Dictionary of Arts and Sciences (1806-07) and the rival British Encyclopaedia (1809), despite Dr. George Gregory and William Nicholson being respectively credited as the editors of the two publications.

Knowledge was presented in such works not only as unity, but as an ordered unity. This coincided with the Enlightenment view of the nature of knowledge, and the principal home of the Enlightenment in Britain, Edinburgh, was the place of origin of some of the most important such works of this period, including the Encyclopaedia Britannica, the Encyclopaedia Edinensis and David Brewster's Edinburgh Encyclopaedia.

In such an atmosphere of increased moral constraint, yet with many members both of the dissenting sects and of the Anglican church retaining a fairly rationalist outlook, the study of natural science was felt to have particular advantages. Firstly it was the study of the natural world. To the early nineteenth century middle-class mind this meant God's creation. "Every step that you advance in the pursuit of natural science", wrote Mrs. Marcet in her Conversations on Natural Philosophy, "will fill your mind with admiration and gratitude towards its Divine Author".[66] Above all the study would demonstrate the order of the universe. As William Phillips wrote of mineralogy and geology, the "more we know of them, the more of order, of design, and of contrivance we shall perceive".[67]

The discernment of order was aided and reinforced by the emphasis placed in most of the sciences on classification. Zoology, chemistry, mineralogy and particularly botany were primarily concerned with classification, usually by external features. In botany the Linnaean system, which was almost universally taught (although often in a slightly modified form), divided plants up into twenty-four classes depending upon the number, length, or position of the stamen in the flowers. An almost perfect system for the amateur, (especially since, if the parts of fructification could not be seen under a simple magnifying glass, the plant was, by definition, in class twenty-four, "cryptogamia"), it was also socially useful. The possibility of finding an order under- lying the seemingly chaotic phenomena of the natural world was reassuring at a time of considerable social turmoil. The efforts of the political economists to detect an order in the economic sphere, which produced the political economy of Ricardo and the Utilitarians in the 1820s, was an effort analogous to, and no doubt receiving support from, the classificatory successes of natural science. As Oliver Goldsmith had written in the late eighteenth century, "any apparent defects in the earth" are merely illusions. " [We] do not behold them at the proper point of distance... [for,] we may conclude, that God, who is regular in his GREAT productions i.e. [the universe, as revealed by Newtonian astronomy], acts with equal uniformity in the LITTLE",[68] i.e. in the organisation of life on earth.

The analogy between the order of the universe as discovered by natural science, and the order of society, was sometimes explicitly drawn. King Coal's Levee, a geological primer in verse, described each mineral in terms of the social hierachy, from King Coal and Queen Pyrites, through Duke Granite, down to Jack Clay; James Dede, in explaining the Linnaean botanical classification, wrote that vegetables could be considered as analogous to Man, and therefore the Class was equivalent to the Nation, the Order to the Tribe or division within the Nation, the Genera to the family, and the Species to an individual.[69]

The study of science was also a rational amusement. It was concerned with 'facts', particularly the classificatory sciences. As John Webster wrote, in his Elements of Natural Philosophy, "[s]peculative theory and mathematical demonstrations have been as much avoided as possible to make way for those useful and evident truths, which are universally received".[70] 'Facts' held no danger, as imagination did. Maria Edgeworth wrote of chemistry that "there is no danger of its inflaming the imagination, because the mind is intent upon realities" and Sarah Fitton thought that this applied equally to botany.[71] This also in part explains the emphasis on the utility of many subjects, even though few works allowed one to actually gain enough knowledge to apply oneself. If science concerned itself with useful results, it was obviously concerned with "reality" and "facts". The Gradgrind mentality of the early Victorians was forming. Indeed, in an almost prophetic passage from Venning's Rudiments of Conchology, 'Father' asks 'Lucy' what an "Operculum" is. Lucy responds: "It is of the 11th class, Conchifera, 2nd order, Unimusculosa, the family is Pectenida, the genus Pecten, and the species Pecten Maximus". " Very well answered", replied Father.[72]

To learn facts was to use the reason. The truths of philosophy "appeal to the reason, not to the passions, to effect their essential and valuable purposes" wrote Margaret Bryan. This rationalism was emphasised in the titles of books, e.g. Rational Recreations, or Rational Amusement for Winter Evenings. Even works such as Accum's Chemical Amusement were written "with a view, to blend chemical science with rational amusement".[73] Science would therefore aid the reader to become more rational. Astronomy, wrote George Carey, was of "admirable use in strengthening the mind, and arming the reason against the effects of ignorance and superstition". This had moral implications, for "morals would be quite vague, and have but few attractions, if founded on ignorance or error".[74] The fact that the study of science could be amusing was also of advantage. Olinthus Gregory admitted to presenting his Lessons, Astronomical and Philosophical in an amusing way so that "it would probably meet with a more welcome reception, and consequently have the better effect".[75] To make doubly sure it was "interspersed with Moral Reflections".

Science was also considered beneficial because it was unconcerned with the social and political realities of the time. Politics "are often apt to inflame the passions and pervert the judgement, - religion, when it leaves the pure and primitive path, becomes intolerant and dogmatic"; but in the study of nature,"all is simplicity, beauty, and harmony", wrote the Edinburgh doctor, William Rhind.[76]

"By withdrawing the mind... from pursuits and amusements that excite the imagination", wrote William Henry, the physical sciences may tend "to the improvement of our intellectual and moral habits; to strengthen the faculty of patient and accurate thinking; and to substitute placid trains of feeling, for those which are too apt to be awakened by the contending interests of men in society, or the imperfect government of our own passions".[77]

Examination of Henry's social background shows more clearly the social uses which he saw for science.[78] A Unitarian member of the Manchester middle classes, closely involved with the manufacturing community, he was the brother of Thomas Henry, jnr., a political reformer. William, however, was not a radical. The passage quoted above he had first given in a speech to the Manchester Literacy and Philosophical Society, and the city of Manchester occupied a special position in the life of the country at the time. Growing very rapidly indeed, it had been a centre of middle-class reformism in the 1790s. This had ended with the trial of Thomas Walker, the secretary of the society, and the general counter-revolutionary tenor of the later 1790s.[79] With the revival of reformism in the early nineteenth century, the middle classes were no longer allied to the aspirations of the lower classes, and the Peterloo massacre of 1819 and other social unrest made the middle classes feel as threatened as the upper classes. Science, then, was to be both a calming influence on all sections of society (if they could be persuaded to study it),and a common centre of interest for the wealthier classes, which they could all pursue regardless of their different religious or political ideals.

John Murray, FSA, also gave lectures to the local Philosophical Society. In his case he lectured in chemistry to the Norwich society. Again, Norwich had been a centre of radicalism in the 1790s and was still troubled in the new century. Significantly, Murray also stressed the social results of chemistry, writing that it allows "[us] to act our several parts to the best advantage, in the circle of social and civil life". Quoting Humphry Davy, Murray made clear the connection between seeing order in the universe and calm, conservative behaviour. A person, Davy had written, "perceiving in all the phaenomena of the universe, the designs of a perfect intelligence... will uniformly appear as the friend of tranquillity and order".[80] Instead of science as a promoter of reform, as the Encyclopedists had hoped, science was now the stabiliser of the social status quo.

B i. Women and Popular Science

By the beginning of the nineteenth century, women in both the middle and upper classes were generally expected to fulfill a similar role, that of the 'gracious lady' in the home. This had, of course, been accepted in the upper classes from much earlier, but for many of the middle classes it only became possible with increased wealth and a consequent ability to employ domestic servants. The middle classes, however, while emulating upper-class ladies in most respects, omitted the freer social manners of the higher ranks, which may have been misinterpreted as the coarseness of the lower classes, rather than as aristocratic sophistication.[81]

Middle-class women had formed the main new class of readers in the nineteenth century.[82] Novels and light reading in particular were especially directed to this new audience. By the end of the century it was common to find women writing such works as well as reading them. Fanny Burney, Mrs. Radcliffe and Mrs. Inchbald are three examples amongst many. Women writers were, however, bound by conventions in a male-dominated society. Books were written anonymously (although the real authorship was usually widely known) and a justification for writing was often felt to be necessary. As a modern scholar has written, "there was one motive which could neither be justified nor excused - ambition... The proper attitude for a female talent was diffidence".[83] Nowhere was this more apparent than when the subject was science. Many female writers addressed the various branches of natural knowledge, particularly those considered especially suitable for women, i.e. botany, entomology and other collecting sciences. Letters on Entomology (1825), Botanical

Lectures (1804) and Conversations on Botany (1817) are three examples of such anonymous works by women.

Some works were also written on the physical sciences and, indeed, the book responsible for making the conversational form so popular in this period was Conversations on Chemistry, published anonymously by Jane Marcet in 1805. The same hand was responsible for Conversations on Natural Philosophy (1819), Conversations on Vegetable Physiology (1829) and Conversations on Political Economy (1816), amongst other works.

The prevalence of female authorship may be shown by a partial list of those women who wrote just on aspects of natural history. These included Esther Hewlett, Charlotte Smith, Mary Trimmer, Priscilla Wakefield, Sarah Fitton and Mary Venning.[84] Nearly all emphasised their dependence upon information from books, lectures etc. by men. Mrs. Marcet was a good example. Vegetable physiology, she wrote, she was only recently acquainted with. Her work on that subject was merely the rearranged lectures of a distinguished Professor from Geneva; her political economy was from Adam Smith, Malthus, Say and Sismondi; she admitted to only an "imperfect knowledge of natural philosophy" and a complete ignorance of [unladylike] mathematics.[85] Similarly, Margaret Bryan wrote:

> "I... offer myself merely as a reflector of the intrinsic light of superior genius and erudition; to moderate its effects in enquiring minds, not fully prepared to imbibe and sustain its profound mathematical energies."[86]

As this last sentence suggests, much of the women's writing was for the education of children, particularly girls. This was a reflection of the role of women in the upper and middle classes, as rational companions to husbands and rudimentary teachers of children.[87]

For women readers themselves many of the works were written by men. This was because writing for women about science was seen to be primarily a process of simplification and censorship. Women required, it was a thought, a presentation fitted to their capacities and to their modesty. George Gregory wrote his Economy of Nature (1804) principally for the entertainment and information of "the more enlightened class of female readers". Consequently he emphasised that "there is not a single expression in the whole that can reasonably offend the most delicate and modest ear".[88] Lalande's Ladies' Astronomy (published in translation in 1815) excluded mathematics and geometry to fit it to its readers' capabilities. Science was also suitable because it was a part of literary culture. This was emphasised by the use of verse popularisations in chemistry and geology and by the inclusion of excerpts from poets in other works. John Bonnycastle, for instance, wrote that he included poetry in order to afford the reader agreeable relief and to enliven the languid portions of his text. Although this might be too florid for a philosophical book, he had found that such passages "generally leave a stronger impression on the mind, and are far more captivating than simple unadorned language".[89]

B ii. Popular Science and the Children of the Wealthier Classes

Education was a popular topic of discussion and controversy in the late eighteenth and early nineteenth centuries. The theories of Rousseau, of the Edgeworths, of Jeremy Bentham, and many others, all disputed the traditional view of the child as innately evil.[90] The growth of evangelical sentiment in the later eighteenth century had a different effect, however, and in most of the houses of the wealthier classes moral education was increasingly emphasised.

John Newbery, the first publisher who made children's books a recognised part of the publishing trade, published his first book, The Little Pretty Pocket Book in 1744. His nephew's widow, Elizabeth Newbery, had taken over the business by the end of the century, and the "difference between the moral and didactic tone of many of Elizabeth's juveniles at the end of the century and John Newbery's in the fifties and sixties is striking".[91] Children were valued for their obedience, sweetness, honesty and self-control. At the same time they also became more strictly controlled, particularly in sexual matters.[92] Men were increasingly forcing both women and children into the role of innocents, in need of protection from all harm by the male of the species.

Children and young ladies and gentlemen were therefore encouraged to read science for many of the reasons already given. It was innocent, it did not excite the imagination etc. In addition, as a rational recreation, it replaced other, worse, activities. William Bingley was worried about reading novels. It would be better, he wrote, for the rising generation if "they could have recourse to a rational source of amusement, rather than corrupt their hearts and bewilder their imaginations with these, the common trash of Circulating Libraries".[93] Natural history could serve as "a substitute for some of the trifling, not to say pernicious, objects that too frequently occupy the leisure of young ladies of fashionable manners and, by employing their faculties rationally, act as an antidote to levity and idleness".[94] For youths the study of natural history would mean that they would "never be at a loss for expedients for passing [their] time, not to be driven to seek amusement in the insipidity of the card-table, or the senseless roar of Bacchanalian revels".[95] At worst, of course, idleness would lead to sexual 'deviancy', either masturbation in adolescents or adultery in married women, both of which would be promoted by the inflaming of the imagination, but there also were many lesser moral sins which could be committed, such as drinking, gambling or even just wasting time.

To promote these moral aims Samuel Parkes, and other authors, added "some of those moral reflections which spontaneously arise in every contemplative mind, when considering the magnificent system of nature".[96] Not all writers agreed with this practice. Joseph Guy's astronomy popularisation was a class book for scholars; consequently, "it did not appear exactly in point to swell the volume by a frequent intermixture of moral reflections, any more than with poetical selections."[97]

In addition to these characteristics of science the scientific method was educationally valuable. In botany, for instance, as J.E. Smith wrote, "to explain and apply to practice those beautiful principles of method, arrangement and discrimination... render botany... a school for the mental powers, an alluring inticement for the young mind to try its growing strength".[98] For William Johns the Linnaean system was "one of the best systems of logic, by which we are taught to compare, to reason, to determine, to adopt, and separate, and finally, to arrive at a certain conclusion, truth".[99] Again this was not unconnected with religious belief, for the Unitarian Olinthus Gregory insisted that as soon as young people were able to exercise the power of reasoning they would be "thereby led to conceive that there must be some First Cause, which produced, governs and regulates the whole".[100]

Children's books were often produced in formats which would allow them "to proceed with some degree of regularity".[101] As well as 'conversations', there were catechisms, grammars (i.e. arranged in numbered paragraphs), letters, descriptions of walks in the country, etc. Many of these emphasised the private family nature of the amusements, the conversations being between mothers and daughters, or the letters from aunts to nieces etc. J.S. Forsyth objected to such "conversational or epistolatory styles", particularly "when forced, as it were, to draw, through such equivocal channels, upon the fictitious correspondence of some garrulous old woman or pedantic spinster, for the higher orders of elementary knowledge",[102] but his complaints did not prevent the publication of sixteen editions of Marcet's Conversations on Chemistry and the popularity of many other similar works.

The education of children of both sexes was similar when young, but as they grew older differences emerged. For boys the instruction was either a way of preparing them for more advanced studies, or else a morally beneficial recreation for those periods of leisure when they were not preparing for adult life. John Bigland's work was designed "to convey... as much important information on the subject of natural history... as the generality of young persons, educated for business, will have leisure to attain".[103] The subject would "strengthen the mind, end superstition, and provide the groundwork for an occupation", as Jeremy Bentham wrote.[104] For girls such education was all that they were to receive. This contrast may be forcefully made by comparison of Marcet's work on chemistry for girls with a plagiarised version for boys by Jeremiah Joyce. In his Dialogues in Chemistry Joyce recommended further reading, including works by William Henry and Thomas Thomson,"which must be recommended to the attention of every person, who would take a full and comprehensive view of this most interesting science".[105] Marcet described the limited education felt to be fitted to women:

> "Without entering into the minute details of practical chemistry, a woman may obtain such a knowledge of the science as will not only throw an interest on the common occurrences of life, but will enlarge the sphere of her ideas, and

render the contemplation of nature a source of delightful instruction".[106]

More or less all that the daughters of the wealthier classes had to learn was a few facts on many subjects. On science this might be, as for Maria and Julia Betram in Mansfield Park, "all the metals, semi-metals, planets and distinguished philosophers".[107] This would enable them to converse politely on such subjects when married. Even this was sometimes felt to be too much. As 'Elizabeth', a character in Morning Walks; or Steps to the Study of Mineralogy, lamented when she discovered the 'lead' in pencils not to be lead after all:

> "How very ignorant I am! And how much I have to learn before I shall be a rational companion for sensible and well-informed people".[108]

C. Books and the Poorer Classes

At least three quarters of the population were of the lower or lower-middle classes. In their hours of leisure they obviously engaged in many different activities. There was never a uniform popular culture, nor a single audience.[109] Even by 1830,when the years of repression following the French Revolution had politicised many more members of the labouring population than ever before, there was no "working-class culture". There were, rather, a number of different audiences.

Despite this however, many activities were found throughout the country. It seems not to be true, as has been thought, that lower-class leisure activities were restricted to the public house in the early nineteenth century. Drunkenness may have been particularly bad in Lancashire, but cock-fighting, bull-baiting and prize-fighting - whatever one may think of them - were very popular sports. Yorkshire men favoured horse-racing; Northumberland pit-men participated in cock-fighting, bowling, foot-races, handball, quoits, cards and even hunting.[110]

It is easy to think of this as a rural culture which died out when the population became predominantly urban, but as E.P. Thompson wrote of the eighteenth century, and as is equally true of the early nineteenth, "urban culture ... was more 'rural' (in its customary connotations), while the rural culture was more rich, than we often suppose".[111] The developments which did take place at this time were due particularly to the building up of the towns, with the consequently greater separation of town and country, and the, by no means inevitable, filling in or closing off of open spaces.[112] This may have led to more use of the public houses as places of social resort, but also it seems to have led, in conjunction with many of the conditions discussed in the preceding section, to more sedate hobbies:

> "The Athletic exercises of Quoits, Wrestling, Foot-ball, Prison-bars and Shooting with the Long-bows are become obsolete ... they are now Pigeon-fanciers, Canary breeders and Tulip growers".[113]

As well as over-emphasising the lack of popular recreations in this period, it seems that many writers, both contemporary and modern, have over-stressed the differences between the culture before and during the industrial revolution.[114] Nineteenth-century writers who seem to have been particularly misleading included those who had themselves risen from the lower classes, e.g. William Lovett and Francis Place. As reformers they stressed the changes far more than the continuities. Yet it seems to have been the case that the culture of the towns and of the rural areas had been a literate culture as well as an oral one at least since the early eighteenth century. These two sections of the ideas and customs of the lower classes lived symbiotically; stories from chapbooks, for instance, passed down orally, as well as vice versa. The sales of almanacs and of the radical press, and the ubiquity of chapbooks all suggest that print was not an alien form to the lower classes. It was, however, a different matter to have access to science popularisations, at least until the cheaper works of the later1820s. As the London Mechanics' Register asked rhetorically in 1825:

> "how many among the thousands who can afford to pay three-pence a week for our publication, have an Encyclopaedia in their possession, or have the means of consulting the scientific works alluded to?"[115]

To ask such a question is, however, to make an assumption about both science and the nature of the diffusion of knowledge. Science, in this view, is knowledge which is discovered by the investigators of the upper classes and then diffused downwards to other sections of the community. In the case of modern science this is largely true, but only because the whole of the community shares this belief. Science has shut itself away from society, and society has come to believe that scientists are the experts to whom the discovery of new knowledge about the physical world should be left. But the very idea of science as an activity of experts and, indeed, as the discovery of such new knowledge, was a concept which only began to be advanced in the nineteenth century. As will be shown in the next chapter, much of the scientific work in the early nineteenth century was classificatory, and the idea that experts were needed for this did not exist. In botany and zoology this classificatory process was attacked, particularly by those associated with Edinburgh science, yet it was by no means defeated at this time.[116]

The lower classes, those dwelling in towns as well as those in country areas, maintained a rich fund of information on plants, animals, the stars and the weather and all other aspects of the natural environment. Such knowledge was transmitted both orally and via texts. Some working men made collections of specimens. "I and a companion of mine ... collected twenty-two large boxes of insects ... British birds' eggs ... fossils, minerals, ancient and modern coins ...", wrote one hand-loom weaver.[117]

Such activities were not, as the middle-class educators liked to believe, indications of the 'rational' minds of the lower classes breaking surface above the sea of superstition and ignorance. The lower classes lived in a world qualitatively different from that inhabited by the rationalists. All things were connected to all others, in a web of influences. 'Superstition', as the rationalists, whether working-class like Richard Carlile or middle-class like Henry Brougham,emphasised strongly, was all around. William Brande said of the Cornish Miners:

> "though a shrewd class of people, [they] are often preyed upon by the most vulgar superstition, and many ancient absurdities are still retained, and cherished in their art. The divining rod and other oracles are yet consulted; genii are said to preside over the mines; and he who inadvertently whistles when below ground, breaks the spirits of his companion for the day".[118]

In the same part of the world, wassailers in Devon were described by William Hone: "Some are so superstitious as to believe, that if they neglect this custom, the trees will bear no apples that year".[119] Samuel Bamford wrote of Lancashire in 1815 that "speculations and ceremonials founded on superstitions of the rural population... were still more prevalent than [in 1844]; when I was a child, a disbelief of them was looked on as an almost impious exception".[120]

As this last sentence suggests, belief in ghosts, witches, the powers of herbs and all other aspects of the supernatural was felt to be tied to Christian faith. Rushton has shown that many charms and cures in parts of rural England combined biblical and astrological elements, particularly survivals from Catholic ritual.[121] 'Raphael', the author of the Prophetic Messenger, wrote in 1828 that in the 1827 almanac he had "deduced an evidence of Christianity" from eclipses, "and proved thereby that Astrology and Theology are twin Sciences".[122] In turn astrology affected not only the human body (the moon in particular was associated with certain organs and joints depending on its position) but was also connected with herbalism. Herbs had to be picked at astrologically favourable times for full effect. The influence of the planets was also a major determinant of weather. The Kentish Almanac of 1823 included a weather table calculated "on philosophical considerations of the attractions of the Sun and the Moon... and confirmed by experience of many years actual observations". The table predicted the weather, depending upon the time of day at which the moon entered its four quarters (i.e. new moon, first quarter, full moon, last quarter).[123] Popular medicine, astrology, herbalism, weather forecasting and religion were all associated one with another.

Much of this traditional culture was recorded and transmitted in the almanacs and chap-books which the poorer classes read. Weather forecasting, prophecy and fortune-telling made up much of these works. The prophecy was often of political and religious events, usually millenerial and conservative in tone. Moore's Almanack of 1800, for instance, predicted that Rome's Kingdom would fall in September "by Famine, Fire and Sword". In November the sentiments were "God bless and preserve George our good and gracious King... the Protestant interest and Religion... the Protestant Nobility and Gentry of this Nation", while even in 1830 it predicted that "The staff of Mahomet will soon be broken to shivers".[124] Weather forecasting was common to almost all almanacs. Often this was limited to a column in the calendar which gave general indications of the weather to come throughout the year but some also included lists of ways in which weather could be forecast. Will's Calendar or Moore's Almanack Improved in 1811 listed prognostications from the appearance of mist, clouds, dew, heavenly bodies, wind, meteors and the behaviour of animals. Even in the middle-class works such lists were often to be found. Time's Telescope for 1814, or A Complete Guide to the Almanack included prognostics from the Atmosphere, Winds, etc., from animals, from vegetables, from philosophical instruments (i.e. the barometer, thermometer, rain gauge and hygrometer) Bacon's prognostics from the Seasons, Herschel's from the Moon and select proverbs. In this case, however, the latter were justified by recommending empirical testing and by quoting Bacon that they were "the philosophy of the common people". Some are straightforward, e.g. "March in Janiveer, Janiveer in March I fear", but some are more enigmatic, e.g.

> "When the sand doth feed the clay,
> England woe and well-a-day.
> But when the clay doth feed the sand,
> Then it is well with England".

In addition it reprinted The Shepherd of Banbury's rules, a seventeenth (?) century collection which had been published in 1744. These are the traditional "red sky at night" type of rules, of which there are twenty-five listed. These rules were also published separately in this period. Once again the repetition of such work was justified in Time's Telescope by the claim that the rules were not superstition but empirically derived knowledge.[125]

Indications of the meaning of "philosophy" to the lower classes come from some of the chapbooks. Partridge and Flamstead's New and Well Experienced Fortune Book, for instance, which circulated in the mid-eighteenth century as well as being published by at least two provincial printers in the early nineteenth,[126] was said to originate in 1814 "from the Astrologer's Office in Greenwich Park",[127] suggesting a connection with the Royal observatory. It was in fact a book explaining how one could tell one's fortune from the use of cards. Dreams and Moles, a book explaining character from the position of moles on the body and interpreting dreams, was written according to "the most Ancient as well as Modern Rules of Philosophy",[128] while the Closet of Mother Bunch, which explained how to get the spouse of one's choice, contained "rare secrets of art and nature, tried and experienced by Learned Philosophers".[129]

Modern philosophy, where it was incorporated, was presented as part of the same pattern. Moore's Almanack declared that watches, almanacs, maps and chronological tables were all "important instruments of science, the result of the accumulated observations and skill of the greatest men in many successive ages of the world. Even Hieroglyphics, which many of the would-be-thought-wise men of the present day, affect to despise, have been studied and recovered from the remotest antiquity".[130] One of these "greatest men" was obviously Newton, and Moore stated that the weather forecasts "are only offered as very probable Predictions from the Influx of the Planets, and Gravitation of the Moon, operating on our Air or Atmosphere".[131] The Prophetic Almanack was more explicit. Quoting Newton that "Aether by its elastic force, is expanded through the whole heavens; and it may suffice to impel bodies, from its denser to its rarer parts, with all that force or impulse which we call gravity", as well as on the nature of light, the author concluded that "from these principles of Nature, which result from planetary influences, arise all changes of weather".[132]

Natural knowledge and philosophy in this traditional 'rural' culture was therefore primarily knowledge of the phenomena of nature. All such phenomena were connected together, however, and each part was believed to affect every other, as well as to influence the future course of events. Natural knowledge was a way of predicting and controlling the environment.[133] As suggested by Moore and in the phrase quoted from Dreams and Moles ancient knowledge was considered to be as good as, if not better than modern philosophy; the latter was not seen as a break with old concepts but as a development of them. In this sense the culture was truly traditional, and this was emphasised by the continued circulation of works produced even centuries before, such as Moore's Almanack, Partridge's Almanack and many chapbooks. The new generations read much the same reading matter as their ancestors had. The most basic knowledge, as well as the most intellectual and mysterious, was astrology. Astrology reduced everything to order indicating a determined society opposed to blind chance or a capricious deity.[134] As Moore's Almanack said:

> "Whate'er the Heavens in their Secret Doom
> Ordained have, must needs to issue come".[135]

These attitudes may be compared with those of the rationalists, whether from the working classes or the middle classes. Richard Carlile, the son of a man who was variously a cobbler, an exciseman, and a schoolmaster, was a rationalist follower of Tom Paine. He became a Deist and then an Atheist, and came to see, as many of the self-educated working men did, superstition as the tool of a despotic state, a means to keep the poorer classes down. A materialist, his Address to Men of Science (1821), which he completed in Dorchester Gaol, read, in part:

> "The chemist can analyse the body of man, and send it into its primitive gaseous state in a few minutes. His crucible and fire, or his galvanic battery, will cause it to evaporate so as not to leave a particle of substance or solid

> matter. And this chemical process is but an anticipation, or a hastening, of the workings of Nature; for the whole universe might be aptly termed a great chemical apparatus... It is the duty of the man of science to... endeavour to restore society to its natural state; to that state which just principles will point out; the mutual support, the comfort, the happiness and protection of each other".[136]

The differences are great; similar although nowhere near as extreme views may be found in Lovett and other writers, who saw the defeat of superstition as the pre-requisite for social, political and economic reform. As reformers they had something in common with the Society for the Diffusion of Useful Knowledge, whose efforts to disseminate scientific knowledge will now be examined.

C i. Science for the Working Classes: The Society for the Diffusion of Useful Knowledge

Inaugurated on 6 November 1826, and active from early the following year, the Society for the Diffusion of Useful Knowledge (hereafter the S.D.U.K.) was a "Plan of co-operation for the moral improvement of the great body of the population". It was intended to function as an overseer of the publication of cheap tracts on subjects deemed by the central committee to be "useful knowledge ".Although not the actual publishers, the Society selected the subject, commissioned the author, approved the text and oversaw the author's remuneration.[137]

The society was the brain-child of one man, Henry Brougham. His major roles in the mechanics' institutes movement and in the Edinburgh Review will be examined below, but some biographical details may be given now. Born in 1778, he was educated at Edinburgh University and became involved at the beginning of the century with the Edinburgh Review. A liberal and a lawyer, he found difficulty in obtaining work in the heavily Tory Scottish legal system and he moved to London in 1804. He soon became involved with the Holland House circle of Whigs and was later elected to Parliament. He came into contact with James Mill and other radicals and began to press for reforms in the House especially on education. He was also prominent amongst the founders of London University and later became Lord Chancellor in the Whig government of 1830.[138] In 1825 his pamphlet Practical Observations upon the Education of the People was published, which both aided the spread of mechanics' institutes and provided the stimulus for the foundation of the S.D.U.K. An attempt was made to form such a society in 1825, but it failed,[139] and it was not until late in 1826 that a prospectus was privately circulated; it was then published in early 1827.

The Society had other links with the three enterprises already mentioned. Articles proposing and supporting such a project appeared in the Edinburgh Review,[140] probably written by Brougham, while the original central (London) committee included twelve members of the original committee of the London University. The provincial committees of the society often included men associated with local mechanics' institutes, e.g. Thomas Traill in Liverpool, Benjamin Heywood and George Wood in Manchester and Edward Baines jnr. in Leeds. There existed a national network of educators.

Brougham remained in control of the society throughout its twenty-year existence, acting as Chairman for nearly all its meetings. In addition he recruited the original committee of forty-seven. Twenty-three of these were Members of Parliament, and fifteen were Fellows of the Royal Society. Only one Tory was on the committee and he was a rather inactive member. Most were liberal Whigs or Radicals, James Mill and Rowland Hill representing the committed Utilitarians. Unitarians, Quakers, Catholics and at least one Jew were all part of a religiously diverse group of men, while professional men, particularly lawyers, and Edinburgh University graduates were all well represented. All in all the original committee (and subsequent members) were very much of the urban middle classes. Liberal Whigs occupied all the offices of the Society on its commencement. Brougham was chairman, Lord John Russell vice-chairman; William Tooke (a solicitor) was treasurer and one of his employees, Thomas Coates, acted as secretary.[141]

Brougham's pamphlet set out the aims of the future society. Everyone, it declared, had at least an hour or two every other day for the acquirement of knowledge, and some money to help pay for it.[142] Thus what was required was merely the provision of cheap publications. The society was to be a free market of knowledge, not a distributor of free, subsidised, or very cheap publications. Number publication, use of lower quality paper and smaller print, and, Brougham hoped, a reduction of taxes on paper and other aspects of the book trade, were to ensure cheapness. The 'useful knowledge' was to be wide ranging, including ethics, politics and history, political economy, the nature of the constitution, party politics and elementary treatises on mathematics and natural philosophy, "which may teach the great principles of physics, and their practical application to readers who have but a general knowledge of mathematics, or who are wholly ignorant of the science beyond the common rules of arithmetic".[143] In many ways, as a recent writer has noted, the ideas expressed in the pamphlet were similar to those of the Scottish Enlightenment ideals of the early Edinburgh Review.[144]

Brougham's prime concern was therefore with the urban literate, numerate artisan.

The S.D.U.K. seemed determined to have greater ambitions. Brougham's claim that the society was for "the moral improvement of the great body of the labouring population" had the penultimate word struck out before it was approved in the minutes of the initial committee meeting.[145] Nevertheless number publication, at 6d. per fortnightly part, and the "liberal abatement in price" offered to mechanics' institutions, reading societies, etc., show that, at least initially, the society was mainly aimed at the poorer classes.[146]

The prospectus promised scientific treatises, each containing "an Exposition of the Fundamental Principles of some Branch of Science - their proofs and illustrations - their application to practical uses, and to the explanation of facts or appearances".[147] The first listed was elementary astronomy, followed by mechanics and including chemistry, mathematics, anatomy and a miscellaneous collection of technological subjects such as dialling, millwork, steam engines and agricultural buildings and machinery. Intellectual Philosophy (including Political Economy and Jurisprudence), histories of science, of art, of nations and of individuals were all to be included.

It was only to be expected that such education for the working classes was objected to by many groups. Those who objected to all popular education objected to the society. Those who objected to anything other than religious education for the working classes objected to the society. John Headlam, Archdeacon of Richmond, wrote that, although "desirous to encourage as widely as possible the diffusion of useful knowledge, it still becomes us to consider whether these vaunted improvements are calculated to advance equally the moral and religious principles of the present generation...; can it be requisite to caution you against giving encouragement to any specious theories of conveying useful knowledge to the labouring poor, without reference to religious instruction?"[148]

No wonder Samuel Hope plaintively lamented that the S.D.U.K. publications had been "shamefully misrepresented... and every successive announcement of the extension of the Society's plan has been a signal for renewed abuse".[149]

To assuage these expected objections the prospectus declared that no treatise would "contain any matter of Controversial Divinity, or interefere with the principles of revealed Religion".[150] As Brougham wrote, "we can only give books to all by keeping from controversial matter". Significantly, however, Brougham continued: "all our scientific lectures are in fact to be largely mixed up with the sublime truths of Natural Theology without which science cannot be well, any more than fairly taught... ",[151] a policy which, as Brougham must have known, was controversial in a period when evangelicals emphasised revelation and believed that the teaching of natural theology on its own was Deistic. As Samuel Holland, Precentor of Chichester, preached, in the presence of the Archbishop of Canterbury, "Philosophy, unenlightened by divine truth [is] a vain deceit". "The Gentiles, ... by contemplating the order and beauty of creation, ... knew God, yet through ignorance of his nature and attributes, they glorified him not as God".[152]

The suggestion that no controversial politics would be included was also not true. Apart from the very activity of educating the poor, the teaching of the Science of Mind (as Brougham called it in the introductory treatise 'On the Objects, Advantages and Pleasures of Science') was necessarily contentious. It was defined as the use of intellectual and moral facilities to draw conclusions about the duties of an individual "both towards himself... and towards others as a member of society; which last head opens to our view the whole doctrines of political science".[153] Francis Place thought the S.D.U.K. was "to publish two sheets periodically octavo double columns for sixpence, each number to contain a treatise on morals or politics, or political economy, or science".[154]

Despite these suggestions, however, directly political tracts were not at first produced. The first series of treatises,later called the Library of Useful Knowledge, contained many on scientific subjects, particularly amongst the early issues. The first publication of all was Henry Brougham's 'Discourse On the Objects, Advantages and Pleasures of Science'. It appeared on 1 March 1827, priced at 6d., the amount which Brougham had suggested, in his 1825 pamphlet,[155] a mechanic could save every week from his wages. By 16 December 1829 33,100 copies had been sold; by 1833, 42,000. It was the best selling of all the Library of Useful Knowledge (LUK) treatises. The early scientific numbers sold over 20,000 copies each, but dropping from 27,900 to 22,350; the decline was stemmed briefly by Bell's 'Animal Mechanics' (a Paleyan tract) which sold 25,025 copies. By 1832 new treatises were selling only approximately 6,000 copies each and by 1835 the number had dropped further to 4,000.[156]

Most of the scientific treatises were issued by 1830, including all of the first two volumes of "natural philosophy", as well as some mathematical treatises, various biographies and a sympathetic account of Bacon's Novum Organum. The first thing that one notices when examining these tracts, ostensibly for those who know perhaps only "the common rules of mathematics", is their complexity. Mathematics is kept to a minimum, but the language shows a complete lack of understanding of, or a complete disregard for, the competence of the supposed audience. One particular phrase, picked out by a critic in the Westminster Review,was from John Millington's treatise on hydraulics. "The orifice of discharge... was an Hyperboloid of the fourth order", explained this London Mechanics Institute lecturer.[157] Often the writing seems more fit for university students; Dionysius Lardner and John Hoppus were in fact both professors at the new London University, as well as LUK authors. David Brewster's 'Optics' was a summary of recent research,rather than an introductory treatise, while Peter Roget attempted a condensed explanation of the whole of electricity and magnetism.

Brougham was among those who noted the difficulties. "My informants in Newcastle and elsewhere", he wrote to Thomas Coates in 1828," greatly strengthen the opinion I before had that more easy treatises are absolutely necessary."[158] Probably in response to this, a one hundred page 'Popular Introduction to Natural Philosophy' was issued, being almost a reprint of Mrs. Marcet's Conversations on Natural Philosophy. In at least one place the treatises were being read by the people they were mainly aimed at. Dr. Thomas Traill told Charles Knight "that many individuals who at first affected to underrate cheap philosophy had begun to alter their tone; and that the mechanics connected with the Liverpool [Mechanics'] Institution read and purchased the Treatises".[159] It was the biographies, however, which found most favour.

J.N. Hays has already analysed the science content of the LUK and has noted four principle features, "utility, basic empiricism, belief in a Providential cosmos, and a faith in the possibility and desirability of broad scientific education".[160] The LUK, despite Brougham's claim that "a knowledge of Chemistry is practically useful and immediately profitable to the bleacher, the dyer, the painter, the glassmaker,[and] the brewer",[161] was not, however, attempting to teach working men new skills. The "utility" was an expression of faith in the benefits of machinery rather than an attempt to teach technology. This lack of true usefulness was criticised by those who had anticipated economically useful material. James Scott, a master workman in Fyfe, complained that "some of the... essays... are not very popular in this quarter, and not a few of our plain matter of fact people ask one another if they know anything about polarisation of light, and if they do, what is its practical utility to the lower classes for whom the publication is professedly issued".[162]

The "basic empiricism" noted by Hays was largely a faith in a (neo-) Baconian empirical methodology. Bacon's Novum Organum, which the authors thought taught such a method, was an early publication, while Peter Roget's nine part, almost 300 page, exposition of electricity and magnetism ended with a note that he had "endeavoured... to illustrate the precepts of Bacon by examples, and to foster that genuine spirit of philosophical inquiry by which alone error can be avoided, and truth attained".[163] Baconian empiricism was believed to show those laws of nature by which everything was ordered. Dionysius Lardner took this to its logical conclusion when he attempted to unfold all the phenomena of mechanics from the simple laws on which he believed it all depended. Faith in reason above sensation was also shown in extraordinary fashion by Brougham's treatises. As 'Paul Pry', in The Blunders of a Big-Wig; or Paul Pry's Peeps into the Sixpenny Sciences, made much fun of, Brougham made many errors, of which one of the most astonishing was his assertion that a stone would move faster if pulled by two oblique forces than by the forces acting together in the direction of motion. Brougham's willingness to trust 'rational' thought above the evidence of sense was shown by his comment that it "is proved by mathematical reasoning, to be the necessary consequence of forces applied obliquely: there is a loss of power but a great increase of velocity" (Brougham's emphasis).[164] Other errors, such as his statement that the weight of water increased when it was forced to rise in a tube, suggest that the superintendence of the Society's committee was not as vigilant as was claimed.[165]

The aim of the S.D.U.K. was to replace the 'bad' reading matter of the lower classes (i.e. novels, political tracts etc.) as well as to give them improving literature.[166] To this end the committee attempted from very early on to widen its scope. Brougham wrote to the Marquis of Lansdowne: "Would your Wiltshire yeomen... read treatises (very cheap) on the natural history of domestic animals, anatomy, etc. -their treatment, diseases etc? Or is there another subject (likely to enlarge their minds) which they would prefer?"[167]The narrow-minded country dwellers were to be helped by the advanced urban middle classes. As the Society's Quarterly Journal of Education made clear in 1833, this too was to be moral education, not economically useful education, for,"in learning something of physiology and of chemistry... [the "farmers"'] thinking powers in general will be strengthened, and he will gradually know how to cast aside prejudices, both in science and morals, for want of that rapid communication of ideas which impels the inhabitants of towns more forward in the course of improvement".[168] These initiatives resulted in the Farmer's Library (later the Farmer's Series), which contained treatises on the horse, husbandry, etc.

Another attempt to reach the labouring classes, including those in the country, was via the British Almanac. The most successful of all the Society's publications in terms of numbers sold,the first edition was the idea and responsibility of Charles Knight, although he had extensive help from other committee members, in particular James Mill.[169] Published just at the beginning of 1828, 10,000 copies were sold in the first week, and 34,000 altogether. The next year's edition proved even more popular selling 41,000 copies at 2s.6d. (compared to 2s.3d. for the first edition).[170] The British Almanac was to contain "remarks on the weather, founded upon science and experience; [and] Astronomical Facts and Phenomena" as opposed to the "absurdities of astrology" of the other almanacs.[171] In addition "some matter of a more general nature and of higher value" was included, i.e. useful directions on health preservation and "sound and practical moral reflections and sayings." (An example of the latter: "Now I have a sheep, and a cow, everybody bids me good morrow".) A history of the previous year was also given, "especially the progress of legislation, of improvement in the arts and sciences, and of the instruction of the people, of all events by far the most interesting".[172]

Like the LUK, however, the British Almanac was not effectively aimed at the level of the labouring classes. In explaining the action of the hygrometer the text referred to "the familiar instances of [moisture on] a bottle of wine brought from a cellar", while the lists of Bank transfer (of stock) days and hackney carriage fares, etc. "which almost every man engaged in the world requires", show the section of society which purchased the work.[173] Yet Knight could write, in the Companion to the Almanac for 1828, that astronomy was explained in order to help eradicate superstition amongst country folk, for whom almanacs were often the only books available .[174] It seems as if the works were aimed at the better-off of the lower classes. The Companion contained short chapters of useful advice to help fix "sound principles of conduct" in people's minds, and for them to teach "their less informed neighbours in the care of their health, and their property".[175] The Companion also contained scientific information, in its explanations of the thermometer, the barometer and the hygrometer, of the cause of tides and in its discussion of the solar system. All these were obviously intended to assuage 'superstitious' beliefs about weather prediction, astrology, etc. It also included a message on the utilitarian nature of science. "The value of science", it read, "is best shown by its influence on the happiness and well being of mankind... [i.e., by] the application of science to the useful arts and domestic economy ".[176]

As time went on the S.D.U.K. came to produce publications for wider audiences. In response to the agricultural disturbances of 1830-31 the Working-Man's Companion was published. Paid for by the Whig government,[177] it consisted of tracts explaining the benefits of machinery and the tenets of political economy. Before this, however, the Library of Entertaining Knowledge was issued. Designed to "meet the wants of a large number of readers to whom the Treatises do not present sufficient attractions",[178] the series marked the beginning of attempts to cater specifically for the lower middle classes. (Charles Knight said that the series was specifically for the sons of the middle classes).[179] It was very much Knight's idea, and related to his earlier attempts, on his own, to produce a 'wholesome' recreational literature for the respectable poor.[180] Knight published the series and wrote the first volume, 'Menageries'. The Library of Entertaining Knowledge (LEK) was to provide "As much entertaining matter as can be given along with useful knowledge, and as much knowledge as can be conveyed in an amusing form".[181]

Rather than using number publication, each subject was printed as a separate volume, priced at 4s.6d. (although it could be bought in two 2s. parts, but only after publication as a volume). In this way the S.D.U.K. was imitating Constable's Miscellany, Murray's Family Library and other such literature. Even with this format, however, sales declined (as the LUK's had), from 23,000 volumes for 'Menageries', to 6,400 for the eighteenth in the series.[182]

Each volume was small (duodecimo) with single columns of print compactly but clearly printed, with wide margins and spaces. Six volumes on the British Museum, as well as volumes on Criminal Trials and on Paris, emphasised the differences between LEK and LUK. The science was confined to natural history. Within the science, however, many features remained constant. A scientific method based upon observation and induction was still propounded. Discoveries arose, wrote

George Craik in his 'Pursuit of Knowledge under Difficulties', "when out of the facts and incidents of everyday experience, a gifted mind extracts new and important truths".[183] In zoology, declared Knight, "the greater our collection of facts, the nearer have we approached to systematic perfection". Natural history might be, as Knight wrote, the "most easily pursued, and the most agreeable in pursuit, of all the various branches" of human inquiry and study,[184] but still it was to physical science that the accolade went for the most advanced field of study, for "not in physics, [but] ... in other departments of knowledge, we are still too much given to accept mere words and phrases, in the place of philosophy".[185]

The pursuit of knowledge, like wealth, was open to all. This was the message of Craik's treatise; difficulties "are impediments only to the indolent or unaspiring, who make, in truth, their poverty or their low station bear the blame which ought properly to be laid upon their own irresolution or indifference".[186] In case this was not clear, Brougham insisted that Craik should especially emphasise "self-exaltation" of humble men, rather than "self-education", i.e. those who had risen socially by "force of merit".[187]

The rationalism of the middle classes was again evident. Adventure of the intellect, Craik wrote, "never excites in us an interest dangerous to feel, nor holds up to us an example criminal to follow".[188] Natural theology was still prominent. Knight recalled later how he had worked hard to make James Rennie's three volumes on insects suitably readable "and especially to trace those evidences of Design which lift the mind... to the constant feeling of the Living Principle of all things", i.e. "that Wisdom, by which the functions of the humblest being in the scale of existence are prescribed by an undeviating law".[189]

One difference in the science content was a much smaller emphasis on systematic presentation. The treatises of the LUK were always very ordered, while Knight's "Menageries" was merely a description of animals at local (i.e London and environs) menageries, although Knight did include a short explanation of the principles of classification in the preface.

The Library of Entertaining Knowledge presented middle-class reformist ideals of science and art for a middle-class audience. As Albert Fry said at Birmingham Mechanics' Institute in 1832:

> "As to the fact that the works in question were supported by the middle classes - it was doubtless true. He who read these books became one of the middle classes... No one could read the Entertaining Series without becoming a better man...The volumes on the Insect Creation alone were full of the deepest interest, and gave a high, refined, and softened tone to the mind".[190]

C.ii. The S.D.U.K. and Popular Natural Knowledge

The above discussion of the S.D.U.K.'s work has clearly shown that its aim, even in teaching science, was moral education, not technical education. As Brougham wrote in the Edinburgh Review, the Society had "the highest good, the moral improvement of all classes, for its end".[191] In this way it was a typical middle-class organisation. Education was a matter of inculcating moral and religious principles, and one of the ways to do this was by teaching the study of nature. The "more widely science is diffused, the better will the Author of all things be known", wrote Brougham.[192] The lower classes were on a par with children and women in the middle classes. All knowledge came from men of the higher classes and diffused downward to all other groups, who had to be protected from corruption, as well as educated. Indeed, a "poor man in civilized life may in a considerable degree be looked on as a savage", the Quarterly Journal of Education said.[193]

The S.D.U.K. did more, however, than just reflect the middle-class concepts of science. The Society was an organisation of political reformers and of rationalists. Facts and laws (but not "hypotheses") were emphasised; the regulation of all aspects of the universe by laws of divine origin was stressed. The economic relationships of men were described by the 'science' of political economy, which was based on a "law of nature, against which it is vain to contend".[194]

The Society taught rational politics and rational religion and not surprisingly was criticised by Tories and evangelicals for so doing. Thomas Love Peacock is well known for his satire on the society in Crotchet Castle, but his was a political attack, not merely humour at the expense of a new enterprise. Political economy ("the science of sciences"), the Edinburgh Review ("sugar plum manufacturers to the Whig aristocracy"), and the S.D.U.K. ("the Steam Intellect Society") were recognised as part and parcel of the reformist movement.[195] The Age, a conservative newspaper, likewise satirised the society when it published the 'March of the Intellect Gazette' prospectus. The fictitious paper was to contain "Mechanics in all its branches, Phrenology, Astrology, Mineralogy, Pneumatics, Periphrastics, Intomics, Broughaminics, Philharmonics, Defamation, Intonation, Incarceration and Humbug in general. It will also propound useful lectures and information upon handicraft of every description, such as shoe-making, jenny-spinning, pipe-stopping, tailoring, basket-making, iron-making, wire-working, etc., and, in short, polite literature of every denomination".[196]

The S.D.U.K. therefore shared many of the ideals of the self-educated working class reformers. Carlile, Lovett, Samuel Bamford: all wished to remove the bonds of 'superstition' from the poorer classes. This was a reflection of the alliance between many middle and working-class radicals which existed in the years before the Reform Act of 1832. Even in 1844 Bamford could forgive Brougham his "errors and imperfections", because "educators are, after all, the best reformers, and are doing the best for their country... [Brougham] led popular education from the dark and narrow crib where he found it, like a young colt, saddled, and cruelly bitted by ignorance, for superstition to ride. He cut the straps from its sides, and the bridle from its jaws, and sent it forth, strong, beautiful and free".[197]

When the image of science as experimental, mathematical, and cumulative, was confronted by the popular concept of natural knowledge described above, there was inevitably a mutual lack of comprehension. The middle-class reformers, supremely confident of their own reasonableness, interpreted all other types of natural knowledge as mere superstition, and consequently as immoral. Nowhere was this better shown than in the discussion of almanacs. Characteristically the reformers ignored previously existing texts, of which they themselves would have approved, e.g. White's Coelestial Atlas or The Imperial Almanac. Characteristically also they over-emphasised the effects of their own publications. The London Magazine, for instance, printed an article (probably by William Hone) in 1828, in which the S.D.U.K.'s British Almanac was described as "at once, rational and popular". The S.D.U.K., "whose Committee is composed of some of the ablest men in the country", had succeeded in one fell swoop in killing off Poor Robin and Season's Almanac, while Partridge and Moore were on their last legs, it was claimed.[198] Also typically, the reformers over-emphasised the degradation of existing publications. Many almanacs, the British Almanac claimed, were obscene and "could never be admitted into any decent house",[199] while the London Magazine described Poor

Robin as "filth which has certainly not been openly printed in any other shape since the days when a general corruption of the society reconciled such abominations",[200] an astonishingly virulent attack on a publication which contained only humorous moral poems and prose. Moore was described as listing the parts of the body which the moon affected, parts "too numerous and disgusting to mention".[201] The latter were presumably the "secret members" which Moore included in his list of knees, arms, hands and legs, etc. Hone could do much better, as when he produced a satire on almanacs, Poor Humphry's Calendar in 1829. Describing himself as the "Chimney-sweeper of Astrology", he effectively ridiculed the usual form of the works, particularly the weather forecasts, e.g. "rain, with cold, and frost and snow provided it be not too dry, and too warm for either".[202] There is evidence, however, that the weather prognostications were treated rather cynically by readers anyway,[203] as were the political prognostications, the reformers again under-estimating the intellect of the poor.

The real trouble with almanacs, for rationalist reformers, was their conservative politics and their enthusiastic, millenarian religion. Neither recognised that, as the London Magazine wrote, philosophy discloses "evidences of the directing wisdom of an Almighty Providence who has arranged all things for our good". Everything "may be referred to undeviating natural causes", i.e. to laws of nature.[204] Astrology, although it did see order in the universe, was not an open, experimental science. Above all it was deterministic, and therefore contradicted the individualistic, self-help philosophy of the reformers.

This was the reaction of the middle-class rationalists to popular natural knowledge, but what was the reaction the other way round? Clearly it is much harder to discover, because of the lack of records, but the slightness of the enthusiasm for

S.D.U.K. publications amongst the poorer classes and the decline in working-class attendance at mechanics' institutes, after the early years, suggests there was no great love for the education.

A comparison of popular natural knowledge and middle-class science suggests a number of reasons why. The popular philosophy was concerned with natural phenomena, with their prediction and to some extent with their control, in a hostile world. The poor did not live in a world where God had "arranged all things for [their] good", and a science which claimed that he had was not welcomed. Their concern with natural objects as living, growing things was different from that of a science concerned with experiments and laws, mathematics and theory. The classificatory science of most middle-class botanists, etc. may have been more acceptable than the induction of general truths from experimental facts. As Samuel Bamford wrote, the caging of animals and confinement of fish for the study of natural history was the wrong way to do it. One should study things in the wild, or "- might I not, addressing some philosophical devotees, ask, Doth not our land exhibit wonders and beauties, and fearful things too, worthy of all your superfluous astonishment, admiration, and awe?"[205]

The science was also foreign, being both from the middle-classes and, usually, from other parts of the country. Neither was calculated to endear it to the labouring population. In Pudsey, for instance, sanitary reformers were regarded as 'Infidels', while William Lovett recalled that, in his home town of Newlyn, inoculation "was looked upon as sinful and a doubting of providence".[206]

Thus, the science of the reformist middle-classes did not share the same outlook, aims, or concerns as popular natural knowledge. Consequently, except among reforming or radical members of the working classes, there was very little to attract the labouring classes to such science. Even for the radicals by no means all of the science was welcome. Demystifying the world to permit social and political reform was one thing, reconstructing it according to undeviating divine laws, which implied the maintenance of the status quo, was another. As Samuel Bamford asked, "-might not an enlightened philosophy discover that something was wanting by, and for, the fellow-inhabitants of our own country"?[207]

Notes to Chapter 2

1. Elie Halévy, A History of the English People in the Nineteenth Century - I: England in 1815, 2nd edn., London and New York, 1949, p.532; R.K. Webb, The British Working-Class Reader, 1790-1848, London, 1955, p.21.

2. Halévy, op.cit. (1), p.533; E.G. West, 'Literacy and the Industrial Revolution', Economic History Review, 1978, 2nd Series, 31, p.371, quoting T.W. Laquer.

3. Webb, op.cit. (1), p.16.

4. Halévy, op.cit. (1), p.533. The counties were Devon, Derbyshire, Lincolnshire, Nottingham, Rutland, Northumberland, Durham, Cumberland and Westmorland; (ibid, p.533 (n 1-3)).

5. Actual numbers were 528,254 in 1821, with a low point in the decade of 481,690. See Abel Heywood, English Almanacks During the First Third of the Nineteenth Century. A Paper read before the Manchester Literary Club, January 15th, 1900, Manchester, (Privately Printed), [1900?], p.11 For the output of political pamphlets and the circulation of radical papers during this period see E.P. Thompson, The Making of the English Working Class, Harmondsworth, 1968, passim and especially parts i and iii and p.789.

6. Thompson, op.cit. (5), p.787.

7. R.D. Altick, The English Common Reader, A Social History of the Mass Reading Public, 1800-1900, Chicago, 1963, p.83.

8. Ibid, pp. 90-1.

9. Frank Beckwith, 'The Eighteenth-Century Proprietary Library in England', Journal of Documentation, 1947-8, 3, 81-98 (85-6).

10. Quoted in T. Kelly, A History of Adult Education in Great Britain, Liverpool, 1962, p.77.

11. Heywood, op.cit. (50), passim. Knight is quoted on p.16. For almanacs in earlier years see B. Capp, Astrology and the Popular Press, English Almanacs,

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13. Thomas, op.cit. (11), pp.347-56.

14. Weiss, op.cit.(12), p.1.

15. Victor E. Neuburg, Popular Literature, A History and Guide, From the Beginning of Printing to the Year 1897, Harmondsworth, 1977, ch.IV; the quotation is from p.205, and was written by William Chambers.

16. For publishing trade information see F.A. Mumby, Publishing and Bookselling, A History from the Earliest Times to the Present Day, 4th edn., London, 1956, especially chs. XI-XIII; Ian Maxted, The London Book Trades, 1775-1800, A Preliminary Checklist of Members, Folkestone, 1977; Marjorie Plant, The English Book Trade, An Economic History of the Making and Sale of Books, 2nd edn., London, 1965.

17. Altick, op.cit. (7), p.276.

18. See Henry Brougham, Practical Observations upon the Education of the People, addressed to the Working Classes and their Employers, 13th edn., London, 1825, p.3.

19. Plant, op.cit. (16), p.311.

20. Altick, op.cit. (16), quotes this from the Penny Magazine of 1835, p.265.

21. J.H. Plumb, The Commercialisation of Leisure in Eighteenth-Century England,Reading, 1973, p.7; Plant, op.cit. (16), p.86. For circulating libraries see H.M. Hamlyn, 'Eighteenth-Century Circulating Libraries in England', The Library, 1947, 5th series,1, 197-222.

22. *The Iris*, 1825,2,15.

23. Maxted, op.cit. (16), Table 4,pp.xxiii-iv; Louis James, *Fiction for the Working Man, 1830-50, A Study of the Literature Produced for the Working Classes in Early Victorian Urban England*, Harmondsworth, 1974, p.6.

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26. Altick, op.cit. (7), pp.218-9, quotes the *Monthly Magazine*.

27. See Beckwith, op.cit. (9), for proprietary libraries.

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29. Beckwith, op.cit. (9), p.92; Money, op.cit. (28), pp. 126, 129.

30. Beckwith, op.cit. (9), p.93.

31. Proprietorships were listed in the front of the *Catalogues* of the Liverpool Library of 1801, 1814 and 1830. 886 proprietorships were listed in 1814.

32. James, op.cit. (23), p.6.

33. T. Kelly, *Early Public Libraries: A History of Public Libraries in Great Britain before 1850*, London, [1966], pp. 127-8.

34. Brougham, op.cit. (18), p.25.

35. *Mechanic's Weekly Journal*, 1824, 1, 190.

36. *Liverpool Mechanics' and Apprentices' Library, 6th Annual Report*, [Liverpool, 1830], p.2.

37. Altick, op.cit. (7) p.197; Brougham, op.cit. (18), p.26.

38. *Annual Report of the Committee of the Leeds Mechanics' Institution...*, Leeds, 1826, p.10; E.A. Storella, '"O, What a World of Profit and Delight": The Society for the Diffusion of Useful Knowledge', University of Brandeis PhD Thesis, 1969, p.76 (n.2). For Mechanics' Institutes see below, chapter VII.

39. R.A. Peddie and Q. Waddington (eds.), The English Catalogue of Books (including the original 'London' Catalogue). Giving in one alphabet, under author, title and subject, the size, price, month and year of publication, 1801-1836, reprinted, New York, 1963. Entries have also been cross-checked against Bibliotheca Londinensis: A Classified Index to the Literature of Great Britain , during thirty years, London, 1848, and the British Library General Catalogue.

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56. 'The English Almanacs', The London Magazine, 1828, 3rd Series, 2, 591-606 (601).

57. For instance Culpepper's Complete Herbal, London, 1815, quarto; E. Sibly, A New and Complete Illustration of the celestial science of Astrology; or the art of foretelling future events and contingencies, by the aspects ... of the heavenly bodies, 12th edn., 2 Vols., London, 1817-13 (sic-2nd vol. is of 11th edn.), quarto.

58. The catalogue was published in 1856 so one cannot be certain that all the pre-1830 works were present in 1830.

59. This information is from the current catalogue. Therefore the caveat of the note above is also applicable here.

60. The 1811 totals are derived from adding the totals in the supplements to the catalogue of 1804, 1808 and 1811 to the numbers in each class listed in the 1801 catalogue.

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84. For the works of these women see Bibliography.

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119. William Hone, The Every-Day Book; or, Everlasting Calendar of Popular Amusements, 2 vols., London, 1826-7, I, 21.

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123. The Kentish Almanack for the Year of Our Lord 1823, Canterbury, [1822?], p.24.

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127. Partridge and Flamstead's New and Well Experienced Fortune Book Delivered to the World from the Astrologer's Office in Greenwich Park, York, 1814. In the collection of the Kendrew printing firm at the British Library, 1870. c. 2, n. 799.

128. Dreams and Moles, with their Interpretation and Signification made far more manifest and plain than any published, to the very meanest capacities. By the most Ancient as well as Modern Rules of Philosophy, York, [n.d. -but in collect loc.cit. (127), n. 800 and therefore contemporary].

129. The Closet of Mother Bunch Newly Broke Open; containing rare secrets of art and nature, tried and experienced by Learned Philosophers, York, 1808, loc.cit. (127), n. 811.

130. Moore, op.cit. (124), 1830, p. 44.

131. Ibid, February, 1800.

132. The Prophetic Almanack; or Annual Abstract of Celestial Lore... for the year 1825, London, [1824?], weather column for January.

133. For a classic characterisation of such natural knowledge in an earlier period see Thomas op.cit. (11). Even in the early nineteenth century much of this retained its potency.

134. Ibid, ch. XI and especially pp. 387, 391.

135. Moore, op.cit. (124), 1800, poem for January.

136. Quoted in Guy Aldred, Richard Carlile - Agitator, His Life and Times, London, 1923, pp. 121-2.

137. So said Henry Brougham at a General Meeting, 6 November, 1826. Quoted in Storella, op.cit. (38), p. 104. For general details of the organisation of the society see Storella, op.cit. (38) and Monica Grobel, 'The Society for the Diffusion of Useful Knowledge 1826-1846', London University MA Thesis, 1932, from both of which much of the organisational detail is derived.

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139. Ibid, p. 347.

140. Edinburgh Review, 1827, 46, 225-44; ibid, 1827, 46, 515-26.

141. Storella, op.cit. (38), ch. VII.

142. Brougham, op.cit. (18), p. 1.

143. Ibid, pp. 1-2, 4-5, 9.

144. T.H. Cook, 'Science Philosophy and Culture in the Early Edinburgh Review, 1802-1829', University of Pittsburgh PhD Thesis, 1976, p. 263.

145. Storella, op.cit. (38), p. 104.

146. The Society for Diffusion of Useful Knowledge,[a prospectus, London, 1827?].

147. Ibid, pp. 1-2.

148. J. Headlam, A Charge, delivered to the Clergy of the Archdeacon of Richmond, in the Diocese of Chester at Preston, and Lancaster, Kendal, Ulverstone, Whitehaven, Richmond, and Boroughbridge; In June and July 1817, London, 1827, pp.11,18.

149. Report of the Liverpool Mechanics' School of Arts, 1830, Liverpool, 1830, p. 9.

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151. Brougham to Althorp, quoted in Grobel, op.cit. (137), p. 22.

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153. [Henry Brougham], 'Discourse on the Objects, Advantages, and Pleasures of Science', Library of Useful Knowledge, Natural Philosophy, 4 vols., London, 1829-38, I, 39 (Treatises separately paginated).

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156. Figures taken from Webb, op.cit. (1), pp. 69-70.

157. [John Millington], 'Hydraulics', The Library of Useful Knowledge, Natural Philosophy, op.cit. (153), I, 4. Quoted in the review of the reports and prospectus of the SDUK for 1830, Westminster Review, 1830, 14 365-94 (373).

158. Brougham, 11 August, 1828. Quoted in Grobel, op.cit. (137), p. 102.

159. Charles Knight, Passages of a Working Life during half a century: with A Prelude of Early Reminiscences, 3 vols., London, 1864, II, 81.

160. J.N. Hays, 'Science and Brougham's Society', Annals of Science, 1964, 20, 227-41 (240).

161. From Edinburgh Review, 1827, 46, 243.

162. James Scott to D. Booth, 24 March 1830, quoted by Grobel, op.cit. (137), p. 101.

163. [Peter Roget], 'Electromagnetism', Library of Useful Knowledge, Natural Philosophy, op.cit. (153), II,Postscript, p. 100.

164. See Hays, op.cit. (160), p. 234 and [Dionysius Lardner],'Mechanics', Library of Useful Knowledge, Natural Philosophy, op.cit. (153), I; [Brougham], op.cit. (153), p.30. Quoted in 'Paul Pry', The Blunders of a Big-Wig; or Paul Pry's Peeps into the Sixpenny Sciences, London,1827, pp. 51-2. (Pry's emphasis).

165. Paul Pry, op.cit. (164), pp. 51-2, took great delight in the fact that the later editions, while no longer including the 'Brougham Balance', still retained many other errors.

166. Charles Knight had long had such an aim. In the Windsor Express of 1819 he complained that: "The mass of useful books are not accessible to the poor... the tracts which pious persons distribute are exclusively religious, and the tone of them is often either fanatical or puerile. The "twopenny trash", as it is called [i.e. the working class radical press] has seen further ... into the intellectual wants of the working classes. It was just because there was no healthful food for this newly created appetite that sedition and infidelity have become so widely disseminated". Quoted in A.A. Clowes, Charles Knight, A Sketch, London, 1892, p. 33.

167. Brougham to the Marquis of Lansdowne, 19 August, 1828, quoted in Grobel, op.cit. (137), p. 103.

168. Quarterly Journal of Education, 1833, 9, 4. Quoted in Storella, op.cit. (38), p. 118.

169. Knight op.cit. (159), II, 58-65, 119.

170. Figures are from New, op.cit. (138), p.354.

171. The British Almanac, for the year 1828..., London,[1827?]. Title page and Preliminary Observations, p. 2.

172. Ibid, pp. 2,4. The 'moral phrase' is from the Calendar page for October.

173. The Companion to the Almanac, or Year-Book of General Information: for 1828, London, [1828?], p. 18; The British Almanac ... or [sic] the year 1829, London, [1828?] p.3.

174. The Companion... for 1828, op.cit. (173), pp. 21-2.

175. Ibid, p. iv.

176. Ibid, p. 179.

177. Grobel, op.cit. (137), p. 112.

178. Ibid, p. 104.

179. Storella, op.cit. (38), p. 122.

180. See Clowes, op.cit. (166), especially ch. III for Knight's early career.

181. Quoted by New, op.cit. (138), p. 354, from the Edinburgh Review.

182. Figures are from Storella, op.cit. (38), p. 123.

183. [G.L.Craik], The Pursuit of Knowledge Under Difficulties; illustrated by anecdotes, 2 vols., London, 1830-31, I, 4.

184. [Charles Knight], The Menageries, volume I, Quadrupeds, described and drawn from living subjects, London, 1829, pp. 1,6.

185. [Craik], op.cit. (183), I, 11.

186. Ibid, I, 53.

187. See Knight, op. cit. (159), II, 134-5.

188. [Craik], op.cit. (183), I, 18.

189. Knight, op.cit. (159), II, 152; [Knight], op.cit. (184), p. 7.

190. Quoted in Webb, op.cit. (1), p. 88.

191. Quoted in New, op.cit. (138), p. 349 from Edinburgh Review, 1826.

192. Brougham, op.cit. (18), p.32.

193. Quarterly Journal of Education, 1835, quoted in A.E. Dyson and J. Lovelock (eds.), Education and Democracy, London, 1975, p. 92.

194. [Charles Knight], A Short Address to Workmen on Combinations to Raise Wages, London, 1831, p. 11.

195. T.L. Peacock, Crotchet Castle, London, 1831; reprinted Harmondsworth, 1969, pp. 138, 158, 192-4.

196. From a cutting in the miscellaneous newspaper collection 745. d. 28, at the British Library, [1830?].

197. Bamford, op.cit. (120), I, 12.

198. London Magazine, op.cit. (56), pp. 591, 602-6.

199. British Almanac, 1828, op. cit. (171), p.2.

200. London Magazine, op.cit. (56), p. 600.

201. Ibid, p. 605.

202. Poor Humphry's Calendar, 2nd edn., London, [1829?], pp. 5, 8.

203. Thomas, op.cit. (11), pp. 352-3, says this was the case in the seventeenth century. Charles Knight attacked almanacs by comparing their weather predictions with other almanacs' predictions in Companion to the Almanac... for 1829, London, 1829, Part One, pp. 7-12.

204. London Magazine, op.cit. (56), pp. 601-2.

205. Bamford, op.cit. (120), I, 239-40.

206. J. Lawson, quoted in Thompson, op.cit. (5), p. 447; William Lovett, The Life and Struggles of William Lovett in his Pursuit of Bread, Knowledge, and Freedom, 2 vols., London, 1920, I, 5.

207. Bamford, op.cit. (120), I, 240.

Chapter Three: The Popularisation of Individual Sciences in Books

A. Sciences in the Early Nineteenth Century

Having examined the book trade and its connections with the popularisation of science in general in the early nineteenth century, this chapter will complement the previous chapter by examining the popularisation of individual sciences in books of the period. In order to make such an undertaking both manageable and meaningful four sciences only have been selected, natural history, geology, chemistry and astronomy.

Throughout the eighteenth century the distinctions between different parts of the scientific enterprise had been growing. By the early nineteenth century astronomy was clearly separate from cosmography, and chemistry from medicine and mechnical philosophy (although overlapping both to some extent). Geology was in the process of formation, from elements of theories of the earth, Wernerian geognosy, mineralogy, stratiagraphy etc, while natural history, as is shown below, was to a large extent divided up into zoology, botany and mineralogy. This increasing specialization means that it is not doing violence to the nature of science at this time to consider it in terms of separate disciplines.

The four sciences chosen have been selected for a number of reasons. Firstly, all were popular with the public in comparison to other sciences. Secondly, the four give a wide spread of contemporary science, in terms of their practical, theoretical and mathematical content. Thirdly, all were of particular interest at this time.

Chemistry was still going through the great reforms of Lavoisier and Dalton and was the scene of many important discoveries, e.g. galvanism and the alkali metals. In technology the application of the results of chemical science to bleaching and dyeing were the first major such uses of science. Geology, as has been noted, was in the process of formation into a recognisably modern form; astronomy, although having been transformed by Newton over a hundred years before, was still seeing major developments (e.g. the discovery of the first asteroids), while natural history was gradually splitting into the separate subjects of zoology, botany and mineralogy.

The relative popularities of these subjects with middle and upper-class audiences may be assumed to have been reflected in the number of books published on the different subjects. The following table lists the number of works located and examined on each subject (these figures are not absolute totals for works published on popular natural history, chemistry etc. but are an indication of their relative strengths):[1]

Subject	No. of works		
Natural history	114	Natural history in general	13
		Works on Botany alone	50
		Works on Zoology alone	37*
		Works on Mineralogy alone	14
Astronomy	44		
Chemistry	42		
Geology	27**		

Notes on the table:

* Including works solely devoted to entomology (9), ornithology (2) and ichthyology (1).

** Including two works on mineralogy and geology jointly.

One comment needs to be made about these figures. The distribution of publication dates over time varied significantly for chemistry, geology and (to a lesser extent) mineralogy. While total book production showed a fall in the years 1811-20 compared with that of the previous decade, followed by a large increase in the third decade of the century, this was not the case for these sciences. Chemistry, judged in terms of book production, was relatively more popular in the first ten years of the nineteenth century than in the subsequent twenty. Geology and mineralogy, conversely, were most popular in the last decade. This latter fact is fairly easily explained, geology was only 'made' as an independent science in the early years of the century, while mineralogy had previously been considered mainly under the label "natural history of the mineral kingdom". Chemistry's relative decline is not so easily explained and will be considered later in this chapter. First, however the most enduringly popular subject, or group of subjects, will be discussed, i.e. the various branches of natural history.

B. Natural History

The popularity of natural history, in its widest sense, in the early nineteenth century is attested to by more than just the book production figures given above. The new mineral collections at the British Museum attracted more people than almost any other section,[2] and even in the 1830s, when the initial flush of enthusium for the publications of the Society for the Diffusion of Useful Knowledge had to a large extent worn off, it was a publication on animal mechanics which revived the flagging sales.[3]

This popularity seems to have continued from the previous century. A modern scholar has suggested that there was a "vogue" for natural history in the years 1750-

70. Certainly the opening of a new Botanic Garden at Cambridge University, the growing tendency for seamen and travellers to make collections to sell on their return to Britain, and a comment in the Critical Review in 1763, that "Natural history is now, by a kind of natural establishment, become the favourite study of the time", suggests that the subject was favoured in the later eighteenth century.[4]

The interest in natural history was maintained into the new century, helped no doubt by the enthusiasm of the King and Queen.[5] In 1819 one author declared that "Botany has been for some years a favourite pursuit".[6] J.L. Knapp, however, expressed surprise in 1830 that "as reason and science dawn on mankind" so few people knew or were interested in natural history.[7] The explanation of this apparent paradox is suggested by Fenwick Skrimshire's statement of 1805 that botany "has been more applied to and has become a more fashionable amusement, than either Zoology or Mineralogy".[8] Natural history then, was not usually considered as a single subject but as the distinct sciences of botany, zoology and mineralogy; of these, botany was the most favoured. The majority of works were written on only one of the three. The very term "natural history" was in fact coming to be used as a synonym for zoology. William Mavor's Natural History and John Hinton's Elements of Natural History were two works which dealt solely with the 'animal creation'. Even those works which did claim to cover all three 'kingdoms' of nature usually devoted far more space to zoology than to botany and mineralogy combined.

Works which did cover animals, plants and minerals were often those written by men associated with Edinburgh. Skrimshire's Essays Introductory to the Study of Natural History (1805), for instance, included three essays on botany, one on mineralogy and six on zoology; he was a one-time president of the Natural History Society of Edinburgh. William Rhind, a member of the Royal Physical Society of Edinburgh, discussed meteorology, geology, zoology and botany in his Studies in Natural History

(1830). This inclusiveness may be explained by the fact that Edinburgh had been, and to a large extent still was, the centre of Enlightenment thinking in Britain, and it was a typical Enlightenment ideal to believe in and try to produce a unified science of nature. Edinburgh University, for instance, maintained a broad school of natural history into the nineteenth century, when many other institutions had much more fragmented curricula.

Connected with the idea of nature as a unity was a belief in 'a chain of being', with each organism allotted a place on an infinite ladder stretching from minerals to man.[9] This concept was often found in works of this period. Oliver Goldsmith (from whom many of the zoological and anthropological ideas of popular authors were taken, and whose History of the Earth was itself reprinted at least seven times in the years 1800-30) insisted that, in the animate world at least, "imperceptible gradations" existed[10]. According to George Graves "a connected chain ... is evident to every reflecting mind" and for Abel Ingpen one of the reasons for studying natural history was that it helped to prove the existence of:

"The mighty chain of beings, lessening down
From Infinite Perfection to the brink
Of dreary Nothing, desolate abyss!"[11]

This opinion could be found in even very cheap books, such as the sixpenny chapbook, Rural Walks in Spring. Every creature, the author wrote, had been fitted for their "respective destinations in the grand chain of creation".[12]

Despite these examples, however, disagreements existed between writers, particularly where the position of man in relation to the rest of creation was concerned. Natural history books would commonly include a discussion of mankind and his place in nature. Many authors referred approvingly to Buffon's belief that, regarding mankind and the "closest" species, the Orang Outang, the "interval which separates the two species is immense".[13] Interpreted on a strict 'chain of being' basis the interval between these species would not only be infinitely small but mankind itself would consist of creatures infinitely separated from each other from the lowest specimen of mankind to the highest.

Bynum has recently pointed out the inherently anti-Christian and anti-anthropcentric nature of such beliefs and has charted their gradual decline in early nineteenth-century Britain.[14] Most popular natural history authors accepted a view derived from Goldsmith that, although there were six distinct groups of men, all were descended from the same original parents. Thus a Linnaean belief in the uniqueness and fixity of species was combined with Buffon's concept of degeneracy to provide an explanation for the differences and similarities between the various peoples of the world, an idea similar to that later formulated by Cuvier for animal species.

Goldsmith's six classes of mankind, of which four had come from Linnaeus and two from Buffon, were: Laplanders, Tartars, Southern Asiatics, Negroes, Aboriginal Americans, and Europeans. The original parents had been European, claimed Goldsmith, proof lying in the 'fact' that white children are sometimes born to black parents, never vice versa; an argument by analogy with varieties of flower, which sometimes revert to their natural characters. Goldsmith's world view was indeed English-centred. Laplanders were "all equally rude, superstitious and stupid", negroes "stupid, insolent, and mischievous"; "our own country", however, bid "fairest for the pre-eminence". Some centuries of "kinder climate, better nourishment, or more civilised manners" would be necessary to reclaim the European nature of the other races[15].

Bynum suggests that the great chain of being was a metaphor of stability and would inevitably be disliked by reformers of all kinds, whether social reformers or evangelicals aspiring to moral reform[16]. Goldsmith, however, was not an evangelical or a moralist, and nowhere did he use the one-ness of mankind to argue for humane treatment for all races. In this respect he differs significantly from those authors writing thirty or more years later, in the early nineteenth century. To John Bigland for instance, negroes were not "indolent, mischievous, [or] revengeful... in any country where they enjoy liberty and good treatment". "Can we refrain from lamenting their hard fate, in being torn from their native country, and carried into perpetual slavery?", he asked, concluding that their "sufferings certainly demand a tear". Fenwick Skrimshire dismissed the possibility that men were related to the apes, and condemned the slave trade as "a commerce that must cause every feeling heart to sicken at the sight, or even at the recital of half its miseries".[17]

The one-ness of mankind and the separateness of the animal creation was a likely belief of moral reformers, therefore, but as the example of Goldsmith shows, it was not necessary to be a reformer to have only a fragmented belief in the chain of being.

The newly acquired emphasis on humanitarianism which pervaded much of the writings and actions of this period not only applied to the treatment of mankind (exemplified by the ban on slave trading in 1807) but was also applied to the treatment of animals. Malcolmson has documented the anti-cruelty movement, particularly as to its effects upon popular recreations.[18] Societies such as the Suppression of Wanton Cruelty to Animals Society (founded in Liverpool in 1809) and the Society for the Prevention of Cruelty to Animals (founded in 1824) were in the forefront of such campaigns, as were their supporters in Parliament. In the years 1821-26 at least one bill a year was introduced on the subject of cruelty to animals (usually concerned specifically with bull-baiting). Only one bill passed into law, becoming the 1822 Cruel Treatment of Cattle Act, and it was not until Parliament had been reformed to give a large middle-class say in the Commons that a more important and comprehensive Act, the 1835 Cruelty to Animals Act, was placed on the statute books.

Popular natural history writers emphasised very strongly that it was wrong to maltreat animals. Analogously to God's overlordship of man, man, "the lord of this terraqueous globe", should "imitate the example of the Deity by shewing kindness and humanity to every living creature".[19] This sentiment was sometimes taken to extremes, for instance in Cowper's poem, quoted by Joseph Taylor:

"I would not enter on my list of friends
(Tho' graced with polished manners and fine sense,
Yet wanting sensibility) the man,
Who needlessly sets foot upon a worm
..."[20]

To Knapp, cruelty to animals was "a compound of tyranny, ingratitude and pride".[21] Other writers published works specifically to condemn cruelty.

The keeping of animals as pets, although benefical in some ways, could possibly occasion cruelty. One book concerned with the subject emphasised the need for correct treatment of the animals, commending the approach of the author's own father: if any cruelty was shown the pet should be removed. This had been so successful that in four years none of the childhood pets had died of starvation ("although many through casual accidents, improper food, and other causes").[22] Such proselytizing was also directed at the poorer classes. A penny pamphlet published in London in 1809 and entitled Vocal Repository, A Word for the Dumb, being a collection of Choice Songs in Behalf of the Brute Creation, contained songs and verses on anti-cruelty themes, including Elizabeth Bentley's "Cruelty to Animals", and "The Goldfinch; Starved to Death in a Cage".

William Hone believed that a great change had occurred in the thirty years before 1825. The practice of making open wounds on the skin of asses of two or three inches in length, in order to make them easier to drive, no longer found favour. "A costermonger, now, would shrink from this", he wrote, "which was a common practice between the years 1790 and 1800". This change, even if real, was probably limited to the urban population, and especially to the metropolitan one. Traditional country attitudes, both the 'hunting, shooting and fishing' of the squires, and the unsentimental attitudes of rural workers and their families to animals probably remained largely unchanged. Certainly bull and bear-baiting and other blood sports survived well into the nineteenth century, and those which continued to receive support from the upper classes (fox-hunting, etc.) still flourish today. A fight between a lion and six dogs, organized by Wombwell, owner of a touring menagerie, in 1826 caused "universal disgust" in London, according to Hone, and yet it was attended by many spectators, who paid up to three guineas for the privilege, in the suburbs of Warwick.[23]

Bi. Zoology

As the various branches of natural history were usually treated separately in popular books in these years, it will be appropriate if they are discussed separately.

In many ways zoology, or, as it was often and significantly called, the "natural history of animals", was the most old-fashioned branch of natural history at this time. Many of the texts, for instance, relied both for form and content on Buffon's great Histoire Naturelle (Paris, 1749-1804) and Goldsmith's Animated Nature (1774). These two works cannot be compared scientifically, the latter being merely a compilation by a skilled professional writer, the former a great work of science, yet both were equally plundered for material by the popularisers.

The works would typically consist of an illustration of each animal (nearly always a wood cut, later often using the superior end-grain technique pioneered by Thomas Bewick); underneath, a text of varying length described the physical appearance of the animal, its habitat and its behaviour, usually in anecdotal terms. The anatomy or physiology of the organisms had no place in such a scheme, which may be clearly illustrated by reference to the works of such authors as William Bingley, William Mavor, Thomas Smith and Mary Trimmer.

The use of anecdotes, many of which found their way into more than one work, was specifically referred to in the titles of many of the texts, e.g. Bingley's Animal Biography; or, Authentic Anecdotes of the Lives, Manners and Economy of the Animal Creation and Mavor's Natural History ... with popular descriptions in the manner of Goldsmith and Buffon. Sometimes the anecdotes were drawn from the Bible, although usually this was when the works were to serve a religious purpose, e.g. the better comprehension of similies and to help authenticate the scriptures by proving the writers to have been where they claimed.[24]

Popular zoology was not, therefore, primarily concerned with keeping animals, although the occasional book on pets was published, and the many works on horse (and other farm animal) breeding would generally include such basic descriptions. Neither was collecting a part of the zoological tradition (other than in the sub-branches of entomology and ornithology). Rather it was an occupation to relieve the "tedium vitae" of the wealthy and unoccupied classes, or a relaxation for the intervals of leisure of those who had to earn their living. As Goldsmith wrote, "we must confess, that it is the occupation of the idle and speculative, more than of the busy and the ambitious part of mankind... an innocent amusement for those who have nothing else to employ them, or who require a relaxation from labour".[25]

This view of zoology as "innocent amusement", although culled from an eighteenth-century source, was still current in the early part of the next century. E. Donovan, for instance, expressed a wish that his Natural History of British Quadrupeds "may be equally applicable to the library of the hunting villa, and not unworthy of a place in the study of the naturalist".[26] The dedication of Thomas Pennant's British Zoology in 1777 to the Dutchess (sic) Dowager of Portland is at least matched by the permission granted to William Wood to dedicate his Zoography of 1807 to Queen Charlotte. The interest in the houses of the country gentry was undiminished.

All sections of this society were catered for. The poetry and literary flourishes ensured the acceptance of zoology as a part of literary culture by both the ladies and the gentlemen. The presence of information on different breeds of farm animals in some of these general natural history works showed that the gentleman as farmer was considered too.[27] The upper class ladies were particularly catered for by George Shaw's lectures at the Royal Institution in 1806 and 1807, which were intended as "a familiar discourse with Lady-Auditors"; William Bingley considered zoology "a study that seems well calculated to employ the female mind".[28]

Zoology was therefore literally old-fashioned, in that its form and much of its content was derived almost unchanged from eighteenth-century sources. It was also old-fashioned for an early nineteenth century recreation in the way in which it interested almost all sections of the community. It has already been noted that middle-class pursuits in this period became private rather than public, 'moral' and 'rational' rather than merely amusing. In particular, pleasure was condemned if it "occasion[ed] needless pain and misery to men or to animals".[29] Yet an interest in animals was spread throughout the community and its gratification often involved public display and cruelty. The middle classes found ways around these problems, so as to indulge themselves in the study of animals, as will be described below, but first the ways in which the lower classes satisfied their curiosity will be discussed.

Many chapbooks were published which described and presented crude illustrations of animals in a way which was very similar to (although of course much briefer than) the books for the wealthier classes. Many of these were designed specifically for children, but their presence in the chapman's pack when opened at cottage doors or at fairs, their illustrations and their simple wording meant that adults as well as children probably read them. Again like the works for the upper classes and like the content of most chapbooks, the texts (and even the woodcuts used) were probably the same as those used a good while before, in the previous century.

Natural history, however, was the main area in which Bewick's woodcuts were introduced into popular study. William Davison of Alnwick was particularly prominent in their use, and he published a series of chapbook natural histories, thirty-six pages long and priced at 6d. Many of the modern natural history chapbooks contained moralistic and exhortative comments similar to those in other children's works and in the adult natural history books for higher classes. Davison, politically liberal and reformist as he was, published works particularly stressing this, as in the Anecdote Book where Franklin, Simpson the mathematician, and William Herschel were all held up as examples of men who,by perseverance, reached success from humble origins.[30]

Occasionally animals appeared, particularly in works for adults, as omens. The oral culture of the past was rendered tangible. "If a hare cross you in the morning", ran one passage, "it is a sign of some loss, or sickness; but if it pass by on your right hand, it is a token of marriage and good fortune". A lamb or sheep was sometimes said to be a symbol of innocence. Generally, however, the treatment of animals was severely rationalist, superstitions and spirits being "only believed [in] by weak people".[31]

The curiosity of the lower classes was also provided for by menageries, both established and touring. Robert Huish listed nine different establishments in 1830, of which the most important were those in London at the Tower of London, at the Zoological Gardens in Regents Park and at Exeter 'Change, near the Strand.[32] The Tower of London menagerie, which claimed to have been in existence since 1465 for the reception of animals given to the Royal Family, charged 6d. for admission to see a grizzly bear, an elephant, some lions, and other assorted curiosities. William Hone claimed that almost every maid-servant in London had been to see the "beasties" in the Tower.[33]

Exeter 'Change, mentioned by Bingley and by Thomas Smith,[34] had a particularly fine lion (called Hector) and, in the 1820s, an elephant, which attracted large crowds. This collection was better looked after than that at the Tower, and the admission prices reflected this at 1s. 6d. or 1s. for two different collections of animals, 2s. for both.

Londoners could also see the touring menageries at fairs. William Hone described the Bartholomew Fair (held near Smithfield every September) of 1825. Atkin's, George Ballard's and Wombwell's menageries were all present as well as other penny animal shows. Of these, Atkin's he considered the best. From 10 a.m. to 9.30 p.m. one could pay 6d. and see tigers, lions, an elephant, zebras, owls, ostriches, etc., etc. "This sixpenny 'show'", Hone wrote, "would have furnished a dozen sixpenny 'shows' at least, to a 'Bartlemy Fair' twenty years ago".[35]

In the rest of the country it was also to fairs that one would go to see animals. Wombwell, claiming by 1828 to possess the only male elephant in the Kingdom, visited Nottingham and Leicester in that year. Messrs Seaman's Zoological Museum displayed:

> "Quadrupeds, birds, fishes, reptiles, insects, minerals, shells, fossils, and coins from every part of the world. Also the head of a Chieftain Warrior..."

"Admittance:	Ladies and Gentlemen	1s.
	Trades people	6d.
	Labouring People and their Children	3d."[36]

Special occasions could also see the publication of cheap pamphlets which contained similar information to that found in more expensive works. One such occasion was the performance of an elephant on stage at the Adelphi Theatre in 1829. Sent over from Paris, the elephant caused a great stir on its arrival and produced packed houses for its 'performances'. A penny pamphlet in the Universal Pamphleteer series commemorated this event and included not only the programme of the play and a transcript of the "humerous prologue" but also the "Natural History of the Elephant, with many curious anecdotes" copied, probably, from Goldsmith.[37]

Another occasion which united diverse sections of London society was the destruction of an elephant at Exeter 'Change. The elephant, which had previously been exhibited at Covent Garden, was shot by a corps of soldiers. The noise attracted a large crowd and after the destruction "the public were admitted (upon payment of the accustomed charge) into the room". Although the room had been flooded with blood "to a considerable depth" it was still "crowded till a late hour at night". These events were described in detail in at least two sixpenny pamphlets, one of which also included a short natural history of the elephant, although concentrating more on the sexual activities of the animals than would have been acceptable to middle-class readers. The claim that members of the crowd offered up to two guineas to be allowed to watch the killing, and the subsequent production at Sadlers Wells theatre of a play called 'Chuneelah: or, The Death of an Elephant at Exeter 'Change', demonstrates that the interest was not merely amongst uneducated and 'blood-thirsty' members of the working classes.[38]

Interest in animals, therefore, was socially widespread, but often had the characteristics of cock-fighting rather than of middle-class 'rational recreation'. Cruelty and 'vulgar' public display, to crowds containing all social groups, characterised much of it.

The middle classes could respond in two ways. They could either ignore zoology, and the fewer books published on this subject compared to botany suggest that it was sometimes considered unsuitable for study, or they could practice it 'correctly'. New animals brought back by explorers and travellers from all over the world could be marvelled at but in strictly controlled conditions.

Such controlled circumstances were created at the Zoological Gardens. Owned by the Zoological Society (founded in 1826), they were first opened to the public in 1827. Admission, however, cost 1s. and also required the signature of a Fellow of the Society. These conditions ensured the exclusion of the lower classes. Entrance was not too difficult to obtain apparently, for the Mirror of Amusement advised its mainly middle-class readership to visit the gardens which "are daily filled with fashionable company". More than their fashionableness and their exclusivity, however, the gardens were justified because they were not merely for "vulgar" display. Rather the animals were "to be applied to some useful purpose as objects of scientific research, not of vulgar admiration".[39] Needless pain and misery to animals could not possibly arise from such useful purposes.

The private study of books was another way in which the middle classes could interest themselves in animals, but only if it was not only morally harmless but positively beneficial i.e. if it succeeded in "uniting amusement with instruction".[40] It had to be "Rational Amusement", which in fact meant that it had to promote a realisation of the existence of God from a study of His creation. William Mavor wrote that he had "endeavoured to display [God's Works] in such manner as may excite the adoration of his rational creatures". "The contemplation of the works of the CREATOR is the highest delight of the rational mind", declared Abel Ingpen.[41] These are but two indications of the overwhelmingly religious context in which zoology was popularised. The recreation was rational because one was drawing a rational conclusion (that of the existence of God) from proper examination of his works. A man "who has spent his life in the study of natural history, and taken no pains to acquaint himself with the ends and designs of Providence in the oeconomy of the world ... is more devoid of true useful knowledge than the illiterate upright man, who... sees enough to lead him to pay his constant adorations and thanks to that great and good Being, who created and sustains this wonderful machine for his use", wrote William Wood.[42]

With the shift of emphasis towards vital rather than purely rational religion it was not enough to merely include natural theology to make a book morally acceptable. Popular writers on zoology attempted to link moral uses to the study of zoology. "When the enemies of Christianity are so industriously at work, and, it is to be feared, with fatal success, in poisoning the minds of youth by means of infidel books", wrote Sarah Trimmer in 1801, "[moral] utility has been my first and principal object".[43] This she hoped to achieve both by displaying the marks of design in the natural world, and by providing a short introduction to revelation. To William Bingley zoology "not only affords us a clear and comprehensive proof of the existence of an Almighty Being... but also furnishes us with abundant sources of observation, of reflection, and comfort".[44]

The behaviour of animals could teach moral lessons. Pets would, if observed, teach "Many useful lessons of morality and industry...[to] the little student of nature", while insects could teach many lessons "of industry and economy; virtue and morality; perfection in various arts, and even civil government" to the "collectors and residents in the country" for whom Ingpen's book was intended.[45] Quadrupeds, Wood declared, show instances of "sagacity, of faithfulness, of docility, and many other good qualities, from which mankind derive innumerable benefits".[46] The anthropomorphism of the authors was often extreme. To Mary Trimmer the sow was "[s]tupid, filthy, inactive, and drowsy, its life ... a round of sleep and gluttony".[47] According to the author of Jack Dandy's Delight: or, the History of Birds and Beasts the kite was terrible and cruel, a coward who attacked only animals weaker than itself. Many authors found good in unusual animals, as well as in dogs, horses, etc. which may have been expected. The lion, for instance, was pardoned his brutal behaviour, because its "anger... is noble, its courage magnanimous, and its temper susceptible of grateful impressions"."Next to man the elephant is the most sagacious animal we are acquainted with", wrote one chapbook author, describing the uses of the trunk, the animal's delight in music and its obedience.[48]

As with many other activities the study of natural history produced moral benefits merely from replacing other more dangerous pursuits but the other major reason given for its study was that one gained a knowledge of the utility of animals to man. The information is given in such a way, however, that one could not use it, but must merely learn it. Many of the children's chapbooks were especially interested in the usefulness of the creatures they described, sometimes producing a rather gruesome impression. The Book of Beasts for Young Persons, for instance, described a cow as the source of butter, cheese, cream, beef, leather, sugar (from its blood) and combs (from its horns) while vaccination also "comes from her aid" A sheep similarly produced wool, good flesh, leather for bookbinding, knife handles from its bones and violin strings from its entrails. Richardson's Natural History of Birds and Beasts contained the memorable description of a chamois as an animal which was "justly admired" for its elegant bounding vivacity, but also (and one suspects even more) for its ability to render up between ten and twelve pounds of suet.[49]

The reason for learning of the utility of animals was, to John Bigland, that otherwise "a person must often betray his ignorance and expose himself to ridicule", but more often it was intended to reinforce the moral and natural theological message. As Mavor wrote, it was:

> "To shew [sic] the economy of animated nature, and from a display of its beauty or utility to enforce that benevolence which is due to all creatures that have life - to lead from the contemplation of his works to the Almighty Parent

of them ALL - is our principal aim on this occasion".[50]

Such were the justifications given for the study of zoology, but in order to produce these moral and religious benefits the study had to be altered and added to. Apart from the obvious "interspers[ing] with religious and moral reflections", the primary object was to remove parts considered objectionable. Miss More wrote in her Strictures on Female Education that "[i]t is to be regretted that Buffon with all his excellencies is absolutely inadmissable into the library of a young lady, both on account of his immodesty and impiety". Goldsmith's History of Animated Nature has many references to a divine author. It is to be wished that some person would publish a new edition of this work purified from the indelicate and offensive parts", and William Mavor implied that he had written a work combining the excellencies of both works but the indecencies of neither.[51] Those parts of zoology "which might excite a blush, or contaminate" the "most delicate" mind[52] were not only the obvious ones of discussions of sexual reproduction, but anything which it was believed may have shocked the sensibilities of women or children. This included, dissection, discussion of internal organs, digestion, excretion, death, etc., etc., all of which Goldsmith discussed in some detail, although the parts considered too explicit were written in Latin.

Buffon's work was not only similarly comprehensive but was widely regarded as impious because of the lack of references to God and its antagonism to the Genesis narrative, a bigger mark against him than in the mid-eighteenth century.

Joseph Taylor was more concerned to render his work literary by interspersing his Anecdotes of Remarkable Insects with poetry, and it is clear that the rendering of zoology suitable for a wider audience rarely involved simplification (although George Shaw made a point of as little a parade of technical terms as possible in his

Royal Institution lectures).[53]

From the preceding discussion it might be concluded that unanimity had reigned over the presentation and content of popular zoology, but this was not so. Almost universal agreement existed upon the moral and natural theological functions of the study but within this framework not all authors concurred. With regard to natural theology there was a reflection of the contemporary state of the subject. Some writers assigned a greater role to it than others (whether it could prove the moral attributes of God or not, whether it supported the scriptures or was secondary to them, etc). Where Paley's natural theology had explained away evil, one authoress did not doubt its existence, yet "God, in all the evil which he permits to take place... has the ultimate good of his creatures in view".[54]

Classification was another area where there were different opinions expressed. Generally authors followed the six-fold Linnaean division into mammalia, aves, amphibia, pisces, insecta and vermes but his sub-division of mammalia was not so popular. In this division into seven orders, man, monkeys, and bats were classed together as primates. William Wood chose instead to follow Ray's classification of quadrupeds because of "the repugnance we feel to place the monkey at the head of the brute creation, and thus to associate him, as it were, with man".[55] Ray's division, as amended by Thomas Pennant in his British Zoology of 1768-70, was a four-fold one into hoofed, digitated, pinnated and winged quadrupeds. Goldsmith adopted another system as a middle way between "the dry and disgusting air of a dictionary" associated with the systems of Ray, Klein, Brisson and Linnaeus, and Buffon's total rejection of system. Refusing to say that "the bat is of the human kind... merely because there is some resemblance in their teeth" he classified animals as of the horse kind, of the cow kind, etc.[56]

Disagreement over the position of animals in the hierarchy of nature was also responsible for different authors beginning their accounts with different creatures, (although for those who considered man he usually came first, supposedly marked out by possession of Reason). In Thomas Bewick's work the horse had to come first because of "his stature, the elegance and proportion of his parts, the beautiful smoothness of his skin, the variety and gracefulness of his motions, and, above all, his utility" and Donovan continued his interest in farm animals by placing the sheep at the head of his work. For those for whom morals were more important than utility it was often the lion who received pride of place.[57]

Most authors continued to use the basic Linnaean division even after Cuvier's scheme with a vertebrate/invertebrate division had become known. George Shaw referred to the new system but excused himself from using it because it was more "forbidding [in] appearance to a general reader".[58] Linnaeus' division was also helpful for popular writers because it was a classification based on external appearances and could therefore be used and understood without having either to consider the internal workings of the animals or, worse still, having to dissect them. John Fleming, a fellow of the Royal Society of Edinburgh, criticised the retention of the "Artifical Method of Linneaus" and indeed its surplanting of previous, physiologically-based, systems.[59]

Two subjects related to zoology were entomology and ornithology, of which the former was more commonly written about by popular authors. In many ways it was intermediate to zoology and botany. As with popular zoology insects could teach lessons; the bee "present[s] us with a striking picture of the happy effects of industry, perseverance, and patriotism" one chapbook declared.[60] Anecdotes of insect behaviour, consideration of their utility, beauty and ability "to excite admiration of the power of the great Author of so many wonders" were all features held in common with zoology.[61] Entomology's affinity with botany lay in the formation of collections. William Wood's Illustrations of the Linnaean Genera of Insects included a preface on "The Method of Catching and Preserving Insects for Collections". Ingpen, Samouelle and Swainson all published similar works. Like zoology and botany, entomology and ornithology, although having lost the eighteenth-century concern with beauty rather than naturalness, shared a much greater concern with rarity and classification by external appearance than with the geographical distribution or internal anatomy of the specimens. From a discussion of zoology we may therefore move via this brief consideration of entomology to an analysis of that most popular of popular sciences, botany.

Bii. Botany

Popular zoology was in many ways more characteristic of eighteenth-century amusements than of nineteenth-century recreations, both in its content and in the wide social spectrum of its followers. Botany was much more suitable as a recreation of the middle classes, from the shopkeepers and tradesmen, up to the old established merchants, the newly rich manufacturers, members of the three professions and especially for the wives and children of these groups. All were searching for a rational and morally unimpeachable 'recreation'.

Botany was considered ideal for women to practice at this time. The image of women which the society fondly cultivated was of pure, delicate, innocent creatures interested in beauty above all else. The study of flowers in the countryside seemed to coincide with these ideals. Botany had other desirable characteristics. Like zoology it could lead to an understanding of the existence and nature of God. John Duncan thought it so suitable that he wrote a supplement to Paley's Natural Theology specifically concerned with it, and his Botanical Theology appeared in

1825. It was morally innocent, for had not Adam and Eve been created in a garden? asked Robert Thornton.[62]

Botany had definite advantages over zoology. Crucially, it was a practical subject. Practical zoology was hardly suitable for a lady, but also the mere reading of books was not desirable. Botany entailed actually being out in the fields, picking flowers, dissecting them, and forming collections or 'herbariums'. The popularisers emphasised this fact. "I beg leave to protest", wrote Thomas Martyn in his introduction to his own translation of Rousseau's Letters, "against these letters being read in the easy chair at home".[63] William Salisbury, himself a botanical lecturer, insisted that to learn botany the only way was "by reading in the book of nature". The author of Dialogues on Botany similarly encouraged the study of nature, claiming that the absence of plates was designed to force the student to study plants, not engravings.[64] Bingley, Hull, Venning, Pinnock and Wildenow were all authors who supplied instructions on forming herbariums.

The objects of study "offer[ed] themselves without expense or difficulty" and the apparatus necessary was simple and cheap; just a glass, a needle, a lancet or penknife, and a pair of scissors, according to Rousseau.[65] Botany was therefore cheap, intellectually undemanding and suited to practical, private study, either individually or in a family group, an activity fitting in very well with middle-class desires for recreation.

Neither was it a sensuous occupation, displaying the "power of the Almighty in the most agreeable and tranquil manner" and able to act as an "antidote to levity and idleness".[66] In addition it was classificatory, depending as it did on the Linnaean division into twenty-four classes of plants according to the number and length of the stamen of the flowers. Thus it had intellectual benefits for children, but the system was also ideal for the amateur botanist as the division depended solely on visible external characteristics. If the parts of fructification could not be seen under a simple magnifying glass then the plant was defined as being in class twenty-four, cryptogamia. After ascertaining the class and order (dependant on the number of pistils), the amateur botanist could, by learning generic and specific characteristics, determine the species of any unknown plant, "which last", wrote Robert Thornton, "is the object and end of botanical science".[67] Although most writers admitted that anatomy, physiology, distribution and utility of plants were parts of botany, popular botany emphasized identification and classification.

J.E. Smith, President of the Linnean Society and owner of Linnaeus' own collections, suggested another reason for the study of botany. It was, he wrote, "a motive for taking air and exercise". Botany's healthiness, encouraging, as it did, country walks (or, as Cannon has suggested, justifying them) was emphasised by many of the authors. Priscilla Wakefield, in her very popular Introduction to Botany, wrote that the study was "an inducement to take air and exercise" and therefore "contributes to health of body and cheerfulness of disposition". "A taste for these pleasures", wrote Robert Thornton, "will render the morning-walk at least as delightful as the evening ridotto".[68]

Botany was "elegance, delight, innocence and safety" unlike "other branches of natural history [where] cruelty, unpleasant sensations, and dangerous or noxious experiments, are scarcely to be avoided". Plants gave "little or no shock to the most irritable sympathies during dissection".[69]

The utility of plants was often mentioned, but as with zoology, merely to inform, not to allow one to use the knowledge. Those works which were concerned with practice were often those which displayed least interest in botanical terminology or methodology. Henry Phillips' History of Cultivated Vegetables was concerned primarily with the agricultural and medicinal uses of plants, but its botanical content was limited to the Linnaean class and order of each subject. Even those works written on gardening, e.g. Charles Marshall's Plain and Easy Introduction... to Gardening or Robert Sweet's Botanical Cultivator, included no botanical knowledge to help with the cultivation of plants, and this despite Sweet being a Fellow the Linnean Society. To Marshall botany had only a social use:

> "The knowledge of botany is not necessary to the business of a practical gardener, but it might be made useful to him, or at least a matter of amusement and relaxation, enabling him to be respectably communicative".[70]

Not all authors agreed even with showing the utility of botany. James Smith, for instance, decried this, and criticised those who "would permit their children to study botany, only because it might possibly lead to professorships, or other lucrative preferment". To Rousseau botany had "no other real use than that which a thinking sensible being may deduce from the observation of nature and the wonders of the universe".[71]

If botany possessed certain intrinsic advantages over zoology as a rational recreation, it was also comparatively easy to remove the unsuitable sections. Even though the Rev. Goodenough thought a "literal translation of the first principles of Linnaean botany is enough to shock female modesty",[72] all that was really required was the removal of references to the sexual nature of Linnaeus' system. Smith, Banks, Phillips, Wakefield and other authors did just that, but not all writers thought it necessary. Robert Thornton's Juvenile Botany included this passage:

> "Son - Is there anything indelicate in learning that plants are male and female?

Father - The constitution of nature being the appointment of an All-wise and All-mighty creator, there can be no impropriety in such knowledge".[73]

The popularity of Rousseau's Letters, despite their neglect of God, indicates the peculiar mixture of Enlightenment, Romantic, and evangelical attitudes to nature found in popular botany. The morality and decency insisted upon derived in large part from the evangelical upsurge in society, yet the weight of natural theology and the emphasis on the "beauty, order, regularity, and inexhaustible variety" of nature are Enlightenment views,[74] metaphors of stability and rationality in the universe. The popularity of Erasmus Darwin's poems in the early 1790s, despite his identification of stamens and pistils with men and women, was yet another view of nature, nature as wonderful and inspiring. The change was coming, however, and the failure of Darwin's evolutionary Temple of Nature (published posthumously in 1803) to win public approval was an indication of increasing piousness,[75] as was the publication by Francis Rowden of a work in 1801, A Poetical Introduction to the Study of Botany. In this Rowden again identified the parts of fructifcation with men and women, but now the parts of the flowers were more usually brother and sister, mother and sons etc. rather than lovers.

An attitude of semi-worship of nature still clearly struck a chord with many of the wealthier classes. This was especially so at a time when the northern industrial towns were expanding so rapidly. Their dirtyness, indiscipline and expansion seemed threatening to many of the rural middle classes. London, the great wen, was also threatening, the size of the population allowing anonymity to the working classes and a consequent impossibilty of social control. London was also the centre of "fashionable society", which to many of the rural middle classes was as morally corrupt as the pastimes of the "lower orders". These attitudes were expressed in many works on popular botany. James Smith, for instance, quoted Rousseau approvingly that "when science is transplanted from the mountains and woods into cities and worldly society, it loses its genuine charms, and becomes a source of envy, jealousy and rivalship".[76] Smith himself left London in 1796 and retired to Norwich, taking the Linnaean collections with him and leaving the Linnean Society to lie almost dormant until his death thirty years later. Robert Thornton also thought that "It is not without a sigh that a thinking man can pass by a lordly mansion, the sweet retreat deserted by its falsely-refined possessor, who is stupidly carousing in some tavern of a polluted city".[77] Here is the expression of the feelings of the rural gentry, the Tory feelings embodied by Jane Austen in Mansfield Park, of love for the country and hatred (and fear) of the towns, particularly London. Many of the botanisers of the early nineteenth century were obviously of these classes, or of less priviliged groups who shared the same ideals, and most were women and children. Many women wrote on the subject (e.g. Sarah Filton, Mary Venning, Priscilla Wakefield and Maria Jackson) while the children were perhaps often like those in Botanical Rambles, for whom "the green-house and flower-garden took up their attention... a favourite gold-finch, doves, and pet-lamb were caressed and fed; the poor in the village ... were enquired after and called upon".[78] These levels of society had presumably also botanised in the eighteenth century, and it seems that as much as the new middle classes took up old hobbies and made them "virtuous", the 'old' middle classes also felt in need of moral justification for hobbies which had not required it half a century before.

The rural aristocracy was as likely to be interested in botany as the rural middle classes. George III and his wife, Queen Charlotte, were both interested in such matters, the King enlarging Kew Gardens and being an "improving" farmer, while the Queen's interest in botany may be assumed from the dedication of a number of Thornton's works to her. Even the Prince of Wales subscribed to Rowden's poetical work.

Members of the working classes were sometimes interested in botany, particularly the hand-loom weavers. J.E. Smith wrote of a school of botanists in Norwich in the eighteenth century which had included journeyman weavers and tailors,[79] while the Spitalfields weavers were described as having been, in the eighteenth century, "almost the only botanists of their day in the metropolis" as well as "the first entomologists in the kingdom".[80] These activities continued into the nineteenth century, by which time "Natural History and especially botany was the hobby of a number of Lancashire men, particularly in and around Manchester".[81] William Johns wrote in 1826 that in "Rochdale there has long been a Botanical Society composed chiefly of labouring mechanics".[82] Samuel Bamford, whose Lancashire work-fellows of 1844 showed "a [great] number of botanists", described a conversation with a friend, aptly named Plant, on "botany" which leads one to believe that such study was as connected with folk beliefs and herbal remedies, as with modern systematisation. Plant believed in "the virtues of herbs under certain planetary influences, and in the occult mysteries of Culpepper [the herbalist] and Sibley [the astrologer]". The conversation centered on "the occult virtues of herbs, and their connection with the spiritual and planetary worlds".[83]

As with animals, plants in folk culture were more than a merely physical entity. It has recently been noted that, before the Romantic poets, flowers appeared in literature always linked to human or symbolic themes,[84] but this symbolism was more than mere allegory. It showed a belief in the sympathies of every part of nature for every other. Thus, according to Culpepper, infusions of all red flowers would help stop bleeding. Plants could play roles in predicting and even forming the future. The Closet of Mother Bunch, Newly Broke Open was one chapbook which included mention of the powers of plants. Hemp seed, thrown over the shoulder, if accompanied by the recitation of the correct verse, would produce a visit from one's true love; a herbal cake of rosemary, bay, thyme, marjoram and southernwood had similar powers if treated properly.[85] The plants often had to be picked at an astrologically favourable time, another indication of the mysterious but real connections believed to exist between all parts of the universe, including man himself.

Such beliefs were by no means confined to the lower classes, however, and just as astrology found powerful and rich patrons the lavishness of some of the herbals which have survived from this period indicate wealthy customers. Culpepper's Herbal, for instance, (reprinted nine times between 1800 and 1830), was published as a leather bound quarto volume in 1815. All the herbs were listed with "a display of their medicinal and occult qualities". The devotees were possibly also rural, for as the London Magazine lamented in 1828, "agriculturalists are certainly still somewhat wedded to old customs and opinions".[86]

Formal popularisations of botany came under increasing attack for their continued use of the Linnaean artifical system of classification, and for their emphasis on classification rather than physiology. As in zoology a new system, that of Jussieu, came to be recognised by orthodox botanists, and particularly by those associated with medical practice or Edinburgh University, as superior. In addition the search for a natural system of classification was revived, after having lain dormant for a number of years. In the eyes of these natural philosophers the popularity and usefulness of the Linnaean system was holding the science back. James Drummond MD criticised works which taught only the Linnaean classification,[87] while James Smith (who had studied medicine at Edinburgh and was first president of the Natural History Society of Edinburgh) was one of the first, and most influential, authors to introduce a discussion of Jussieu's system into a popular or elementary work. Smith also emphasised physiology rather than mere systematisation and received increasing support for this view in the 1820s from, amongst others, the authors of

<u>Conversations on Vegetable Physiology</u>, the <u>British Botanist</u> and <u>Dialogues on Botany</u>. All promoted what the latter called "the really instructive parts of the science - the physiology of plants, and the progress of vegetation".[88]

As with Cuvier's scheme for animals, however, Jussieu's was not common even by 1830. This was for a number of reasons. It was new, it was French, it was unsuitable for the casual investigator, particularly so as it could not be successfully practised with a simple magnifying glass. In addition it was more complicated and could "never supersede Linnaeus, to a beginner".[89] It was also, with its concern with internal differences, out of step with the attitudes of current English science (and, indeed, society) which cared more to classify both people and objects by their external clothing than to investigate their nature any further. As Jussieu's and Cuvier's systems did get accepted by the natural philosophers the gap between popular and serious (even if still amateur) science widened considerably.

<u>Biii. Mineralogy</u>

Popular entomology shared many of the features of popular zoology and botany, and in some ways popular mineralogy was intermediate to geology and botany. It became popular from about the end of the first decade of the nineteenth century, if judged in terms of book production. By 1819 John Mawe wrote that it "has of late become so fashionable, that almost every one who visits the coast has been employed in searching for these pretty productions, and forming collections of them",[90] and the immense success of his introductory work gives credence to this claim, no fewer than ten editions having been published in the next nine years. Seaside holidays, increased work on canals and increased mining all exposed the earth more to the public gaze.

Interest created a demand for instruction "of which", according to William Phillips in 1816, "there was an almost total deficiency in this country, until very lately". Now, however, instruction could be obtained at the Royal and Surrey Institutions, from Mrs Lowry or Mr. Webster, or in crystallography from Mr. Larkin of Gee Street.[91] One could also buy specimens and models. John Mawe was the proprietor of one such shop in the Strand where ready-made collections, each specimen labelled, "may be obtained at a cheap rate", i.e. from two to ten guineas. Mawe also sold small cases containing all that was required for a walking tour, including hammers and, as he particularly stressed, proper bottles for acids (i.e., presumably, with ground glass stoppers).[92]

Mineralogy was obviously, therefore, like botany, a practical hobby involving collecting, although whether it was merely a collection of pebbles from the beach or samples of rocks was up to the collector. Collecting, a long established British hobby, was in many ways, when applied to nature, a symbol of man's ability to control rather than be afraid of nature. Classifying and collecting nature involved displaying the rationality behind the seeming chaos of the natural world, an Enlightenment view which had very little in common with belief in the mysterious interconnections of every object. Mineralogy, if anything, was a better field for collecting because of the lack of necessary preparation or, more crucially, of preservation techniques to ensure a good collection.

Collecting itself was also morally justifiable. A character in Mary Venning's Rudiments of Conchology says that in his youth he had "made a collection [of shells], more with a view to my improvement than with the design of possessing a number of rare shells", and William Bingley noted the greater moral emphasis in collecting of recent years: "blind curiousity, which formerly was the principal motive in making collections, is now giving way to more noble and more estimable ideas."[93]

Both private and public collections were very common. In London the British Museum was a centre of attraction. With the purchase of the Hatchett collection in 1799, and more especially of the Grevill collection in 1810, (valued at over £13,000), the museum obtained the finest mineralogical collection in the world. Charles Konig, the mineralogist, was appointed Keeper in 1813 and he subsequently acquired Van Moll's collection. The rise in attendance figures for the museum (from nearly 12,000 in 1805-06 to almost 100,000 in 1830-31)[94] and the frequent references to the collections in the literature shows their popularity. Arthur Aikin, in his 1813-14 lectures to the Geological Society, said that he had seen many of the rarer specimens at the Museum, while Mary Venning's Rudiments of Mineralogy was subtitled, "designed for Young Persons, with references to the collections of minerals in the British Museum".[95] General natural history museums also existed in London, e.g. the London Museum of Natural History at the Egyptian Hall in Piccadilly. Nor was it only London which had museums. According to Venning "many of the provincial towns are forming collections",[96] and both Robert Bakewell and John Mawe particularly recommended the museum at Matlock in the Derbyshire Peak District.

Popular mineralogy fitted into the prevailing world view of the middle classes in other ways. The detailed classificatory schemes of Werner and Hauy possessed an equivalent paedagogical value to Linnaeus' botanical system, and their reliance on external characteristics tied in with the growing empiricism of the period.

References to holidays at the sea, to two guineas or more spent on collections and to museums, most of which would have had, like the British Museum, restrictive entry policies, all indicate in which sections of society these books found their audience. Mineralogy was suited to ladies "who, since their attention has been invited to scientific subjects by the establishment of public institutions equally fitted for the instruction of both sexes, have cultivated Mineralogy with great ardour".[97] But it was also suited to, and more so than botany, those "young persons whose usual abode is in a town". It ensured that "their occasional excursions into the country and to the seaside [would] be productive of knowledge as well as pleasure".[98]

Mineralogy's other benefits, compared to botany and zoology, were that it was new, made possible for the first time only by the growth of travel and of holidaying at the seaside, and that it involved neither cruelty nor even a sexual system of classification or anything else which would have required censorship. Lastly, and perhaps most importantly, it was associated with the recently developed belief in "a moral, almost religious quality" of landscape, as Plumb has phrased it.[99] In its form it was therefore very like botany, as a middle-class recreational science, but in its subject matter mineralogy was like geology, concerned with the hills and vales all around and with the earth beneath.

C. Geology

Geology was more provisional and unstable than botany or mineralogy and yet, paradoxically, made greater claims of authority. Linnaeus' artificial system in botany merely provided a framework for classification, making no claim to be a reflection of reality; geology provided theories of events in the past. In this way it was not only accidentally controversial, but inherently so. The formation of such a science, possessing as it did many of the features of modern physical science, was not accidental, but to a large extent consciously carried out. This process may be traced back into the seventeenth century, but major changes occurred in the early nineteenth century which 'made' geology, and these were promoted most vigorously by members of the Geological Society of London founded in 1807. Members emphasised the distinctiveness of their new empiricist and non-speculative attitudes from the all-embracing system builders of the past.[100] "Persons have been called Geologists", wrote William Brande, "who, gifted with prolific imaginations, have indulged in fanciful speculation... Others, by careful, diligent, and extended observations of the present state of the earth's surface, have endeavoured, in the path of induction, to trace the nature of the agents which have once been active... If they frame theories, they do so upon the results of actual research; if they indulge in speculation, they assign to it its proper place."[101]

Associated especially with Edinburgh University graduates this empiricism was also mixed with a belief in the natural progression and development of sciences, anticipating the positivism of Comte. Geology's time was widely considered to have come, e.g. by Robert Bakewell, who wrote that the natural order of sciences was astronomy, mathematics and mechanical philosophy, chemistry and then mineralogy and geology.[102] Francis Jeffrey wrote in the Edinburgh Review that a theory of the earth was not yet possible because "to so short a distance are we yet removed from the period when mineralogical phenomena first derived explication from chemistry".[103] Thus theories such as those of Werner and Hutton were speculative, but empirical geological investigation, using mineralogy as the "alphabet" of geology to facilitate "the more difficult, and more important study of the science of geology" was necessary and desirable.[104]

Despite these features, geology had many possibilities as a polite recreational science. It was practical, outdoor, fairly easy to understand and associated with the growth in travel; it could be considered as polite knowledge and it could be practised by both sexes. One could choose to read of it in books or practise it the country, whether collecting fossils, finding and collecting rock samples or identifying the strata. In addition it was associated with the growing appreciation of landscape, particularly the wild and desolate hills which had previously been feared rather than appreciated for their beauty. Appreciation of the landscape was often linked by authors to worship of God, as in the verse of Robert Montgomery:

"... Long may I remain the adoring child
Of Nature's majesty, sublime or wild;
Hill, flood and forest, mountain, rock and sea,
All take their terrors and their charms from Thee,
From Thee, whose hidden but supreme control
Moves through the world, an universal soul."[105]

Mountainous landscape was considered to have the strongest effect. "A country destitute of mountains, may be rich, well cultivated, elegant and beautiful, but it can in no instance be grand, sublime or transporting", wrote one author.[106]

Geology was suited to natural theology above all other "part[s] of natural knowledge ... awaken[ing] in us the most profound sense of the excellence and perfection of Nature's works" wrote William Brande. "It is a study which opens to the traveller new sources of amusement and delight, and amidst the sublime imagery of a mountainous district, the feelings naturally exalted, are yet more raised and refined by the contemplation of its uses and subserviency to life".[107]

Geology, a suitable recreation for the middle classes, also had attractions for the upper classes. Described by J.F. Campbell as "the hunting of ice-marks", it could be "combined with other sport, [for the] spoor leads to the haunts of grouse, deer and ptarmigan; to grand scenery and to regions of fresh air".[108] Interest in its uses by the upper classes was suggested by Robert Bakewell's advertisement to "noblemen and gentlemen" offering analysis of soils, stones, minerals and metallic ores "and the uses to which they may be most profitably applied".[109]

The "attention of the public mind", however, was "directed to Geology, to a degree, and in a manner, entirely unknown in former times", as an anonymous author wrote in 1826,[110] for other reasons. Geology was more than just another mineralogy or botany, and this caused the explosion of interest in it which occurred in the 1820s and continued, with the publication of Lyell's Principles, into the early Victorian era.

Firstly the different nature of geology, as it was 'made' in the early nineteenth century, attracted people who would not have been interested in purely recreational sciences. Geology was progressive, concerned more with discovering new facts than with merely fitting observed objects into a pre-existing and comprehensive classificatory scheme. Lacking such a system it did not have the paedogogic advantages of botany or mineralogy. It was also a science which dealt in unobservables, objects and events buried physically in the ground and temporally in the past. This historical nature of geology meant that it was theoretical, and consequently liable to alter as new discoveries were made, despite the empirical claims of its main practitioners. In many respects it was more like the chemistry or natural philosophy of the period.

Those who took an interest in geology and joined the Geological Society, (which, at first at least, was open to anyone) and yet were not of the inner core of dedicated researchers, felt attracted by such a science. In the provinces the membership of the Society, other than scattered medical men, clergy, landowners or inhabitants of University towns, centred on the mining areas.[111] It was not however, the mine-owners themselves, seeking economic benefits from the science, that joined. Rather it was the 'progressive', largely reformist, often dissenting, provincial middle class of manufacturers and merchants.[112] Such people liked an activity which had an aura of economic usefulness, which was embued with a masculine image, derived from its practice in rugged country, chipping samples of rock from the mountains etc., and which, above all, claimed to contribute something to man's knowledge. Influenced strongly by the attitudes of Edinburgh as many of these northern provincial classes were, they would have agreed with the Edinburgh Review that geology was "[not] to be acquired, either in lecture rooms or cabinets", nor without a general knowledge of natural philosophy and mathematics. Geology was, they believed, a serious subject, requiring expertise and producing results worthy of the effort spent in its study. It was indeed a "more difficult, and more important study" than botany or mineralogy,[113] and this was welcomed by many members of the provincial middle-classes, in whom the Protestant work-ethic was firmly lodged.

Secondly, the truth claims of geology meant that it could serve as the battle ground for a dispute (mainly within the Anglican Church) between the more fundamentalist believers and the more liberal. The position and importance of natural theology had come under attack in religious circles from evangelicals in the late eighteenth and early nineteenth centuries; with geologists disputing a literal interpretation of Genesis, the religious fundamentalists had many of their fears confirmed about the inadvisability of natural theological argument, particularly if used as a crucial factor in support of a belief in the scriptures. A group of "scriptural geologists" arose who disputed the ability of empirical investigation to determine the true history of the earth, and relied on interpretation of the scriptures as the source of truth.[114]

'Mineral Geology' was criticised by one of the scriptural geologists, Granville Penn, for going beyond the bounds of induction, as practised by Bacon and Newton, when it attempted to investigate Creation or the Deluge.[115] George Bugg, while he denied that geological discoveries did in fact disagree with the Bible, warned that "If the Bible and Geology disagree it is utterly impossible for any man to indulge in "speculating" upon Geology, without directly or indirectly violating that respect and submission which the "word of God" requires".[116]

Against such mosaical geologists argued writers such as Thomas Chalmers and John Bird Sumner.[117] Both biblical hermeneuts, i.e. showing willingness to alter their interpretation of the Bible, it was the Scottish evangelical Thomas Chalmers who first suggested that an interval perhaps existed between the original creation of the universe and the six days of Genesis in which the physical formation of the earth occurred. He suggested this in his article on 'Christianity' in the Encyclopaedia Britannica in 1814, later published separately in a revised form. Sumner, a 'moderate' evangelical and future Archbishop of Canterbury, suggested in his Treatise on the Records of Creation that Moses had only declared three things about the history of the earth. These were that God created all things, that at the world's formation all was chaos and confusion, and that no more than 5,000 years ago the earth underwent the catastrophe of the Flood. Other than this the Bible was silent, and Sumner suggested that perhaps previous worlds had existed from the ruins of which this (also temporary) one had been built.[118]

That this debate was inside religion, and not between religion and science, is clear. Indeed that Sumner and Chalmers were both evangelicals displays the impossibility of ascribing opinions to one group, or describing one group as 'for science' or 'against science'. Sumner insisted on the necessity of faith in Biblical records, otherwise God "remains the inactive deity of philosophic theism", yet for him "the real use of Natural Theology is to show the strong probability of that being true which Revelation declares",[119] an idea which to those who emphasised 'faith' rather than 'reason' would have been anathema.

The battle between these groups continued into the 1830s and 1840s and its course and decline has been described by Millhauser. Its influence in popularising geology was important, as Millhauser has written:

> "The 'geologizing' young person ... was an educated, and to some extent a class, phenomenon; we do not often find him among the chapel congregations, the purchasers of Keepsakes and the less demanding sort of homiletic literature. But these too counted for something in the formation of public opinion, and what little they knew of the science... they had probably learned incidentally to their religious interests."[120]

Geology was popularised in forms suitable for all three groups, i.e. those who saw it as another polite recreational science, those who saw it as a serious and worthwhile study (although not necessarily studying it all that seriously themselves), and those whose interest in it was mainly concerned with its religious implications. Although the groups overlapped, distinct differences existed in the nature of geology presented.

Mary Venning, in her polite exposition of mineralogy, saw geology as the "science which teaches us to distinguish the masses of which the earth is composed".[121] Geology was not historical, not theoretical, not concerned with fossils etc. Compare this with Robert Bakewell's definition of geology, as:

> "knowledge of the structure, composition, and arrangement of the materials which form mountains, rocks, or strata, ... [of] the changes which are taking place on the surface of the globe ... [and] an investigation of the causes that have probably operated in the formation of rocks and mountains, and also those by which the revolutions of the earth's surface have been subsequently

effected".[122]

Bakewell was a populariser of geology as the members of the Geological Society would have recognised it, although not actually one of their number. Conversations on Geology also contained a historical definition of geology, as that "which treats of the first appearance of rocks, mountains, valleys, lakes, and rivers; and the changes they have undergone from the Creation and the Deluge, till the present time".[123] As the last phrase suggests, this work, although a polite popularisation in many ways, was designed to popularise Penn's scriptural theories, which of course were themselves concerned with historical events. Polite popularisations therefore emphasised the factual nature of geology, others its historical, and therefore inevitably speculative, nature. This last was played down by the popularisers who were members of the Geological Society or subscribed to the general attitude of its members, because they wished to separate themselves from the theories of the earth which earth science had recently been concerned with. In particular the Wernerian versus Huttonian debate current in Scotland through much of the early nineteenth century was to a large extent ignored by the English school.[124] William Phillips, for instance, a member of the Society, wrote in his Outline of Mineralogy and Geology (1815) that geology was "altogether modern, as a science" and consequently it was too early to formulate a true theory of the earth.[125] John Mawe similarly declared that although he used Wernerian terminology he did not accept the theory, nor made an "attempt to account for the manner in which they [i.e. rocks] were produced". "It is by no means improbable", he wrote, "but that many more varieties will be ranked in this formation, [i.e. the Secondary Formation] when our ideas become unfettered, and our reason has fair play, in opposition to theory, which it is now the fashion to follow".[126]

Polite popularisations were more likely to present the choice as between Werner and

Hutton, probably because their grand theories were more interesting to the imagination of the general reader. William Brande, although himself a member of the Geological Society, still explained the Wernerian and Huttonian theories in his lectures to a general audience at the Royal Institution in 1816, and he gave a cautious approval to Hutton's ideas.[127] Again Conversations on Geology, which particularly emphasised the Romantic nature of geology, also stated the choice as beween Werner, Hutton or Penn, a fitting combination for a polite popularisation of mosaical geology. John Mason Good, in his pious popularisation of all the sciences of nature, The Book of Nature, (1826), expressed a clear preference for Werner's theory because, he thought, it agreed with the scriptures.[128]

One last topic upon which different opinions were expressed, and which again can be linked to a certain extent to the audience aimed at by the popularisers, was diluvialism. It was generally accepted in the late 1810s and 1820s that the earth had suffered a number of catastrophic revolutions, following the theories of Cuvier. Diluvialists usually identified the last of these revolutions with the biblical flood. (Scriptural geologists, of course, accepted the Noachian deluge as an indisputable fact and rejected Cuvian theory).

Mary Venning's polite popularisation suggested that fossil plants were remains from pre-diluvian times.[129] The general opinion of the 1820s seems to have been that new evidence supported identification of the last catastrophe and the deluge. William Pinnock's Catechism of Mineralogy of 1821 claimed that "the most patient and accurate examinations... added to the discoveries made by modern voyages and travellers, afford every reason to believe that the earth was for a considerable time wholly overflowed with water"[130] and a letter from 'A.B.' published in the Gentleman's Magazine of 1823 agreed. That "Noah's flood was universal", it read, "... I think, from appearances and discoveries upon different parts of the globe, ...

cannot now be doubted".[131] John Scafe expressed a similar view in his verse introduction to geology.[132]

William Brande was again slightly agnostic, saying just that secondary rocks "seem to have resulted from some great catastrophe, probably the deluge, tearing up and modifying the former order of things".[133]

John Mawe and Robert Bakewell both followed the non-controversial line of many of the Geological Society members by discreetly avoiding comment, but William Phillips boldly claimed that "an universal inundation" had occurred, which must have required "the miraculous intervention of the great author of Nature".[134] Also a diluvialist, as well as a leading geologist of the time and a leading Biblical hermeneut (and also an Anglican minister), was William Buckland. Although he changed his mind in the 1830s, Buckland's belief in the reality of the flood also demonstrates the complexity of the religious and geological ideas disseminated in popular geology of this time. Buckland and Cuvier were the particular theorists of so-called "mineral geology" to which Penn opposed his "Mosaical geology" and yet both Buckland and Phillips thought some form of deluge had occurred.

Geology was popularised in this period to a wide social spectrum, although mainly to the wealthier classes. The actual nature and content of the subject depended to some extent on how it was popularised. As a polite recreational science the emphasis was on the ahistorical and romantic features of the science; as a serious knowledge-producing subject its possibilities for natural theology were still emphasized but there was a tendency to avoid controversy and to play up the empirical and technical nature of the study; and as an arena for an attack on biblical liberalism and natural theology the emphasis was on the contrasts between the historical theories of mineral geology and the description of the history of the earth given in the Bible.

D. Chemistry

Geology has been considered immediately after mineralogy because of the strong connections between the two, not only in subject matter but in the writers who popularised the subjects. Chemistry, however, was chronologically first in public esteem. The first decade of the nineteenth century saw a great increase in interest in chemistry amongst the general public, and although it was not sustained at the same level throughout the period, it still ranked high in the public estimation in 1830. Even if to say it was "universally esteemed a quite essential branch of liberal education", as John Smith MD did,[135] was an exaggeration, it was true that it was, as Richard Stack wrote, "frequently matter of discourse in polite and well educated societies".[136]

This was shown by the increasing tendency of British writers to publish elementary texts. In the later eighteenth century those who wished to learn chemistry depended upon foreign, usually French, works either in the original language or in translation. As Thomas Thomson noted in the Preface to his System of Chemistry, Macquer, Fourcroy, Chaptal, Lavoisier and the Dutchman Boerhaave had all been translated, while no eminent British philosopher had, in recent years, published an elementary text. The System of Chemistry was designed to rectify this, containing "a full detail of the vast number of facts which constitute this important science, blended with the history of their gradual developement [sic] and of the theories which have been founded on them", and being more complete even than Fourcroy's six volume Systême des Connaissances Chimiques (Paris 1801-02).[137]

Although chemistry was never the basis of religious dispute it was, like geology, popularised to three main groups. In this case, however, it was to professional (i.e. medical) students, general readers and children.

Many works were published for the medical student because, especially at Edinburgh, the medical student studied chemistry as a part of his course. Thomson's System was of this kind, William Nisbet produced a General Dictionary of Chemistry which was for the use of students and contained many medical entries, and later William Brande published a book designed for the use of medical students at the Royal Institution. E. Turner MD, who lectured first at Edinburgh, and later at the newly opened London University, published a work for those who were attending lectures.[138]

The distinction between works for the general reader and elementary works for medical students was usually not very large, although Fenwick Skrimshire's Chymical Essays was, he insisted, "not to be considered as a strictly scientific work, but ... [for] the class called general readers, by which is meant, those who are desirous of an acquaintance with various literary and scientific subjects, without entering into the minutiae of any science".[139]

Thomson's System, comprehensive as it was claimed to be, still supposed "no previous knowledge of chemistry".[140] James Parkinson's Chemical Pocket-book, as well as being "for the occasional reference of the professional student", was calculated to be "an agreeable pocket companion for the lovers of Chemistry in general; and more particularly for those who may be just engaging in the study of this most useful and interesting science".[141]

The general audience was sometimes hoped or claimed to be very wide. Walter

Weldon wrote for the "laborious mechanic" as well as for the "amateur, or the female reader", all of whom may have been put off by "the expense, and labour, of three or four volumes".[142] Samuel Parkes was the only author who wrote specifically for "the superintendents of manufactories",[143] but Andrew Ure hoped his Dictionary of Chemistry of 1821 would interest manufacturers, medical students and general readers, while Colin Mackenzie claimed he wrote for chemical students, manufacturers, political economists, heads of families and artisans.[144] Works for children included Parkes' Chemical Catechism, Marcet's Conversations on Chemistry (for girls) and the plagiaristic version by Jeremiah Joyce, Dialogues in Chemistry (for boys). Parkes' work was "especially ... [for] those parents who are not qualified by previous acquirements, to instruct their children in the elements of this science, than which there can be nothing more essential, in whatever line of life they may be destined to move".[145]

Children's works came in the usual dialogues, grammars etc; the general reader could choose "popular essays", pocket-books or, like the student, elementary treatises or dictionaries. Some works claimed to be elementary and advanced, by using small type or foot-notes for the detailed information. Ure and William Ottley both suggested orders of reading in order to transform their dictionaries into elementary introductions.

The main features which distinguished books for medical students from those for the general reader or amateur student were those of comprehensiveness, and consequently, of size and price. Thomson's System had four octavo volumes and cost 36s. in 1802, and it had five volumes priced at £3 by the third, 1807, edition. Similarly the translations of Fourcroy and Chaptal which were used by students at the beginning of the century had three volumes each. Repeated editions of these works (e.g. Thomson's System reached its fifth edition in 1817, John Murray's

Elements of Chemistry its sixth in 1818), suggest comparatively large sales, despite the prices. Works for general readers tended to be one or two volumes, at 5s.-12s.

Children's works were often cheaper. Pinnock's Catechism cost only 9d. in 1823 and contained a short explication of the science. Many of these works were also successful, e.g. Parkes' Chemical Catechism reached its eighth edition in 1818. Marcet's Conversations (1805) was the first commercially successful work for children, and the conversational form was used by other writers for children's books in many subjects. Despite being priced at 14s. in 1805 for the two volumes, the work reached its fifteenth edition in 1846.

Just as zoology, mineralogy and botany were popularised through media other than books (i.e. menageries, museums, lectures, etc), so was chemistry. In some ways, indeed, it was the foremost science for lectures in the early nineteenth century, at least until geology became so popular from the 1820s. Both Marcet's work, and the similar one by Joyce, recommended attendance at lectures, preferably the famous and fashionable ones of Humphry Davy at the Royal Institution.[146] James Parkinson expressed the hope that his work would "induce those who are not of the medical profession, to seize the opportunity of obtaining fuller information, by the pleasing and expeditious mode of Public Lectures".[147] A number of the works were by lecturers, sometimes being almost transcripts, as in Goldsworthy Gurney's Lectures... delivered at the Surrey Institution (1823); William Henry's Epitome of Chemistry used descriptions of the experiments he had performed in his 1799 lecture course; Skrimshire's Essays were part of the material he had gathered for a never delivered lecture course; John Murrary FSA (not to be confused with his Edinburgh namesake) wrote his Elements of Chemical Science "exclusively for those who had honoured his public discourses with their presence".[148]

Chemistry was also a practical subject, but instead of collecting one could perform experiments. Both Fredrick Accum and William Henry used their works, to some extent, to advertise the sale of chemistry "chests" and supplies, as well as their own private lecturing and teaching. Joyce and Henry also gave lists of works for further reading, Henry naming Chaptal, Fourcroy and Nicholson (i.e. his Dictionary of 1795).[149]

Popularisation of chemistry in books was, therefore, like that of zoology and mineralogy, part of a wider spectrum of methods of popularisation.

In geology, it has been shown, the use and audience of the books affected their content. This was not generally the case in chemistry, the attitudes and content of works for students, general readers and children being very similar. Like those subjects already discussed, however, the subject was felt to need a justification for its study. Authors almost invariably informed their readers in a preface or introduction of the benefits that reading the work and studying the science would bring to them. To British authors, at least, it was not sufficient that chemistry was an intellectual pursuit. Even works of some detail, such as those for medical students, included such a preface, which may be compared to at least one continental writer, Fourcroy, who included no reasons or justifications for the science in the Preface to his Philosophy of Chemistry.

The justifications for the study of chemistry were often those given for the other sciences already discussed. It withdrew "the mind... from pursuits and amusements that excite the imagination"[150]; it was enjoyable, "wide scenes of interest and amusement...constantly opening upon the mind", and yet also useful, yielding "vast advantages... to those who are engaged in the most useful and profitable arts".[151] It could be, as Fredrick Accum hoped his Chemical Amusement would be, "rational amusement", instructing and improving as it entertained.[152] Chemistry was an ideal source of natural theological instruction. "No study can give us more exalted ideas of the wisdom and goodness of the Great First Cause", wrote Thomson,[153] and indeed one of the main purposes of Parkes' Chemical Catechism was "to exhibit, in a popular form, a body of incontrovertible evidence of the wisdom and beneficience of the Deity".[154]

All these justifications resulted in moral improvement, with the social and political effects that that implied. Chemistry, John Murray FSA wrote, "improves the mind... before [Truth's] radiance, the haggard vissage [sic] of superstition sickens into death".[155] The rationalism of these authors was clearly stated. The study of chemistry could achieve the desired intellectual improvement, many authors felt, more effectively than many other contemporary disciplines for several reasons. Firstly its methodology was favourable. Extreme empiricism was emphasised by many of the authors. To William Brande, for instance, "induction from experiment is exclusively the basis of chemical science". Quoting from Francis Bacon, Brande wrote that one should follow no mentor but objective truth.[156] Other writers emphasised Baconian empiricism, Gurney referring to the late Lord Chancellor as "the great father of modern experimental philosophy".[157] Such a methodology would produce mental improvement and the abandonment of superstition more effectively even than the empirical but not experimental methodology claimed for geology. Faith in the method would mean one would not accept "as a chemical fact, what is incapable of proof by a chemical experiment". In turn this would make one wary of dogmas and assertions and "compare, reason, and judge" for oneself, John Joseph Griffin wrote.[158] "If a youth has been taught to receive nothing as true, but what is the result of experiment", agreed the zealous Unitarian Samuel Parkes, "he will be in little danger of ever being led away by the insidious arts of sophistry, or of having his mind bewildered by fanaticism or superstition".[159]

Chemistry was particularly improving for another reason, for it involved the "induction from well ascertained facts, of general principles or laws".[160] To understand why this was morally beneficial it is necessary to return to the natural theological functions of chemistry. It could help to display not only the existence of God, but also His nature. The induction of laws, and the laws themselves meant that chemistry could display the order and stability of the universe by "unfold[ing] to us those laws by which the universe is governed; which laws have preserved a sublime and uninterrupted order since they were first impressed on matter by its Creator; and in virtue of which that order can alone be expected to be preserved through future ages".[161]

Thus faith in a rational, ordered, universe, combined with that chemical reductionism already noted in mineralogy and geology, meant that chemistry was the most appropriate science to demonstrate the order of the universe, the nature of God, and, by no very difficult extension, the law and order which should exist in society. As Davy said in 1802 to the Royal Institution, he who perceives " in all the phenomena of the universe, the designs of a perfect intelligence, will be averse to the turbulence and passions of hasty innovation and will uniformly appear as the friend of tranquillity and order".[162] Appreciation of the beauty of the universe, therefore, was not appreciation via the senses, but rather an intellectual appreciation of the "finest symmetry and truest order".[163]

Lastly, and connected to this, chemistry was particularly suitable to improve the morality of the reader because of its close connection with economic utility. As has already been shown every science was to some extent justified because it was of economic benefit to man, but none more so than chemistry.

John Murray of Edinburgh, for instance, wrote that to chemical investigations "we are indebted for our knowledge of many of the phenomena of nature, and the establishment and improvement of many of the arts", listing natural history (especially mineralogy), animal and vegetable physiology, medicine, pharmacy, and agriculture as recipients of essential aid from chemistry. In addition the arts of making bread, brewing, tanning, soap and glue-making, metallurgy, glass-making and pottery "are likewise arts the principles of which are immediately dependent on Chemical Science".[164] Thomas Thomson ascribed to chemistry a similar all important role in the arts:

> "The glass-blower, the potter, the smith, and every other worker in metals, the tanner, the soapmaker, the dyer, the bleacher, are really practical chemists, and the most essential improvements have been introduced into all these arts by the progress which chemistry has made as a science".[165]

In spite of this, however, the popularisations of chemistry of this period were not attempts to help potters and smiths, etc., being both too difficult and too expensive, and containing no detailed explanations of industrial chemistry or descriptions of innovations which could be applied to the arts. Most of the works were simply descriptions of the principles of attraction, repulsion etc, followed by lists of preparations and properties of the different elements and compounds (Samuel Parkes' Chemical Essays was a rare exception, concerning itself as it did with industrial processes). Most of the works which were concerned with practical applications, (as in the case of gardening books), were those which paid least attention to the scientific aspects of the subject. George Carey's 500 Useful and Amusing Experiments in the Arts and Manufactures, for instance, contained discussions of industrial processes such as the preparation of paints and gilding, and descriptions of chemical experiments to demonstrate the effects of electricity, galvanism and magnetism, the properties of water etc. He did not, however, attempt to link up these sorts of knowledge, but aimed only to diffuse knowledge of the separate processes.

Neither was there, at this time, widespread application of chemical knowledge to the arts. Bleaching, dyeing, the extraction of ores and a few other minor areas were the only processes which received any aid from the use of scientific principles. Overwhelmingly, the arts depended upon techniques developed empirically over many years, a fact which the popularisers of chemistry must all have known.

Why, then, did the authors wish to convince their readers of the economic utility of chemistry? And why was this utility considered a justification for its study? Partly it was because of direct moral and social benefits from economic utility. William Henry reminded his readers of the French use of native resources to manufacture nitre during the Napoleonic Wars. It was to useful industry that Britain must "look for the permanency of its riches, its power, and, perhaps, even of its liberties".[166] Goldsworthy Gurney claimed the economic utility of chemistry had lifted us from barbarism and prevented us from returning to it.[167]

More importantly however, it was due to a different understanding of the nature of economic utility. From the work of William Paley and from other natural theological works of the late eighteenth and early nineteenth centuries, it was widely accepted that everyting had a use, to man, to animals, or even to the inhabitants of other planets. The utility of an object was therefore considered teleologically. To J.S. Forsyth, for instance, the use of the atmosphere was to:

> "support both animal and vegetable life [and]... combustion; it ministers to several of the pleasures we derive from our senses, it gives buoyancy to the

> clouds, and enables the feathered creation to transport themselves with ease from one part of the earth to another".[168]

This implied of course that God had designed air to act in all these ways. Similarly according to Samuel Parkes, the

> "principle of evaporation is of very general utility, it is subservient to many natural processes, and it is perpetually of use to man in every occupation of life.
>
> What is the ultimate use of this principle?
>
> The Almighty has contrived that moisture should continually rise from the earth, and from the various bodies upon its surface, to shield this world of ours from the intense heat of the sun, and to return in rain to water the ground, causing grass to grow for the cattle, and corn and herbs for the service of man".[169]

The explanation for the emphasis upon the economic utility of all the sciences lies here. Just as evaporation was designed by God, it was believed, to cause crops to grow and cattle to be reared "for the service of man", so chemistry was contrived by God to be the "cause" of brewing, metal-working, bread-making, etc., etc. The utility of any object was an indication of its divine origin and divine purpose.

Thus, when Goldsworthy Gurney wrote that he was to attempt to convince his audience of the worth of chemistry by "impress[ing] them with a sense of its beauty and utility",[170] both beauty and utility were underpinned with moral and religious implications. The beauty of chemistry lay in its embodiment of the order and harmony of the universe; its utility showed it to be a contrivance of God.

The over-emphasis upon the utility of chemistry, as it seems from a modern vantage point, is to be explained by this different concept of chemistry. As an object of divine rather than human origin, chemistry was not merely those laws which man had discovered, but a whole body of laws by which God regulated natural phenomena. One tried to reduce all sciences to chemistry, because it was chemistry that God used as the basis of all phenomena in the universe and which God had designed, amongst other things, so as to allow the prosecution by man of the useful arts. Rather than just the principle of evaporation, chemistry was a corpus of such principles, some of which man had discovered and some of which he had not. By implication, God also encouraged man to discover the rest so as to both understand God better and to perfect the arts. If this explanation of the different concept of chemistry in the early nineteenth century is accepted it becomes easy to understand the claims for chemistry as the basis of the arts and as the source for their improvement. Thomas Henry made perfect sense when he wrote that extraction of metals, the making of glass and porcelain, the production of wine and the dyeing of linen, etc., "are only a few of the arts that are dependent on chemistry for their improvement, and even for their successful practice",[171] as did John Murrary when he wrote that "many of the phenomena which nature presents to our observation, aris[e] from the chemical actions of various substances on each other, and many of the arts [are] ... nothing more than a series of chemical processes".[172]

The experimentalism of chemistry was often emphasised, as might have been expected from authors who acclaimed an empirical methodology. Fredrick Accum wrote that "experiments... performed by the student himself... have a more permanent effect upon the mind, than either bare positions of precepts, or the rapid illustrations inseparable from public and popular courses of lectures". John Griffin agreed that as chemistry was "entirely founded upon experiment" then lectures and books "will never benefit him who attends to nothing else".[173] Experiments, it was often claimed, could be easy, simple and cheap. David Blair's school book contained upwards of a hundred experiments "so contrived as that they may be performed without any previous knowledge of the subject and with little or no apparatus".[174] John Griffin supplied instructions for adults to experiment "on a small scale for self-instruction".[175] One of the most successful works, Accum's Chemical Amusement consisted of descriptions and instructions for the performance of simple experiments, especially those producing changes in colour, sharp rises or falls in temperature and other spectacular or curious phenomena. To these Accum "added the explanation to each... in order to enable the operator to contemplate the phenomena with advantage, as particular objects of study, if his inclination should lead him that way".[176] Thus, although amusement was justified by reference to instruction, it was possible to find works whose main purpose was to provide curious and amusing experiments for the leisured classes to perform for the delight of themselves and their friends.[177]

Few writers, however, wrote in detail of the necessary apparatus, of preparations, and of the necessity for care with toxic and corrosive materials, as David Boswell Reid and John Griffin did, yet the necessity of using such materials gave chemistry a masculine image.

Chemistry's concern with the laws of nature, and consequently with theory, also seems to have given it a more masculine aura, as the idea of wrestling with fundamental truths was an attractive one and therefore, in the early nineteenth century, a subject considered (by men) to be more suited to men.

In fact, as Donovan has noted,[178] chemistry in the late eighteenth and early nineteenth centuries was very concerned with classification, (although the quantitative work of Lavoisier and the atomic theory of Dalton was soon to change this). Idealistically, however, it was a science akin to mechnical philosophy rather than to natural history. Both Thomas Thomson and Andrew Fyfe noted this, contrasting 'natural history', the study of isolated bodies, with 'natural philosophy', the study of the actions of bodies upon each other. Chemistry fell in the latter category and was divided from mechanical philosophy, which dealt with the motion of sensible masses, because it dealt with invisible motions.[179]

The ideal of chemistry as a theoretical subject found expression also in attitudes to mathematics in chemistry. Other than in Lavoisian quantitative methods chemistry was non-mathematical at this time, yet Goldsworthy Gurney hoped that laying down general laws would "render mathematically certain what was before dependent on mere accidental circumstances",[180] while Humphry Davy expressed the hope "that at no very distant period the whole science will be capable of elucidation by mathematical principles".[181]

Walter Weldon's popularisation for the use of the amateur, the artisan and the female reader, expressed the intention to use only "the most explicit and popular terms, avoiding mathematical and as far as is possible, complex arithmetical calculations, and controversial points".[182] Thus, in a polite popularisation, the authors both emphasised and excluded the 'difficult' parts, i.e. mathematics and terminology.

The wish to omit controversial points is also interesting, similar as it is to the attitude of the polite popularisations of geology, yet in fact there were very few areas of controversy in the presentation of chemistry in popular works in this period.At the very begining of the century, it might have been expected that there would be some disagreement over the adoption of Lavoisian oxygen theory, especially as only five years before, in his Dictionary of Chemistry, William Nicholson had written," I have not adopted the nomenclature of the Antiphlogistons...I did not think myself at liberty to anticipate the public choice, by using it in an elementary work".[183] There was almost no retention of phlogiston theory, however, even though Fourcroy felt the need to justify his adoption of the anti-phlogistic theory in the fifth edition of his Elements of Chemistry.

The popularisers were, in general, very up to date in terms of developments within the science itself. Partly of course this was because many of the authors were also active in research, e.g. Davy, Henry, Thomson etc. Only two years after Dalton's publication of his atomic theory, for instance, William Henry included an outline of it in the 1810 edition of his Elements. By the ninth edition of 1823, he had rearranged the work, basing it on the electrochemical dualism of Berzelius. The result of these rapid changes, both in the science and in its popularisations, was that those books which were not subject to frequent revision quickly came to seem staid and outmoded, as Henry's Elements itself did in its later editions. In 1829 Graham criticised Parkes' Chemical Catechism, which was unrevised since the author's death in 1825, for the brevity of its section on atomic theory and the insufficiency of the treatment of affinity.[184]

What controversial points there were often derived from the quicker or slower adoption of new theories by different authors. Andrew Fyfe, for instance, refused to adopt the electro-positive/electro-negative division of non-metallic elements which Ure, Henry, Weldon and others had all adopted.[185] Similarly, divisions existed over the position and nature of caloric, light, electricity, galvanism and magnetism, the so-called 'imponderable' substances. Some authors treated them merely as another group of elements, some as quantitatively different; the material theory of caloric as a liquid was quietly dropped over the years. Usually the subject was divided into earths, acids, alkalis, combustibles and metals. Vegetable and animal chemistry were usually discussed (although only superficially in comparison to the treatment of mineral chemistry). The maintenance of sections on the chemistry of live organisms was a legacy of the formation of chemistry as a modern subject, separate from medicine. The division of the natural world into mineral, vegetable and animal kingdoms, persisted into the nineteenth century.

Such relations lived on also in the occasional linkage of mineralogy to chemistry, for instance in the Aikins' Dictionary of Chemistry and Mineralogy and Accum's lectures on experimental chemistry and mineralogy. William Brande and James Mitchell even included geology in their works, although by this time the structures of the two disciplines were very different. The changes which had occurred were symbolised by the adoption of an inorganic/organic division by E. Turner in his Elements of Chemistry of 1827.

The problems of authors writing at a time of fundamental change were recognised by William Henry and other authors. One solution which occurred to Thomas Thomson was to present the science in the manner in which, he believed, it had originated, i.e. by giving the individual facts first and then inducing the general laws. Unfortunately the Edinburgh Review found the second edition of his System of Chemistry initially dull, due to the lists of facts given before any general laws. "We are therefore inclined", wrote the reviewer, "still to prefer the common didactic method of first explaining the more general doctrines, to Dr. Thomson's apparently more philosophical arrangement of arriving at all his general doctrines by induction."[186] The almost universally held belief that this was the method of discovery of the science, despite its pedogogical short-comings, was also reflected in discussions of the history of chemistry. The origin of the science in alchemy was found very embarrassing, being 'superstitious', and presenting an apparently easy route to success. Its failure, however, showed clearly that it had not used the inductive method and the science of chemistry was, therefore, unconnected with it. "Chemistry, considered as a science, is only of modern origin" wrote James Mitchell, and a writer in the Edinburgh Review put its age at only eighty years.[187] Chemistry had progressed positivistically to a science, being "eminently and rapidly progressive" according to John Murray.[188] His namesake claimed that it was only with Bacon that chemistry "assumed true dignity, and rose from the dross of alchemy".[189] The strong connections of chemistry with Edinburgh, the centre of its study and diffusion within Britian, probably explains the almost uniform Enlightenment and rationalist ideals of the popularisers of the science in the early nineteenth century.

E. Astronomy

In his 1819 book Elements of Astronomy Joseph Guy asserted that, for "those who hold a respectable rank in society, a general acquaintance at least, with the order of the heavenly bodies, and the laws by which they are governed, must at sometime necessarily become a part of their inquiries".[190] Perhaps Guy was exaggerating in order to encourage people to purchase the work, but A. Maxwell, writing in 1817, concurred. Of astronomy, he wrote, "it has become fashionable, at least to have some little knowledge of it, sufficient to appear in parlour conversation".[191] The emphasis on a superficial knowledge seems to have been more pronounced than was the case in the sciences discussed earlier in this chapter. Perhaps this was because of the belief, identified by George Carey, "that it is necessary to study a tedious course of mathematics, previous to entering upon the study of this science".[192]

The dependence of physical astronomy on mathematics marked it out from all the other sciences dealt with so far. The major works in the field, such as that by John Bonnycastle, were designed for those unable to understand Newton's Principia because of their lack of mathematical knowledge. Bonnycastle admitted the knowledge imparted would therefore be superficial to some extent, particularly as he had chosen only those parts "likely to excite the curiosity and attention of the uninformed reader".[193] Similarly, James Ferguson's Astronomy Explained Upon Sir Isaac Newton's Principles was subtitled "...made easy to those who have not studied Mathematics".[194] Both of these works were originally eighteenth-century publications, but the same feature was evident in early nineteenth-century books, such as Rev. A.Mylne's Elementary Treatise on Astronomy... Intended for the use of those who are not much conversant in mathematical studies, and William Phillips' Familiar Lectures on Astronomy... for the use of [those] ... not conversant with the mathematics. Popularisation of physical astronomy was often synonymous, therefore, with non-mathematical explanation of Newtonian results.

Astronomy did not only consist, however, of physical astronomy. Indeed in the eighteenth century it was considered primarily a subdivision of cosmography. In this sense astronomy was the counterpart for the heavens of geography for the earth. This attitude persisted in some writings in the new century. In this guise astronomy and geography were concerned with finding meridian lines, latitude, longitude, time etc., and with maps, the stars' and planets' positions, eclipses, chronology etc. By the early nineteenth century astronomy was generally considered a separate subject, but still taught in association with geography "in every system of liberal education".[195]

Both subjects were taught by use of the "globes", i.e. the terrestrial, celestial and armillary spheres. Within astronomy as an autonomous subject, therefore, the prime distinction was between physical and plane astronomy. As Joseph Guy distinguished them, "plane" or "pure" astronomy was concerned with the magnitudes, orbits, and distances of the heavenly bodies; "physical" astronomy investigated the causes of motions of the planets.[196] Thus, plane astronomy was concerned with "saving the appearances", physical astronomy with everything else.

George Carey denied that physical astronomy was a legitimate occupation, when he wrote that "it is no part of [an astronomer's] business to contemplate the nature of the celestial bodies; but [only] their motions, their magnitudes, and the various phenomena arising from their motions." Carey could therefore approvingly quote Keill that "There is no science in which there remains fewer difficulties to be explained."[197] Few writers actually denied the validity of physical astronomy in this sense, but many recognised, as Rev. A. Mylne did, that while the causes of the motions of the heavenly bodies were the most interesting to a philosophical mind they were outside the scope of his book.[198] This uncontroversial nature of plane astronomy perhaps made it particularly suitable for the education of children. With definitions like this, clearly Newton's work fell both within and without plane astronomy, but the continuing tradition of education by the use of the globes generally relied very little on Newtonian work, other than in merely ascribing the order of the solar system to the operation of gravity.

Education in astronomy, usually with the use of the globes, was still common. This is shown by the fact that ten of the authors or revisers of the books considered in this section are known to have been school-teachers or private tutors. A further nine lectured on the subject, either at university (e.g. Vince at Cambridge) or privately (e.g. James Ferguson, William Walker and William Phillips).[199] Such schools were for the children of the upper and middle classes. William Prior's work was for use particularly in "ladies' schools", where it would rectify a deficiency of suitable works which, he said, had led to the neglect of the subject.[200] Joseph Guy, on the other hand, claimed that :

> "In some establishments of high respectability, both for young ladies and gentlemen, Astronomy has succeeded Geography and the Globes."[201]

Astronomy, like chemistry, was also popularised to students and to general readers. University students did not generally study the subject, however, and Vince's work was one of a small number suitable for such readers. General readers included the ladies who read Lalande's Ladies' Astronomy, translated into English and published in 1803.

To suit such a general audience various devices were used. Sections of verse, both original and from approved poets (particularly Pope and Thomson) were often included eg. in Bonnycastle. Olinthus Gregory included moral reflections in his children's work. As with chemistry, works appeared in varied formats, including a poem with philosophical footnotes, letters, conversations, and even a book in the form of a novel. Also like chemistry astronomy was linked to other media, eg. to lectures by William Walker, jnr., whose Epitome of Astronomy was divided into "scenes", each pertaining to a display of an eidouranion (a type of orrery) at his and his father's lectures.

The typical content of an astronomy popularisation, like that of zoological ones, came from eighteenth-century works, particularly those by Ferguson and Bonnycastle. The latter was constantly reissued throughout this period, reaching its eighth edition in 1822,having been originally issued in 1786. Ferguson was often considered out-dated, being criticised as such by both Richard and William Phillips (no relation). Bonnycastle was still widely read and used and the content of the work consisted of a consideration of the use and advantage of astronomy; a discussion of the figure and motion of the earth, and the nature and arrangement of the solar system and the firmament; a brief history of astronomy; the nature of tides; latitude and longitude; the causes of night and day, and the seasons; the determination of time and the calendar; and a discussion of mensuration of the earth. Bonnycastle then considered the distances and sizes of the bodies in the solar system; the nature and motion of light; the constellations; and, finally, a discussion of the phenomena of the bodies of the solar system, including comets and eclipses.

This list gives a fair indication of those subjects considered to fall within the boundaries of astronomy in the early nineteenth century, although some writers (e.g. Carey and Guy) also discussed the nature of the earth's atmosphere. It was still often considered necessary to give proof of the spherical nature of the earth as well as of its motion. Those works designed primarily for schools, or to teach the use of the globes, etc., concentrated upon latitude and longitude, the names and configurations of the constellations, the use of the globes themselves and the solution of problems on these topics. In this way works such as those of Bryan, Squire, Carey, Treeby, etc., introduced mathematics into their texts. In contrast William Walker, Catherine Whitwell, and others, concentrated on popularising Newtonian astronomy non-mathematically. Both emphasised the ease of learning this form of physical astronomy. Walker claimed the eidouranian was a means of:

> "rendering astronomical truths so plain and intelligible, that even those who have not so much as thought upon the subject, may acquire clear ideas of the laws, motions, appearances, eclipses, transits, influences, etc. of the planetary system."[202]

Whitwell, whose book was written for girls, assured her readers that mathematics was only necessary for pure or plane astronomy; physical astronomy was perfectly comprehensible without it.[203] As mathematics was not considered very suitable for ladies, or even for the general class of reader, a rather ironic situation arose in the early years of the century. That part of astronomy which depended on the most complicated mathematics (i.e. Newtonian astronomy) was found far more suitable for popularisation to general readers than plane astronomy, depending as it did only on fairly simple geometry and arithmetic. That this was so was due both to the excellent work of eighteenth-century popularisers such as Desaguliers and Ferguson, who had done so much to concretise Newton's rather abstract discoveries, and no doubt also to the interest generated by the work of William Herschel, an Englishman by adoption, and in particular by his discovery in 1781 of the first new planet to be found since classical times, Uranus.

It is in fact noticeable that despite the continued use of Ferguson and Bonnycastle that new work which had occurred in the science rapidly found its way into the popularisations. Herschel's theory on the nature and consequent habitability of the sun, although only first published in 1795,[204] was generally recounted, if not always unreservedly accepted. Carey in 1825 insisted that he had included the work of Herschel and LaPlace to ensure accuracy and modernity.[205] The Edinburgh Review included praise of La Grange and La Place as early as 1808, although a less consciously 'progressive' source would not have been likely to praise the philosophers of a supposedly atheistic country with which Britain was at war.[206] The discovery of the first asteroids (Ceres, Pallas, Juno and Vesta) in the very first decade of the century was also almost universally reported.

One other group of works existed which by virtue of its enormous sales must have diffused the principles of astronomy more widely than those of any other science, i.e. the almanacs. Some, belying their universal condemnation by reformers responsible for or supporting the British Almanac or the S.D.U.K., included astronomical information and excluded astrology. The Coelestial Atlas, by Robert White, published throughout this period, contained information on the longitude and latitude of the sun and the moon and the times of their rising and setting. In addition tables gave, amongst other things, the positions of the Georgian Planet (i.e. Uranus) and of Jupiter's satellites; listings of "Speculum Phaenomenonum" (i.e. conjunctions, etc. of the planets); the declination of the fixed stars; and the sun's semi-diurnal arc. Rider's British Merlin and The Imperial Almanac were similarly free of astrology and contained astronomical information; the latter, for instance, had a table of facts about the principal elements of the solar system.

Of course these were not the most popular almanacs. As an article in the London Magazine in 1828[207] explained, White's Ephemeris, along with the Ladies' and Gentlemen's Diaries, were the reading matter of schoolmasters, Rider's British Merlin that of the squire. Yet even "the astrology and the filth"[208] of the popular almanacs coexisted with astronomical information. Every almanac had listings of the rising and setting of the sun, the majority (including Moore and Old Robin, two of the most popular and most criticised of the productions) had forecasts and explanations of the eclipses of both sun and moon for the year as well as much other astronomical information. It was possible to suit almost any taste in the astrological and astronomical content. Wing, for instance, included the usual Judicium Astrologicum (i.e. prognostications for the year ahead) but replaced the weather predictions usually given in the calendar with astronomical predictions (e.g. "Great Dog Star south at 10 tonight", or "Mercury stationary as seen from the earth"). William Rogerson's Temporis Calendarium, written, he claimed, at the Royal Observatory at Greenwich, contained no astrological predictions, but did include a table which predicted the weather from the times of movement of the moon, into a new quarter, as well as a short explication of the astronomical knowledge of the time. Almanacs, therefore, did undoubtedly spread the knowledge of astronomy. Where they differed was that often it was diffused as a subject subservient to astrology, and the planets, like the animals and plants in chapbook literature, were part of a cosmos where every part had connections and influence with every other. It was the Enlightenment rationalism, the morality and the rational religion which was missing, rather than the knowledge itself.

The justifications given for the study of astronomy by the writers of the formal popularisations, repeating as they did those given for study of the other sciences, displayed just these features. Astronomy had "moral" uses and "physical" ones, wrote Christopher Irving in his tremendously successful Catechism of Astronomy.[209] Moral uses included its natural theological content, making it "a complete antidote to atheism", and, for other authors, intellectual improvement, replacement of less desirable activities and its use in defeating 'superstition', i.e. astrology.[210]

Such arguments were often found in the popularisations, and may be seen in Bonnycastle, whence they were probably derived, although there is no reason to believe they were original to him.

The "physical" uses given were usually in navigation, geography, chronology and the determination of time. Navigation was sometimes linked to commerce, and the social use of navigation was made explicit by Carey when he wrote that navigational superiority had led to the superiority of the British Navy, and thus to the high trade and prosperity of Great Britain.[211] Bonnycastle added agriculture to the list, insisting that for husbandmen it was necessary in order to know when the seasons were about to change, although also admitting that this was less important now than in historical times. Determination of exact time was a necessity for modern society, however, and Bonnycastle contrasted this with "the uncivilized and solitary barbarian, who computes his time by the falls of snow, or the progress of vegetation, and is utterly ignorant of the more refined wants of society".[212] Chronology could also serve religious purposes, demonstrating that the darkness at Christ's crucifixion was supernatural, as well as helping in other ways to confirm and illuminate the Biblical narrative, in the same way as natural history was occasionally used.[213]

Again these technological uses of astronomy were mere justifications, demonstrating the God-given benefits of the science. In none of the works could one learn how to navigate etc.

Astronomy, like the other sciences, demonstrated in its popular forms the great complexity of natural theology in the early nineteenth century, and like geology, but on a smaller scale, it was the scene of a controversy between biblical hermeneuts and literalists. While at least two authors quoted Young's phrase, "An Undevout Astronomer is mad",[214] it was generally felt that study of the Bible was essential for true understanding of the nature of God. Olinthus Gregory, for instance, was "cautious in checking any inclination to scepticism during the study of Natural Philosophy: and in guarding against a mischievous misapplication of the word Nature".[215] This deist or even atheist trend was to be checked by his advice "to study, with particular attention, that much-neglected book the BIBLE".[216] George Carey, however, even went so far as to quote a heathen, Cicero, on the nature of God.[217]

Catherine Whitwell, who displayed her evangelism when she told her readers that "you live in a wicked world, [but]... there is in this world an entire remedy... the Bible", still hoped to show that the history of astronomy would "wonderfully corroborate" the Mosaic history, which would simultaneously corroborate the history of Christ, because "between the Old and New Testament, there exists an indispensable bond of union".[218] For Margaret Bryan astronomy led to belief in "the discernible attributes of the Deity, which all accord with the Scripture communications, and are perfected by them".[219]

Where astronomy imitated geology, although on a lesser scale, was in the writings of Thomas Chalmers and the reactions to it. Chalmers, although an evangelical, was not antagonistic to natural philosophy, but wished merely to emphasise the limitations of natural theology. The moral attributes of God were not, as Paley had said, visible in nature. There is no "moral telescope", he wrote, to show "the doings or the deliberations which are taking place in the sanctuary of the Eternal".[220] In effect, his lectures at Glasgow (later printed as A Series of Discourses on the Christian Revelation, viewed in connection with the Modern Astronomy) were delineating spheres of competence of natural theology and revelation. Natural philosophy was therefore given free reign to investigate the natural world, and it was this aspect of his writings which provoked the ire of the fundamentalists.

A. Maxwell replied to Chalmers in a work published in the same year of 1817. Modern astronomy, he wrote, was a defence of the Infidel. The speculations of "Herschel, or some other daring pretender" on the plurality of worlds, the distance of the stars and the speed of the earth were not supported by evidence, while the Bible was the "only standard of principle and truth". Maxwell attacked the very practice of natural theology, particularly in Paleyan form:

"Intricate controversies and ingenious disquisitions on the origin of evil - on the purposes of the Almighty, and the free agency of man are not, I think very favourable to real piety and genuine religion".[221]

The existence of inhabitants on other planets, consequently unaware of Christ's redeeming purpose, or of some kind of multiple incarnation of Christ was anathema to such believers. Denial of the plurality of worlds was often, therefore, connected with a denial of the distance of the stars from the earth, and of the heliocentricity of 'modern astronomy'. William Wood, in his Astronomy made Plain, attempted to prove that the sun was never more than 3,000 miles from the earth. "If this theory be true it will follow, of course, that this earth is the only one God made, and that it does not whirl round the sun, but vice versa the sun round it."[222]

Belief in the plurality of worlds (i.e. the inhabitation of the other bodies in the universe) was very widely shared, even extending to comets and the sun for many writers. Fontenelle's famous work on the subject, originally issued in 1686, was said to be "still very generally read" in 1815 and at least three editions appeared in the years 1800-30.[223] Derived largely from the discovery of the immense size of the universe, and the belief that God was a deity whose creation would be both full and useful, most authors agreed with Mrs Marcet that it seemed "more rational to consider the planets as worlds revolving round the sun; and the fixed stars as other suns, each of them attended by their respective system of planets."[224]

The creatures which inhabited the rest of the universe were generally regarded as "beings capable of rationality and enjoyment, like ourselves."[225] Belief in the great chain of being was sometimes combined with the plurality of worlds, as when Henry

Baker wrote (in his eighteenth-century poem, reprinted in 1808) that "some may be reasonably supposed far more exalted in the scale of creative beauty, as well as intellectual abilities, than the human race".[226] This view was echoed by Jevons when he wrote that some of the inhabitants of other planets "may be as much superior to man as man is superior to the brutes."[227] William Walker hypothesised that inhabitants of the universe were destined to pass from planet to planet and system to system in successive lives.[228] The unconcern with which the writers could view a universe teeming with other creatures seems remarkable to the modern mind reared on The War of the Worlds and other fearful suggestions of the nature of the universe and its possible inhabitants. Not only was the idea treated with equanimity because of the absence of almost any concept of space travel, but more importantly because the universe was ruled over by a rational Deity, and was therefore populated by infinite "worshippers of his glory".[229] The optimism of such a view compares strikingly with that of Coleridge. The prospect of a plurality of worlds filled him with gloom. Of all the other planets he asked, "are [n]one exempt from the Morbus pedicularis of our verminous man-becrawled Earth?"[230]

Many writers stated that the universe was a place of order and calm: Catherine Whitwell wrote of the wonderful system, the worlds "all in motion, yet calm, regular, and harmonious",[231] a view expressed even by the millenarian author of the Prophetic Almanack.[232] The universe was seen as a perfect society, from a blueprint supplied by middle classes. Margaret Bryan wrote of the sun (in terms reminscent of Copernicus) as "like the father of a family".[233] To Robert Woolsey it was the monarch of the solar system, under the Deity.[234]

Having established the universe to reflect their own prejudices, many authors did not hesitate to draw lessons from the universe for society on earth. For Squire the facts of astronomy were "fitted to establish in youth the firmest conviction of those eternal truths on which the moral and physical government of the world are built".[235] To Mary Sherwood it was the undeviating behaviour of the planets which afforded "Christians a glorious example to pursue".[236]

The dependence of Newtonian astronomy on the law of gravity and the laws of motion made it particularly admired as a science. Partly it was because it was simple and neat but mainly it was because gravity was considered as the law by which "God superintends, restrains and directs the whole".[237] Newton was praised principally for discovering "that law which regulates all the heavenly motions" and gives "harmony and order... throughout the whole creation";[238] gravity was sometimes described as God's arm or God's finger.[239] The Edinburgh Review claimed astronomy was at "the head of the physical sciences" primarily because a single law explained perfectly the motions of the heavenly bodies.[240] Astronomy was praised because it had discovered God's method of action, and showed the rationality of it; astronomy itself was often taken, like chemistry, to be the method by which God ordered the universe rather than a man-made science. Thus William Phillips called it "a system of the utmost beauty and harmony".[241]

The 'true', Copernican, system was often praised for being simple and harmonious, and Lalande, for instance, claimed that "all irregularities were perfectly explained by his [i.e. Copernicus'] new system".[242]

A contrasting attitude to astronomy appeared in Moore's Almanack for 1800. The universe was not made strikingly beautiful because the laws governing it were understood but it was the actual phenomena which were beautiful. An eclipse of

1800 was to "produce a beautiful and splendid Annulus or Ring of Light, encompassing the Orb of the Moon on every Side; which will be awfully grand, even to those that are acquainted with the Principles of Astronomy."[243] The contrast between those who saw the universe as grand and awesome, and those who saw and admired it as a regulated uniform society, is striking. Astronomy fitted well with the contemporary rationalism which saw the senses as inferior. "When it is considered how liable all our senses are to deception, and what wrong ideas are generally formed of the different parts of the universe from mere cursory observation", wrote Olinthus Gregory, "the absolute necessity of the dissemination of true philosophical principles will the more obviously appear."[244]

Such a contrast was also shown in attitudes to observation. Although Charles Smith's readers would "have ocular or visible opportunities of proving the TRUTH or FALSEHOOD of this little work",[245] few other of the formal popularisations were very concerned with observation, except occasionally of constellations and other features visible with the naked eye. The Prophetic Almanack "being calculated to prepare Mankind for the Coming of Christ's Kingdom upon Earth", however, was very concerned with observation, giving "A Batch of Celestial Treats for all Seasons" i.e. a guide to phenomena observable in the heavens throughout the year. Probably this was because the author thought that comets, eclipses and other celestial phenomena were some of the most important signs of the approaching Day of Judgement. By 1830 Moore's Almanack included information on where and when to observe the position of the planets throughout the year, while Henry Season's Speculum Anni for 1827 included a section wherein "The Various Phenomena of the Planetary Bodies [were] Pointed Out; Being very useful for Telescopic Observers".

The lack of faith in sensory perception shown by many of the formal popularisers was both an advantage to the popularisation of astronomy and a disadvantage. It was of advantage because it meant that astronomy, by reducing seemingly chaotic phenomena to rational order, was a fine example of the advantages of reason. It was of disadvantage, however, because one was unable to show the truth of the propositions to the ordinary non-mathematical reader. Many authors fell back on an almost scholastic appeal to authority. For William Phillips it was to the authority of mathematics. Astronomy, he wrote, "has a right to demand the most implicit consent, because [it is]... corroborated by the most rigid mathematical investigation. Astronomy therefore may truly be said to be the most perfect of all the sciences"[246] (and, by implication, the best to teach). Other authors appealed to modern astronomers or writers, even ironically to that great scourge of scholasticism, Bacon. Bryan wrote that "the fact of the planets revolving round the sun is now accredited on the best authority, deduced from observations and calculations of the most eminent astronomers and mathematicians".[247] Mrs Marcet asked her 'pupils' "when any one has given such convincing proofs of sagacity and wisdom as Sir Isaac Newton, when we find that his opinions are universally received and adopted, is it to be expected that any objection we can advance should overturn them?"[248] Many authors appealed to the authority of the ancients. Copernicus was generally credited only with reviving a Pythagorean doctrine which "had been so long in obscurity, that the restorer of it was considered as the inventor".[249] Some authors went further, suggesting that the knowledge was very ancient perhaps even from before the flood. Smith quoted Keill's comment that "the true astronomy is the most ancient of all; for it was preserved in the school of the Pythagoreans, to whom it was delivered by the first astronomers, either Egyptians or Chaldeans".[250]

F. Some Comparisons

In all of the subject areas discussed in this chapter the authors were primarily middle-class, as was their intended audience. Convinced of a harmonious universe run by a rational God they believed or hoped that the social order would reflect these realities. With their optimism and their faith in natural theology, the authors showed attitudes which would not have been out of place in the middle of the previous century.

The popularisation of the different subjects was up-to-date, even in those subjects such as chemistry and geology which had recently undergone revolutionary changes. The criticism of popularisations at the time came from those who were dissatisfied with the taxonomic state of the science and who wished for science based on causal laws, e.g. of physiological functions, rather than from people dissatisfied with the actual popularisation of the science.

The middle classes expressed their individualism by emphasising objects as distinct in themselves, whether they preferred taxonomy (placing the object in a hierarchy) or 'modern science', with its concentration upon the interactions of bodies. Both attitudes may be distinguished from the popular idea of a community of nature, an idea recently taken up again by modern ecologists and environmentalists.

The variation in popularity of the sciences is not easy to explain. Davy's prominence, his frequent discoveries, the novelty of chemical (especially electro-chemical) lectures and the subsequent development of more theoretical approaches to the science may all be considered to have contributed to the changing levels of popular interest in chemistry in these years. Geology, new, modern, historical and, (whatever the Geological Society members might proclaim), inevitably speculative, rose in the second half of the period to equal, if not displace, chemistry.

Mathematics seems to have made little difference to popularisation. Most science at this time was not even quantitative, far less mathematical. Where it was most important, in physical astronomy, it could be most easily ignored.

Notes to Chapter 3

1. Figures for total book production are from Ian Maxted, The London Book Trades, 1775-1800, A Preliminary Checklist of Members, Folkestone, 1977, table 11, p.xxxi.

   The numbers of books given for each subject are those located, consulted and determined to be popular science. They are listed only to give an idea of the proportions in which books on the various subjects were published. No more accurate figures can be given because only when located and consulted can books be determined to be popular works or not. Even then, as discussed in chapter I, the classification is sometimes difficult. However, the figures may be considered as indicative of the relative popularities of the subjects, at least in literary form, for there was no obvious discrepancy in the proportions of works not located for each subject.

2. E. Miller, That Noble Cabinet, A History of the British Museum, London, 1973, p.114.

3. The treatise, by Bell, was very concerned with natural theology. By 1832 the sales were supposedly "falling off in all directions", yet this treatise sold 25,025 copies. See R.K. Webb, The British Working-Class Reader, 1790-1848, London, 1955, p.69.

4. See W.P. Jones, 'The Vogue of Natural History in England, 1750-1770', Annals of Science, 1937, 2, 345-52, and D.E. Allen, The Naturalist in Britain, A Social History, London, 1976, chapter II. The quotation is on p.45.

5. Kew Gardens were owned by the Royal Family and were particularly favoured by Queen Charlotte, although the Price of Wales (later George IV) allowed them to decay both when Regent and King. See W.J. Bean, The Royal Botanic Gardens, Kew: Historical and Descriptive, 2nd edn., London, 1908, especially chapters IV, V.

6. Dialogues on Botany, for the Use of Young Persons; explaining the structure of plants, and the progress of vegetation, London, 1819, p.v.

7. [J.L. Knapp], The Journal of a Naturalist, 3rd edn., London, 1830, p.47.

8. F. Skrimshire, A Series of Essays Introductory to the Study of Natural History, 2 vols., London, 1805, II, 85.

9. The classic treatment of the history of this idea is A. Lovejoy, The Great Chain of Being, A Study of the History of an Idea, Cambridge (Mass.), 1970.

10. Oliver Goldsmith, A History of the Earth, and Animated Nature, 4 vols., New edn., Liverpool, 1810, I, 394.

11. G. Graves, The Naturalist's Pocket-Book, or Tourist's Companion, Being a brief introduction to the different Branches of Natural History, with approved methods for collecting and preserving the Various Productions of Nature, London, [1817], p.3; Abel Ingpen, Instructions for Collecting, Rearing, and Preserving British Insects; also for collecting and preserving British Crustacea and Shells... Intended for collectors and residents in the Country, London, 1827, p.xiii.

12. Rural Walks in the Spring. With Moral Reflections, Birmingham, [1800?], p.26 (In the H.M. Lyon collection of chapbooks for children at the British Library, shelf-mark C.121. aa.5).

13. e.g. William Wood, Zoography; or, the Beauties of Nature Displayed, 3 vols., London, 1807, I, 149.

14. W. Bynum, 'The Great Chain of Being after Forty Years: An Appraisal', History of Science, 1975, 13, 1-28.

15. Goldsmith, op.cit. (10), I, 345-61.

16. Bynum, op.cit. (14), p.12.

17. John Bigland, Letters on Natural History: exhibiting a view of the power, wisdom, and goodness of the Deity, so eminently displayed in the formation of the Universe, and various Relations of Utility which inferior Beings have to the Human Species, 2nd edn., London, 1810, p.50; Skrimshire, op.cit.(8), I, 64.

18. R. Malcolmson, Popular Recreations in English Society, 1700-1850, Cambridge, 1973, esp. Appendix and chapter VII.

19. Bigland, op.cit. (17), p.43; The Wonders of the Microscope; or, an explanation of the Wisdom of the Creator in objects comparatively minute: adapted to the understanding of Young Persons, London, 1823, p.25.

20. Quoted in Joseph Taylor, Anecdotes of Remarkable Insects; selected from Natural History, and Interspersed with Poetry, London, 1817, p.9.

21. [Knapp], op.cit. (7), p.132.

22. Sketches from Nature; or, Hints to Juvenile Naturalists, London, 1830, p.xvii.

23. William Hone, The Every-Day Book; or, Everlasting Calender of Popular Amusements, 2 vols., London, 1826-7, I, 654; See ibid, I, 489-500 for details of the lion fights and ibid, I, 599-600 for a description of Wombwell's menagerie and Hone's opinion of the reaction of London to the lion fight.

24. See e.g. T.M. Harris, The Natural History of the Bible; or, a description of all the quadrupeds, birds, fishes, reptiles, and insects, trees, plants, flowers, gums, and precious stones, mentioned in the Sacred Scriptures, London, 1824, Preface, pp. i-iii.

25. Ingpen, op.cit. (11), p.xiv; Goldsmith, Op.cit. (10), I, xii.

26. E. Donovan, The Natural History of British Quadrupeds, 3 vols., London, 1820, I, Advertisement, (n.p.).

27. For farm animals see ibid, and Thomas Bewick, A General History of Quadrupeds, 5th edn., Newcastle-upon-Tyne, 1807. The text is by Ralph Beilby, Bewick was the illustrator.

28. George Shaw, Zoological Lectures, delivered at the Royal Institution, 2 vols., London, 1809, I, Advertisement, (n.p.); William Bingley, Animal Biography; or Authentic Anecdotes of the Lives, Manners, and Economy of the Animal Creation, arranged according to the System of Linnaeus, 2nd edn., 3 vols., London, 1804, I, 22.

29. Jonathon Dymond, speaking in 1829, quoted by Malcolmson, op.cit. (18), p.103.

30. The Anecdote Book: A selection of amusing anecdotes for children, Alnwick, [1840?], p.1; reproduced in W. Davison, Halfpenny Chapbooks, (intr. by P.C.G. Issac), Newcastle-upon-Tyne, 1971.

31. The Egyptian Fortune-Teller, quoted in H.B. Weiss, A Book about Chapbooks, The People's Literature of Bygone Times, Trenton (N.J.), 1942; reprinted Hatboro, 1969, p.99; A Visit to the Tower, being an account of several birds and beasts, York, [1820?], loc.cit. (12), p.8; Rural Walks, op.cit. (12), p.29.

32. Robert Huish, The Wonders of the Animal Kingdom, exhibiting delineations of the most distinguished wild animals, in the various menageries of this country, London, 1829.

33. Hone, op.cit. (23), I,243, quoting the opinion of an anonymous author.

34. William Bingley, Animated Nature; or, Elements of the Natural History of Animals, London, 1814, p.35; Thomas Smith, The Naturalist's Cabinet, 6 vols, [London], 1807, I, 27.

35. Hone, op.cit. (23), I, 584-601 (591).

36. Much of the information on menageries is derived from the collection in the British Library of handbills and posters etc., shelf-mark 1889.b. 10/5-8.

37. The Universal Pamphleteer, No.28, The Extraordinary Performances of the Great Siam Elephant, at the Adelphi Theatre: with the Programme of the Piece... To which is added the Natural History of the Elephant, with many curious anecdotes, London, [1829], (Loc.cit. (36), 10/6 f.11).

38. John Taylor, The Life, Death, and Dissection, of the Largest Elephant, Ever Known in this Country, and which was destroyed a few days since at Exeter 'Change, London, 1826; A Correct Detail of the Destruction of the Furious Elephant at Exeter 'Change on March 1st 1826, with Interesting Particulars of the Singular Habits, Economy, and Natural History of that Extraordinary Animal, London, 1826.

39. *Mirror of Literature, Amusement and Instruction,* 1828, *12*, 145, 148-50 (148 and note).

40. Shaw, op.cit. (28), I, 1.

41. William Mavor, *Natural History for the Use of Schools; founded on the Linnaean Arrangement of Animals*, London, 1800, pp. iii-iv; Ingpen, op.cit. (11), p.xi.

42. Wood, op.cit. (13), I, vii-viii.

43. Sarah Trimmer, *An Easy Introduction to the Knowledge of Nature and Reading the Holy Scriptures Adapted to the Capacities of Children,* 11th edn., London, 1802, p.ix.

44. Bingley, op.cit. (34), p.iii.

45. *Sketches*, op.cit. (22), p.vi; Ingpen, op.cit. (11), p.xii.

46. Wood, op.cit. (13), I, xiii.

47. Mary Trimmer, *A Natural History of the most Remarkable Quadrupeds, etc.,* 2 vols., Chiswick, 1825, I, 73.

48. *Jack Dandy's Delight: or, the history of birds and beasts; in prose and verse,* York, [1820?], loc.cit. (12), p.15; Bewick, op.cit. (27), p.201; *Juvenile Miscellany,* London, [1800?], loc.cit. (12), pp.24-8.

49. *The Book of Beasts for Young Persons,* Banbury, 1830?, loc.cit. (12), pp. 4,7; *A Natural History of Beasts and Birds,* Derby, [1810?], loc. cit. (12), p.19.

50. Bigland, op.cit. (17), pp.iv-v; Mavor, op.cit. (41), p.x.

51. Mavor, op.cit. (41), p.ix. He also quotes More on the title page.

52. Smith, op.cit. (34), I, iv.

53. Shaw, op.cit. (28), I, Advertisement, (n.p.).

54. *Letters on Entomology*, London, 1825, p.19 quotes this phrase.

55. Wood, op.cit. (13), I, xvii.

56. Goldsmith, op.cit. (10), I, ix, 394.

57. Bewick, op.cit. (27), p.l; Donovan, op.cit. (26). For the lion first, see e.g. Smith, op.cit. (34).

58. Shaw, op.cit. (28), I, 16.

59. J. Fleming, A History of British Animals, exhibiting the descriptive characters and systematical arrangement of the genera and species of quadrupeds etc. of the United Kingdom, Edinburgh, 1828, p.viii.

60. Rural Walks, op.cit. (12),p.16.

61. Letters on Entomology, op.cit. (54), p.2.

62. R.J. Thornton, Botanical Extracts; or, Philosophy of Botany, 2 vols., London, 1810, pp.3-4.

63. J.J. Rousseau, Letters on the Elements of Botany, addressed to a Lady, (tr. T. Martyn), 8th edn., London, 1815, p.xi.

64. W. Salisbury, The Botanist's Companion, or An Introduction to the Knowledge of Practical Botany, and the uses of plants, 2 vols., London, 1816, I, iv; Dialogues on Botany, op.cit. (6), pp. vi-vii.

65. Priscilla Wakefield, An Introduction to Botany, in a series of familiar Letters, 3rd edn., London, 1803, p.iv; Rousseau, op.cit. (63), p.26.

66. Henry Phillips, History of Cultivated Vegetables, 2nd edn., 2 vols., London, 1822, I, 2; Wakefield, op.cit. (65), p.v.

67. R.J. Thornton, A Grammar of Botany, London, 1811, p.l.

68. J.E. Smith, An Introduction to Physiological and Systematical Botany, London, 1807, p.x; S. Cannon, Science in Culture: The Early Victorian Period, Folkestone and New York, p.l; Wakefield, op.cit. (65), p.iv; Thornton, op.cit. (62), p.2.

69. W. Pinnock, The Young Lady's Library, London, 1829, p.307; J. Duncan, Botanical Theology, Oxford, 2nd edn., 1826, p.2.

70. Charles Marshall, A Plain and Easy Introduction to the Knowledge and Practice of Gardening, with Hints on Fish-Ponds, London, 5th edn., 1805, p.419.

71. Smith, op.cit. (68), p.xviii; Rousseau, op.cit. (63), p.59.

72. Quoted by W. Blunt, The Compleat Naturalist, A Life of Linnaeus, London, 1971, p.245.

73. R. J. Thornton, Juvenile Botany, London, 1818, p.7.

74. Rousseau, op.cit. (63), Preface, p.xi.

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161. Gurney, op.cit. (157), pp.17-18.

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168. J.S. Forsyth, The First Lines of Philosophical and Practical Chemistry, London, 1828, p.13.

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172. Murray, op.cit. (164), p.7.

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174. Rev. David Blair [pseud. i.e. Sir Richard Phillips], A Grammar of Chemistry, London, 1809, p.iv. This was a pirated version of Parkes' Chemical Catechism, later stopped by court injunction.

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182. Weldon, op.cit. (142), p.v.

183. William Nicholson, A Dictionary of Chemistry, 2 vols., London, 1795, Preface,p.vii.

184. Graham, op.cit. (163), p.v.

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186. [Andrew Duncan], 'A System of Chemistry, by Thomas Thomson', Edinburgh Review, 1804, 4, 120-51 (123).

187. James Mitchell, A Dictionary of Chemistry, Mineralogy and Geology, London, 1823, p.1; [Thomas Thomson], 'History and Present State of Chemical Science', Edinburgh Review, 1829, 50, 256-76 (262).

188. John Murray, A System of Chemistry, 4 vols., Edinburgh, 1806, I, vi.

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191. [A. Maxwell], The Plurality of Worlds, London, 1817, pp. 3-4.

192. George Carey, Astronomy as it is Known at the Present Day, London, 1825, p.iii.

193. John Bonnycastle, An Introduction to Astronomy in a Series of Letters, 8th edn., London, 1822 (originally 1786), p.vi.

194. James Ferguson, Astronomy Explained upon Sir Isaac Newton's Principles, and made easy to those who have not studied Mathematics, London, 1756. Having reached its 12th edition in 1809 this work was reissued in a revised form in 1811 by David Brewster.

195. W. Jevons, Elements of Astronomy, London, 1828, p.iii.

196. Guy, op.cit. (190), p.1.

197. Carey, op.cit. (192), pp.1-2.

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200. W.H. Prior, Lectures on Astronomy, London, 1826, p.viii.

201. Guy, op.cit. (190), p.iii.

202. William Walker, An Epitome of Astronomy, 15th edn., Bungay, 1802, p.2.

203. C.V. Whitwell, An Astronomical Catechism; or, Dialogues between a Mother and her Daughter, London, 1818, p.2.

204. On Herschel's work on the sun see Simon Schaffer, '"The Great Laboratories of the Universe". William Herschel on Matter Theory and Planetary Life', Journal for the History of Astronomy, 1980, 11, 81-111.

205. Carey, op.cit. (192), p.v.

206. [John Playfair], 'Review of Traité de Mechanique [sic] Céleste by P.S. Laplace', Edinburgh Review, 1808, 11, 249-84 (264,279).

207. London Magazine, op.cit. (86), p.601.

208. Ibid, p.601.

209. Christopher Irving, A Catechism of Astronomy; containing a concise explanation of the nature and properties of the heavenly bodies, 6th edn., London, 1819, pp.71-2. This work, which was published under the patronage of HRH the Duke of Kent, reached at least 21 editions.

210. Astrology was not, however, absent from the formal popularisations. Ebeneezer Sibly's A New and Complete Illustration of the Celestial Science of Astrology was repeatedly reissued in this period. In 1817 the work was published in quarto at 42s., and it would have given its reader a fairly up to date introduction to contemporary astronomy.

211. Carey, op.cit. (192), p.5.

212. Bonnycastle, op.cit. (193), p.8.

213. Carey, op.cit. (192), p.5; Whitwell, op.cit. (203), pp.3-4; cf. Harris, op.cit. (24).

214. e.g. James Mitchell, The Elements of Astronomy, London, 1820, p.4.

215. Olinthus Gregory, Lessons, Astronomical and Philosophical, 6th edn., London, 1824, pp. iv-v.

216. Ibid, pp.306-307.

217. Carey, op.cit. (192), p.1.

218. Whitwell, op.cit. (203), pp.3-4.

219. Margaret Bryan, A Comprehensive Astronomical and Geographical Classbook, for the use of schools and private families, London, 1815, p.18.

220. Thomas Chalmers, A Series of Discourses on the Christian Revelation, viewed in connection with the Modern Astronomy, Glasgow, 1817, p.90.

221. [Maxwell], op.cit. (191), pp.5, 103, 118.

222. William Wood, Astronomy made Plain, Chatham, 1819, p.19. See also William Woodley, The Divine System of the Universe, London, 1830, and [Maxwell], op.cit. (191).

223. For a discussion of the belief in the plurality of worlds and its mid-nineteenth

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225. J. Mitchell, On the Plurality of Worlds, London, 1813, p.4.

226. Henry Baker, The Universe, A Philosophical Poem, Taunton, 1808 (originally 1727), p.6 (n).

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228. Walker, op.cit. (202), p.33 (n).

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231. Whitwell, op.cit. (203), p.44.

232. The Prophetic Almanack; or , Annual Abstract of Celestial Lore... for 1825, London, [1824], 'A Batch of Celestial Treats for all Seasons', Preamble (n.p.).

233. Bryan, op.cit. (219), p.3.

234. Robert Woolsey, The Celestial Companion, Islington, 1802, p.8.

235. T. Squire, A Popular Grammar of the Elements of Astronomy, London, 1820, p.v.

236. Mrs Mary Sherwood, Introduction to Astronomy Intended for Little Children, Wellington (Salop), 1817, p.25.

237. Woolsey, op.cit. (234), p.8.

238. Rev. J. Seally, The Lady's Encyclopaedia, London, 1788, III, p.21.

239. In Tom Telescope [pseud.] , The Newtonian System of Philosophy, New edn., London, 1812, p.7, and Gregory, op.cit. (215), p.57.

240. [Playfair], op.cit. (206), p.249.

241. W. Phillips, Eight Familiar Lectures on Astronomy, London, 1817, p.2.

242. Lalande, op.cit. (223), p.xxiii.

243. Francis Moore [pseud.], Vox Stellarum: or, A Loyal Almanack for the year of human redemption, 1800, London, [1799?], p.37.

244. Gregory, op.cit. (215), 6th edn., 1824, pp.iii-iv.

245. Charles Smith, A Familiar Explanation of the Appearance of the Planets, Andover, 1821, Preface (n.p.).

246. Phillips, op.cit. (241), p.4, (his emphasis).

247. Bryan, op.cit. (219), p.6.

248. Marcet, op.cit. (224), p.132.

249. Guy, op.cit. (190), p.43.

250. Smith, op.cit. (245), p.31.

Chapter Four: Science and Periodicals

A. Periodicals in the Early Nineteenth Century[1]

The periodical press in the first decades of the nineteenth century was a very important part of the publishing trade. As with novels, the reading of periodicals first became wide-spread amongst a general middle-class audience in the early eighteenth century. Foremost at this time were Addison and Steele's Spectator and Tatler; after 1750 Johnson's Rambler was the most famous essay serial. General magazines such as the Gentleman's Magazine also sold very well[2].

The late eighteenth century saw a sharp increase in the number of periodicals published (rising in London from thirty-six titles in 1790 to sixty-four in 1800)[3]. This growth continued into the new century. More important than the increased number of titles, however, was the growth in readership. Circulations increased enormously in the first thirty years of the nineteenth century. The Monthly Review and the Critical Review, with estimated circulations of 5,000 and 3,500 respectively in 1797, were rapidly eclipsed in the first decade of the new century by the Edinburgh and Quarterly Reviews, not primarily because they lost circulation but because they failed to gain it in a growing market. The Edinburgh's circulation, for instance, rose from approximately 2,000 in 1803 to 7,000 in 1807 and to 13,000 in 1814[4]. Cheaper publications had much larger circulations: Cobbett's Weekly Register sold 40,000 -70,000 copies per week in 1816, while The Mirror of Literature, in 1823, was claimed to be selling an average of 80,000 copies every week[5]. Circulation cannot, of course, be equated with readership[6]. With libraries and book clubs, the swapping of publications between friends and workmates, and the practice of reading aloud, the ideas contained in a publication could have circulated very widely.

The causes of the growth in circulation are hard to pinpoint exactly. Was the demand already in existence or was it created by the cheaper and more easily available publications? The answer is probably that both were true to some extent. The high political tension of the post-Waterloo era produced a market for the cheap radical press of this period, and the habit of reading or listening to excerpts from these papers must have both permitted and provoked the establishment of cheap 'non-political' magazines in the 1820s and 1830s. Even the subsidised religious tracts so widely distributed in the early years of the century perhaps formed reading habits where none had existed. The crucial difference in early nineteenth-century reading, however, lay in the demand for new reading matter. The lower classes, particularly those in stable communities, were by no means unacquainted with printed works but they showed little desire for new works. The Bible, Pilgrim's Progress, chapbooks: all had been read many times. Children read what their parents had read. Now, however, the rapidly changing political, social and economic conditions produced both the need and the facilities for the dissemination of new ideas; the ideal vehicles for this dissemination were pamphlets and cheap periodicals.

The Government was not slow to react to such potentially dangerous developments. Paper tax, advertisement duty, pamphlet tax and stamp duty were either newly imposed or sharply increased. In 1815 stamp duty was 4d., advertisement duty 3s. 6d.; unstamped periodicals were forbidden not only to contain 'news' but also advertisements. The financial position of many journals and magazines was therefore perilous. A price sufficiently cheap to attract purchasers but high enough to bring in a suitable revenue was found to be an impossible compromise by many of the short-lived publications at a time when 3d. (a typical price for a cheap weekly publication in the 1820s) might buy a workman a half-pound of meat, and yet would buy the publisher only a quarter-pound of paper.

One result of the financial difficulties of many publishers was the rapidity with which new initiatives were taken and copied. The turbulent social and political situation, the reductions in paper prices after the French Wars, the invention and development of new paper-making and printing techniques, etc. also all contributed to the rapid series of changes which occurred in the 1820s in particular. Yet all new developments usually had roots firmly in the publishing community of the time and it is important not to overestimate the novelty of any single publication.

Periodical publication, it must also be remembered, was overwhelmingly centred on London and, to a lesser degree, Edinburgh[7]. Consequently distribution through the country was uneven and added to the expense of publication. While large towns and cities would have agents for the major publishers, obtaining publications from smaller publishers, or in smaller towns, was inevitably more difficult. For the rural population stamped publications were often the only ones obtainable, restricting the possible purchasing public by more than doubling the price of cheap periodicals. Cheaper magazines had a principally urban, particularly metropolitan, circulation.

The wider distribution of periodicals than popular science books, both because of their cheaper price and because their science content was bound-up with coverage of other topics, makes them important and useful in any consideration of the popularisation of science. For practical reasons it has been necessary to restrict sampling of books principally to those devoted to a science or sciences. With periodicals a more general range may be examined to give a better idea of the image of science in the minds of those with no particular interest in it.

Unfortunately periodical publications also present unique problems. Over the life of a single periodical editorship, contributors and publishers may all change, not to mention the opinions of those staff who do remain.

Thus John Aikin, a Unitarian radical and founder-contributor of the Monthly Magazine in the 1790s, found himself "cured of all theoretical ideas of reform" by 1802, in the aftermath of the French Revolution[8]. As well as variations in their attitude to scientific topics, the amount of coverage varied, and it must be remembered that in general publications science formed only a small part of the content. Readers could ignore it if they so wished.

B. Eighteenth-Century Traditions Continued

"By 1710", wrote W.J. Graham, "the ingredients of the eighteenth-century miscellany were pretty well determined. Instructive or moral essays, entertainment in the form of poetry, fiction, epigrams, riddles, etc., biographical notices, feature articles on scientific subjects of interest to the curious... [etc]."[9]

One hundred years later similar publications persisted, most famously the Gentleman's Magazine. Founded by Edward Cave in 1731, by 1778 editorship was in the hands of the printer John Nichols, who continued editing the magazine until his death in 1826. Although the magazine did not finish with Nichols' death (it was issued until 1877) by the 1820s it was definitely becoming old-fashioned and rather stale. William Hazlitt described it in 1823 as "a well-preserved piece of useless antiquity...[containing] all that is forgotten, or soon to be so".[10]

This had by no means always been the case. Although it had begun primarily as a compilation from other sources, in the later eighteenth century there was an increase in the number of original essays published. In 1797 its circulation was over 4,500[11] and this at a price of 1s. 6d. for its monthly parts. A new series was begun in 1809, after a fire had devastated the office, at which time the price was increased to 2s. a month.

Science in the Gentleman's Magazine consisted of miscellaneous small items on a wide range of sciences. The emphasis was on the curious and peculiar. Thus, in the volume for 1800, there is a report of a toad found alive inside a stone.[12] Books reviewed were those thought to be of possible interest to the middle and upper class readership. J.P. Tupper's essay on the probability of sensation in vegetables was thought "not improbable... [to] engage the attention of the Ladies, and find its way as well to the toilette as the closet"."On this subject the Reader will find both amusement and instruction".[13] Similarly, Frederick Accum's Chemical Amusements was described as an "amusing and instructive work" containing 103 "interesting experiments which, it will readily be acknowledged, when performed by a student himself are better adapted to fix the attention than either bare positions or precepts, or the rapid illustrations [of] ...popular courses of lectures".[14] The Gentleman's Magazine embodied the middle class preference for private study tempered by amusement.

Politically, especially after the French Revolution, the Gentleman's Magazine was Tory. This resulted not only in disdain for French politics but also remarks antagonistic to French science. A review of the eighteenth century criticised the revolution as having produced a "system fatal to Liberty civil and religious... such a Revolution, the seeds of which had been sown, and its growth nurtured in Infidel Philosophy".[15] A correspondent, J. Crane M.D., satirically remarked with regard to the new chemical terminology: "Our kind neighbours, the French, are so good as to supply us with the technical terms, which are not quite so intelligible; as Pluvoise, Ventose, Germinal, etc.", (i.e. the revolutionary regime's new names for the months of the year).[16] Connected with such views was the support of the Gentleman's Magazine for revelation over natural theology and physical science. "The evidence of a plurality of worlds is merely probable and presumptive;" wrote 'R.C.' in a letter in 1800, "of the truth of Christianity we have positive proof".An article in the same year on the 'Infidelity of D'Alembert' included the passage:

> "Without interfering with the accuracy of mathematical truth, the believers in Revelation have a more sure word of prophecy and information, which the most accurate mathematician cannot pretend to possess".[17]

The treatment of science in the Gentleman's Magazine was therefore fairly constant. It was considered as "subjects of interest to the curious" but not as something of over-riding importance, and while it could usefully combine amusement and instruction, little encouragement was given to the serious student.

Of the magazines and miscellanies set up in partial imitation of the Gentleman's Magazine, one which lasted for many years was the Universal Magazine of Knowledge and Pleasure. Originally issued in 1747, the magazine's title was shortened to the Universal Magazine in 1803 and this was followed by a New Universal Magazine from 1814 to its closure in 1815. W.J. Graham described it as "a 'popular' magazine in the modern sense" "filled with experiments in the more popular phases of science, facts of husbandry,etc., including... local history, mathematics, and sport".[18] Similarly priced at 1s. 6d. and also a monthly, the Universal must have been similar to the Gentleman's Magazine although its circulation in 1797 was considerably less, at under 2,000.[19]

The Entertaining Magazine: or, repository of general knowledge, a fifty-six page monthly production from the years 1813-15, included, as well as "Biography, Manners and Customs of Foreign Natives, Essays, Tales, Adventures, Poetry, Astronomy, Diary of Nature, Guide to the Almanack etc. etc."[20], reprints for the "younger classes" of readers of eleven essays collectively entitled "The Contemplative Philosopher" from the Universal Magazine of 1785-92.[21] Combining large amounts of scientific poetry of the eighteenth century (e.g. by Thomson and Young) with explicit natural theology, these essays covered atmospheric phenomena, the existence of God, the solar system, the universe, the figure and motion of the earth, and gravity, "by which the beauty, order and harmony of the universe are invariably maintained".[22] The Entertaining Magazine was also interested in the remarkable (e.g. earthquakes) and the amusing, including in the first volume excerpts from Accum's Chemical Amusement describing simple but visually interesting experiments. These could "claim this advantage over all other branches of knowledge, that, while they unveil the properties to which the Almighty has subjected the matter of the universe, they amuse the mind, by presenting to the eye, unexpected phenomena and striking appearances, well calculated to gratify a laudable curiosity, or to diffuse mirth and surprise through a social circle."[23]

Volume one of the magazine also included paragraphs on animal biography, as did volume two; the latter also contained a regular series of "Popular Essays" on science. The writer of the introduction to the first essay proclaimed himself "anxious to disseminate, among persons of both sexes, and every age and condition, a taste for science and the means of acquiring it, at a small expense of time and money".[24] These popular essays covered chemistry, arithmetic, acoustics, astronomy and geography, and political arithmetic, amongst other subjects. Gas lighting was one subject discussed, the article emphasising its use in factories (eg. in Phillips' and Lee's cotton manufactory) and its economical nature.[25] Such facts indicate that the Entertaining Magazine was aimed at an urban and primarily middle-class audience. An interesting reflection of the education of such people occurred in the third and last volume where a 'Popular Essay on Astronomy and Geography' contented itself with a description of peculiar occurrences, the author "here suppos[ing] that the reader is acquainted with the cause of these phenomena, an explanation of which may be found in every elementary work on astronomy".[26]

This may be compared with The Museum, a journal which flourished briefly in Leicester in the 1790's under the superintendence of Richard (later Sir Richard)

Phillips, the founder of the Monthly Magazine. The first issue of the magazine commenced with a 'lecture' on the universe, an engraved diagram of the solar system forming the frontispiece. The content is typical of eighteenth-century rationalism (Phillips being a radical at this time, and supposedly a 'Jacobin'). The solar system displayed God's glory while the plurality of worlds, "multiplied without end", provided accommodation for infinite numbers of rational inhabitants. "The relations which unite all the worlds to one another, constitute the harmony of the universe".[27] The bi-monthly publication contained a lot of science [28] and rather than being 'Jacobin' showed a partiality to manufactures, to sciences which aided manufactures, and to the constitution of Britain:

> "If you see extensive manufactures in any nation, you may be sure it is a civilised nation; you may be sure property is accurately ascertained and protected". "[As] the two sciences which most assist the manufacturer are mechanics and chemistry ... [and] , as in this country every one is free to rise by merit, [Arkwright] acquired the largest fortune in the country".[29]

Other eighteenth-century periodicals which were issued throughout the period were The Ladies' Diary (1704-1840) and the Gentleman's Diary (1741-1840, when the two combined). Both contained some astronomical articles and mathematical questions, as did the Gentleman's Mathematical Companion (1798-1827) and The Scientific Receptacle (1779-1809), usually in the form of queries which were answered by contributors in subsequent issues.

One other periodical which was founded in the eighteenth century and continued into the nineteenth, although in both cases only just, was James Anderson's Recreations in Agriculture, Natural History, Arts and Miscellaneous Literature (1799-1802). Originally issued in three separately paginated sections for agriculture, natural history, and the arts etc., following the pattern of Benjamin Martin's Magazine of the Arts and Sciences, of 1755, this format was soon discontinued.[30] The periodical's "primary object was, to give strength and energy to the human mind, by gradually sapping the foundations of prejudice and ignorance".[31] This it intended to achieve by "a series of dissertations", with no systematic plan, on natural history and the arts etc., by a national survey of agricultural practices, and by being a medium for publishing information contributed by agriculturalists.[32] The publication was issued in monthly parts of approximately 80 pages until the end of the sixth volume when Anderson admitted that it was too much effort for him, as an old man, to produce, and the title ended.[33]

Aimed as it clearly was at pragmatic farmers and amateur improvers,[34] Anderson's Recreations was one of the few publications designed for a mainly upper-class readership. The Director (1807), although very different, was another. Remembered now, if at all, as the medium for conveying Davy's Royal Institution lectures to a wider public, this weekly, thirty-two page publication, priced at 1s., consisted of four sections. It was to contain essays on literature, the fine arts and manners; a 'Bibliographiana', or account of rare and curious books and of book sales; analyses of the lectures at the Royal Institution and a description of the principal pictures exhibited for sale at the British Gallery.

Published only "during the winter season", the Director was the most comprehensive attempt to site science within a literary (indeed fine art) framework. One of the original essays was written by Davy, on 'Parallels between art and science' in which Davy distinguished pure and applied science and attempted to link pure science with the fine arts. "The mechanical arts", he wrote "and the fine arts can hardly be compared; the objects of the first being utility, of the last, pleasure... In the truths of the natural sciences there is perhaps a nearer analogy to the productions of the refined arts. The contemplation of the laws of the universe is connected with an immediate tranquil exaltation of mind, and pure mental enjoyment".[35] The publication seems not to have succeeded in attracting sufficient support, however, for only two volumes were issued.

Richard Phillips, founder of The Museum, moved to London and founded in 1796 the Monthly Magazine. Part of the dissenting and especially Unitarian network which had so much influence on the periodical press of the 1790s, the Monthly Magazine had John Aikin and William Taylor (both Unitarians) as two of its main contributors. A circulation of approximately 5,000 in 1797 dropped to one of between 3,000 and 4,000 in 1822 and Phillips sold the magazine in 1824.[36] Always liable to include scientific articles, the magazine stood for and discussed liberal objectives (abolition of capital punishment, better treatment for the insane, etc). This included an interest in the progress of literary and philosphical societies, the first nine volumes including eight miscellaneous papers of the Newcastle society. As Carnall suggests, however, the magazine's demise (its nature being altered after it was sold) owed much to the loss of interest by the general public in an encyclopaedic and miscellaneous approach. The nineteenth-century audience began to look for more substance in their reading and the general approach became less attractive. Specialization gradually increased and a disdain for the generalist came with it. As the Edinburgh Review commented on Coleridge in 1817, "Mr C., with great talents, has, by an ambition to be everything, become nothing."[37]

C. Science-Based Periodicals

Ci. General Science Periodicals

The late eighteenth century saw the first establishment of science-based periodicals which lasted for any appreciable lengths of time outside the academies. In the 1790s two types were published. First was the Repertory of Arts and Manufactures, founded in 1794. Concerned primarily with technological developments, "one of the principal objects [was], to establish a vehicle, by means of which new discoveries and improvements in any of the useful Arts and Manufactures, may be transmitted to the public; particularly to Artists, [and] Manufacturers".[38] To this end the periodical included patent specifications and excerpts from transactions of societies (excluding "much speculative or other matter, foreign from the purpose of this publication"). Contributions were also requested from "those who cultivate the useful arts, whether they do so for profit or pleasure."[39]

The journal continued for sixty-eight years doing just as it promised, describing patent specifications and giving excerpts from books and transactions on new processes and machines. In 1805 it was joined by The Retrospect of Philosophical, Mechanical, Chemical and Agricultural Discoveries, a three-monthly digest, it was claimed, of all scientific journals and patent specifications. At this time the Repertory cost 2s. 6d. while the Retrospect was priced at 3s. 6d., but the Retrospect was the first to close, in 1813.

The 1790s saw also the foundation of the first scientific research journals to be generally published, beginning with 'Nicholson's Journal' or The Journal of Natural Philosophy, Chemistry and the Arts in 1797. Alexander Tilloch began a rival publication in 1798, The Philosophical Magazine, Comprehending the Various Branches of Science, the Liberal and Fine Arts, Agriculture, Manufactures and Commerce, which absorbed Nicholson's Journal in 1813. Both journals contained translations of foreign articles, abstracts of Royal Society papers, reports of societies etc., and although Tilloch's object had been "to diffuse Philosophical Knowledge among every class of society, and to give the Public as early an Account as possible of everything new or curious in the scientific World, both at Home and on the Continent", both journals soon became serious science journals and lost any claim to being popular .[40]

Thomson's Annals of Philosophy appeared as a rival to the Philosophical Magazine on the cessation of Nicholson's Journal in 1813, but it was also absorbed by the

Philosophical Magazine, in 1826. Other science journals included Brewster's Edinburgh Philosophical Journal, and its successor the Edinburgh Journal of Science (1824-1832, when it was taken over by the Philosophical Magazine).

By the 1820s, however, more popular journals had been founded, such as the London Journal of Arts and Sciences. First issued in 1820, this monthly journal contained "reports of all new patents, with a description of their respective principles and properties: also, original Communications on subjects connected with science and philosophy; particularly such as embrace the most recent inventions and discoveries in practical mechanics."[41] The emphasis on technological devices did not prevent the journal also listing lectures at the metropolitan institutions and giving short reports of society meetings, including those of the Royal Society, the Society of Arts, the Horticultural Society and the New Society of Arts at Edinburgh. A new series was begun in 1828 under the editorship of W. Newton, 'Civil Engineer', and C.F. Partington of the London Institution; each issue was reduced from the original eighty pages to sixty-four. The price was then 1s.

The Register of Arts and Sciences underwent a similar, although rather greater, change in 1828. Printed and published in 1824 for George Herbert this single column, fortnightly, journal contained sixteen pages and was priced at 3d. (raised to 4d. from October 1825). As with the London Journal, the Register was intended to be primarily concerned with technological developments, giving "A Correct Account of Several Hundred of the most important and interesting inventions, discoveries, and processes".[42] As a fortnightly publication it was able to boast "the earliest description of every new patented invention".[43] The Register's early volumes were not exclusively technological however; the first thirty-seven numbers included series on the "Elements of Natural Philosophy", while an "Encyclopaedia of the Useful Arts" was spread through the first forty-seven numbers (although it was still on letter 'A' when it finished). The termination of both these series seems to have coincided with a change of publisher and therefore perhaps of editor.[44]

The Register of the Arts is a good example of the possible changes in nature of a journal over the years, for from issue number sixty-six, Cowie and Strange became the publishers, previously publishers of the London Mechanics' Register. Almost immediately the Register of Arts began to cover the lectures of the London Mechanics' Institution, as well as giving news of other metropolitan institutions.[45] Issue sixty-seven contained a report of Wallis' lectures on astronomy while notices of the formation of the Southwark Mechanics' Institute appeared shortly afterwards.[46] By issue seventy-eight the reportage of lectures had increased substantially, eleven pages of this issue being taken up by an illustrated report of George Birkbeck's lecture on the power loom at the London Mechanics' Institution.[47] Shortly after this, however, the publishers changed again, first to L.Hebert and then to B.Steill, and a new series was begun at the close of volume four, under the editorship of L.Hebert, 'Civil Engineer'. With this change, and the contemporaneous alteration in title from Register of the Arts and Sciences to Register of the Arts, and Journal of Patent Inventions the journal became very similar to the London Journal of Arts and Sciences, and the Repository of Arts, being concerned almost exclusively with patents and technology. Although the 'Address' in volume four mentioned the praise of the President of the London Mechanics' Institution (i.e. Birkbeck) for the magazine, and despite the recruitment of Robert Christie, secretary to the institution, to the staff of the magazine, it was clearly stated that, while faithful and regular notice of the London institution meetings would be given, this would be amongst similar reports of all other scientific and literary institutions of London and no regular reports of lectures would be given.[48]

Before C.F. Partington became joint editor of the London Journal he had conducted briefly the Scientific Gazette. Emerging from the Circulator of Useful Knowledge,[49] the Scientific Gazette was "a work wholly devoted to the various and interesting pursuits of science".[50] A quarto publication, the Gazette was priced at

8d. a week, and contained sixteen pages per number. Only just over one volume was published, i.e. thirty-one numbers running from 2 July 1825 to 4 February 1826, but in this time the Gazette contained descriptions of new machinery and new chemical apparatus, summaries of foreign books and reports on science, biographies of famous natural philosophers and notices of scientific institutions. These included Partington's own, the London Institution, and the metropolitan mechanics' institutes. The size and price of the journal meant that it was not aimed at mechanics or artisans but at "those who, through the cultivation of science, at once derive a pleasurable benefit themselves, and impart a general good to society". The aim was indeed to produce a journal similar to, but probably more popular than, Brande's Quarterly Journal of the Arts and Sciences, edited at the Royal Institution from 1816. Partington also recognised the benefits of a weekly publication, claiming that his journal would be more novel than Brande's quarterly serial.[51]

Partington, as a lecturer not only to the London Institution but also to many mechanics' institutes, was fully in favour of such educational provision ;[52] a very favourable review of Brougham's pamphlet advocating the education of the working classes appeared in the third issue. Such education would, it was claimed, lead to an understanding of the connections of interest between the "producers" and the "capitalists" and would lead to general prosperity, breaking down "poverty, and its necessary concomitant - anarchy". Although the Scientific Gazette recognised these social benefits of education, their origin lay not in this, it was said, but in the mechanics' desire to acquire knowledge and the capitalists' "disinterested wish ... to improve the condition and the happiness of a body of men with whom they were daily and hourly brought into contact."[53]

A similar publication, but one devoted to chemistry only, was the Annals of Chemical Philosophy (1828-29). Appearing every two months, at a price of 2s. 6d., its object was "to bring before the chemical reader, in a condensed form, that which can only be obtained by much difficulty, labour and expense".[54] This it did by reprinting selected papers from Philosophical Transactions etc., by translating foreign articles, and by reviewing books.

The Annals of Chemical Philosophy was addressed to "the scientific and practical Chemist, the Physician, Manufacturer, Artist, and Scholar";[55] its object was not "to teach the elements of science, but to furnish those interested in Chemical inquiries with the latest and most useful information."[56] The journal was conducted by William Maugham, a lecturer on chemistry and materia medica at his home at 44 Trinity Square, Blackman Street, Borough, London; his magazine included miscellaneous information on the proceedings of scientific societies such as the Royal Society, the Royal Institution and the Geological Society. This is just one more instance of the close connection between scientific lectures and institutions, and the scientific periodical press. General science periodicals would mostly cover the proceedings of one level of institutions or another, from reprinting papers from the Philosophical Transactions to reporting lectures at the London Mechanics' Institution. In the case of Brande's journal the periodical was edited at the Royal Institution while Partington's Scientific Gazette proclaimed that its editor was "of the London Institution".

Such connections also existed between many of the mechanics' magazines and various institutions, and were particularly common in the 1820s. Indeed, many of the general science periodicals of those years shared many features of the mechanics' magazines, and the dividing line is unclear.

General science periodicals were concerned primarily with physical science and often with the diffusion of technological knowledge rather than pure science. Most were aimed at urban dwellers and professed themselves in favour of education of the labouring classes in mechanics and the useful arts. Most also encouraged contributions from readers, particularly on new inventions or devices of their own.

Cii. Natural History Periodicals

Throughout the early nineteenth century natural history, and primarily botanical, magazines were regularly commenced, although often they lasted for only a short while. In 1805 Charles Konig and John Sims, both fellows of the Linnean Society, began their Annals of Botany, an attempt at a serious scientific journal of botany. The journal did not prosper, however, and financial difficulties caused its closure in the following year. More successful was Curtis' Botanical Magazine, which began in 1787 and was conducted by various men through to 1844. In 1817 a similar, rival magazine appeared, The Botanical Cabinet by Conrad Loddiges and Sons. Issued in parts but not in true periodical format (i.e. with no recurring title page, etc.), both magazines consisted of coloured plates of plants, with their generic and specific descriptions, and perhaps a paragraph on each plant relating to methods of cultivation, flowering, utility, etc. Curtis' Magazine, (conducted in 1817 by John Sims MD, FRS, FLS), was "intended for the use of such LADIES, GENTLEMEN, and GARDENERS, as wish to become scientifically acquainted with the plants they cultivate".[57] The Botanical Cabinet attempted "to direct the minds [of readers] ... to a source of amusement at once intellectual, exalted, delightful, and unbounded". Plants, it was opined, cannot have been created merely as food for animals but to afford an inexhaustible source of the purest and most innocent pleasure".[58] A similar magazine founded somewhat later was W.J. Hooker's Botanical Miscellany (1830-33).

In 1823 E. Donovan founded a publication on similar lines but with wider aims. The Naturalist's Repository, or Monthly Miscellany of Exotic Natural History was designed to be a "miscellaneous assemblage of elegantly coloured plates, with appropriate scientific and general descriptions of the most curious, scarce, and beautiful productions of nature".[59] The plates depicted shells, insects, animals, birds, etc. from foreign countries.

Hand-coloured plates inevitably put the price of such natural history periodicals beyond the reach of the poorer classes of the community, and Donovan's work was for the wealthier classes, "either as a work of taste for the library of the general reader, or the admirer of nature, the folios of the amateur, or the professed Study of the experienced Naturalist".[60] Even J.C. Loudon's Magazine of Natural History, and Journal of Zoology, Botany, Mineralogy, Geology and Meteorology (founded 1829), although its object was a "more general diffusion of a knowledge [of natural history] ",[61] was issued in two-monthly parts of approximately one hundred pages each, the price of which must have been beyond a labouring man's pocket. This despite the fact that natural history was "consider[ed] to be in an especial manner calculated for raising the character of the labouring classes of a community".[62] The magazine was divided into four sections: original communications; reviews; collectanea; and miscellaneous intelligence; throughout the emphasis was upon pleasure rather than utility: "all knowledge is pleasure as well as power".[63]

The study of natural history, Loudon thought, was morally and religiously useful, having a "beneficial influence on the moral sentiments and conduct" and leading to a "love of truth, the foundation of justice and honesty". The object of the magazine was accordingly to make its readers "practical and scientific, naturalist [s]".[64] The desired audience was a provincial one, (one feature being a report on "Natural History in English Counties"), and one without an interest in the application of the science to industry. The "perpetual appeal to utility" was even criticised in one article.[65]

Natural history periodicals were directed to a higher and wealthier social class than the general science periodicals, and in particular to a rural rather than an urban audience. Natural history was a study for pleasure, for a better understanding of God's handiwork and, therefore, for moral benefit. The study was not directed primarily at considerations of economic utility.

D. The New Reviews

The late eighteenth century was a period in which review periodicals were very successful. In the years 1793-6 five reviews were published all of which lasted for ten years or more. The major reviews, the Monthly Review and the Critical Review, as well as the Analytical, were controlled by a network of dissenting editors and contributors. Circulations at this time were approximately 5,000 for the Monthly, 3,500 for the Critical and the Tory British Critic and 1,500 for the Analytical Review. Recent work has suggested that these publications were not so controlled by the publishers for promotional reasons as had been thought, but there is no doubt that the arrival of a new form of review at the beginning of the new century made these publications quickly out of date.[66] The journal which helped bring about this transformation was the Edinburgh Review, founded in 1802.

The Edinburgh Review differed most markedly from the old style of review in its selective policy. Where the old magazines dealt with perhaps fifty books a month in an effort to become an encyclopaedia of contemporary knowledge, the Edinburgh reviewed only twenty-nine works in its first quarterly issue. The Edinburgh was also very much a journal of opinion, developing a style of essay writing under almost a pretence of reviewing a work, which style reached its peak in the Westminster Review.

The Edinburgh Review's first appearance on 10 October 1802 created enormous interest.[67] At an expensive 5s. a copy, 750 were sold almost immediately and a reprint of the same number was required by November. 2,150 copies sold in

Edinburgh alone within a year, a town with only approximately 100,000 inhabitants.

One purpose of the Edinburgh Review, which it always retained, was to be educational. Francis Jeffrey, editor almost throughout the period,[68] wrote to Francis Horner:

> "I always profess to write for babes and sucklings, and take no merit but for making things level to the meanest capacities".[69]

The Edinburgh Review in its early years had a central 'core' of contributors, Jeffrey, Henry Brougham, Sydney Smith and Francis Horner. All four were Scottish Whigs with similar backgrounds. Jeffrey, Brougham and Horner were lawyers who found it hard to obtain work at the Tory-dominated bar. All the reviewers had attended Dugald Stewart's lectures on political economy given in the University of Edinburgh and Stewart was "the intellectual and personal exemplar that the Reviewers patterned themselves on".[70] Brougham, Horner and Smith soon moved to London, becoming members of the Holland House circle of Whigs, while Jeffrey remained in Scotland, eventually becoming a leader of the Scottish Whigs and a law lord.

Articles relating to science (i.e. reviews of science works, works on medicine and surgery, practical science or technology, and philosophy of mind[71]), occupied a fairly large portion of the early issues of the Edinburgh Review, articles on literature, travel and political economy taking up much of the rest. Over the twenty-nine year period 1802-30 approximately 10 per cent of the articles were concerned with science. The distribution over time was by no means even, however, with a steady drop throughout the period. Percentages for the five-year periods shown are given in the table:

Years	Total Articles	Science Articles	% Science
1802-05	260	49	18.8
1806-10	282	32	11.3
1811-15	202	23	11.4
1816-20	198	18	9.1
1821-25	189	11	5.8
1826-30	192	9	4.7
	1323	142	10.7

Of the 139 science articles, thirty-five (25%) were on the earth sciences, twenty-nine (21%) were on chemistry and twenty-four (17%) were on medicine and surgery. All these subjects were especially associated with Edinburgh University in this period. The university also maintained a broad-based natural history course, and a further eleven articles, in addition to those on geology and mineralogy, were on natural history.

Authors on science in the Edinburgh were many and varied but by far the largest single contributor was Henry Brougham. In the period considered he wrote thirty-nine articles including at least twelve on scientific education (in the years 1824-30). The other main contributor was John Playfair, who wrote fifteen articles on science between 1805 and 1816. The drop in the number of science articles may be explained partly by Playfair's cessation of writing which occurred shortly before his death in 1819. Otherwise, it was Brougham's loss of interest in the Edinburgh Review as a medium for diffusing knowledge in favour first of Parliament (he was a member from 1810-12 and 1816 onwards) and then of institutions devoted to education of the lower and middle classes, i.e. the mechanics' institutes, the Society for the Diffusion of Useful Knowledge and London University. Brougham's interest in pedagogy, the philosophy of education and the diffusion of 'rational' knowledge, (including science and political economy), he kept all his life.

The coverage of science by the Edinburgh Review was characterised by a disdain for hypotheses and praise for an inductive methodology in the Newtonian and Baconian style. This was particularly so for Brougham who thought that "an hypothesis is a work of fancy useless in science, and fit only for the amusement of a vacant hour".[72] Similarly, for Thomas Thomson, "Bacon explained the true method of investigating nature by induction";[73] even John Playfair, (whose attachment to the Huttonian hypothesis in geology was often toned down by Jeffrey)[74], wrote in 1802:

> "to so short a distance are we yet removed from the period when mineralogical phenomena first derived explication from chemistry, that attempts to form a theory of the earth may still be considered rather as exercises for fanciful and speculative minds, than as sources of improvement to useful science".[75]

Economic utility, and indeed all help for manufacturers, was valued by the Edinburgh Review. James Headrick criticised Robert Jameson's geological work for "never deviat[ing] into practical utility",[76] while the Journal des Mines, a periodical devoted to applications of geology and mineralogy, received two long and favourable reviews. Technology was rhetorically subordinated to science. Thus, according to Thomas Thomson, it was "owing to the progress which Chemistry has made of late years, that so many important improvements have been introduced into all our manufactures".[77]

Utility was not valued for merely economic reasons, however; manufactures were seen as an agent of improvement of mankind.[78] This historicist belief, a type of positivism, was similar to that of continental rationalists, e.g. Condorcet. Science itself made "slow but continual advances",[79] aiding manufactures which in turn promoted civilisation. As Thomson continued: "Could we suppose it [chemistry] brought to perfection, how different would the state of society become!"[80] Gregory Watt thought that:

"In the present state of society, metallic substances are among the most powerful of our moral and physical agents".[81]

This faith in manufactures may be contrasted with the reviewers' attitude to agriculture in which, "if any change is attempted, it usually proceeds on some partial observation, or false and imperfect analogy", and which had made "little progress... to[wards] the dignity of a science".[82]

Connected with the faith of the Edinburgh Review staff in a scientific method of induction ("that rigorous mode of investigation which, going gradually from particulars to things that are a step more general, excludes by degrees every theory but one"[83]) was their belief in the applicability of such a method to religious investigation. In a review of Paley's Natural Theology it was stated that the "great book of the universe lies open to all mankind... the bulk of the volume is legible without assistance".[84] Dismissing "certain false opinions as to the opposition of religion and philosophy" scientific laws themselves were underpinned by the existence of God, a "law presuppos[ing] an agent".

There were limits to the use of scientific methods in religious investigations, however, as the Review showed in its treatment of Erasmus Darwin's Temple of Nature. According to a review of 1803, the "fundamental error, which appears to us to pervade and infect the whole of Dr. Darwin's scientific speculations, is a presumptuous contempt, or perhaps a gross ignorance, of the legitimate bounds of philosophical inquiry". The reviewer criticised Darwin for "not restrain[ing] himself within the narrow bounds of observation... instead of copying from the great volume of Nature which now lies open to our view, he fondly attempts to penetrate the veil which must for ever conceal her mysteries from mortal eye".[85]

In 1806 John Murray, the London publisher, first suggested to George Canning the need for a conservative rival to the Edinburgh Review[86]. With the increased emphasis on party politics of the latter from 1808, Canning (by then Foreign Secretary in the Duke of Portland's administration) and Sir Walter Scott, helped found the Quarterly Review, published by Murray and edited by William Gifford. The Quarterly never became a Tory party organ although its 'core' of reviewers included a political 'helmsman' in John Wilson Croker, who acted to some extent as a 'go-between' for the government and the publication. The other main-stays of the Quarterly were Robert Southey and Sir John Barrow, Secretary of the Admiralty. Unlike the reformist Edinburgh Review the Quarterly always had, as a recent study has claimed:

> "This respect for precedent, this clinging to prescription, this reverence for antiquity which are so often ridiculed by conceited and superficial minds."[87]

The Quarterly Review had no member of its inner circle as interested in the natural and social sciences, and their diffusion, as Henry Brougham was. Unsurprisingly, therefore, fewer science articles appeared in the Quarterly than in the Edinburgh, particularly after Thomas Young ceased writing for the journal in about 1814. The very first natural science article in the Quarterly Review, in part one of volume one, (February 1809), was written by Young on a supplement to La Place's Mécanique Céleste and in it the policy of the Quarterly to science was succinctly expressed:

> "It is not our object to present our readers with a full account of every improvement which may be made in science; we shall be more anxious to give a true representation of the tone and spirit of the works which we may notice, and of the merits and demerits of the author as compared with those of their predecessors and contemporaries".[88]

Thomas Young was an apt choice to lead the coverage of science in the Quarterly

Review for a number of reasons. He was a very competent natural philosopher and mathematician, having been Professor of Natural Philosophy at the Royal Institution, and also a physician of high reputation. Not a political reformist, he also had a personal grudge against Brougham, who had bitterly attacked his work in the Edinburgh Review. Young therefore brought a desirable spirit of rivalry to the scientific coverage matching that of the political and literary sections. On the Edinburgh he commented, it" has long assumed an air of authority, which may have imposed on the timid, and satisfied the superficial student;... We trust... we shall have inspired the candid lovers of science with a salutary distrust".[89]

In particular Young disliked the partiality he thought he detected to French science in the Edinburgh and its" uniform discouragement of all domestic pretensions to scientific merit".[90] Young himself believed that:

> "There will be occasional fluctuations in the scientific pursuits of its [Britain's] inhabitants... but in the true ground-work of all natural philosophy they will perhaps always remain unrivalled".[91]

Young disliked over-praising people merely because of their reputations. The struggle he had to establish his wave theory of light he attributed especially to the influence of Newton's rejection of Huygen s' wave theory. On LaPlace he commented, "we have reason to believe, that like another Hercules, he has often been enriched at the expense of a multitude of his predecessors".[92] This sceptical attitude towards great men contrasted with Brougham's opinion that Newton had "the most brilliant career of solid discovery, that any mortal was ever permitted to run".[93]

Similarly connected with Young's espousal of a controversial theory (and perhaps with his actual experience of scientific research) Young held a less naive empiricist view of scientific method. "It has been justly conceded", he wrote, "that 'we should not hastily reject even the wildest hypothesis'".[94]

Other differences existed in the attitude of Quarterly Review writers to science and technology, as compared with the Edinburgh. Utility was seldom used as a justification for the study of science and sometimes abused: an objection to classical learning "... is made on the ground of... utility, this being it seems, 'the sole standard by which all systems of education must be tried'" but while manufactures "are highly necessary... their results are not of the first order of good, nor are they the principal ends of human life".[95] Manufactures "are... not without their concomitant evils",[96] was another comment contrasting with the attitude of the Edinburgh reviewers. No idea of a moral benefit from the study, particularly of physical science, existed. "Physical science treating of the properties of matter, whether in the form of plants, minerals or planets, is no more than a number of well authenticated facts". Rather, it was classical learning which was "nothing else than man's moral nature... All that deserves the name of wisdom... is drawn from this source... The fruit of other studies is only learning or science".[97]

This high estimation of classical learning, along with "this respect for precedent" helps explain the lack of interest in natural theology, mentioned only to complain that "a spirit of unbelief in revealed religion is become unhappily common".[98] The Quarterly was written for a rural conservative audience; the Edinburgh for urban middle classes with industrial or professional connections. The Quarterly was for the landed aristocracy, those who could not "entertain the least doubt of the advantages which agriculture possesses over the mining [and , by implication, every other] trade".[99]

The basic difference in the attitudes to science of these two reviews may be simply summed up. For the Edinburgh a sure scientific method could give certain knowledge in all fields; command of this method was therefore intellectually very important. This knowledge could be applied to improve all aspects of man's existence, for physical improvement necessarily lead to moral improvement. For the Quarterly science was a collection of facts, the learning of which was simple and of little intellectual benefit, (although Young's attitude was more sophisticated than this). Application of these facts to manufactures may be of some use or benefit materially, but no more. Agriculture and the land was of far greater importance than manufactures.

In the second half of the period under consideration two similar reviews were founded but in an almost symmetrical reversal of circumstances. In 1817 a Tory review was founded in Edinburgh while seven years later a reformist review was founded in London. These were respectively Blackwood's Magazine and the Westminster Review. Both were founded for similar reasons i.e. disappointment with the already existing publications. William Blackwood wished to produce a high Tory rival to the Edinburgh Review, the Quarterly being, he felt, too staid, with little appeal to the younger Scotch Tories.[100] After a false start under the editorship of James Pringle and Thomas Cleghorn, Blackwood himself took over the editorship in October 1817 and the career of the 'Maga' began.

Blackwood's Magazine always upheld its Scots nature, even above its Toryism if these conflicted. It also defended the cities of the English north against the growing power of London. Espousing a rural and semi-feudal society, Blackwood's laid more stress on the responsibilities of the landed classes than on their privileges, unlike the Quarterly Review. William Johnstone expressed this clearly in an article published in 1829:

> "As Tories, we maintain that it is the duty of the people to pay obedience to those set in authority over them: but it is also the duty of those in authority to protect the people who are placed below them".[101]

Writers in the Quarterly Review and Blackwood's Magazine expressed similar attitudes to science. Physical science was treated no more favourably in the latter than in the former. The sixth volume of Blackwood's contained an article on "some effects of an excessive application to the Study of Physical Science considered".[102] The author noted the current faith in the intellectual and moral benefits of scientific education, "a persuasion, that the knowledge thus acquired to the human mind [i.e. by practising physical science] was of high importance, not only for the powers which it added to human art, but for its direct influence on the faculties and character of the mind". This, the author declared, "may easily be over-rated".[103]

The writers for Blackwood's foresaw no moral benefit from the study of physical science; this could only come from a religious education. The author of the article referred to thought that the study of physical science might even be a hindrance to moral improvement: "It may be said, especially, that when the study of physical science becomes on any account the favourite and general pursuit of an age, it tends strongly and directly to obscure moral truth [because] ... it seems to allow the mind the privileges of its higher nature, and yet calls it down into the sphere of sense [deceiving]... the mind into too low an estimate of its other most important [i.e. religious and spiritual] faculties".[104]

Chemistry was singled out for condemnation as not a "pure intellectual science [but] ... an enormous accumulation of facts".[105] Modern chemistry was compared to alchemy, its progenitor, "perhaps the most mysterious and full of imagination of all the sciences", which gave a strength of mind and an insight to its practitioners which to modern chemists was foreign.[106] To Blackwood's, as to the Quarterly, physical science was taken to be a mere accumulation of facts useful only in its application to arts and trades.[107]

In commenting on Brougham's plans for education, David Robinson, an extreme Tory, wrote that "what he is principally anxious about is, instruction in the physical sciences - in other words, instruction in the mechanical callings of life",[108] ignoring the moral benefits Brougham expected from education in the physical sciences.

This disagreement over the nature of physical science did not preclude a basic agreement on the nature of knowledge as "a power of thought necessarily indefinite", but Alexander Blair rejected the opinions of those who believed, as he thought, that knowledge lay "solely in the perception of relations... a definite possession to the mind... limited, and already completed".[109]

Underlying this conflict was a basic disagreement between 'rationalists' and 'non-rationlists'. Blair rejected the work of encyclopedists, who believed that the community of human science did not "truly exist, until it were materially constructed", correctly recognising the similarity between the ideas of the French Encyclopédists of the eighteenth century and those of the nineteenth-century advocates of the diffusion of knowledge. Blair also explicitly rejected the belief implicit in many of the writings of the advocates of the diffusion of knowledge, that the possibility of education was open to all. This neglected, Blair wrote, "the restraints of time, of strength, of inevitable avocation".[110]

One aspect of science on which Blackwood's did differ significantly from the Quarterly Review was natural history. Probably this was due to Blackwood's home being in Edinburgh. Edinburgh University was at this time a home of the serious study of natural history and the Professor of the subject, Robert Jameson, contributed to the 'Maga' on geology, mineralogy and botany. One of the main contributors to the magazine, John Wilson, was the brother of James Wilson, an author on natural history and a member of the Wernerian Natural History Society of Edinburgh which Jameson had founded. Consequently favourable reviews of works by James Wilson and other natural history writers appeared in Blackwood's, as well as notices of interesting facts and occurrences in geology and botany.

Natural history, although "a good deal neglected in our own country", was said to require "no other compulsion to its pursuit, than the delight it brings with it, in overflowing abundance", in contrast to the "cold and barren knowledge" too often made the first principle of education. In almost Rousseauan terms, natural history was claimed to be learnt effortlessly by children "not imprisoned in houses and towns" but "placed in natural life". Such an education would be "an innocent employment of time", keeping the "mind in health by continued activity... [avoiding] the burden and danger of unoccupied time" and, "far the highest consideration, ... from every part of nature there speaks one voice, the voice of religion".[111]

The partiality of Blackwood's Magazine to a rural society, as well as its Edinburgh base, combined to give a faith in both natural history and natural religion lacking in the Quarterly Review. The religious and moral implications of the study of nature meant that natural history was a suitable, and indeed desirable, part of education. It "was not painful labour, imposed upon unwilling minds", but it nourished the mind, the appetite growing with the feeding.[112] Contrast this with chemistry, at first "inviting, grateful and invigorating to the intellectual faculties", but which, "passing over the just limits of a natural interest, begin[s] to contract the capacity... [it] had before enlarged, and to stifle the animation of thought [it] had helped to kindle".[113]

Natural history was suitable not only for the education of children but even for those whose "dispositions are perverted or repressed by the circumstances and manner of their life" taking one "out of the conflict of human life... into the midst of calm, beautiful, majestic order".[114] This could include even the labouring classes, whose education should consist of religious instruction and secular instruction "of a moral kind", embracing astronomy and natural history on the "just grounds of adoration and gratitude".[115]

If Blackwood's Magazine did not think physical science very useful nor took it very seriously,[116] the Westminster Review certainly did. Founded in 1824 with money supplied by Jeremy Bentham, the Westminster was a reformist periodical first and foremost, prompting the satirical remark in Blackwood's Magazine, "whatever our subject - Reform is our object".[117] Both of the initial joint-editors, John Bowring and Henry Southern, were Unitarians and the magazine always had strong connections with rational dissent. The main writer on science, Thomas Southwood Smith, was a Unitarian minister turned physician. Politically, the magazine was always firmly Benthamite and Utilitarian (although James and J.S. Mill refused to co-operate with it from 1828, beginning their own rival London Review in the 1830s), but the publication was never commercially succesful, with a circulation of little more than 1,000 on average.

For the Westminster Review science had two purposes: as a method of education in rational thinking, and as an aid to economic production. In this way its philosophy was very similar to that of the Edinburgh, but the Westminster was both more extreme and more explicit. As the publication was primarily concerned with espousing reformist opinions, coverage of science in general was restricted to occasions on which it was felt positive good could come of the article. This included not only articles by Southwood Smith arguing for the reform of the regulations on the use of dead bodies in anatomy,[118] or for the repeal of the sanitary laws,[119] but also articles criticising the scriptural geology of Granville Penn[120] and the opinions of G.P. Scrope on volcanoes.[121] In cases such as the latter, as well as in Smith's articles on physiology, the opportunity was taken to summarise contemporary knowledge and recent research on the subjects in detailed articles which had much of the character of scientific treatises. (Indeed much of Smith's writings on physiology were reproduced in his contribution on that subject to the Library of Useful Knowledge). These were considered sufficiently important topics for lengthy articles not only for political reasons (the sanitary and quarantine regulations, for instance, were felt to have ill effects "on commerce in general"),[122] but also because restrictions on the use of corpses in anatomy and the diffusion of 'erroneous' scientific opinions slowed the 'progress of mankind'.

Science helped this 'progress' of mankind in two ways, although these were in fact linked. Firstly it was useful. Southwood Smith wrote in volume eleven (1829):

> "There is not a year that passes which does not afford fresh illustration of the value of science, which does not show, by some new and unexpected application of it to the utilities of life the inexhaustibleness of its power to lessen the evils which are incident to man, and to add to the substantial happiness of his condition".[123]

The uses of science were considered a part (and the most important part) of the science itself. Thus chemistry was not merely "a lecture at the Royal Institution or a dose of salts" but also included dyeing, iron-making, etc.[124] Utility was an agent of moral improvement. Gas lighting, the "greatest of all our most recent applications of chemistry", was claimed to have "suppressed more vice than the Suppression Society".[125]

To the Edinburgh Review's Baconian slogan, "knowledge is power", to the Magazine of Natural History's "knowledge is pleasure as well as power", and to Blackwood's "knowledge is a power", the Westminster added "knowledge is economy", and "knowledge is virtue".[126]

The second of these two slogans applied equally, the writers of the Westminster Review believed, to private life as to public, i.e. to science as education as well as to science as the source of public improvements. Education in general was considered good as it produced an informed public. This improved the moral conditions of mankind, for "[i]gnorance is the impure and muddy fountain whence nine tenths of the vice, misery, and crime, to be found in the world are really derived",[127] and it helped produce rational government as "modern despotisms... have been checked by popular opinion".[128] The ideal type of education was one based on physical science, (which included political economy, considered to be as certain as any other branch of science), although natural history was felt to be suitable for the early education of children, ready as they then were for the sensual rather than the rational aspects of nature.[129]

Physical science was portrayed as true knowledge, and almost as the only form of true knowledge. Thus, "sciences in some form, knowledge, facts, realities are the proper and only useful occupations of absolute youth";[130] "real education [is], the acquisition of useful knowledge".[131] Yet it was not just knowing facts which was important, but the learning of them. The "physical sciences form the best discipline in useful knowledge... the pursuit of general knowledge and of the sciences... enlarg-[es] and strengthen[s] the mental faculties... which is never the result of mere literary pursuits".[132] The Westminster claimed that "in some shape or other, scientific knowledge is necessary in every department of government, in the legislature, in the law... [and] that it is needful to agriculturalists and country gentlemen".[133] Also it was claimed that "the most enlightened people will always maintain a decided superiority over those who are less informed; that they will excel them, not only in invention but in industry; that they will resist or conquer them in arms, that they will exceed them in moral order, and, what is not less important will form, or reform, a political state better administered".[134]

In this way the Westminster Review was able to link science, utility and economic improvement, education and moral virtue and, as ever, make them point to Reform.

E. Mechanics' Magazines

In the 1820s first appeared cheap periodicals specifically aimed at the lower classes. The first and longest lasting of those designed for mechanics and artisans was the Mechanic's Magazine itself and it and its successors may conveniently be grouped together in this section under the collective title mechanics' magazines. First appearing on 30 August, 1823, the Mechanic's Magazine had a format which, while not original in periodicals, was to set the model for its rivals. Octavo, containing sixteen pages and with an illustration of a technological device or construction occupying most or all of its front page, it was priced at 3d. and continued to be so throughout this period. At this price it was in fact more expensive than John Limbird's Mirror of Literature, Amusement, and Instruction (founded in 1822) but in many other ways it followed the earlier magazine. An article on the illustrated object was followed by excerpts from other magazines and contributions from readers. The middle-class Mirror began with an article on a new treadmill in Brixton jail but the Mechanic's Magazine commenced with a memoir of James Watt. Apart from including items of a more technological nature than the Mirror's pot pourri, the Mechanic's Magazine's title was also intended to remedy the situation that:

> "there is no periodical Publication, of which that numerous and important portion of the community, the Mechanics or Artisans, including all who are operatively employed in our Arts and Manufactures, can say 'This is ours, and for us'".[135]

The magazine's object was to "comprehend a digested selection from all the periodical publications of the day, both British and Foreign, and from all new works, however costly, of whatever may be more immediately interesting to the British artisan". The purpose was not narrowly utilitarian, however, the magazine intending to "contain also a due portion of that lighter matter, which those who toil most stand in need of, to relieve and exhilarate their minds - as Essays on Men and Manners, Tales, Adventures, Anecdotes, Poetry, etc.".[136]

In this latter statement, and in the declaration that "The rights of the poor shall ever find in us a warm advocate", the magazine displayed its working class origins, making it very rare amongst mechanic's magazines. It was edited by Thomas Hodgskin and Joseph Clinton Robertson, both of whom had recently come to London from Edinburgh. Hodgskin,[137] who had much influence on the political views of the early magazine, was the son of a storekeeper in Chatham docks and an ex-seaman. He seems, however, to have had little interest in physical science and much more in propagating his own almost anarchist politics and political economy, helping to found and later lecturing to the London Mechanics' Institution. Robertson was also involved in the foundation of the institution, probably being responsible for first suggesting it, but he soon turned against it when he saw control being taken over by George Birkbeck, Henry Brougham and other middle-class liberals. This resulted in arguments with the publishers of the Mechanic's Magazine, Knight and Lacey, which continued until 1829 when Knight and Lacey renounced all interest in the publication. By this time the Mechanic's Magazine had settled down to a format in which most of the magazine was contributed by correspondents. The contributions were fairly miscellaneous, on new technological devices, perpetual motion machines, mathematical problems posed and solved by readers, etc. Some regular series existed, an analysis of scientific journals beginning on 1 January 1825, a series on mechanical geometry on 12 June 1824 and an occasional series of mineral descriptions on 21 January 1826, but most was occupied with contributions describing a new or improved mechanical device. Chronometers, wheels, steam engines, air balloons and perpetual motion were favourite topics. The magazine therefore had what Susan Sheets-Pyenson has called a "low science ideology",[138] a belief in an ideal of experimental, inductivist 'low science', possible to be understood and created by anyone. To this end no censorship or selection was imposed, with the object of encouraging "by every possible means, the class of men to whom it is more particularly addressed, to commit their thoughts and observations to writing, for the public benefit".[139]

Many people seem to have found this a congenial policy, for the Mechanic's Magazine sold approximately 16,000 copies per week in 1824 and, according to Brougham, 1,200 copies on the first day of issue in Manchester alone.[140] Such a 'low science' ideology did not please everyone, however; 'Mathematicus Senior' wrote to the Mechanic's Weekly Journal; or, Artisan's Miscellany, in January 1824 to express his disgust at the perpetual motion schemes and other 'mistakes' which had appeared in the first eight numbers of the Mechanic's Magazine, concluding that the Mechanic's Weekly Journal, although not perfect, was much better.[141]

The Journal began on 15 November 1823 with the object "not so much to amuse those for whom it is adapted, as to collect, at a cheap rate, that information which may be said to be sealed from the body of British mechanics, as well from the costliness and great number of the books which contain it, as from the abstruse manner in which it is generally imparted". The magazine was to "be devoted exclusively to subjects of practial utility"[142] and this lack of interest in pure science suggests a rather more conservative stance than that of the Mechanic's Magazine. "The Artificer will improve his own art more by considering the established practices of other Artists," it was avowed, "than by the mere study of the theory of his own art".[143]

That the Mechanic's Weekly Journal was run by more conservative members of the wealthier classes, who wished to restrict the mechanics' education to matters of immediate utility, is also indicated by the campaign of the Journal against the London Mechanics' Institute.

Contributions and editorials in the journal claimed that mechanics were already educated by factory owners, that many societies for such education already existed, that one central society would be less useful than many small local ones, and that Birkbeck had founded the institution merely to provide jobs and money for himself and his friends.

This campaign appears to have drawn little support, however, and neither does the journal itself, filled as it was with lists of patents, articles on how to make straw hats and artifical slates etc. After only one volume on 8 May 1824, the editors declared that they had not found "sufficient encouragement to proceed in the weekly and cheap mode of publication,... [and] determined to discontinue it in future".[144]

The nature of the Mechanics' Weekly Journal indicates that the aims and objects of the mechanics' magazines were no more identical than were those of the new reviews. Format may have been similar, but content frequently was not. Other rivals to the Mechanic's Magazine included the Mechanic's Chronicle (1824), The Mechanic's Gallery (1825) and the Mechanic's Oracle (1825). The last named was edited by Alexander Tilloch, editor of the Philosophical Magazine. It was therefore another publication for, not by, the working classes, being "devoted, principally, to the instruction and improvement of the working classes". It was designed "for the diffusion of sound practical knowledge; particularly respecting the numerous contrivances and manipulations called into daily exercise, in the production of... commodities".[145] A similar prospectus to the Mechanics' Weekly Journal ensured a similar content and a similar demise after a single volume, shortly after Tilloch's own death.

The longest lived and most successful rival to the Mechanic's Magazine was the London Mechanics' Register (1824-6), continued as the New London Mechanic's Register (1826-8). Originally published by Cowie and Strange, the first number was issued on 6 November 1824. A large part of the purpose of the periodical was to support the mechanics' institute movement, in particular the London Mechanics' Institution. The Mechanic's Magazine had turned against the institution from July

1824 and the Register replaced it by giving extensive descriptions of the lectures given there as well as reports of the general meetings etc. The New London Mechanic's Register, (which was no longer issued in periodical format, merely in regular parts), was even more concerned with the publication of the lectures, which it saw as its great value.[146] Its aim was to become a permanent record of the facts presented in the lectures.

In addition to the large amount of mainly pure science recorded in the lecture reports, the London Mechanics' Register contained many scientific series. An eight part series on 'familar lessons in mineralogy' ran in volume one, while volume three included articles on Black's experiments on caloric (heat); an eight part 'Introduction to the Study of Botany' ran in volumes three and four. Single articles on pure science or queries from readers on scientific (especially chemical) subjects were also common. Interestingly, the magazine also contained more political content than any of the others so far considered. As well as full reports of Birkbeck's lecture and other speeches on the combination of workers the first volume had three sections of editorial on this same subject.[147] In this way, and in its much greater emphasis on pure rather than applied science, the London Mechanics' Register provided a journal very similar in content to the courses at mechanics' institutes.

A similar magazine, but aimed at a more middle-class audience, was the Circulator of Useful Knowledge (1825). Containing a mixture of science, literature, travel, etc. the journal supported the proposed London University for the middle classes and reported many lectures from the London Institution, the Royal Institution and the London Mechanics' Institute. The magazine expressed the intention of "diffusing a knowledge of this highly interesting and instructive science", political economy, thereby clearly indicating its middle-class reformist allegiance.[148]

Strong links between the middle-class scientific institutions and the periodical press in the 1820s were also shown by the Iris (1825-6). This periodical particularly supported the City of London Literary and Scientific Institution, printing notices of meetings and reports of lectures, as the London Mechanics' Register did for the mechanics' institution.[149]

One other periodical specifically addressed to the labouring classes but not primarily concerned with the subject of mechanics was the Chemist (1824-5). Published, as the Mechanic's Magazine was, by Knight and Lacey, the format was very similar. The 'Apology and Preface' in the first volume referred disparagingly to British chemists, refusing to dedicate the magazine to the foremost of them, ie. Sir Humphry Davy, because of his lack of interest in the education of the labouring classes.[150]

The object of the Chemist was "to give an outline of the principles of chemistry, with their numerous applications, as well as a history and description of all the arts which are connected with this science".[151] Brougham described the publication as containing "an admirable collection of the most useful chemical papers and intelligence";[152] a series on "Chemistry as a Science" and a "Dictionary of Chemistry" must have been very useful to a beginner. Unfortunately after a year it was decided that the magazine would not pay, and it was stopped. Before that occurred, however, the journal was instrumental in founding the London Chemical Society. The subscription fee of one guinea every six months, as well as the presence of "a great many ladies" at an early meeting must make one doubt whether the membership of the society, and therefore also the readership of the magazine, was really to be found amongst the "working classes".[153]

F. The Images of Science in Periodical Publications

The image of science presented in periodical publications of the early nineteenth century has been shown to vary with the anticipated class of readership and also with the political outlook of the magazines and journals.

Publications for the wealthier classes treated science as part of a general literary culture. Not until the Edinburgh Review did a periodical of influence with the higher classes espouse a view of science and its applications as intellectually important, and, as has been shown, also of vital moral interest. Conservative responses emphasised the superiority of religious education over physical science education and of agriculture over manufactures.

The new reviews were journals of opinion. Those publications concerned with communicating information on science were generally technological or natural history periodicals. The former, while useful for diffusing knowledge of patented inventions, could have been only of limited use to aspiring natural philosophers amongst the lower classes. Natural history periodicals, with their coloured plates and monthly parts, circulated among higher-class rural audiences. Their prevailing ideology of science, as with those general magazines which were published in this period, emphasised classification and curiosities, although also including large amounts of moral justification of the study.

Notes to Chapter 4

1. Periodical publications, for the purposes of this chapter, are defined as those which are issued in regular parts, with a standard title-page or heading, and which are intended to carry on indefinitely.

2. General bibliographical information on the periodicals discussed in this chapter comes from a number of sources. Most important are M.Wolff, J.North, D. Deering (eds.), The Waterloo Directory of Victorian Periodicals, 1824-1900, Phase 1,[Waterloo (Ont.),1977]; W.J. Graham, English Literary Periodicals, 1930; reprinted New York, 1966; D.A. Kronick, A History of Scientific and Technical Periodicals, 1665-1895, 2nd edn., Washington City, 1898; for those periodicals covered, the most useful source is W.E. Houghton (ed.), The Wellesley Index to Victorian Periodicals, 1824-1900, 3 vols., Toronto and London, 1966-79.

3. Ian Maxted, The London Book Trades, 1775-1800. A Preliminary Checklist of Members, Folkestone, 1977, table 9, p.xxix.

4. Derek Roper, Reviewing Before the Edinburgh, 1788-1802, London, 1978, p.24; R.D. Altick, The English Common Reader, A Social History of the Mass Reading Public, 1800-1900, Chicago, 1963, Appendix, pp. 391-6.

5. Altick, op.cit. (4), appendix.

6. Susan Sheets-Pyenson, 'Low Scientific Culture in London and Paris, 1820-1875', University of Pennsylvania PhD thesis, 1976, p.60, quotes D. Thompson giving two to three readers per copy.

7. Ibid, p.17 (note 27), says over four-fifths of all contemporary British periodical publishing took place in London.

8. Quoted in Roper, op.cit. (4), p.255.

9. Graham, op.cit. (2), p.145.

10. Quoted in Graham, op.cit.(2), p.159.

11. Altick, op.cit. (4), appendix.
12. Gentleman's Magazine, 1800, 70i, 134. See Bibliography for full titles of periodicals.
13. Ibid, 1812, 82i, 250.
14. Ibid, 1817, 87ii, 247-8.
15. Ibid, 1800, 70i, Preface, p.iv.
16. Ibid, p.48.
17. Ibid, pp.42, 502.
18. Graham, op.cit. (2), p.168.
19. Altick, op.cit. (4), appendix.
20. The Entertaining Magazine, title page. The copies of the Universal Magazine possessed by the British Library were unfortunately destroyed in the war. The reprinted articles in the Entertaining Magazine are therefore one way to tell what this magazine was like.
21. Entertaining Magazine, 1813, 1, 9 was the first of this series, the rest also being included in volume one.
22. Ibid, 1813, 1, 594.
23. Ibid, 1813, 1, 145.
24. Ibid, 1814, 2, 35.
25. Ibid, 1815, 3, 5-8.
26. Ibid, 1815, 3, 62.
27. The Museum, 1795, 1, 1-3.
28. In this publication Phillips showed no sign of his later belief in a mechanical explanation of gravity. For this theory see his Essay on the Proximate Causes of the General Phenomena of the Universe, London, 1818. See also William Lovett, Life and Struggles of William Lovett in Pursuit of Bread, Knowledge and Freedom, London, 2 vols., 1920, I, 37, for a description of Phillips explaining his theory to Lovett after a meeting of the London Mechanics' Institute.

29. The Museum, 1795, 1, 29-30.

30. Recreations in Agriculture, Natural-History, Arts, and Miscellaneous Literature, 1799, 1, part one of the Arts etc. section, p.43.

31. Ibid, 1801, 4, 479.

32. Ibid, 1799, 1, Natural History Introduction, p.45; Agriculture Introduction, pp.32-4.

33. Ibid, 1802, 6, 565-8.

34. Ibid, 1799, 1, Agriculture Introduction, p.22.

35. [H. Davy], 'Parallels between Art and Science', The Director, 1807, 2, 193-8.

36. See Geoffrey Carnall, 'The Monthly Magazine', The Review of English Studies, 1954, New Series 5, 158-64.

37. Quoted ibid, p.164, from Edinburgh Review, 1817.

38. The Repertory of Arts and Manufactures, 1974, 1, Advertisement, i.

39. Ibid, pp. iii-iv.

40. For Nicholson's Journal see S. Lilley, ' "Nicholson's Journal", (1797-1813)', Annals of Science, 1948-9, 6, 78-101. For the Philosophical Magazine see A. and J. Ferguson, 'The Philosophical Magazine', in A. Ferguson (ed.), Natural Philosophy Through the Eighteenth Century and Allied Topics, London, 1972, pp. 1-9 (quotation p.6).

41. London Journal of Arts and Sciences, 1820, 1, Title page.

42. The Register of Arts and Sciences, 1824, 1, Title page.

43. Ibid, 1827, 4, Address, p.iv.

44. Joseph Capes was the new publisher.

45. See below (section E) for other reports of mechanics' institute lectures.

46. The Register of Arts and Sciences, 1826, 3, includes reports of Wallis' lectures, (see e.g. p.300); ibid, pp.336, 349 mentions Southwark Mechanics' Institution.

47. Ibid, 1827, 4, 82-92.

48. Ibid, 1827, 4, Address, p.iv.

49. See below, section E.

50. The Scientific Gazette; or, Library of Mechanical Philosophy, Chemistry and Discovery. Quotation is from The Circulator of Useful Knowledge, Amusement, Literature, Science, and General Information, 1825, 1, iv.

51. Scientific Gazette, 1826, 1, Address, p.2.

52. Scientific Gazette, 1826, 1, 308, reports Partington opening the Chichester Mechanics' Institute.

53. Ibid, 1826, 1, 34-6.

54. The Annals of Chemical Philosophy, Exhibiting a Concise View of the Latest and Most Important Discoveries in Chemistry, 1828, Introduction.

55. Ibid, Address.

56. Ibid, 1829,No.2.

57. Curtis' Botanical Magazine; or, Flower-Garden Displayed, 1817, 44, title page.

58. The Botanical Cabinet, 1817, 1, Introduction.

59. The Naturalist's Repository, or Monthly Miscellany of Exotic Natural History, 1823, 1, Advertisement.

60. Ibid.

61. The Magazine of Natural History, and Journal of Zoology, Botany, Mineralogy, Geology, and Meteorology, 1829, 1, Preface, p.iii.

62. Ibid, p.6.

63. Ibid, p.1.

64. Ibid, pp.6-7, 9.

65. Quoted in Sheets-Pyenson, op.cit. (6), p.101 from the Magazine of Natural History, 1829, 1, 13.

66. See Roper, op.cit. (4). Circulation figures are on p.24.

67. On the Edinburgh Review see John Clive, Scotch Reviewers, The Edinburgh Review, 1802-1815, London, 1957; T.H. Cook, 'Science, Philosophy, and Culture in the early Edinburgh Review, 1802-1829', University of Pittsburgh PhD thesis, 1976, and the Wellesley Index, op.cit. (2), vol. I, Toronto, 1966, pp.416-546.

68. i.e. during the years 1803-29. Before this Jeffrey and Sydney Smith edited it;

from 1829 Macvey Napier was in charge.

69. Quoted by Clive, op.cit. (67), p.54.

70. Cook, op.cit. (67), p.6.

71. Philosophy of mind was considered by the Edinburgh Review authors as scientific. Analysis is my own: there were many borderline cases but the figures are for comparison, rather than absolute totals.

72. Edinburgh Review, 1802-3, 1, 451.

73. Ibid, 1829-30, 50, 256-76 (259).

74. See Cook, op.cit. (67), pp.200-10 for a discussion of Playfair's reviews of geological works. His Huttonianism was sometimes edited down.

75. Edinburgh Review, 1802-3, 1, 201.

76. Edinburgh Review, 1805, 6, 245.

77. Ibid, 1806, 8, 78-86; ibid, 1808, 9, 67-83; ibid, 1829-30, 50, 275.

78. The firm belief of the Reviewers in this concept was noted in Clive, op.cit. (67), ch.VII.

79. Edinburgh Review, 1802-3, 1, 290.

80. Ibid, 1829-30, 50, 275.

81. Ibid, 1803, 2, 391.

82. Ibid, 1813-14, 22, 252.

83. Ibid, 1811, 18, 93.

84. Ibid, 1802-3, 1, 289.

85. Ibid, pp. 290, 300; ibid, 1803, 2, 498-9, 492.

86. For the Quarterly see Wellesley Index, op.cit. (2), I, 696-782, and F.W. Fetter, 'The Economic Articles in the Quarterly Review and their Authors, 1809-52', Journal of Political Economy, 1958, 66, 47-65, 154-70.

87. Disraeli's phrase, applied to the Quarterly in Wellesley Index, op.cit. (2), I, p.699.

88. Quarterly Review, 1809, 1, 107.

89. Ibid, 1810, 3, 481.

90. Ibid.

91. Ibid, 1809, _1_, 108.

92. Ibid, 1809, _1_, 110.

93. _Edinburgh Review,_ 1802-3, _1_, 455.

94. _Quarterly Review_, 1810, _3_, 475.

95. Ibid, 1810, _4_, 201, 203.

96. Ibid, 1814, _12_, 410.

97. Ibid, 1811, _6_, 182; ibid, 1810, _4_, 203.

98. Ibid, 1817, _17_, 451.

99. Ibid, 1812, _7_, 351.

100. For _Blackwood's Magazine_ see _Wellesley Index_, op.cit. (2), I, 7-209; F. Fetter, 'The Economic Articles in _Blackwood's Edinburgh Magazine_, and their Authors, 1817-53', _Scottish Journal of Political Economy_, 1960, _7_, 85-107, 213-31, and A.L. Strout, _A Bibliography of Articles in Blackwood's Magazine, Volumes I Through XVIII, 1817-1825_, Lubbock, Texas, 1959.

101. _Blackwood's Magazine_, 1828, quoted by Fetter, op.cit. (100), p. 104.

102. _Blackwood's Magazine,_ 1819-20, _6_, 35-9.

103. Ibid, p.35.

104. Ibid, p.38.

105. Ibid, p.39.

106. Ibid, pp.36-8.

107. See above, reference 97, for _Quarterly's_ attitude.

108. _Blackwood's Magazine_, 1825, _17_, 544.

109. Ibid, 1824, _16_, 29, Blair's emphasis.

110. Ibid, pp.29, 33, Blair's emphasis.

111. Ibid, 1820, _7_, 618-21.

112. Ibid, 1828, _23_, 856-7.

113. Ibid, 1819-20, _6_, 39.

114. Ibid, 1828, _23_, 857-8.

115. Ibid, 1830, 27, 9.

116. As shown in the satirical review of Accum's work on food adulteration, supposedly enough to make the reviewer turn "pale in the act of eating a custard", Blackwood's Magazine, 1819-20, 6, 542-54 (544).

117. Ibid, 1826, 20, 191. For the Westminster see Wellesley Index, op.cit. (2), III, 528-705.

118. Westminster Review, 1824, 2, 59-97.

119. Ibid, 1825, 3, 134-67.

120. Ibid, 1825, 4, 457-95.

121. Ibid, 1826, 5, 356-73.

122. Ibid, 1825, 3, 530.

123. Ibid, 1829, 11, 97.

124. Ibid, 1827, 7, 295.

125. Ibid, 1829, 11, 290, 302.

126. Ibid, 1830, 13, 272; ibid, 1828, 9, 334.

127. Ibid, 1825, 4, 92, quoting from J. M'Culloch's Discourse on Political Economy.

128. Ibid, 1827, 7, 269.

129. Ibid, 1824, 1, 57.

130. Ibid, 1828, 9, 330.

131. Ibid, 1827, 7, 314.

132. Ibid, 1828, 9, 361.

133. Ibid, 1827, 7, 316-7.

134. Ibid, 1825, 4, 152.

135. Mechanic's Magazine, 1823-4, 1, 16.

136. Ibid, p.16.

137. For Hodgskin see E. Halévy, Thomas Hodgskin, London, 1956. For the foundation of the London Mechanics' Institute see T. Kelly, George Birkbeck, Pioneer of Adult Education, Liverpool, 1957, book one, ch.V. The renunciation of interest in the Mechanic's Magazine by Knight and Lacey was announced in

the London Mechanics' Magazine, No.307, 1829, 320.

138. Sheets-Pyenson, op.cit. (6), p.13.

139. Quoted ibid, p.66.

140. Altick, op.cit. (4); H. Brougham, Practical Observations Upon the Education of the People, addressed to the Working Classes and their Employers, London, 1825, 13th edn., p.24.

141. Mechanic's Weekly Journal, 1824, 1, 182-3.

142. Ibid, p.16.

143. Ibid, title page inscription.

144. Ibid, pp. 47-8, 60-3, 75-7, 141; ibid, p.409.

145. The Mechanic's Oracle, and Artisan's Laboratory and Workshop, 1825, 1, 1.

146. New London Mechanics' Register, 1827, 1, Advertisement, p.iii.

147. London Mechanics' Register, 1825,1, 100-2, 383, 428-30.

148. The Circulator of Useful Knowledge, Amusement, Literature, Science, and General Information, 1825, 1, 195.

149. The Iris, A Journal of Literature, Science and the Fine Arts, London, 1825-6.

150. The Chemist, 1824, 1, Apology and Preface, pp.v-viii.

151. Ibid, p.viii.

152. Brougham, op.cit. (140), p.3.

153. The Chemist, 1824, 1, 405; ibid, 1825, 2, 162. For the London Chemical Society see below, chapter V, and W. Brock, 'The London Chemical Society, 1824', Ambix, 1967, 14, 133-9.

Chapter Five: London Societies and the Popularisation of Science.

A. London in the Early Nineteenth Century

By comparison with Paris, Vienna, and Berlin, London was the home of approximately two, four and six times as many people respectively, in the early years of the nineteenth century. In Britain itself, the population of London, (estimated at 958, 863 in 1801), was more than eleven times that of the second city, Liverpool.[1] Most of Britain's population lived in small towns or in rural areas, but more than one in ten inhabited the metropolis.

In the years 1800-30, however, great changes occurred. London grew by some twenty per cent, an increase by comparison with the rural population, and with the total population of the country, but it was outgrown by the northern industrial towns. With such changes came changes also in the economic role and importance of London. Members of the provincial manufacturing classes in particular began to see their towns as important centres in their own right; cultural institutions were formed which were not only imitative but often innovative. In turn these developments produced a reaction amongst the middle classes of London, who saw in the provincial towns the formation of a culture and of social institutions radically different from the 'fashionable society' of the rich in London.

The complex and evolving relationship between London and the provinces was mirrored by that between the districts of London. The City, refusing to take responsibility for the inhabitants of anywhere but the square mile, remained institutionally separate and aloof from the growing suburbs; the latter, particularly when formed by settlement about nucleii of ancient villages, e.g. at Hackney, Camberwell, Hammersmith etc., began increasingly to generate an economic and social life of their own. Developments of this kind could only increase the awareness of the middle classes that they had separate interests from the landed families. For the former, London, and increasingly suburban London, was a permanent home; for the latter it was merely the place to spend the social 'season', and the home of government and business.

For the poorer classes of London inhabitants life was still very like it had been in the previous century. Overwhelmingly a craft city, immigrants to the city would often settle in areas traditionally associated with their skills. The unskilled would congregate in the already overcrowded poor areas of the city, where life was hard but cheap to sustain. Building workers and those wishing to be domestic servants found the best chance of employment in the new suburbs.

This was the city which formed the setting for the societies discussed in this chapter.

B. The Development and Range of Societies

The early nineteenth century was exceptional for the number of new and often innovative institutions which were founded in the period. In the mid-1790s the only major scientific institutions in London were the Royal Society, the Society of Arts, the Linnean Society, the British Museum and the Royal Observatory. By 1830 these had been joined by the Geological, Astronomical, Zoological and Geographical Societies, while Entomological and Mineralogical Societies had also been founded in the interim, although they had failed to survive. As well as these societies the Royal, London, Surrey and Russell Institutions and many smaller societies had been founded. Uniquely, also, this period saw the foundation of the first mechanics' institutes and the first new University in England for over half a millenium in Gower Street in 1828.

In the late 1790s two general societies interested in serious scientific experimentation were formed. On 25 January 1794 the Society for Philosophical Experiments and Conversations was established. From its published minutes it appears to have lived up to its name, members practising and discussing experiments. The other society was the Askesian Society, founded in Plough Court in 1798.[2] At least one man was common to both societies, the Quaker William Allen. The Askesian Society numbered many dissenters amongst its membership including Richard Phillips and Arthur Aikin, a Unitarian and future president of the Chemical Society. Aikin, like Allen, showed the characteristic behaviour of many such men in this period, i.e. they belonged to many different societies and institutions, both at once and also successively. Aikin, for instance, was a founder member of the Geological Society, a member of the London Institution, and later the Secretary of the Society of Arts. The Askesian Society also included Humphry Davy amongst its number, and nine of its members were instrumental in helping to found one of the earliest specialised scientific societies, the British Mineralogical Society (founded 1799). The two societies merged in 1806 and then combined, in 1807, with the newly formed Geological Society of London, but before this occurred there was some suggestion of the London Institution providing accommodation for both. A manuscript note amongst the records of the London Institution suggested that "The repetition of Askesian Experiments in the Laboratory with the opportunity authors might have of elucidating their papers - would be mutual -the Lecturers would also by this means have a fair chance of introducing much new matter".[3]

Popular societies were also connected with the more scientific societies in other ways. Early specialised societies, such as the Geological Society (1807) and the Astronomical Society (1820), believed that no expertise was required to belong to the societies. The institutions themselves would function as co-ordinators and analysts of the observations of the members.

They were to function as the Baconian inductivists, the membership in general merely providing the 'natural history' of the rocks, the sky, etc.[4] Later specialised societies, such as the Zoological Society (1826) and the Royal Geographical Society (1830), were more selective in their membership, and the former two societies also became more insistent on competence in the subject before entry, but it is clear that the difference between 'scientific' and 'popular' societies in the early nineteenth century was much less than it is today.

This may be illustrated by comparison of the Regulations of the Astronomical Society with those of the Philosophical Society of London, a general literary and philosophical society which closed down in 1820.[5] The annual subscription of two guineas was the same for both institutions; the regulations for balloting for entry, and the three-quarters majority required, were identical. While there can be no certainty of the later society having taken its rules from the earlier one, the membership of the last president of the Philosophical Society in the new society suggests that the 'scientific' society was partly modelled upon the older, more 'popular' one.

At the opposite end of the spectrum to specialist societies many miscellaneous institutions may have been responsible for some diffusion of scientific information. This included libraries, which were often socially exclusive, e.g. the Westminster Public Library of No.10 Panton Street which insisted members be approved by the committee "To prevent the introduction of improper persons".[6]

For a wider range of social groups there were circulating libraries[7] and museums, including not only the British Museum, but also a wide range of private museums. These were often concerned with natural history (e.g. British Zoological Museum of Oxford Street), or, increasingly, with displays of machinery, e.g. Merlin's Mechanical Museum in Princes St., Hanover Square, and Week's Exhibition of Mechanism at the top of the Haymarket.[8]

The former was run by John Millington, a lecturer at the Royal and London Institutions and at mechanics' institutes, and an author for the Society for the Diffusion of Useful Knowledge. These private commercial undertakings are a reminder that not all non-literary science popularisation occurred under the auspices of societies. The most important private commercial popularisation was by private lecturers, who must now be briefly considered.

C. Private Science Lecturers in London

The early nineteenth century saw a proliferation of private lecturers, particularly in London. Many lecturers would tour the neighbouring counties as well, but their base was often their private house in the metropolis.

Lectures ranged from detailed expositions of materia medica, chemistry, anatomy and physiology for medical students given in the lecture theatres of hospitals, to those given in theatres primarily for entertainment. Examples of the former were those by William Allen, (notes of whose lectures, taken by a student, are extant in Cheetham's Library in Manchester)[9], or those by George Pearson of St. George's Hospital; of the latter, examples are Paul de Phillipstahl's lectures at the Lyceum and Walker's lectures at the Theatre Royal, Haymarket.[10] In between such extremes came the private tutors who would give lessons or talks in their own or their clients' homes, usually for substantial fees. Fredrick Accum, for instance, advertised:

"Lectures... devoted to those Promoters of the Science, who are not inclined to acquire a knowledge of Chemistry from the Study of Books professedly written for beginners, nor from the attendance of Public Lectures, calculated for a mixt audience".[11]

In 1812 Accum was charging 27 guineas for thirty lectures in operative chemistry or thirty-four guineas for thirty-six mineralogy lectures. Resident pupils were charged 160 guineas per annum or 260 guineas including accommodation.[12]

Many other names could be added, including Mrs. Lowry who taught mineralogy in Great Titchfield Street, or Mr. Larkin who gave lessons in crystallography in Gee Street. Those who wished to make enough money to live on from scientific pursuits in these times had often to write and sell books, to sell scientific apparatus or specimens, to teach and to lecture, if they had no inherited wealth.[13]

As Ian Inkster has noted these private lecturers often lectured also under the auspices of institutions.[14] From a purely economic point of view it is of no surprise to find such people helping found and run societies which employed scientific lecturers. Thus, in examining London's scientific societies, the activities of very many of the private lecturers will be inevitably taken into consideration. Many examples of private lecturers who also spoke under the aegis of societies may be given. Thomas Garnett lectured at the Royal Institution and privately in Great Marlborough Street, Robert Bakewell taught at the Surrey and Russell Institutions, and in King Street; Mr. Hardie taught at the Surrey Institution and at the Theatre of Science, Pall Mall; John Tatum was founder of the City Philosophical Society and a private lecturer, etc., etc.[15] The foundation of more societies as the century progressed, particularly the early mechanics' institutes, greatly expanded. the market for such lecturers and speeded up their incorporation into the institutional network of the time. These institutional lectures might be only open to members, or might be also open to the general public at higher prices. At the Russell Institution in 1815, for instance, Charles Singer's lectures on electricity and electro-chemistry cost non-members £1 11s. 6d. for the course of lectures, but annual subscribers were admitted for £1 4s.[16]

Those lecturers who did not share in the institutional matrix were possibly those at the most popular and theatrical end of the spectrum of lecturers, such as Walker, with his Annual City Course of Philosophy at Paul's Head, Capheaton Street, priced at 2s. 6d. a lecture,[17] but generally the institutional matrix discussed in this chapter was supplemented by a very similar, but less formal, private set of options.

The main institutions of this period which helped to popularise and diffuse science may best be dealt with in three groups. Mechanics' Institutes will be discussed in a later chapter. The varied social institutions of the middle classes are covered later in this chapter, but considered first will be a number of societies with many common features, the London Institutions.

D. The London Institutions

Under the collective heading of the London Institutions may be considered four institutions closely related in style and facilities, the Royal Institution (founded 1799), the London Institution (founded 1805), the Surrey Institution (founded 1808) and the Russell Institution (founded 1808), as well as two less successful imitative foundations, the General Institution of 1805 and the Metropolitan Literary Institution of 1823. As the Royal Institution was the original and to some extent the model for all the others, it will be discussed first.[18]

The Royal Institution was founded in 1799 although it did not function until 1800. Housed in Albemarle Street in the City of Westminster, hereditary shares were originally priced at 50 guineas, making one a proprietor of the institution. There seems to have been an early disagreement over the object and aims of the Institution. Count Rumford, often credited as the founder, appears to have wanted a society directly related to the diffusion of information on technical developments, such as his own new designs of fireplace, while Thomas Webster wanted to educate mechanics and artisans.

Neither got their own way, Webster's plan being found particularly undesirable because of its supposed "political tendency".[19]

Rumford left the Institution in 1802 and Webster soon followed. The Institution became a fashionable literary and scientific institution. The first professor, Thomas Garnett, had originally proposed two types of course, a twenty lecture (i.e. one evening per week) course, with no abstract reasoning and interesting and entertaining experiments, for those who "came chiefly for amusement or because it may be fashionable", and a 100 lecture five mornings a week course for the more dedicated. In fact Garnett began with lectures on Tuesday and Thursday afternoons at 2 p.m. for the 'fashionable' and Monday, Wednesday and Friday evenings for the convenience of artisans.[20] These latter were soon stopped, in 1800 or 1801. Garnett's lectures on Natural and Experimental Philosophy were published in outline in 1801, as were his lectures on Chemistry.[21] In this season the lectures, of which there were eight on Natural and Experimental Philosophy, were on Tuesdays at 2 p.m. for Philosophy, and Thursdays and Saturdays at 2 p.m. for Chemistry. These outlines give some clue to the perceived requirements of a lay but wealthy audience. Garnett began by emphasising the "Utility of Natural Philosophy [and] The pleasure it affords to the mind". "Philosophy", he insisted was "favourable to religion". Astronomy in particular "inspires us with the most sublime ideas of the Creator", while natural philosophy was also essential for "those who study medicine".[22]

Having justified the study of natural philosophy morally, by emphasising its utility both materially and spiritually, Garnett proceeded to attempt to attract an audience eager for entertainment. "In the Lectures on Electricity", he proclaimed, "a great variety of entertaining experiments are introduced".[23] In the lecture on optics the "nature of vision, is illustrated by a beautiful artificial eye, exactly resembling the natural one, and by models of long, short, and good sighted eyes".[24] In order to entice even those with absolutely no previous knowledge the outlines stressed that "The nature of telescopes, microscopes, etc. is shown by models in which the rays of light are represented by silk strings, by which means this branch of science is rendered perfectly plain to those who have not so much as thought on the subject".[25]

The presentation of chemistry was similar. Again Garnett stressed that "it is not a science merely calculated to gratify curiosity and afford entertainment".[26] One significant difference between Garnett's Royal Institution and Andersonian Institution lectures did exist, however. Although in both he emphasised the need of the farmer to have a knowledge of chemistry to ensure proper use of manures and prevention of disease, only in the London lectures did he actually recommend works to be consulted upon this topic, including Young's Annals of Agriculture, Kirwan on manures and Kame's Gentleman Farmer.[27] The audience expected at the lectures was obviously one both wealthy and interested in agriculture, i.e. members of the landowning aristocracy.

Morris Berman has persuasively argued that the initiators of the Royal Institution were predominantly improving landlords, who saw the institution as means of using science to improve agricultural practice. Unfortunately, in arguing this, Berman has to some extent deliberately played down the role of the lectures in the institution in order to argue that there was "a departure within the ruling class itself from traditional notions [of a "dilettanti conception of science"] and it is this development that makes the Royal Institution a turning point in the organisation of science".[28] There is, however, ample evidence in the lecture courses of the Institution to show that a dilettante concept of science was valued as much, if not more , than a utilitarian one. What seems to have happened, indeed, was that the initiators disagreed over the type of lectures to be given, for after Garnett resigned in 1801 and Webster and Rumford departed in 1802, what Berman calls the 'landed interest' gained control and introduced in the season 1803-4 non-scientific lectures for the first time.

Young, Dalton, Davy and William Allen on natural philosophy and chemistry were supplemented not only by Sheridan on optical experiments and J.E. Smith on botany but also by lectures on Architecture, Belles Lettres and Painting. This trend continued, and in the season 1806-7 Davy and Allen were the only lecturers on science subjects, along with ten lecturers on literary and general subjects.[29]

The landed gentlemen and their friends who controlled the Institution for many of its early years seem to have wanted primarily an entertaining place of resort during the London season where one could safely take one's wives and daughters; it was also hoped that the institution would produce benefit to the agricultural community; proprietorship would therefore demonstrate one's 'progressiveness' and one's enlightened patronage. Henry Broughham in fact disparaged the institution by suggesting that ladies attended it only to hear of the most fashionable new theory.[30]

The Royal Institution lecturers appear to have retained their references to utility (moral, religious, and economic) and their commitment to entertainment.Certainly the most famous scientific lecturer of the time, Humphry Davy, included references to all these. "The information to be derived from Geology is applicable to many purposes. In a number of instances", he declared, "it may be made subservient to the wants of life. And all the theoretical views belonging to it when accurately pursued lead to beautiful truths". "The general usefulness of the Knowledge of Nature [is] in increasing mental enjoyment and in strengthening and exalting our sentiments", he continued.[31]

As is well known, Davy was a very popular lecturer and it seems likely that this was as much due to his personality as to the content of his lectures. Yet he seemed suited to the audiences he received. His religious references were almost completely free of the moralising tone of the evangelicals of the period, he gave very little justification of science by reference to its industrial utility, and he continually emphasised the mystery and beauty of the sciences he lectured on. Chemistry, he said, was not yet perfect because it had no "precise and beautiful theory" but mineralogy had become a science as it was "now founded upon a beautiful and methodical classification".[32] "The contemplation of the laws of the universe", he thought, "is connected with an immediate tranquil exaltation of mind, and pure mental enjoyment... Nature cannot decay: the language of her interpreters will be the same in all times. It will be an universal tongue, speaking to all countries, and all ages, the excellence of the work and the wisdom of the Creator".[33] This almost literary approach to science must have fitted well into the increasingly literary nature of the Institution in its early years.

Davy's attitudes must have proved congenial to his audience in other spheres also. In many respects he flattered them outright. "The arts and the sciences also are in a high degree cultivated, and patronised by the rich and privileged orders", he declared, "The guardians of civilisation and of refinement, the most powerful and respected part of society, are daily growing more attentive to the realities of life".[34] He placed the upper classes at the centre of (and therefore reassuringly in control of) any diffusion of scientific knowledge. As he emphasised in his lectures to the Board of Agriculture:

"It is from the higher classes of the community, from the proprietors of land... that the principles of improvement must flow to the labouring classes of the community".[35]

If Davy fitted well with the audience and proprietors of the Royal Institution in its first twelve years, then his successor, William Brande, was also fit for his employers, for, as recent research has shown,[36] the Royal Institution, from the time of its going public by Act of Parliament in 1810 fell increasingly under the control of men whom Berman has described as liberal reformists, usually middle-class professionals, such as doctors and lawyers. Their takeover was marked not only by Brande's appointment but also by the introduction of lectures by Charles Babbage in 1815, Peter Roget on Comparative Anatomy in 1812, (although lectures on the same subject had been refused in 1810, because the then still aristocratic managers thought that it would give offence to "part of their audience"[37]), John Millington on Natural Philosophy and John Wallis, also of the London Mechanics' Institution, on Astronomy. At the same time, while poetry and architecture lectures continued, although not so commonly as before, the Royal Institution began to act as a private medical school with both Brande and later Faraday giving private nine o'clock lectures on chemistry to medical students. In many ways the altered circumstances meant that, paradoxically, the Institution became more like its first imitator, the London Institution.

The London Institution, (founded 1805), was clearly modelled on the Royal Institution. Its original plan, as reported to the inaugural meeting at the London Tavern on 23 May 1805, was to provide a library, lectures and reading rooms. The Institution, which was to be "upon a liberal and extensive scale", would consist of proprietors, paying 75 guineas for a hereditary share, and life subscribers, paying 25 guineas each. 100 subscribers were felt to be required, and so popular was the scheme that the subscription list was closed only five days later, on the 28th May.[38] The printed address circulated before its formation made clear, however, that the proprietors were as much interested in emulating the provincial literary and philosphical societies as in copying the Royal Institution.

"It has long been a subject of complaint and reproach", the address read, "that while several of the more populous provincial Towns have laudably distinguished themselves by the zeal, alacrity, and spirit with which they have patronized undertakings favourable to the progress of literature and science, the metropolis of the British Empire is still destitute of a public library, upon any scale at all commensurate to the wants of its inhabitants".[39]

The title of the institution itself, "The London Institution for the Advancement of Literature and the Diffusion of Useful Knowledge" also suggests a grand literary and philosophical society.[40] This is confirmed by the fact that, although the Institution did contain laboratory space and scientific instruments, no full time professor was appointed until 1840 and little or no research work was done in its laboratories before this. Other circumstances support this interpretation of the London Institution , i.e. as intended originally to be a social institution for the very wealthy middle classes. Firstly, as Cutler has shown, the proprietors were initially overwhelmingly mercantile or commercial, as was to be expected from an institution for the wealthy in the City of London. Sir Francis Baring, the first president, was an East India Company servant, while the second, Lord Carrington, was head of a large banking family.[41] Secondly, the regulations for ladies, allowing them to subscribe to lectures but not to become proprietors,[42] were more in keeping with the attitudes of the wealthy middle classes than the regulations at the Royal Institution, where ladies could be proprietors. Thirdly, the moral objects of the institution, as stated in the printed address, were again more characteristic of middle-class aims than of the aims of the aristocracy. Indeed the objects listed were very like those which would later be stated to be the objects of the Liverpool Royal Institution, (founded 1814), also a primarily mercantile institution. The objects were: "...to afford rational amusement or instructive employment to the young or the unoccupied, to withdraw from vicious or frivolous pursuits talents adapted to prove beneficial to society; to give a useful direction to the curiosity of the inquisitive and the attention of the studious".[43]

In the London Institution, as in the Royal Institution, there seems to have been a conflict of interests amongst the founders. As has been suggested above, the primary aim was at first to be the establishment of a public library. Lectures were to be designed merely "to excite curiosity and engage attention, and to direct the inquisitive to the study of those authors who are best qualified to communicate distinct and accurate ideas of the subjects on which they respectively treat".[44] This contrasts strongly with the manuscript note already quoted which suggested the accommodation of the Askesian and Mineralogical Societies in order to aid the discovery of new matter for the lecturers to use.[45] When this indication of conflict is considered it seems less surprising that no lectures were in fact delivered until 1819, on the completion of the Institution's home in Finsbury Square. Hays[46] interprets this delay as due to financial caution in the managers of the institution, and it is certainly true that they showed a characteristic mercantile interest in the management of their money, but it seems more likely that there was, as Kelly suggests,[47] a disagreement over whether lectures should be given or not. This, in about 1815, resulted in the ousting of much of the wealthier merchant interest by a group of middle-class professional men, mainly lawyers and doctors, who subsequently took the decision to build. By the time lectures began in 1819, the London Institution was controlled by a group of men similar to those by then in charge of the Royal Institution. In 1827, by which time George Birkbeck (one of the major figures in the Mechanics' Institutes movement) was a manager, the declared aim of the Institution was "to render the Lectures so various and comprehensive that they may form a school of general scientific instruction".[48]

No attempt was made to institute private lectures for medical students, as at the Royal Institution, but the public lectures of both showed remarkable similarity. William Brande gave the first ever course at the London Institution, including the inaugural oration, and in the next ten years John Millington, J.E. Smith, P.M. Roget,

J. Harwood and J. Wallis were just some of the lecturers who visited both societies.[49] Thomas Webster, the man who had left the Royal Institution in 1802, returned to lecture to it in 1829 when Professor of Geology at the new University in London, and he lectured to the London Institution in 1827 and 1828. Michael Faraday, who first lectured to the Royal Institution in 1827, also lectured in the same year to the sister society.

Given these similarities, it is justifiable to assume that the content of the lectures to the Royal Institution from Brande's appointment in 1813 onwards was similar to that of the London Institution's lectures in its early years. Hays has attempted an analysis of these lectures and has discovered that although utility was emphasised in an economic sense, particularly when mechanics or machinery were involved, the object was to help the audience understand the utility of science, rather than to teach them applicable science.[50] Natural theology was also emphasised, particularly in the biological lectures, while astronomy, zoology and electricity were particularly amenable to visually stimulating means of presentation. Hays concludes that the institution presented science as a justifiable study because of its utility, its natural theological value and its edifying and amusing nature.

In addition to these valid conclusions, however, there is an element of rationalist and reformist thinking in the lectures which Hays has overlooked, and which can help explain some of the features of presentation. These middle-class professionals were mostly subscribers to the reformist attempts of the Radicals and the Liberal Whigs, supporting their efforts at forming a rationally organised society. The preponderance of physical science, either chemistry or natural philosophy, can therefore be explained by the belief that this, of all activities, was the most rational. Thus William Brande, in his lecture courses, particularly emphasised the laws of nature upon which the sciences depended.[51] Indeed the very first lecture after the inaugural speech was "of Powers and properties and the general laws of

Chemical Change" while his first two lectures on electricity in 1823 were on the history and laws of electricity.[52]

Their reformism was expressed by John MacCulloch in his lectures in 1826 on "Capital, Currency and Commerce", (i.e. on Liberal political economy) and in the lectures of John Gordon Smith in 1826. Smith's title was "Application of Medical Sciences to Purposes of National Interest" "viz. to legislation and the administration of justice". Medicine could provide, as an applied science, a rational guide in situations ranging from determination of the cause of death (Smith gave "Quotations from important trials, whose issues have been directed by Medical Testimony") to aiding the "Economy of public buildings, as hospitals, prisons, manufactories etc and Superintendence of the poor". Even Dr. Spurzheim's lectures on phrenology, delivered in 1827, emphasised phrenology's social applications. "Phrenology", he claimed, "is the basis of Education and Legislation".

The very emphasis on science in the lectures at the London Institution may be ascribed to the rationalist beliefs of the managers. Even the rare literary courses could be presented 'rationally', as when Dr. Crotch lectured on "National and Scientific Music".[53]

In the fourteen years between the foundation of the London Institution and the first lectures being delivered, those men by then managing the institution, (which was described in 1823 as "perhaps unrivalled by its convenience, its elegance, and the style in which it is fitted up"[54]) had become wealthy and established in the London middle classes. Earlier, however, this first generation of post-French Revolution reformists -many of whom were from the provinces and of non-conformist religious beliefs - were in no position to found or join such prestigious societies. It is probable that men of this type were behind the "General Institution, for Promoting a Knowledge of Literature and the Sciences; with their application to the useful and ornamental arts", of 1805.

The prospectus declared that the "intimate union between the practical Sciences and the Arts is a modern discovery", and that the "magnificent fabric, in the western part of the metropolis, the Royal Institution of Great Britain, has been regarded in the city as a model worthy of imitation, and a London Institution is on the point of commencing. There are many who had proposed to unite in this association, but who, on offering their names, found they were too late; others, of a congenial taste, had not even heard of the proposed establishment till the 'subscription for the names of proprietors was closed'".[55]

The institution was not, however, to be merely an overspill society. "Both these descriptions", the prospectus continued," being thus excluded, [they] determined on uniting with others already engaged in the formation of an institution more easy of access than those magnificent establishments". The institution was therefore to combine "persons of merit and talent, possessed but of slender means" with "liberal individuals, possessed of affluence", and for this purpose the terms would be "an easier expense" of only £10 a share, plus an annual subscription of £2.[56]

Little appears to have come from this suggestion, but three years later, in 1808, two other Institutions were formed, the Surrey and the Russell Institutions. The former, located just south of the river in Blackfriars Bridge Road, was a fairly lavish establishment if not quite on the scale of the Royal or London Institution. Proprietors' hereditary shares were priced at 30 guineas; and the managers in 1808 included the Lord Mayor, the Rt. Hon. John Ansley, four other aldermen, and four members of parliament.[57] The first accounts showed that 719 shares were sold to 458 proprietors; approximately £5,400 was spent on fitting up the building, buying apparatus etc. and a further £2,000 on books. £250 was spent upon the philosophical apparatus.[58] Lectures began almost immediately, on 31 October 1808, and were given at 7 p.m. on Mondays, Wednesdays and Fridays throughout "the season". The seasonal nature is an indication that it was still the wealthy who were expected to attend but the practice of lecturing only in the evenings, breaking as it did with that of the Royal Institution, suggests a membership having at least part of their time occupied in business or employment.

The Institution soon ran into financial difficulties. Despite the offer of subsidiary subscriptions permitting access for friends and family to the reading room, news room, lectures, laboratory, reference and circulating library, the necessary finance was not forthcoming and the institution closed on 23 March 1823.[59]

The lectures in the institution seem to have followed a similar pattern to those in the institutions already discussed. Fredrick Accum lectured here on chemistry, Robert Bakewell on geology and Hardie on various subjects. The Observer reported that one of Hardie's astronomy lectures included "a grand display of meteors, aurora, borealis [sic] , real lightning, and other phenomena, [which] produced a sublime effect".[60] Later lecturers included those who also lectured at the Royal and London Institutions. The lecturers for the season 1816-17, for instance, included John Millington on Astronomy and W. Crotch on Music.[61] The last two seasons of operation included twelve lectures by James Murray on chemical science, nine from C.F. Partington on experimental philosophy, twelve from Goldsworth Gurney on "Elements of Chemical Science", seven lectures from James Rennie on the "Latest improvements and present state of philosophy and science in Britain and on the Continent", and eight lectures on pneumatics and electricity by Charles Woodward. Rennie's course included two Christmas lectures to which children were admitted, on "Meteorology with experiments" and "Geology with specimens".[62]

At least one man blamed the demise of the institution on its lavishness. The building was in the style of a Greek temple with eight Corinthian columns, while the lecture theatre, with a capacity of 500, had two galleries supported by Doric columns of Derbyshire marble.[63] James Jennings was the critic, as well as the prime mover behind a plan for a "New Surrey Institution".[64] The prospectus promoted a more economical establishment, and one which could be used by the proprietors' children under the parents' supervision:

> "The Merchant, the Manufacturer, and Students in Law, Physic, and Divinity, will have easy access to works on the various subjects connected with their pursuits, and will be enabled to obtain the most valuable information at a small expense of time and money;- the Man of Leisure will always find a store of recreative reading -while PARENTS will have the constant satisfaction of enabling their sons and daughters at home, to benefit by the LIBRARY OF CIRCULATION".

At first shares were to cost 25 guineas but this was later reduced to ten, plus an annual subscription of two guineas.

The new institution, now named the 'Metropolitan Literary Institution', was formally inaugurated 7 November 1823 at 6 Chatham Place, Blackfriars Bridge. Lectures were delivered on phrenology, chemistry, mechanics and poetry in 1823. A journal was published in 1824, the Metropolitan Literary Journal, but this ceased in December of the same year and the institution itself appears to have become inoperative by about 1830.[65]

A more successful institution was the Russell Institution.[66] Established in Great Coram Street, near Russell Square, on a more modest scale than any of the previous institutions, it was said to be still flourishing in 1839.[67] Initiated by some gentlemen of Russell Square and nearby as a "Literary and Scientific Institution" it was inaugurated on 8 January 1808, when, with James Scarlett in the chair, it was proposed that a maximum of five hundred proprietors' shares at 25 guineas each be issued. Having as its objects the provision of a library containing works both ancient and modern, English and foreign, and of lectures on "Literary and Scientific Subjects", it was a reformist professional urban middle-class association from its beginning. The lectures were "to afford Useful Instruction rather than Popular Entertainment"; James Scarlett was a lawyer and prospective Whig MP and later Baron of the Exchequer. The patrons included the great Whig landowners, the Duke of Bedford, the Marquess of Lansdowne and Rt. Hon. Lord Holland; the proprietors included Francis and Leonard Horner and Edward Wakefield, and by 1826, Charles Aikin (Arthur Aikin's brother), Robert Bakewell, Peter Roget and R.J. Millington. Roget and Horner were both proprietors of the Royal Institution in the 1820s, Millington, Roget and Bakewell were all lecturers at the Royal, London or Surrey Institutions, and regular lecturers at those institutions, e.g. Pond and Hazlitt, lectured at the Russell Institution.[68]

Russell Square was an area, mid-way between the City and Westminster, which was near to the law schools and formed a centre for the homes of the professional middle classes.[69] (London University, of which Leonard Horner was the first warden, was of course founded nearby in 1828). Given these connections between the Institutions, it seems more likely that the other major institutions were modelled on this one, rather than vice versa, after they became influenced by the professional middle classes. All the institutions also had close connections with the specialised scientific societies via shared membership. William Brande and Thomas Webster were among the members of the Geological Society while William Allen, George Birkbeck, John Bostock, Michael Faraday, John Millington, John Pond and Charles Babbage all belonged to the Astronomical Society.[70]

E. Institutions of the Middle Classes

Although it has been argued that the London Institutions became organisations controlled by members of the middle classes, they remained organisations of and for the wealthy. The middle classes of early nineteenth century London contained very diverse elements, both financially and intellectually, from merchants and bankers of the City and the East India Company, through lawyers and doctors, to tradesmen, schoolmasters and clerks. Thus the diversity of "middle-class" institutions in this period was enormous .

Socially, one of the lowest institutions which flourished at this time was the Spitalfields Mathematical Society.[71] Begun in 1717 as a society primarily of weavers studying mathematical problems, by the early nineteenth century it had become a more middle-class society, and a more scientific one. Essentially a private society, the Spitalfields Mathematical Society had began with the square of eight (64) members before its enlargement to 81, probably after another mathematical society and a historical society combined with it in 1772 and 1783 respectively.

By 1804 the regulation stipulating one hour's silence during each Saturday evening meeting had been abandoned, signalling presumably also the abandonment of the individual attempts at solving mathematical problems for which this hour had been allotted.

The scientific interests of the society developed soon after its foundation, for it had been agreed to purchase electrical apparatus as early as 1746, and by the early nineteenth century science appears to have taken over, for there was even some talk of beginning a mathematical class, in 1819.[72] By 1804 the regulations showed that members were required to give lectures in rotation on natural philosophy or mathematics, under pain of fine of 2s. 6d.[73] No divinity or politics could be discussed at meetings under the society's articles.

As well as books, scientific apparatus could be borrowed. The low fines of 1d. per week (increasing "in an arithmetical progression"), the limit of 10s. on fines if books or instruments were lost, and the subscriptions of only 3s. 3d. per quarter plus 3d. a night (although doubled in 1805)[74] shows that this society was for men of no great wealth. A number of factors indicate however that in the early nineteenth century it was by no means a working man's society. The Historical Preface to the 1804 Catalogue claimed that from its instigation the Society "had for its object to introduce to the middling classes of the community studies which had hitherto been confined to the libraries of the learned, or the investigation of the opulent".[75] By late 1823 a correspondent to the Mechanic's Weekly Journal declared that "the far greater number of its members[are] ... manufacturers, or some way connected with them",[76] while an examination of the manuscript membership list in the back of the Guildhall Library's 1804 Catalogue reveals occupations ranging from sugar refiner, schoolmaster, and prerogative officer, to doctors of medicine. Other members worked at the Stock Exchange, the Alliance Life (Insurance) Office and the East London Water Works. One of the last of the 179 entries, which spanned most of the first thirty years of the century, was that of H.Wright (?) of London University.

The membership of the society at this period therefore appears to have consisted not of the journeymen weavers, bakers, bricklayers and braziers of the early and middle eighteenth century,[77] but of master manufacturers and members of the less wealthy middle classes.

The early nineteenth century saw more changes in the constitution of the society. The long established tradition of pipes and porter with the philosophy was stopped as an institution in 1801 "and left to the private taste of members". This reform was not, however, appreciated by many members who ceased to attend, resulting in the restoration of practice.[78] By 1805 each member had to contribute 4d. per evening for "refreshments".

The payment for and provision of drink and tobacco seem to have continued at least until 1823, when the charge was 6d. a night, but by then the practice was coming under attack from the moral reformists of the higher middle classes. James Jennings complained that:

"There is a conviviality attending the meetings of the Society, which is, perhaps, somewhat derogatory to it as a literary and philosophical association; but its age entitles it to respect".[79]

By 1839 drinking and smoking at the meetings had again been banned. By this time, although the society was said to embrace many of scientific and literary distinction, the membership had dropped to 54, the subscription had risen to £2 per annum [80] and the society had become a literary and philosophical society with random and fairly miscellaneous lectures. The society was eventually absorbed into the Astronomical Society in 1845.

In the early years of the century the society appears to have concentrated upon science. The public lectures, which probably ran from 1798 - 1808 and 1819 - 1826, were entirely scientific.[81] Advertised as "illustrated by a variety of appropriate experiments", the subjects covered in 1806 were mechanics, hydrodynamics, pneumatics, electricity and magnetism, fire and chemistry, astronomy and optics.[82] The lectures were given in seasons running usually from November to April and for the fourteen lectures of 1806 the average attendance was approximately 130. Dr. Wilkinson's course on galvanism was very popular, his third lecture drawing over 300 people.

Prices at this time were 1s. per lecture or 9s. per course. When lectures restarted in 1819 the same pattern both of lectures and attendance prevailed, with an average of about 140 at each lecture. On average 200 people attended lectures on electricity and over 300 those on galvanism, presumably because of the spectacular experiments performed in these two subjects.[83] Jennings listed the subjects lectured on in the session 1822-23, which included mechanics, hydraulics, pneumatics, chemistry, optics, astronomy, electricity, galvanism, magnetism and botany. A total of 23 lectures were offered and all were given gratuitously and therefore (presumably) by society members.[84,85]

The question remains, what sort of man would belong to the Spitalfields Mathematical Society? Able to afford 26s. annual subscription (in 1823), and able to profit from the library of some 4,000 mathematical, scientific and historical books, and from the large collection of scientific instruments (which included a 44" acromatic telescope valued at 21 guineas, an electric machine worth £15, an "aurora borealis flask" and two large double-barrelled air pumps[86]), the typical member was clearly not ill-educated or poor. Yet the conviviality of the meetings, and the area in which the society was situated, (the building itself being described by Charles Knight in 1842 as "a humble building, bearing much the appearance of a weavers house and having the words 'Mathematical Society' written up in front"[87]) seems to separate the society from the wealth and splendour of the London Institutions. The explanation must be sought in the social context of the Society.

The centre of London's silkweaving industry, Spitalfields lost the less skilled parts of the trade in the early years of the century.[88] With an enormous increase in population (59,000 in 1811, 90,000 by 1831), the percentage of weavers declined (from 55 per cent in 1770 to 26 per cent in 1813) and unskilled workers proliferated.[89] The area became very poor, 60 per cent of workers earning less than two pounds per week.

Consequently, the middle classes of the district, estimated at some 6 per cent, grouped together socially as a means of cultural preservation. Many were religious dissenters, especially Quakers and Unitarians, and their rationalist religious beliefs fitted well with a society based on natural philosophy. As will be discussed later, they also grouped together to form a mechanics' institute for the education of the lower classes, again as a means of preserving their culture and their livelihoods, but social conditions got gradually worse and members of the middle classes began to move away from Spitalfields.

The membership list of the institution shows that many members moved house two or three times in the course of their membership, settling often in suburbs such as Hackney, Islington and even Camberwell. The long standing president, Benjamin Gompertz, who was a fellow of the Royal Society as well as a founder member of the Astronomical Society, himself lived in Vauxhall. From this evidence , and from the fact that, increasingly, members gave their addresses of employment, rather than their home addresses, it can be concluded that the Spitalfields Mathematical Society lost many of its connections with its locality; it became in the 1830s an institution of a rather more genteel and literary nature.[90]

Another, but very different, type of middle-class scientific institution was the City Philosophical Society, instituted in January 1808. Formed as a mutual instruction society for young men, the laws of 1812 explained that it had been founded because, of all the Institutions "for the promotion of Philosophy and Literature... the expensive scale of their establisments necessarily precluded a large class of the Public from participating in the advantages to be derived from them". The City Philosophical Society would be one in which members gave gratuitous lectures, and funds would be spent in purchasing a "select Library".[91]

Meetings of the society were held at the house of its secretary, the science lecturer John Tatum, at 53 Dorset Street, Salisbury Square, every Wednesday at 8 p.m. Lectures were given every fortnight and alternate meetings were spent discussing the last lecture, reading original essays, or hearing extracts from new or scarce works on arts, sciences or literature. The democratic nature of the society was underlined by the rotation of the offices of president and vice-president.[92]

By 1812 lectures had been given on "Astronomy, Anatomy, Aerology, Botany, Chemistry, Drawing, Engraving, History, Mathematics, Metaphysics, Mechanics, Physiognomy, Rhetoric, Music, Electricity and Galvanism".[93] The lectures were given by the members in turn. As in the Spitalfields Society "no topic of Theology or Politics [could] be discussed in the society", yet this regulation did not prevent the society from being refused a licence under the 1817 Seditious Meetings Act.[94]

A maximum of 100 members were permitted,each paying 32s. per annum.[95] From 1813 one of these was a young bookseller's apprentice, Michael Faraday. In 1816 he gave six lectures to the society on "the attraction of cohesion, on radiant matter, [and] on diverse simple bodies";[96] a year later he gave a talk on "Some Observations on the Means of Obtaining Knowledge".[97]

While the City Philosophical Society does not seem to have organised public lectures in the same way as the Spitalfields Society, visitors were allowed into the lectures at the invitation of members. A letter in the Mechanic's Weekly Journal (although not one to be completely trusted) claimed that Tatum in particular often gave lectures on "the elementary parts of the physical sciences and chemistry in a very plain manner... perfectly adapted to the understanding of plainly educated men".[98]

Similar societies were Mr. Hardie's of Conway Street, Fitzroy Square, which met on Tuesdays at 8.30 p.m.,[99] and possibly the London Chemical Society of 1806 of Old Compton Street, Soho where Joyce and Accum lectured and which was said to have sixty members.[100] The Academical Society of London and the British Philosophical Society were two other contemporary scientific and literary societies, about which little is known,[101] but three other societies reflect different aspects of institutional life at the time.

The Philomathic Institution of Burton Street, Burton Crescent, was founded in 1807 "to cultivate the intellectual powers, and promote the advancement of Science and Letters.Its constitution [was] of a more extensive and popular character than that of many other societies".[102] Patronised by the Duke of Sussex, the President in 1823 was Dr. W.B. Collyer. At that time approximately fifty members met every Tuesday evening to discuss miscellaneous philosophical and literary subjects and every Friday to read essays and lectures etc. The annual subscription was two guineas.[103] Again, politics and religion were forbidden, but it too was refused a licence in 1817.[104] From the evidence of the Philomathic Journal, published by the Institution, it seems that the society by no means concentrated upon science. The first volume contains only an article on phrenology and a review of a book criticising Copernican astronomy as its scientific content,[105] and later volumes followed the same pattern, although they reflect the nature of the society in the 1820s, and not necessarily earlier.

The Philosophical Society of London, founded in 1810, supposedly as a successor to Samuel Varley's London Philosophical (or Chemical and Philosophical) Society, was much more scientific. Inkster's claim that it was almost wholly scientific and acted as a transitory society for occupationally and socially mobile men, who later made themselves serious and recognised scientists in such other groups as the Geological, Linnean and Royal Societies, is however hard to support.[106] Firstly it must be pointed out, as already argued above, that the 'scientific' societies of the era were by no means as separate, either in form or standard, from the more 'social' societies as they are today. Also from the discussion above it is clear that a rigid separation of science and literature was rare at this time, even in such prestigious societies as the Royal or London Institutions. Thirdly, while Inkster is right to point to the strong medical, reformist and non-conformist connections of many members, it is obviously not right to say that the presence of such men, including the dissenting minister Rev. W. B. Collyer, indicates a serious and dedicated approach to science, for Collyer went on to become the President of the Philomathic Institution. Further, examination of the printed remains of the society suggests that it was both more literary and more prestigious (and so more establishment orientated) than Inkster suggests.

According to G.N. Rankin's 1819 pamphlet, the society was founded by T.J. Pettigrew and friends in October 1810 to undertake discussion of all literature and science except theology and politics.[107] Its constitution, including as it did Ordinary, Honorary and Corresponding members, an ornate swearing in ceremony and a 2 guinea entrance fee, suggests a society which saw itself as rather grand. Honorary membership was to be restricted to Peers, M.P.s, Judges "of one of the Superior Courts of Justice", hereditary nobles of a foreign state, authors "of some scientific Work of Celebrity" or Professors of some branch of Philosophy. The fine for not giving a promised lecture was one guinea, and that for a library book overdue was 1s. a day.[108] Three Royal Dukes (Kent, Sussex and Cambridge) were all members in 1815, the Duke of Sussex actually taking the chair at some of the most important meetings.[109] This was very possibly the society which refused admission to a working man, Timothy Claxton, in 1817.[110]

According to Rankin, a "very large proportion of the literary men of this country were numbered among its members, as well as many distinguished foreigners" and a "large and important foreign correspondence" was established,[111] before internal disputes caused the Society to split. The Royal Dukes, the President, the Earl of Carysfort, the Duke of Orleans, the Rt. Hon. Earl Pomfret, the Lord Bishop of Salisbury and many others including Collyer, Sowerby and a Mr. Coleridge, left the society. The society was not to become, as the Duke of Sussex had hoped, "useful, ornamental, and beneficial to this country", nor "capable of attaining no small measure of utility and celebrity" as Collyer had thought.[112] The annual report for 1819-20 laments that the ordinary membership was now down to thirty, attributing this to "the desultory and unattractive nature of Ordinary meetings" compared to the "splendour and general interest" of public meetings and of former times. The president, Olinthus Gregory, wrote in a postscript that he would have resigned had he but had the secretary's new address, and on this rather comic note of disorder, in August 1820, the Philosophical Society of London dissolved itself.[113]

Further out in the suburbs, and on a less noble scale, was to be found the Hackney Literary and Philosophical Society.[114] Started by a man educated at a Scottish University, John Clennell, (who also conducted the New Agricultural and Commercial Magazine), the Society's first meeting occurred at Clennell's house on 30 January 1810.

Two lectures by John Sadler were given on 10 and 17 February and were said to be well attended. The first general meeting was held at the Mermaid on 26 March when elections were held and the regulations adopted.[115] These were very like those of a typical provincial literary and philosophical society. Meetings, for instance, were held just once a month, on the first Tuesday, when:

"The subjects for conversation shall comprehend the Mathematics, Natural Philosophy and History, Chemistry, Mineralogy, Polite Literature, Antiquities, Civil History, Biography, Questions of General Law and Policy, Commerce and the Arts; but Religion, the practical branches of Law and Physic, British Politics, and indeed all Politics of the day, shall be deemed prohibited subjects".[116]

This last condition of the Hackney Literary and Philosophical Society may usefully be compared with the activities of the Hackney Dissenting Academy, a short-lived and radical Unitarian school of 1786-96. Associated with Priestley and Price, the Academy taught a comparatively large amount of both physical science and reformist ideas, and consequently closed down from lack of financial support when the reaction to the French Revolution made the ideas of 'rational' philosophers unpopular, because of their perceived association with deism or atheism. Specifically, the ban on politics and religion, although common to such societies at this time, may be considered to have been a necessity in an area where the lack of such prescription had forced an earlier institution to close.

A " collection of philosophical instruments and natural and artificial curiosities, forms a part of the plan of this Society, and donations will be thankfully received", the regulations continued. Subscriptions were to be one guinea per annum or ten guineas for life membership.[117]

The first year's report of the society, written by Clennell, displayed attitudes characteristic of the Scots and provincial middle classes, attitudes which were soon to be shared by almost all the Victorian middle class: the rejection of ostentation, the equation of intellectual and moral activities, and a belief in the piety of these actions. "In the discoveries of science", Clennell wrote, "we are exerting ourselves for the cause of humanity...The lover of science, the explainer of those laws by which the mighty arranger of nature has appointed her revolutions, enjoys also his pleasures: convinced that the more he discovers of her works, the more he must love her divine architect...Oh fortunate attainment of the human mind, in thy enjoyment alone it is, that excess partakes not the nature of crime".The projected building would be "not consecrated by pride or ostentation but by plainness and unobtrusiveness".[118]

The lecture programme for the year showed the characteristically miscellaneous curriculum of a truly literary and philosophical society. Apart from lectures by Robert Thornton on botany, which were given gratuitously on 12, 14, 26 of May and 2 June, and which "were visited by a very respectful audience, whose attention must have been highly gratifying to our worthy botanical associate", the season included a talk on a curious wooden punch ladle from a cowherd in Dunkeld, a translation of a literary portraiture of France in the eighteenth century and an account of wild cattle in Chillingham Park read from a Board of Agriculture account.[119] Typically also, the Scottish educated Clennell gave a disprop ortionate number of papers, and those usually on rationalist and scientific subjects. Thus Clennell lectured on "the general improveability [sic] of the human mind, in mechanical as well as in every other part of science" and on "the advantages of mutual intercourse" of such institutions.[120]

One further society founded in the 1820s demonstrated both that specialist societies were not necessarily any less 'popular' than general ones and also that, whatever the aims of the originators of a society, social circumstances dictated the formation of a society very similar to those already in existence. The London Chemical Society of 1824[121] was first suggested by correspondents to the Chemist, a short lived journal published by Knight and Lacy.

Aimed at a similar readership to that of the Mechanics' Magazine, the issue for 22 May 1824 contained a letter from 'A.W.'[122] suggesting the formation of a mutual improvement society. After further discussion in the magazine the same correspondent suggested a 1s. entrance fee and a 1s. a week subscription. After some initial meetings the society was inaugurated on 12 August 1824 for "the study of chemistry in all its branches". By this time, however, the entrance fee was set at one guinea, with a half-yearly contribution of another guinea.[123]

The first president was George Birkbeck of the London Mechanics' Institution; he delivered an inaugural address on 25 November 1824 at the City of London Tavern before an estimated 300 people, including a "great many ladies". Birkbeck said that "we are exceedingly desirous, although it is not consistent with the present constitution of the Society, that [ladies] should hereafter become participators also, as members".[124] Thus a society which had grown out of a journal produced specifically for the "working classes"; which 'J.G.' had suggested should have not more than twenty members, paying 1s. a month and working their way systematically through Henry's System of Chemistry, etc; and which 'A.W.' had suggested should be a group for communal purchase of instruments and chemical tests, etc., had become a society of young middle-class men and women with lectures from such circuit lecturers as Charles Partington.[125]

The 1820s also saw the development of institutions for the middle classes connected with the mechanics' institutes movement. In 1825, the year in which five suburban mechanics' institutes were founded in London, institutions were founded by those who initiated the mechanics' institutes for the young of the middle classes. These societies were called Literary and Scientific Institutions and the Eastern, Western and Cosmopolitan societies were all founded in 1825.[126]

The Cosmopolitan Institution was "for the Economical, rapid and efficient diffusion of useful Knowledge, among all Classes of Society" via a library (of circulation as well as reference), reading and conversation rooms, schools (i.e. classes) in English, French, Latin and other languages, and lectures on polite literature, geography, astronomy, and the sciences in general.

Although designed, it was claimed, for "all classes of Society", the Institution was especially intended for "Bankers, Merchants, Solicitors etc." The subscription was £2 per annum, payable half yearly.[127]

Identical terms were demanded by the Western Literary and Scientific Institution, founded in 1825 in Leicester Square. Its object was "the Diffusion of Useful Knowledge among Persons engaged in Commercial and Professional Pursuits".[128] At the inaugural meeting on 10 November 1825 J.C. Hobhouse, George Birkbeck and Henry Brougham were all present, all three of whom were leading figures in the London Mechanics' Institution. Brougham "observed that the Institution was for those who had part of their time occupied, and part unoccupied" and it would have a beneficial effect on both "the upper classes" and the "labouring classes", the former by encouraging them to stay ahead and the latter by providing them with both assistance and stimulus.[129]

Meeting every Thursday evening, the Western institution held mathematics and botany classes and later mineralogy and entomology classes. The institution had the King as a patron (both George IV and William IV) and Sir Robert Peel and the Marquis of Lansdowne as two of its vice-patrons. George Birkbeck became one of its vice-presidents and John Abel Smith its treasurer. Unlike in Mechanics' Institutions, ladies could subscribe, but not to full membership, merely for use of the lectures and library.[130]

Similar institutions seem to have been the Camberwell, Peckham and Kennington Literary Institution[131] and the Surrey Literary Institution. The former was opened (on 1 February 1825) with a speech from Rev. I. Peers M.A., as was the latter, on 25 February 1825. Many ladies were said to be present at this second occasion when the President was revealed to be John Kay Esq., Alderman; George Birkbeck was again a vice-president.[132]

Apparently more concerned with formal education was the City of London Literary and Scientific Institution. The Institution was designed specifically for young and unmarried "Clerks, and other Gentlemen engaged in Commercial and Professional pursuits". The Institution would provide purely intellectual education, "without that reference to manual skill which is so important to operative Mechanics".[133]

Founded in 1825, the Institution was situated at No.165, Aldersgate Street and inaugurated by three talks from the Scottish political economist J.R. M'Culloch, given at the London Coffee House on Ludgate Hill in May and June of that year.[134] The terms were to be an annual subscription of two pounds, an extra one pound allowing the member to be accompanied to the lectures by a lady.[135] Lectures, which were to be given on "Polite Literature, History, Mathematics,...Trade and Commerce and...Natural and Moral Philosophy", were delivered usually every Wednesday evening, while classes were also held to teach Latin, French, Italian, Spanish, shorthand, globes and logic, as well as to discuss historical and philosophical questions.[136] The institution appears to have been fairly successful. On the occasion of the first half-yearly meeting, 7 September 1825, it had eighty-nine volumes in its library and 556 members. By 1828 there were over 600 subscribers and in 1839 approximately 1100.[137] Most members were young tradesmen, merchants and bankers' clerks and in 1825 the aim of the institution was said to be to give "the youth of the City...an after education of the highest order, comprising a knowledge of the sciences, and of the living and dead languages".[138]

Before a permanent home was found for the institution lectures were held at a variety of venues. Ten lectures on natural and experimental philosophy were given by Charles Partington in Moorgate from 10 August 1825 at 8 p.m. The syllabus included electricity and magnetism, light, optics, pneumatics, mechanics and acoustics, and including their applications in engines, pumps, the safety lamp etc.[139]

The benefits of the institution were to be both intellectual and moral. The strength of the mind would be improved "by the habit of following the Lecturer through a series of well connected facts, and of accurate and philosophical reasonings". The moral advantages were to be gained by preventing the members "becoming addicted to vicious and degrading habits and pursuits".[140] Members would acquire "salutary and unexpensive tastes" as well as "studious and rational acquaintances", making the Institution particularly suitable for "those parents who are introducing their sons into professions, and are seeking to protect them against the multifarious temptations of London".[141]

The presence amongst the officers of James Mill and other Radicals and liberal Whigs shows that there was a reformist aim as well as an educational one. At an early meeting of the society on 3 June 1825 a unanimous resolution was passed which stated:

> "That Literary and Scientific Institutions on a moderate scale of expence [sic] are eminently calculated to increase morality and happiness, and are among the most efficient means of promoting the true interests and prosperity of society".[142]

The Utilitarian aim here expressed of efficiently and economically promoting "morality and happiness" could be achieved via educational institutions for the middle classes because, as M'Culloch wrote:

"It is on the intelligence, public spirit, and morality of those classes [i.e. the "middle classes"] - of those who are alike removed from the temptations to idleness and inconsiderate conduct caused by the possession of vast wealth on the one hand, and from the contracted and selfish feelings apt to be generated by the necessity of unremitting application to some species of bodily labour on the other - that the good government and lasting prosperity of every country must be principally dependent". A rationally educated middle class would therefore mean "that public opinion, - ...to which... the proudest minister must consent to bow - [would] be exercised by those who are well-informed".[143]

To M'Culloch, a political economist, the teaching of that subject was particularly important, for although the ideas of Smith and Ricardo would not make better clerks or book-keepers, "you must bear in mind, that those who now fill these subordinate...situations are rapidly advancing to those that are higher".[144] Thus, although politics were banned from discussion, the rationalist reformists in control of the Institution believed that political economy, even espousing as it did extreme laissez-faire capitalism, was not politics but science. As Ellis said of political economy, in one of his lectures on the subject, "its evidence is founded on observation and experience...its principles are legitimate deductions from established facts, it is obvious that Political Economy is one of the most certain of the sciences".[145] Poor relief, law and government legislation would also all benefit from the "habit of abstract reasoning, [which] will suggest measures of salutary reformation". This habit was to be derived especially from study of the works of men such as Newton and Bacon, in particular Bacon's "greatest work, the Novum Organon".[146]

The City of London Literary and Scientific Institution, both in its instigators and in its aims, may be seen as in many respects a prototype of the University of London, founded in 1828. The prevailing view of adult education in the early nineteenth century was very different from that of today. Thus the London Institution could claim in 1822 to be "a school of general scientific instruction".[147] The Quarterly Review saw it and similar institutions as providing a University type of education for men previously unable to receive one.[148] This was not exaggeration on the part of these authorities, but a reflection of contemporary attitudes, for education received at the Universities themselves, both at Oxbridge and in Scotland, relied primarily on the provision of miscellaneous facilities which could be used by the students as they wished, with no set curricula or compulsory examinations. Indeed at Oxbridge the facilities were perhaps even fewer. Lord Monson wrote to his son at Christ Church in 1847 that he was "quite surprised at your account of lectures and themes, we had nothing of that kind in my day".[149]

New conceptions, both of the best method of education and indeed of the nature of education itself, were being formed in the early nineteenth century, and the professions, particularly medicine, were in the forefront of these changes.One recent historian has written that the "misfortune was that London University was created when no one in England quite knew what a University should do, what its function in society...should be".[150] This is a misleadingly Whiggish interpretation of the foundation of the University, for the modern concept of the function and purpose of a university was being made in this period; specifically by the founders of the London University and its emulators, i.e. King's College London (1828) and Durham (1836). It was not possible to wait until the 'proper' function of a university was understood, for only through the foundations themselves and their interraction with the community was even a measure of agreement formed.

F. London and Popular Science Societies

London's size and social milieu had extensive effects upon the development and nature of societies in these years. Merely because of the large population of the metropolis it was possible for like-minded men to group together in societies. Entrepreneurs were also able to establish libraries, schools and museums. Superimposed upon this background of activity was the growing wealth, and therefore confidence, of the middle classes. At first this wealth belonged to merchants and manufacturers, but through their patronage, it soon spread to the service professions. Many of these men, particularly the medical men, had been trained in Edinburgh and other centres of Enlightenment thought, thus producing an intellectual vanguard amongst the urban middle classes with 'progressive' ideas both in political reform and in education. These ideas, crucially for the popularisation of science, included a new concept of the nature and value of science in society.

Contemporaneous with these developments, the growth and change of the outlying districts of London affected societies founded in these localities. The decay of the Spitalfields area, connected with the growing suburban movement, led to the Spitalfields Mathematical Society losing touch with both its locale and with the weaving trade associated with that locale. The society consequently became a higher-class and more literary organisation. The middle-class suburban movement also helped stimulate the foundation of new institutions such as the Hackney Literary and Philosophical Society, which was a provincial Literary and Philosophical Society in all but its geographical location.

Notes to Chapter 5

1. For early nineteenth-century London see G. Rudé, Hanoverian London, 1714-1808, London, 1971; F. Sheppard, London 1808-1870, The Infernal Wen, London, 1971; M.D. George, London Life in the Eighteenth Century, Harmondsworth, 1966. Population figures are from Sheppard, pp.xvi-xvii.

2. Minutes of the Society for Philosophical Experiments and Conversations, Instituted in London 25th Jan. 1794, London,[1795]. For the Askesian Society, and a general discussion on science lectures and institutions in early nineteenth-century London see Ian Inkster, 'Science and Society in the Metropolis: A Preliminary Examination of the Social and Institutional Context of the Askesian Society of London, 1796-1807', Annals of Science, 1977, 34, 1-32.

3. Guildhall Library, London Institution, Original Papers Book, 1805-1817. This contains both the quotation given and the suggestion that the societies should merge.

4. On the Baconianism of the early Geological Society see M.J.S. Rudwick, 'The Foundation of the Geological Society of London: Its scheme for Co-operative research and its struggle for Independence', British Journal for the History of Science, 1962-3, 1, 325-55 (333-6). See also P.J. Weindling, 'Geological Controversy and its Historiography: the Prehistory of the Geological Society of London', in L. Jordanova and Roy Porter (eds.), Images of the Earth, Essays in the History of Environmental Sciences, Chalfont St Giles, 1979, pp. 248-71. On the programme and ideals of the Astronomical Society see the Address and Regulations of the Astronomical Society of London, Established February 8, 1820, London, 1821, pp.2-3, 6.

5. Compare Address, op.cit.(4), pp.20-36, with the Statutes and Regulations of the Philosophical Society of London, Instituted October 5, 1810, [London] , 1820.

6. Westminster Public Library, No. 10 Panton Square, Rules, Settled June 6th

1798, [London, 1798].

7. See for instance James Cawthorn's Catalogue of the British Library, No 24 Cockspurs Street, [London, 1830?] .

8. See A Catalogue of British Quadrupeds and Birds, contained in the British Zoological Museum, Oxford Street, London, 1795; For Merlin's Museum see Inkster, op.cit. (2), p.10 and W.C. Oulton, The Traveller's Guide; or, English Itinerary, 2 vols., London, 1805, I, cxxv. See this last reference also for Week's Museum.

9. E. Halévy, A History of the English People in the Nineteenth Century, I: England in 1815, 2nd edn., London, 1949, p.564.

10. Inkster, op.cit.(2),pp.6,8.

11. Catalogue of Chemical Preparations, Apparatus and Instruments for Philosophical Chemistry. Prepared and Sold by Frederick Accum, Old Compton Street, Soho, London, 1805, p.ii.

12. Catalogue of Chemical Preparations..., London, 1812, Advertisement.

13. William Phillips, An Elementary Introduction to the Knowledge of Mineralogy, London, 1816, Preface, (n.p.). Accum, John Mawe and William Henry are three examples of men who wrote and lectured on science, sold their professional advice and sold equipment and specimens.

14. Ian Inkster, 'A Note on Itinerant Science Lecturers, 1790-1850', Annals of Science, 1972, 28, 235-6.

15. Inkster, op.cit. (2), pp.6-7.

16. Halévy, op.cit. (9), p.565.

17. Ibid.

18. For the Royal Institution the two most comprehensive works are Bence Jones, The Royal Institution: Its Founder and its First Professors, London, 1871, and, more recent and more challenging, M. Berman, Social Change and Scientific Organisation, The Royal Institution, 1799-1844, London, 1978.

19. Quoted in Berman, op.cit.(18), p.25.

20. Jessie E. Milton, 'Lectures and Lecturers in the First 100 Years of the Royal Institution', Proceedings of the Royal Institution of Great Britain, 1977, 50, 133-44 (133-4).

21. T. Garnett, An Outline of a Course of Lectures on Natural and Experimental Philosophy, delivered at the Royal Institution of Great Britain, London, 1801; idem, Outlines of a Course of Lectures on Chemistry: delivered at the Royal Institution of Great Britain 1801, London, 1801.

22. Garnett, Natural Philosophy, op.cit. (21), pp.3-4.

23. Ibid, p.9.

24. Ibid, p.15.

25. Ibid.

26. Garnett, Chemistry, op.cit. (21), p.2.

27. Ibid, p.27.

28. Berman, op.cit. (18), p.71

29. The lectures delivered at the Royal Institution in each season are listed in the Managers' Minutes, pp.319 ff.

30. See, for instance, Edinburgh Review, 1802-3, 1, 452.

31. H. Davy, Geological Lectures, 1805, No.1, in Box 16 at the Royal Instutition.

32. [H.Davy], A Discourse, Introductory to a Course of Lectures on Chemistry, London, 1802, pp.7,17.

33. [H.Davy], 'Parallels between Art and Science', The Director, 1807, 2, 193-8 (196-8).

34. [Davy], op.cit. (32), p.21.

35. H.Davy, Elements of Agricultural Chemistry, in a Course of Lectures for the Board of Agriculture, London, 1813, p.24.

36. Berman, op.cit. (18), Chapter IV.

37. Bence Jones, op.cit. (18), p.290.

38. [A Report of Two Early Meetings of the London Institution] in Banks collection at the British Library.

39. Printed address in the London Institution records at the Guildhall Library.

40. cf. Berman, op.cit. (18), pp.92-3, who says it was intended to be a research institute like the R.I., but to aid not land but commerce.

41. J.C. Cutler, 'The London Institution, 1805-1933', University of Leicester PhD thesis, 1976, ch.I.

42. [Report], op.cit. (38).

43. Address, op.cit. (39), cf. Liverpool R.I.'s aims (see below, chapter VI).

44. Ibid.

45. See above, section B.

46. J.N. Hays, 'Science in the City: The London Institution, 1819-40', British Journal for the History of Science, 1974, 7, 146-62 (155-6).

47. T. Kelly, George Birkbeck, Pioneer of Adult Education, Liverpool, 1957, p.47.

48. London Institution, Auditor's Account, 1822, Preamble.

49. cf. the list of lectures in the R.I.Managers' Minutes, pp. 319ff, with A Descriptive Catalogue of the Lectures Delivered at the London Institution, London, 1854.

50. Hays, op.cit. (46), passim, esp. pp. 161-2.

51. See also his praise of Bacon in W.T. Brande, An Introductory Discourse... to the London Institution, London, 1819,esp. pp.13-14,22-23.

52. The Guildhall Library has a collection of syllabuses for courses at the London Institution, from which the information in these sections comes.

53. Cutler, op.cit. (41), appendix VI, table I, has calculated the percentage science of each year's courses of lectures at the London Institution. The average for the first eight years (including 1821 when no lectures were given) is over 87 per cent, compared with only c.40 per cent in the next three years. (Cutler's figures have been corrected for 1828-9 when she has overlooked Webster's ten lectures on the Motive Forces of the Arts).

54. J. Jennings, A Lecture on the History and Utility of Literary Institutions, London, 1823, p.37.

55. Plan of a General Institution for promoting a knowledge of Literature and the Sciences, with their application to the Useful and Ornamental Arts, [London, 1805], p.1, in Banks Collection at B.L.

56. Ibid, pp.1-2.

57. For the Surrey Institution see Geoffrey Carnall, 'The Surrey Institution and its Successor', Adult Education, 1953-4, 26, 197-208. Supplementary information is derived from the miscellaneous collections of papers on the institution in both the British Library and the Guildhall Library. The Surrey Institution always referred to itself as the Surry Institution, but as other contemporary sources use the term Surrey Institution the modern spelling has been used throughout.

58. Surrey Institution Auditor's Report, 1808, in B.L. collection on S.I.

59. See Surrey Institution Auditor's Report, 1813 and questionnaire for the extra subscriptions offered; see the 1816 lectures handbill for the facilities of the institution in that year. The Mechanic's Weekly Journal suggested that the closure was due to disagreement over which books to have in the library, but I have found no evidence to that effect. (M.W.J., 1824, 1, 191).

60. Inkster, op.cit. (2), pp.7-8.

61. cf. with the lack of science in the Philomathic Society, below.

62. Syllabuses are in the miscellaneous collections, loc. cit. (57).

63. Described by Carnall, op.cit. (57), p.197.

64. His complaint was in the Metropolitan Literary Journal, 1824, p.3. For the new institution see Carnall, op.cit. (57), pp. 200ff, and Abstract of the Amended Prospectus for a New Institution, London, 1822, in B.L. Collection. Minutes of a meeting to discuss the foundation of the new society are bound with the copy of Jennings, op. cit. (54), in the British Library.

65. Carnall, op.cit. (57), pp.202-8.

66. This account of the Russell (or Russel) Institution is derived from An Account of the Proceedings, with A Prospectus of the Russell Institution, for the Promotion of Literary and Scientific Knowledge, London, 1808 and A

Catalogue of the Library of the Russell Institution, London, 1826, pp.1-3, and the list of proprietors.

67. A. Booth, The Stranger's Intellectual Guide to London, For 1839-40, London, 1839, p.106.

68. Jennings, op.cit. (54), p.40 (note).

69. John Bostock, for instance, the chemist who was very prominent in the Liverpool Literary and Philosophical Society, moved to Great Coram Street when he came to London.

70. Address, op.cit. (4), membership list, pp.69-75. Interestingly the Mechanics' Weekly Journal, although generally antagonistic to the mechanics' institutes, listed the public lectures of the London Mechanics' Institute, John Tatum's Theatre of Science, the Spitalfields Mathematical Society and the Russell Institution.

71. The two most important accounts of the Spitalfields Mathematical Society are Henry Cawthorne, 'The Spitalfields Mathematical Society, (1717-1845)', Journal of Adult Education, 1928-9, 3, 155-66, and J.W.S. Cassells, Presidential Address to the London Mathematical Society, November, 1978, of which there is a typescript in the Guildhall Library. This has also been published in Bulletin of the London Mathematical Society, 1979, 11, 241-58 although I have not seen this version.

Cawthorne had access to now destroyed minute books, but some records of the society remain in the British, Guildhall and University College, London, Libraries. The Guildhall Library copy of A Catalogue of Books, belonging to the Mathematical Society, Crispin Street, Spitalfields, London, 1804, has a manuscript membership list bound with it.

72. Cawthorne, op.cit. (71), p.159.

73. A Catalogue, op.cit. (71), p.ix. The regulation read: "Every member shall in rotation give a lecture on mathematics, or on some branch of natural

philosophy, or perform, or cause to be performed, some experiments relative thereto, each night of the meeting, between the hours of nine and ten".

74. Corrected, with the date of alteration, in manuscript in the British Library copy of A Catalogue, op.cit. (71), p.v.

75. Ibid, p.i.

76. Mechanic's Weekly Journal, 1824, 1, 70.

77. Cawthorne, op.cit. (71), p.156.

78. Cassells, op.cit. (71), p.10. For the effects of the Seditious Meeting Acts on this and other societies see I. Inkster, 'London Science and the Seditious Meeting Act of 1817', British Journal for the History of Science, 1979, 12, 192-6 and P.J. Weindling, 'Science and Sedition: How Effective were the Acts Licensing Lectures and Meetings, 1795-1819?', British Journal for the History of Science, 1980, 13, 139-53 (143 for the S.M.S.).

79. Jennings, op.cit. (54), p.50 (note).

80. Booth, op.cit. (67), pp.17-18.

81. The years were good for the society financially. Consequently financial problems could not have prevented lecturing (cf. Cawthorne, op.cit. (71), pp.160-1).Perhaps the break was due to the Seditious Meetings Acts. See Inkster and Weindling, op.cit. (78).

82. Cawthorne, pp. 159-60.

83. Ibid, pp. 160-1.

84. Jennings, op.cit. (54), p.50 (note). As mentioned, the Mechanic's Weekly Journal also listed the Spitalfields Society's lectures.

85. The Ground Plan of the Society, in the Receptacle of the Mathematical Society, included a mineral room, repository, chemical room, lecture room (about 34 ft^2), an Entrance and landing, a coal room, a library and a committee room (Cassells, op.cit. (71), p.18).

86. Catalogue, op.cit. (71), contains a list of instruments owned by the society. The list in the British Library copy is annotated in manuscript with each

piece's value (pp.33-44).

87. Charles Knight, London, 6 vols., [London], 1841-4, II, 397.

88. See George, op.cit. (1), pp.188-96 for a discussion of the weavers in the early nineteenth century.

89. Information in the next paragraph is from P. McCann, 'Popular Education, Socialization and Social Control: Spitalfields 1812-1824', in P.McCann (ed.), Popular Education and Socialization in the Nineteenth Century, London, 1977, pp.1-40.

90. The drop in membership of the society and in attendance at the public lectures, (from an average of 115 in 1824-5 to about one half this in 1825-6), suggests that any journeymen weavers who still belonged left with the distress which began after the abolition of the Spitalfields Acts in 1824. By 1829 average attendance was only 24 (Cawthorne, op.cit. (71), pp.161-2).

91. Laws of the City Philosophical Society, Instituted January 1808, London, 1812, pp.vii-viii.

92. Ibid, pp.12,13-14.

93. Ibid, p.ix.

94. Ibid, p.18; Inkster, op.cit. (78), p.194.

95. Laws, op.cit. (91), pp.11, 27.

96. Halévy, op.cit. (9), p.565.

97. M. Faraday, Some Observations on the Means of Obtaining Knowledge, and on the facilities afforded by the Constitution of the City Philosophical Society, London, 1817.

98. The letter cannot be trusted because the Mechanics' Weekly Journal was carrying on almost a campaign against mechanics' institutes, and many letters were published suggesting similar facilities were already available. This letter was in MWJ, 1824, 1, 62. See above, chapter IV, section E.

99. Ibid.

100. Inkster, op.cit. (2), pp.5-6.

101. Although see Inkster, op.cit. (78), pp. 193-5, for some discussion of these Societies.

102. The Philomathic Journal and Literary Review, conducted by the Members of the Philomathic Institution, 1824, 1, 4.

103. Jennings, op.cit. (54), p.51(note).

104. Inkster, op.cit. (78), p.195.

105. Philomathic Journal, op.cit. (102).

106. Inkster, op.cit. (2), pp.9, 11-13.

107. G.N. Rankin, Reply to a pamphlet purporting to be a "report of the council and committee of the Philosophical Society of London, presented to A Special General Meeting of the Society, held at the Crown and Anchor Tavern, Strand, on Tuesday the 1st of December, 1818", London, 1819, p.1.

108. Statutes, op.cit. (5), pp.8-9, 11-12.

109. Rankin, op.cit. (107), pp.2,5.

110. Kelly, op.cit. (47), p.69.

111. Rankin, op.cit. (107), pp.2, 24.

112. Ibid, pp. 6-7, 8, 23.

113. Annual report of the Council for 1819-20 and other proceedings of the Philosophical Society of London, London, 1820, pp.4-7.

114. The account here is based on Regulations of the Literary and Philosophical Society of Hackney Together with the First Year's Report of its Proceedings, and a Catalogue of the Library, London, 1811. See also Inkster, op.cit. (2), p.11.

115. Regulations, op.cit. (114), p.9.

116. Ibid, p.2.

117. Ibid, pp.1-2.

118. Ibid, p.8.

119. Ibid, pp.10-11.

120. Ibid.

121. For the London Chemical Society see W.H. Brock, 'The London Chemical

Society 1824', Ambix, 1967, 14, 133-9, and The Chemist magazine of 1824-5.

122. Brock, op.cit. (121), p.134 suggests that A.W. was probably a mis-print for A.M., ie. A. Marreco, Esq, a vice-president of the society.

123. Ibid, p.136.

124. The Chemist, 1825, 2, 163-7 is a report of the speech. The quotation is from p.165.

125. See The Chemist, 1824, 1, vii; ibid, p.206; ibid, p.167; Brock, p.136.

126. See Kelly, op.cit. (47), pp.313-4 for a list of Mechanics' Institutions, and Literary and Scientific Institutions in London.

127. Proposal of the Cosmopolitan Literary and Scientific Institution for the Economical, rapid, and efficient diffusion of useful knowledge, among all Classes of Society, [London, 1825?]. A copy of this is in the Place manuscripts, British Library. Add. MSS. 27824, f.69.

128. See the Laws of the Western Literary and Scientific Institution, Established 1825, for persons engaged in commercial and professional pursuits, London, 1834. A handbill advertises the institution in the Place manuscripts, British Library Add. MSS. 27824,f.106.

129. Brougham's address was reported in the London Mechanics' Register, 1826, 3, 58. See also p.57 for details of attendance at the meeting etc.

130. Laws, op.cit. (128), passim.

131. Not a Literary and Mechanics' Institution as Kelly, op.cit. (47), calls it.

132. London Mechanics' Register, 1825, 1, 224 for Camberwell and ibid, 1825, 1, 237; ibid, 1825, 2, 157 for the Surrey Literary Institution.

133. Prospectus of a Literary and Scientific Institution for Persons Engaged in Commercial and Professional Pursuits, to be called the City of London Institution, [London, 1825], pp.1-2.

134. Ibid, p.3.

135. Laws for the Constitution and Government of the City of London Literary and Scientific Institution for persons engaged in commercial and professional

pursuits, London, 1825, pp.12, 15.

136. Prospectus, op.cit. (133), p.2; Catalogue of the Library of the City of London Literary and Scientific Institution, No.165 Aldersgate Street, London, 1827, p.iv.

137. The Iris, 1826, 2, 161-5, reports the first half-yearly meeting. The magazine was to some extent connected with the institution, reporting and advertising its lectures and meetings; Thomas Denman, An Inaugural Discourse pronounced on the occasion of opening the theatre of the City of London Literary and Scientific Institution, London, 1828, p.5; Booth, op.cit. (67), p.149.

138. London Mechanics' Register, 1825, 2, 362.

139. The Iris, 1826, 2, 64, 77.

140. Prospectus, op.cit. (133), p.2; J.R. M'Culloch, A Discourse Delivered at the Opening of the City of London Literary and Scientific Institution, 30th May, 1825, London, 1825, p.13.

141. Denman, op.cit. (137), p.15.

142. Prospectus, op.cit. (133), p.4; Denman, op.cit. (137), p.16, lists the officers of the institution.

143. M'Culloch, op.cit. (140), pp.10,17.

144. Ibid, p.14.

145. The Iris, 1826, 2, 406.

146. Denman, op.cit. (137), pp.8,10-11.

147. See above, reference 48. Compare this institution with the aims of the London University: "to bring the means of a complete Scientific and Literary Education home to the doors of the inhabitants of the Metropolis, so that they may be enabled to educate their sons at a very moderate expense, and under their own immediate and constant superintendence" (Prospectus of the London University, [London, 1828?]).

148. 'Scientific Institutions', Quarterly Review, 1826, 34, 153-79 (171-2).

149. F.M.L. Thompson, English Landed Society in the Nineteenth Century, London,

1963, p.86.

150. D.S.L. Cardwell, The Organisation of Science in England, 2nd edn., London, 1972, p.50.

Chapter.Six: The Popularisation of Science and Provincial Societies

A. The English Provinces in the Early Nineteenth Century

In the early nineteenth century the English provinces were undergoing a major change in their relationship with London. Within the context of a rapidly rising national population (from under nine million in 1801 to over thirteen million in 1831) the centre of gravity of both population and economic wealth was shifting appreciably northwards. London's population grew by over twenty per cent in the years 1821-31, but the populations of Liverpool, Manchester, Leeds, Birmingham and Sheffield all increased by over forty per cent. Bradford grew by sixty-five per cent. Compared to these towns of the industrial North and the Midlands, London's influence waned.

Such changes had far reaching effects on the attitudes of the inhabitants of these expanding towns. A pride developed in the towns themselves and in the concept of the provinces. Nearly thirty years before Benjamin Disraeli wrote that Manchester was as great an achievement as Athens a member of the short-lived Leeds Philosophical Society wrote of the town:

> "The second Athens soon her shell shall burst,
> And Fame with pride shall rank her with the first".[1]

Even in 1793 members of the Newcastle-upon-Tyne Literary and Philosophical Society asked whether it was "not highly desirable that these provincial Literary Societies might become more general?"[2]

This pride in the provinces extended to cover the developments occurring in industry upon which much of the expansion and growing prosperity of the towns depended. Spinning of both wool and cotton were extensively powered by steam engines by the 1820s; Newcastle was becoming a chemical industry centre, as was Liverpool to a lesser extent; in many other towns traditional industries were being transformed in their methods and new industries were being established. To the Newcastle Literary and Philosophical Society these industries provided powerful justifications for the establishment of the institution. The origin and chemical properties of coal might be investigated with aid from the coal-viewers of the local mines. In return the gentlemen enquirers could investigate the nature of damps in the mines and suggest ways to destroy them. The members might help to improve the machinery and methods of working in both the coal and the lead mines and encourage the establishment of manufactures dependent upon plentiful and cheap fuel. The proximity of large chemical works would provide opportunities for studying the processes involved and would supply cheap materials for experiments.[3]

The unprecedented changes occurring at this time lead to the creation of new cultures. The development of such provincial cultures was a characteristic of the late eighteenth and early nineteenth centuries throughout areas touched by the Enlightenment.[4] They were generally institutional cultures, that is, based upon libraries, societies, theatres etc., although much of the content of the culture might perhaps have been in existence before. It has been argued that this production of cultural institutions was often a way of providing an ideology and an identity for the higher social classes in situations of little or no political power,[5] and it was certainly the case that many of the growing provincial towns were often controlled by a small number of unrepresentative men, e.g. the Common Council of Liverpool and the Court Leet of the Lords of the Manor at Manchester.

It must not be thought, however, that there was only one provincial culture or even only one type of provincial town. Not only were the rural communities, including their market towns, often largely unaffected by these changes, but between the expanding industrial towns there were large differences. Manchester, in many ways the heart of the early Industrial Revolution, was a city of social cleavage. The beginnings of modern social classes may be said to have appeared here in the late eighteenth century.[6] The subsequent doubling of population from approximately 70,000 to 140,000 which occurred in the years 1801-31 was accompanied by a widening of the gulf between the middle and working classes. Manchester became economically wealthy but socially disordered.[7] A similar situation arose in Leeds; the masters of large factories felt separated from their hands, many of whom were women and children. Both may be contrasted with Birmingham and Sheffield, towns of small manufacturers working closely with the men they employed. Birmingham and Sheffield were consequently much more socially and politically uniform. Liverpool was different again, with its conservative elite of old mercantile families and an 'up-and-coming' group of newer merchants and manufacturers who traded in industrial goods rather than the slaves and comestibles of the West Indies, as the established firms tended to do.

Manchester and Liverpool are indeed good examples of the contrasts which could exist. Only some thirty miles apart in the North-West of England, yet they were very different in nature. Manchester had a teeming working population, many very poor, and a relatively large community of liberal manufacturers and merchants.In Manchester, the "most active provincial centre of anti-slave trade opinion"[8] in the late eighteenth and early nineteenth centuries, middle-class life looked as much, if not more, to Edinburgh for its intellectual lead, than to London.[9] Liverpool, on the other hand, was a much more conservative city, where the old mercantile groups and the new industrial manufacturers and merchants were both strongly represented. The former, however, had political power and their attitudes, which were much more attuned to London and with the general English upper classes, tended to prevail.[10]

In examining the nature of the local scientific culture as expressed in the societies concerned with science and natural philosophy it must therefore be remembered that the local social circumstances varied considerably and, with them, the type, format and uses of the institutions considered.

B. Independent Lecturers in the Provinces

Just as in London, there were numerous independent scientific lecturers operating in the provinces whose contribution to the popularisation of science should not be ignored. Unlike those in London, however, most lecturers operating in the provinces were itinerant, travelling from town to town to give short courses of lectures after advertising in advance in local newspapers.[11] Most lecturers were localised in one area of the country, but some, usually the most successful, had sufficient reputation and finances to tour the whole country.

Such lecturers became common in the early eighteenth century, John Desaguliers and James Ferguson being two early practitioners. By the end of the century there was a large increase in the numbers of itinerant lecturers. By 1819 there was said to be "scarcely a town of considerable note in Great Britain, which is not sometimes visited by these travelling lecturers",[12] and Ian Inkster has found references to fifty such men operating in the years 1790-1850 in urban Sheffield, Nottingham and Derby alone.[13] Long lists of names of such lecturers have also been compiled for Manchester and Birmingham in the late eighteenth century.[14]

The subject matter of the lectures seems to have ranged widely both in content (e.g.

from technology to botany) and in seriousness. Thomas Garnett lectured at Liverpool, Manchester, Warrington, Lancaster, Birmingham, and Dublin in the years 1795-6 before being appointed Professor of Natural Philosophy at the Andersonian Institution in Glasgow where he gave similar lectures.[15] James Walker, jnr., in 1799, gave a lecture at the Norwich theatre described by one recent commentator as "less a rigorous intellectual adventure for a modest group of laymen avid for information than an elegant evening's entertainment for a large audience." The use of theatres by such lecturers seems to have been quite common.[16] At the Theatre, Leeds, in 1801, Mr Lloyd from London gave three 'Astronomical Lectures', "illustrated by the New Dioastrodoxon; or, Grand Transparent Orrery, Twenty-one Feet [in] Diameter." In order to attract as wide an audience as possible graded prices of admission were offered. Subscribers to all three lectures could have the use of a box for 7s. 6d. or else watch from the Pit for 5s. Non-subscribers could see individual lectures for 3s. 6d., 2s.6d., or, in the Gallery only,for 1s.[17] This indicates that scientific lectures could be part of the general theatrical and popular culture of the day; those organised by private subscription of a dozen or twenty people, and given privately in a home, were not the limit of scientific popularisation.[18] The fact that such itinerant lecturers were most common in the late eighteenth and very early nineteenth centuries might also indicate that they were part of a wider collection of itinerants attracted by the new centres of population in the provinces and the improvement in the road system, for, as E.P. Thompson writes, "The Wars were the heyday of the itinerant lay preachers". The dissemination of science and religion shared a common method, and the former was often declared to have a religious purpose, to promote "admiration of the power and wisdom of that Omnipotent Being who governs, disposes, varies and beautifies Animated Nature."[19]

Itinerant lecturers have not been considered in greater detail in this chapter both because, as itinerants, very little remains to indicate the nature of their activities, other than many small adverts in a large number of provincial newspapers, but also because more and more in the early nineteenth century those who did continue to lecture did so under the auspices of provincial societies and institutions. Thus the former may be considered as encompassed to a great degree by the latter. Often, as Inkster has noted, the lecturers were themselves members of a scientific society .[20]

An early example of lecturing by an established lecturer within a society was that of Dr. Henry Moyes at the Kingston-upon-Hull Subscription Library. Moyes, a blind man, lectured on chemistry at Bristol in 1782, in Birmingham in the same year, at Manchester, at Leeds in 1805 and in many other places.[21] The Hull Library had been founded in 1775 but only occupied a new building in 1801 which allowed it to hire out rooms for lectures. Moyes lectured on "the philosophy of natural history, and... the philosophy of chemistry, both of which were numerously attended". The organisation of such lectures seems to have become more formal in subsequent years, for by 1805 the committee requested "Dr. Birkbeck... to give a course on mechanical philosophy, which he did in the succeeding winter, with the aid of a very complete apparatus".[22]

Such events occurred more often as literary and philosophical societies became established in many new towns. The Leeds Philosophical and Literary Society organised public lectures in the 1820s including six by Dalton on mechanics and meteorology in 1823. Subscribers paid 2s. a lecture, non-subscribers 2s. 6d.[23] Sheffield Literary and Philosophical Society hosted public lectures by John Webster, Richard Phillips and William Smith in the 1820s. At the Yorkshire Philosophical Society subscribers paid 3s. 6d. a lecture or one guinea a course to hear lectures by John Murray and Richard Dalton, while at Newcastle-upon-Tyne the Literary and Philosophical Society formed a "New Institution" as the forum for public lecturers, in which Robert Bakewell lectured on geology and mineralogy.[24]

C. The Development of Provincial Societies

The origins of many of the societies which concerned themselves with science in the early nineteenth century can be traced back directly or indirectly to societies and groups formed in the eighteenth century, that time of great commercialisation of many middle-class leisure actitivies.[25] Self-improvement and amusement could be combined in libraries, discussion groups and formal societies and many were founded. The eighteenth century was also the period in which the Dissenting Academies flourished: educational establishments originally for ministers for the non-conformist churches but later expanded to teach a wide ranging curriculum of subjects to lay and clerical students.[26] The presence of many Dissenters in early provincial societies suggests that the societies were often influenced by such academies, the object being, to some extent, to provide a similar education for their (adult) members. Certainly the Manchester Literary and Philosophical Society had many members associated with the Warrington Dissenting Academy when it was founded in 1781.[27] This was by no means always the case, however, and, as in London, so also in the provinces, many different types of society were founded. The most common in the late eighteenth century was the 'Literary and Philosophical Society', the name first being used probably by the original Liverpool Philosophical and Literary Society founded in 1779.[28] Similar institutions were soon founded in many parts of the provinces including Manchester (1781), Leeds (1783) and Newcastle (1793). Leeds, Liverpool and probably others failed after a short while. Few societies began in the war years, the first major foundation of the nineteenth century being the Liverpool Literary and Philosphical Society of 1812. The pace of formations increased as the century progressed, important and long lasting societies being founded at Bath (1816), Leeds (1819), York (the Yorkshire Philosophical Society) (1819), Hull (1822), Sheffield (1822) and Scarborough (1827), noticeably mostly in Yorkshire.

The gap between these lists suggests that the reaction to the French Revolution had some effect on the societies and it is fairly easy to see what this was. Justly or unjustly the societies were associated with reformist ideals ("Jacobin" ideals during the counter-revolutionary reaction). This was both because the very discussion of ideas, especially by men of non-conformist faith and not of the established ruling classes, was looked upon as possibly dangerous, and also because this seemed to be borne out when two prominent members of the Manchester society, Thomas Walker and Thomas Cooper (the Vice-President), were tried for high treason. Joseph Priestley, the best-known British natural philosopher of the time, was also associated both with reform movements and scientific societies.[29] Most societies which did exist made a point of banning political and religious discussion, a trend which carried on into the 1820s, but they were still looked upon with suspicion. In 1803 the Newcastle-upon-Tyne Literary and Philosophical Society reported that "Charges have indeed gone abroad, that our meetings were of a different kind, - but they have been totally without foundation".[30]

By the end of the 1810s and into the 1820s similar institutions were being formed not only in the industrial towns but also in smaller market towns and ports which had not been affected by the Industrial Revolution to nearly the same extent. These more minor foundations, often comparatively short-lived, included societies in Portsmouth, the Isle of Wight, Chatham, Taunton and Canterbury in the South, and Whitby in the North.

In addition to these general literary and philosophical societies the early nineteenth century saw the establishment of more specialised provincial societies including the Royal Geological Society of Cornwall (1814), the Manchester Society for the Promotion of Natural History, the Newcastle Museum of Natural History and the Natural History Society of Preston, the last three of which all flourished at some time in the 1820s. The Banksian Society of Manchester (1829) seems to have been a natural history society for working men.

More formal educational institutions were also established; in the eighteenth century the Manchester College of Arts and Sciences was founded; in the nineteenth, societies taking some inspiration from the (London) Royal Institution, but with more specifically educational aims were established, e.g. the Liverpool Royal Institution and the Manchester Royal Institution. As in London, therefore, there were many different types of society, general and specialist, small and select or large and willing to accept all comers (who could pay the subscriptions). Where more than one institution existed in a town, overlapping membership was common and membership of societies was often combined with membership of libraries and other existing institutionalised forms of recreation.

D. The Organisation and Institutional Functions of the Societies

Despite the differences in aims and objects, all the societies functioned in similar ways. All were private societies, the membership contributing all the necessary funds to maintain their activities. The members' subscriptions and entrance fees would usually be used to provide a library, often a museum and a collection of scientific apparatus and either purpose-built or rented accommodation. Members would meet regularly to hear papers by one another, to discuss literary and philosophical topics and perhaps to attend lectures by invited lecturers. Larger institutions would sometimes have other functions, for instance the Liverpool Royal Institution also ran schools.

Despite these basic similarities of function there were many differences between the societies. The size of the institutions varied widely. The Pottery Philosophical

Society, for instance, never had more than thirty members throughout its sixteen-year existence, while the Yorkshire Philosophical Society had less than thirty members at its inception but nearly three hundred in 1831. At this time it exceeded even the Leeds and Manchester Literary and Philosophical Societies but Newcastle was larger with approximately 500 names on its roll.[31] Some of the provincial societies, therefore, were merely small groups of men meeting occasionally for a comfortable discussion; others soon became fairly large scale organisations. Such differences were also reflected in the price of membership, and in the ease of joining. Those institutions which were based to some extent upon the Royal Institution in London used high fees as their guarantee of exclusivity. The Liverpool Royal Institution had two classes of membership, those who paid £100 and those who paid £50 for permanent shares in the institution, the former giving more privileges than the latter.[32] The Manchester Royal Institution, founded in 1823, took note of the financial difficulties of the London institutions and charged hereditary governors one guinea per annum in addition to the price of a share, set at forty guineas. As well as such members the institution attempted to guarantee itself a continual income by admitting life subscribers and annual members, the latter paying three guineas a year. Even here, however, steps had to be taken to limit the number of governors and after 1827 prospective proprietors had either to be elected or to inherit a share.[33]

The provision for election of subscribers was used by the cheaper Literary and Philosophical Societies to ensure social exclusivity of the membership. Liverpool, with an entrance fee of only one guinea and a subscription of another half-guinea per year, insisted on four-fifths of the voters in a ballot for membership approving the prospective subscriber.[34] Other societies copied, on a less grand scale, the range of possible subscriptions of the Royal Institution and other large societies. At Sheffield, for instance, the elected proprietors had to pay two guineas on entrance and two guineas per annum. Annual subscribers (who could include women) paid one guinea a year. At Scarborough women were allowed to become proprietors, but the payment here was at least £25. Life members paid at least £5 entrance fee and £1 per annum, annual subscribers likewise one pound.[35] The Literary and Philosophical Societies therefore varied widely in their membership fees, but generally they were small amounts each year, the high entrance fee or election usually ensuring that members were of sufficient social standing.

Societies would usually meet once a month, sometimes throughout the year, occasionally only in the winter. Hull Literary and Philosophical Society, for instance, met on the first Monday of each month from November to May at 7 p.m., although the May meeting was held at 11 a.m. in order to hear the annual report. The Liverpool Society met at 7 p.m. on a Friday in each month from October to May. The meeting ended at 9.30 p.m. Seven o'clock proved too early for some members, however, and it was soon amended to 8 p.m. "for the Purpose of ascertaining whether such change will secure more regular attendance".[36] If one wants to assess the influence of membership of such societies on the dissemination of scientific knowledge it must be borne in mind, therefore, that even as large and successful a society as Liverpool met for only twelve hours in a year. The Yorkshire Philosophical Society showed its higher social origins by meeting once a month at noon on a Monday.[37] Membership was obviously not held by many who had to work regularly in the day, even though at five guineas initial fee and one guinea per annum the society was comparatively widely accessible.[38]

E. The Membership and Declared Aims of the Societies

In 1790 John Aikin wrote that Dissenters had been the principal promoters of all plans for mental improvement, "whether by the lectures of itinerant professors in natural philosophy, or by the establishment of public libraries".[39] Their involvement in such schemes was maintained into the next century, particularly by the most rationalist dissenting sect, the Unitarians. By this time Presbyterians and Unitarians were almost synonymous, but the numbers sharing such faith, particularly since the French Revolution, had declined sharply. Despite the relative scarcity of Unitarians in the general community, three of the most active founders of the Manchester Literary and Philosophical Society, one quarter (3 out of 12) of the first committee of the Sheffield society, and the President and five others of the original proposers of the Liverpool Literary and Philosophical Society, subscribed to that creed.[40] Politically, many societies had a high proportion of reformers. At Leeds, for instance, the initiator of the society, Edward Baines jnr., and his father were both political liberals, as were John Marshall, T.W. Tottie and M.T. Sadler, all founder members. William West was a Quaker opposed to the slave-trade.[41] At Sheffield the President, Dr. Arnold Knight, was "a frequent speaker at Liberal public meetings"; Thomas Asline Ward, a Vice-President, who had been a member of the earlier, short-lived, Sheffield Society for the Promotion of Useful Knowledge (1804), was President of the local Subscription Library and was Treasurer and Secretary of the Book Society; he "played a notable part" in Reform movements, "as a leader and champion".[42] Such connections even extended to the Yorkshire Philosophical Society where the most active gentleman member, Sir George Cayley, was a Whig and a Dissenter and first president of the York Mechanics' Institute.[43] The pattern was often repeated, especially in the societies of the northern industrial towns. Many members, and often the most active and earliest to join, were non-conformists in religion and reformist in politics.

The occupations of the members of many of the societies were typically middle-class. Medical men, ministers (usually non-conformists), merchants, manufacturers, and newspaper men were well represented amongst the most active members of many societies. At Sheffield in 1822 the President was a physician, one of the vice-presidents was a Unitarian minister, the curator was a surgeon, as was one of the secretaries; the other secretary was a solicitor and the treasurer, Offley Shore, was a banker.[44] At Leeds the twenty-one founder members included three surgeons and three physicians (all but one associated with the Leeds Infirmary), a medical student, three merchants, three manufacturers (two of woollen garments), two newspaper men, a banker, and a solicitor.[45] In the Pottery Philosophical Society, of the seventy-three people who belonged to it during its existence, thirty-two were connected with the pottery industry, nine were merchants of other types, eight were medical men and six were ministers (only one an Anglican). The northern industrial town societies also seem to have had a tendency to broaden their membership as time went on, but often the medical men and ministers remained the most active performers in many societies, with manufacturers and merchants etc. as the main audience.[46]

These characteristics do not, however, appear to have been universal. In the south, and in smaller, non-industrial, towns in general, the founders and the 'average' member appear to have been different. At York, the four founders were a gentleman of private means, a solicitor and land agent, a surgeon, and an ex-Oxford, Anglican, clergyman.[47] At Scarborough the President was Sir J.V.B. Johnstone, Bart., and the patrons included the Baliffs of Scarborough, the Duke of Rutland and the Earl of Mulgrave. Benefactors and proprietors included the MPs The Rt. Hon. C.M. Sutton, W.J. Denison, R. Fountayne Wilson and W. Duncombe as well as the Archbishop of York.[48] The Isle of Wight Philosophical Society had Lord Yarborough and Sir Richard Simeon, Bart., as President and Vice-President ,[49] while the President of the Taunton Literary Institution was also an aristocrat, Sir T.B. Lethbridge, Bart. MP. When the Bristol Philosophical Institution was opened in 1823 the inaugural lecture was given by Dr. Charles Daubeny F.R.S., Professor of Chemistry at Oxford when "upwards of 350 persons of the first respectability[were] present, half of whom were ladies".[50] It therefore seems that 'Literary and Philosophical', or similar terms, were used to cover many societies which, in membership at least, were very varied. The nature of the local community and local circumstances obviously had a large amount of influence on the nature of the society.

In a similar fashion the actual objects of the societies, while being superficially identical, in fact were very varied. Most would have agreed that the object was the increase and diffusion of useful knowledge. Most, too, would have agreed on the methods of achieving this, as stated in the Regulations of the Hull Literary and Philosophical Society, ie. "by... public lectures; by the reading of original essays and papers; by literary and philosophical conversation; by requesting the communications and correspondence of scientific persons; by collecting books and philosophical apparatus; and by forming a Museum of specimens of natural history and of the arts".[51] The primary distinction was between those intending to discuss all subjects (except of course "the particular party-politics of the day, and the peculiar need of any sect of Christians")[52] and those only interested in selected subjects. The Philo-Union or Cambridge Literary Society was one of the former, being founded in 1826 to "discuss subjects relative to History, the Arts, Science, etc., etc. "This, it was hoped, would result in "the diffusion of general knowledge, and the discussion of all subjects but those of a Theological nature".[53] At the Isle of Wight Philosophical Society, however, the monthly assemblies in the Town Hall during the winter seasons were for listening to a lecture "by one of the members, upon any subject of natural history, or of general literature".[54] For the Yorkshire Philosophical Society it was "one of the principal objects... to encourage a taste for Natural History"[55] as well as antiquarian pursuits; in the Scarborough Philosophical Society Prospectus the "general object of the Projected Society" was said to be "to promote science, and its specific object... to investigate the local Natural History of Scarborough and its vicinity".[56] Those Literary and Philosophical Societies in areas without large new middle-class communities seem often to have been more concerned with natural history than natural philosophy.

If these were the stated functional aims of the institutions, what were the stated social aims? There was some rhetorical claim that science would aid industry. Mr T.O. Cooper, President of the Liverpool Philomathic society in 1828, in delivering the annual address to the society at the Liverpool Royal Institution claimed that "there is scarcely any trade or occupation in which useful lessons may not be acquired, by studying one science or another".[57] The Yorkshire Philosophical Society Council gave an example of the useful lessons which had been acquired in their 1828 report:

> "Deprive the miner of the safeguard by which experimental chemistry has of late years provided for his preservation; and the explosive atmosphere through which he now passes uninjured, will resume its destructive force, and leave no doubt of the utility of science by which the blasts of death have been disarmed".[58]

Mostly, however, the objectives were religious, moral and social. Rowland Detrosier, a radical located somewhere between the working and middle classes, claimed that the study of mineralogy, geology, botany, and entomology in the Banksian Society "unfolds... the precepts of the moralist, the experimental knowledge of the philosopher [and] the history of ... [man] in the details of past ages" in the hours of leisure. "Relieved from the tediousness which is the constant attendant on the leisure hours of the ignorant, (except, indeed, when they are indulging in riotous excess, or are lost to consciousness in the torpidity of sleep) the man who devotes his leisure moments to the cultivation of his understanding, feels the importance of that knowledge...". Such knowledge would also make one more useful to one's fellow men, and help one see through such 'impostures' as astrologers and fortune tellers. Moral lessons could come from insects directly, for "the provision which [bees] appear to make for the severity of winter affords to the great majority of mankind a useful and salutary lesson".[59] As "it has been deemed of importance to bestow the light of science on the labouring classes", wrote William Lempriere in response to such initiatives as the Banksian Society and the Mechanics' Institutes," it surely is still more essential, that the middling ranks (upon whom the welfare of society so mainly depends), should also partake of its beneficial influence".

Fellow members of the Isle of Wight Society were recommended to learn of the works of creation, the laws regulating them, and the practical application of such laws.[60] This would teach moral and religious lessons, for the book of nature "cannot be studied without advantage; as sufficient is shewn [sic] to prove the Omnipotence and boundless wisdom of its Author".[61] The personal advantages which such study would give included the habits of watching and recording and, according to the Council of the Leeds Literary and Philosophical Society, in a phrase reminiscent of the aims of the founders of the mechanics' institutes, it "is the object of your Society to diffuse knowledge, not so much by purveying it to those around it, as by communicating such habits of patient investigation and rigorous self-discipline as are essential to all substantial and valuable acquisitions", as advocated by Bacon "the great Reformer of Experimental Philosophy". According to the Council, "beneficial results have already discovered themselves, - in an increased spirit of inquiry, and a more general taste for useful knowledge, occasionally even perceptible in the more elevated tone of social intercourse"; in particular it had "contributed much to remove the asperities of party feeling whether arising from religious distinctions or political differences".[62]

Social harmony was also the aim of other societies, for the Council of the Yorkshire Philosophical Society expressed the belief that "science, with a secret moral charm, allays the animosity of parties, and pours a friendly feeling over the most discordant mind".[63] Clearly the integration of men with opposing political and religious views was felt to be very necessary in these years; provincial literary and philosophical societies were often seen as a means to that end. To clarify how and why this was so and to elucidate some of the generalisations made in the above sections of this chapter, a selection of societies will now be considered in more detail.

F. Three Northern Literary and Philosophical Societies

Considerable work has been done in recent years on individual provincial societies, particularly on those in the North of England. Comparisons between societies have seldom been made, however, despite the fact that each case illuminates others. Using both original research and secondary source material referring to the Liverpool, Manchester and Newcastle Literary and Philosopical Societies this section will try to present a broader picture of the nature of such societies in the early nineteenth century.[64]

The earliest foundation of the three societies was the Manchester Literary and Philosophical Society, founded in 1781. Originally it was primarily a group of medical men, fourteen of the twenty-four founding members being either physicians (six), surgeons (six) or apothecaries (two). The Society continued to be associated with medical men especially those working at the Manchester Infirmary (founded 1752). Only two of the original members were manufacturers but by 1809-11 56 per cent of men joining in this period belonged to this category. The religious faiths of the membership also showed an alteration in the balance present with thirty per cent of the new intake of 1809-11 being Unitarians, the highest percentage of such men in any such period.[65]

The Manchester Society was closely associated with natural philosophy and natural history. Although Thackray has noted that there was little direct technological link with the science practised and discussed, and that much of the science was polite and almost ornamental (i.e. natural history, astronomy etc.),[66] the presence of John Dalton as Secretary of the Society (and later Vice-President and President), Peter Roget as a Vice-President and the chemist William Henry as another Vice-President meant that the society was very concerned with experimental physical and medical science. Despite this, however, the lectures seem to have been social occasions, for they were open to the public and in 1805 Benjamin Silliman, attending one of Dalton's lectures, expressed himself "surprised to find attractive young women in the audience, as well as a variety of laymen".[67] The local middle-class population apparently provided the audience and the patronage for the local men of science.[68]

The Newcastle Literary and Philosophical Society was founded twelve years after the Manchester Society, being instituted on 7 February, 1793. At only one guinea per annum, with apparently no entrance fee, the society was very inexpensive, perhaps in an attempt to entice coal-viewers as well as mine-owners to join. The Society did in fact grow rapidly, having a membership of approximately 500 by 1830. The most active member of the Society was a Unitarian minister, Rev. William Turner; he was elected by the members in June 1802 to become lecturer on natural and experimental philosophy, which task he carried out single-handedly, apparently until 1825-6. Other lecturers, including his son and namesake, then supplemented his lecturing. Usually he gave twenty or twenty-one lectures a year on physical and life sciences, including optics, chemistry, electricity, mechanics, natural history and courses on the animal, vegetable and mineral kingdoms.[69]

Robert Bakewell also gave public lectures under the auspices of the Society on geology and mineralogy designed "to elucidate the Natural History of the Earth and its Mineral Productions". The course, "illustrated by Experiments, Mineral Specimens, and numerous original Drawings and Sections" was not, however, designed for coal or lead-mine owners if one judges from subscription rates. Gentlemen were charged 25s. for the course (of ten lectures), ladies one guinea; families (a maximum of five people) could attend at the cheap rate of only 65s.[70]

Despite Newcastle's situation in a lead and coal mining area, and with many chemical works, the society was not primarily connected with technological subjects. Few coal-owners joined and little co-operation was given in the society's attempt to investigate the coal-fields.[71] The Society did have a large mineral collection and many of its monthly papers were concerned in some way with mining,[72] but the society was also known for its botanical collection. The subjects which it intended to discuss were given in the original plan of the institution: mathematics, natural philosophy, civil history, biography, questions of general law and policy, commerce and the arts.[73] An examination of the subjects of papers given in some of the early years of the nineteenth century confirms that this was so. In 1802 the papers included discussion of the new lectureship on natural philosophy, two biographical discussions, two papers on safety at sea and, (the only reference to mining), a paper on beautiful formations of crystals of common salt "in a colliery lately on fire". Similarly, in 1803, essays were read on the nature and uses of history, on productive labour and on style; an achromatic telescope and Attwood's machine were exhibited and an account of an important but simple improvement in the mode of blasting was explained. This interest in mining, but not to the exclusion of everything else, was still noticeable in 1814 when a paper on the magnesia and coal formations of Northumberland and Durham took its place amongst other monthly discussions on the influence of taste, the migration of birds, sky-fallen stones, alluvial soils, sculpture, the state of the poor, etc.[74]

The Liverpool Literary and Philosophical Society was one of the first such societies founded in the nineteenth century, it being inaugurated on 21 February 1812. It did however have antecedents, possibly in the society of the same name of 1779 and certainly in the literary circle formed in the late eighteenth century by a group of prominent Unitarians. Those Unitarians who did not transfer to the Established Church in the late eighteenth century became fairly isolated and it is no surprise to find them joining together in literary groups.[75] William Roscoe, William Rathbone, Dr. Curie, Edward Rushton, Rev. Shepherd, Rev. Yates and Rev. Smith joined with a solitary Anglican, William Smyth, in discussions which were terminated in the years of counter-revolution. Of these men Rathbone, Smith, Currie, Shepherd and Yates were all amongst the original members of the new institution, while Roscoe joined subsequently. In the years between these two organisations, however, the Unitarian community had become swollen by the influx of new families and had become wealthy from business, usually trading or banking. By 1806 the local Whig party was dominated by Rational Dissenters; the town itself was governed by a primarily Tory Common Council which consisted mainly of representatives of the old slave-trading families. Liverpool thus had two groups of wealthy middle-class men.[76]

The Liverpool Literary and Philosophical Society was founded in the main by the former group. Of the sixteen men who inaugurated the society one-half are known to have been other than Anglicans, six of them Unitarians. Twenty of the fifty-five original members were Unitarians; another three were Quakers. The first President, Theophilus Houlbrooke "had been a clergyman of the Church of England, but his opinions no longer agreeing with the Church, he gave up his living" and, indeed, became a Unitarian. Liberal political opinion was also well represented; Rev.

Joseph Smith, a Unitarian minister and one of three vice-presidents,had been one of the eighteenth-century reformists branded as a "Jacobin", while William Rathbone was also a radical and founder member. Another vice-president John Bostock was also a Unitarian and the step-son of Rev. John Yates, the Unitarian reformer.[77]

Of the members, merchants were easily the most numerous. The initial sixteen members included seven merchants, as well as two brokers. Three medical men, two ministers and a member of the legal profession completed the known occupations of these men. Of the fifty-five original members over half (23) were merchants, another six were brokers, seven were medical men, and five were ministers.

The society, with an entrance fee of only one guinea, and an annual subscription of a half-guinea, grew steadily. Eighty-six more subscribers joined by 1830. By this time, however, the membership was considerably more diverse,symbolised by the presence of five Anglican clergymen. More conservatives, and men with a wider range of occupations also joined. The social aims of the society were stated clearly. To a Unitarian minister it was for the members to:

"Quit their accustomed cares awhile:
Profession quits his technic lore,
And Commerce rests upon his oar".[78]

To the President, Theophilus Houlbrooke, the "Function of Literary Societies" was to produce an agreed body of knowledge, i.e. to "correct long established error ...[and] to prevent the establishment of erroneous theories and opinions". Social harmony would come from this, for, as William Dixon said, the society's object was "the mutual interchange of Literary communication unclouded by Political animadversion or Sensual excess".[79] The society had social, not technical aims, therefore, and indeed it was industry which would help science, not vice versa: "The enlarged state of our home Manufactures furnishes an ample field for Mathematical investigation and Chemical experiment", claimed Dixon.

This lack of technological interest may be illustrated by analysis of the papers and communications presented to the society in the years 1812-30.[80] The totals and percentages for science and the main other categories are given below:

Subject	Total	Percentage (of total)
Physical science	34	11.3
Geology and Mineralogy	9	3.0
Botany, Natural History etc.	29	9.7
Technology	23	7.7
Travel, Expeditions etc.	30	10.0
Literature, Antiquities and Fine Arts	35	11.6

From this it would appear that physical science was one of the most discussed subjects throughout the period. If, however, account is taken only of the years 1817-30 a different picture emerges:

Subject	Total	Percentage (of total)
Physical Science	16	7.8
Geology and Mineralogy	5	2.3
Botany, Natural History etc.	24	11.4
Technology	12	5.7
Travel, Expeditions etc.	25	11.9
Literature, Antiquities and Fine Arts	25	11.9

This gives a more accurate picture of the typical subjects of papers throughout these years. The initial large percentage of physical science, and its subsequent sharp decrease, may be easily explained. At first Thomas Traill MD and John Bostock MD gave the majority of papers, and as befitted Edinburgh trained doctors they concentrated on medicine and physical science. Bostock, however, left for London in 1817, and Traill's contributions decreased in number, particularly so after he founded the Mechanics' Institute (officially termed the Mechanics' School of Arts) in 1825. Initially, therefore, the society seems to have functioned as a forum for men of science to perform to an audience, but it soon became more an association of equals discoursing on general topics. The primarily social nature of the occasions was emphasised by Rev. H. Higgins, who, in 1868, reported that "Mr Rathbone had often spoken to him (Mr. Higgins) of the delightful associations of those early times, when the members of the society frequently met in each other's houses, and, after spending the evening in literary and scientific discourse, concluded with oysters and porter", in much the same way as the Cambridge Philo-Union followed their meetings with a bread, cheese and ale supper for the sum of 6d.[81]

Comparison of these three societies therefore shows that in the early nineteenth century the Manchester society was the most scientific of the institutions, and the most connected with the local middle-class industrialists. While Thackray has interpreted the attachment of the Manchester middle classes to science as the attempted formation of a culture separate and distinct from the culture of the upper and lower classes,[82] this does not seem to have occurred in the Newcastle and Liverpool Societies, and indeed, not to have been attempted at Liverpool. No doubt these differences may be associated with the different social circumstances of the towns. Manchester was the centre of Rational Dissent and Reformism in the provinces and had little local upper-class population. The town was still officially run by the Lord of the Manor and the emergence of many new middle-class manufacturers and merchants associated with the industries led to the development of a wide and fairly united middle-class community. In Newcastle the local industrialists, in the form of the coal-owners, refused to co-operate with the society and so no united association could be built up. In Liverpool the Society appears to have been founded by socially marginal men, in order to help assimilate themselves into the wider ruling cultural and social elite of the established mercantile families.

G. The Manchester and Liverpool Royal Institutions

Two of the towns discussed above also saw the establishment of more prestigious and formal institutions, in the shapes of the Manchester and Liverpool Royal Institutions.[83] In this case, however, it was the Liverpool establishment that was founded first. On 31 March 1814 at the Liverpool Arms Hotel, Castle Street, a group of wealthy local citizens met to consider establishing "an Institution for the promotion of Literature, Science, and the Arts". B.A. Heywood took the chair and the meeting decided that an attempt would be made to gain permission to call the institution the Liverpool Royal Institution. The object of the Institution was to be achieved in six ways:

"I By Academical Schools

II By Public Lectures

III By the Encouragement of Societies who may unite for Similar Objects

IV By Collections of Books, Specimens of Art, Natural History etc.

V By providing a Laboratory and Philosophical Apparatus

VI By Association of the Proprietors"

An immediate attempt was made to obtain a suitable building for such activities, which it was estimated would cost £20,000.[84] In this way the institution marked itself off from literary and philosophical societies. The latter could exist without a permanent home; the former was in many ways the building itself. In some of these characteristics the Institution was modelling itself on the Royal Institution of Great Britain in Albemarle Street, London. In other characteristics it was attempting to go further than the London establishment. The Royal Institution itself had by now given up any notions of providing 'academical' schools, and had never entertained any idea of itself as a local cultural culture. These two aims were basic to the Liverpool Institution, as shown by the fact that at the first meeting the Institution declared itself "glad to concur with the Literary and Philosophical Society, and with the Society of Artists".[85] By the time suitable premises had been arranged (in 1817) the Society of Artists and the Literary and Philosophical Society both had rooms specially designated for their use on the premises.

The emphasis on 'academical' schools illustrated the essentially middle-class nature of the institution, for it was characteristic of such groups, particularly of those who were non-conformist, to look for cheap, efficient, secular and local schools for their sons. Consequently a classical and a mathematical school were established. This middle-class nature was also shown by the occupations of the proprietors named on the Royal Charter, which was granted in 1822. Of the twenty-one men named five were merchants, three "doctors of physic", two Unitarian ministers, one a barrister and one a banker. In addition, however, there were men from higher social levels. Two men were described as 'Esquire', one as a Gentleman, three were Oxbridge graduates and one a Lieutenant-General. Two members were of the Gladstone family, John Gladstone MP being the Vice-President.[86] This mixture of men, from Dissenting middle-class to Anglican upper-class, was also illustrated by the composition of the original committee. Half were Literary and Philosophical Society members, (Houlbrooke, Shepherd, Bostock and Corrie, of whom the first three were Unitarians) and half were not (Heywood, Dirom, Gladstone and Roscoe, only the last of whom was a Dissenter).[87] The Liverpool Royal Institution was an attempt to provide a single cultural centre which the whole local educated community could use; this idea found favour amongst all sections of the community, even the Common Council immediately offering help and eventually giving £1,000 to the Institution.[88]

The Liverpool Royal Institution had a successful number of years after it first started to function in 1817. Financial difficulties meant that the four permanent professors of botany, chemistry, physiology and anatomy did not continue in their posts for very long, but regular lectures were given on a wide variety of subjects including not only natural history, botany, anatomy, physiology and zoology but also reading, poetry, modern languages, literature, moral philosophy, architecture and music. In this field the Institution was therefore functioning very like its London model.[89]

The schools, having been originally planned to be three in number and Literary, Scientific and Design in subject, and to provide an education "preparatory either to entering at a University or engaging in Business", were soon renamed the 'classical' and 'mathematical' schools.[90] The decreased emphasis on science education may probably be attributed to the proportional decline in Rational dissenters from the original committee's fifty per cent. This is not to say there was no interest in science but it seems to have been mainly in life sciences. The Museum of Natural History was in fact the most popular of the Institution's activities, and the attitude to physical and experimental science is perhaps well illustrated by the expenditure of £300 on scientific apparatus, but £500 on obtaining a Charter.[91]

The Royal Manchester Institution appears to have been a similar society. Its first meeting occurring in October 1823, the London Mechanics' Register reported in 1825 that the "manufacturing interests" had given over £34,000 to the Manchester Institution for the Promotion of Literature, Science, and the Arts, as it was then known.[92] Like the Liverpool Institution the establishment was to have three functions, as a civic centre, hiring rooms to other local societies, as an art gallery, and as a means of diffusing knowledge. Again a building was immediately planned and in this case built especially for the institution and designed by Charles Barry. The original committee contained men from a wide cross-section of social groups, including gentry, medical men, merchants and cotton mill owners. Liberals, Tories, Whigs, Unitarians, Quakers and Anglicans were all members.[93] The Institution's aim of social harmony was clearly stated. A letter circulated to propose the society declared that it 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".[94]

It was not, however, the 'objective truths' of science which were considered particularly important here. Indeed literature and the arts were considered to "tend even more perhaps than the sciences themselves, to diffuse through the discordant elements of society a pervading emotion of friendly sympathy and mutual satisfaction".[95]

The picture which emerges most clearly from this consideration of provincial societies is simply one of diversity. It is obviously not true, as some commentators have suggested,[96] that even if the societies all began as literary and philosophical societies they all became primarly scientific within a "few decades". Indeed the general nature of the Leeds Philosophical and Literary Society's activities were commented upon in the 1822 Report. The "objection of those who anti-cipated, that it would soon become merely an Association of Chemists or of Naturalists, has received a gratifying refutation", read the 1822-3 report.[97]

Some of the societies concerned themselves with a range of sciences, some only with natural history. Leeds appears to have been an attempt to 'educate' the middle classes by those who later attempted to 'educate' the working classes in the Mechanics' Institute. The Yorkshire Philosophical Society, on the other hand, was largely an association of gentlemen naturalists.

Similarities did exist. Very little interest in the direct connections of science and industry was shown by any of the societies, although industry was sometimes studied as the expression of scientific processes. The rhetoric of societies was often far more technological. The Liverpool Royal Institution claimed:

> "to diffuse a more general taste for scientific and literary subjects, so as to enable the town of Liverpool to keep pace with, if not to excel, other populous communities, as well abroad as at home, in those discoveries and improvements which have of late years been as astonishing as they are useful, and seem still to be proceeding in an increased ratio".[98]

In general, however, the nature of the societies, the image and role of science within them and their relationship to wider society has been shown to vary so much that it is dangerous to interpret all such societies in terms of a detailed study of one society in the industrial north, or one in the Midlands, etc. To understand such a society one must look at it individually, for labels, particularly 'Literary and Philosophical', can conceal more than they reveal.

Notes to Chapter 6

1. Address spoken at the Second Anniversary of the Leeds Philosophical Society, March 1817, By a Member, Leeds [privately printed], 1817, p.7.
2. Plan of the Literary and Philosophical Society of Newcastle upon Tyne Instituted Feb. [sic] 7, MDCCXCIII, [Newcastle], 1793, p.3.
3. Ibid, pp.5-7.
4. N.T. Phillipson, 'Culture and Society in the 18th Century Province: The Case of Edinburgh and the Scottish Enlightenment', in L. Stone (ed.), The University in Society, London, 1975, II, 407-48 (407).
5. Ibid, passim, discusses the case of Edinburgh after the Act of Union.
6. Asa Briggs, Victorian Cities, Harmondsworth, 1968, ch. III.
7. For the characteristics of the northern industrial towns at this time see Briggs, op.cit. (6), and Donald Read, The English Provinces c. 1760-1960 A Study in Influence, London, 1964, especially ch II.
8. Ibid, p.40.
9. For the connections in science between these two cities see J.B. Morrell, 'Science in Manchester and the University of Edinburgh, 1760-1840', in D.S.L. Cardwell (ed.), Artisan to Graduate, Manchester, 1974, pp. 39-54.
10. Contrasts and similarities between Manchester and Liverpool are well drawn in F.Vigier, Change and Apathy; Liverpool and Manchester during the Industrial Revolution, Cambridge (Mass.), 1970.
11. The major exception to this was obviously lecturers at the two universities, but the science lectures given there were generally poorly attended with a few exceptions such as Buckland's geology lectures at Oxford. For this see J.M. Edmonds, 'The Founding of the Oxford Readership in Geology, 1818', Notes and Records of the Royal Society of London, 1979-80, 34, 33-51. Quite a lot has

been written on itinerant science lecturers in the eighteenth and nineteenth centuries. See, for instance, F.W. Gibbs, 'Itinerant Lecturers in Natural Philosophy', Ambix, 1960, 8, 111-17; Ian Inkster, 'Culture, Institutions and Urbanity: The Itinerant Science Lecturer in Sheffield 1790-1850', in S. Pollard and C. Holmes (eds.), Essays in the Economic and Social History of South Yorkshire, Sheffield, 1976, pp.218-32.

12. John Griscom, quoted in Inkster, op.cit. (11), p.222.

13. Ian Inkster, 'A Note on Itinerant Science Lecturers, 1790-1850', Annals of Science, 1972, 28, 235-6 (236).

14. A.E. Musson and E. Robinson, 'Science and Industry in the Late Eighteenth Century', Economic History Review, 1960-61, 2nd Series, 13, 222-44 (231 and note); John Money, Experience and Identity, Birmingham and the West Midlands, 1760-1800, Manchester, 1977, p.151 (n51).

15. T. Kelly, George Birkbeck, Pioneer of Adult Education, Liverpool, 1957, p.25. For the syllabus of one of his Liverpool lectures see pp. 59-60.

16. T. Fawcett, 'Popular Science in Eighteenth-Century Norwich', History Today, 1972, 22, 590-5 (595); Inkster, op.cit. (11), p.219 notes that many such lectures were given in theatres by the 1820s.

17. Leeds Mercury, or General Advertiser, 7 March 1801.

18. This was the way many of the more 'serious' lecturers organised courses. See, for example, James Ferguson's terms, reproduced in A. Ferguson (ed.), Natural Philosophy Through the Eighteenth Century and Allied Topics, London, 1972, p.151.

19. E.P. Thompson, The Making of the English Working Class, Harmondsworth, 1968, p.426; Fawcett, op.cit. (16), p.595.

20. This growing institutionalization is pointed out by Inkster, op.cit. (11) and idem, op.cit. (13), p.236. A good example is John Dalton, lecturer and member (later President) of the Manchester Literary and Philosophical Society.

21. For Moyes' itineraries see Gibbs, op.cit. (11), p.116; Musson and Robinson, op.cit. (14), p.23 and J.A. Harrison, 'Blind Henry Moyes, "An Excellent Lecturer in Philosophy"', Annals of Science, 1957, 13, 109-25.

22. An Account of the Rise and Progress of the Subscription Library at Kingston-upon-Hull, Established 6th December, 1775, Hull, 1810, pp.17-18.

23. E. Kitson Clark, The History of 100 Years of Life of the Leeds Philosophical and Literary Society, Leeds, 1924, p.154.

24. For Sheffield see W.S. Porter, Sheffield Literary and Philosophical Society, A Centenary Retrospect, 1822-1922, Sheffield, 1922, and Inkster, op.cit. (11). References to lectures at the society appear in Porter, pp.22, 25; Inkster, p.226. For the Yorkshire Society see A.D. Orange, Philosophers and Provincials, The Yorkshire Philosophical Society from 1822 to 1844, York, 1973, p.29. For Newcastle see R.S. Watson, The History of the Literary and Philosophical Society of Newcastle-upon-Tyne (1793-1896), London, 1897.

25. Apart from those works already mentioned above, the most important works on provincial societies are: (primarily for the eighteenth century) R.E. Schofield, The Lunar Society of Birmingham, Oxford, 1963; A. Thackray, 'Natural Knowledge in Cultural Context: The Manchester Model' [i.e. on the Manchester Literary and Philosophical Society], American Historical Review, 1974, 79, 672-709, and, for an early nineteenth-century society, S.Shapin, 'The Pottery Philosophical Society, 1819-1835: an Examination of the Cultural Uses of Provincial Science', Science Studies, 1972, 2, 311-36.

26. For Dissenting Academies see N.Hans, New Trends in Education in the Eighteenth Century, London, 1951, chs III, IV; and H. McLachlan, English Education Under the Test Acts. Being the History of the Non-conformist Academies, 1662-1820, Manchester, 1931.

27. Musson and Robinson, op.cit. (14), p.226.

28. See the reference to this society in the Centenary Roll of the Liverpool

Literary and Philosophical Society, volume one, under Rev. Joseph Smith.

29. For Walker and his trial see F.Knight, The Strange Case of Thomas Walker, Ten Years in the Life of a Manchester Radical, London, 1957. For the reactions of the local people of Birmingham to Priestley's radicalism see R.B. Rose, 'The Priestley Riots of 1791', Past and Present, No.18, Nov. 1960, 68-88.

30. Tenth Year's Report of the Literary and Philosophical Society of Newcastle upon Tyne. To which are annexed a supplement to the Catalogue, and a list of the new members, Newcastle, 1803, p.5.

31. Shapin, op.cit. (25), p.315; Orange, op.cit. (24), p.15.

32. Resolutions of the Meeting held for the formation of the Institution on March 31st, 1814, p.4, in Resolutions, Reports and Bye-Laws of the Liverpool Royal Institution. March, 1814- March 1822, Liverpool, privately printed, 1822. The institution gained permission to use the term Royal Institution on 4 August 1817 (ibid, p.29).

33. R.F. Bud, 'The Royal Institution', in Cardwell, op.cit.(9), pp.119-33 (121). Alternatively proprietors could donate 60 guineas.

34. Liverpool Literary and Philosophical Society, Minutes, p.84, 4 Nov.1814. This was an increase from the two-thirds majority originally required.

35. Porter, op.cit. (24), p.14; First Report of the Scarborough Philosophical Society, instituted in 1827: and the Museum opened to the public August 31, 1829, Scarborough, 1830, Regulations 3-5.

36. The Laws and Regulations of the Literary and Philosophical Society at Kingston-upon-Hull, Established November 1822, Hull, 1823, pp. 4-5; Minutes, op.cit. (34), pp.4,61 (13 Mar. 1812, 3 Dec. 1813).

37. Orange, op.cit. (24), p.11.

38. Consideration of such facts as the time of meetings upsets the purely economic considerations of the possibility of access to libraries, societies etc. Thus, the claim of the Yorkshire society that it fixed "the terms of

subscription as low as possible, in order that no cultivator of science might be excluded from it by pecuniary considerations" cannot be taken at face value as an indication of a willingness to associate with men of science from all classes. Quoted in G.W. Roderick and M.D. Stephens, 'Nineteenth-Century Educational Finance: The Literary and Philosophical Societies', Annals of Science, 1974, 31, 335-49 (337).

39. Quoted in Gibbs, op.cit. (11), p.111.

40. Thackray, op.cit. (25), p.694; Porter, op.cit. (24), p.18; see biographical notes by J. Hampden Jackson in the Liverpool society's Centenary Roll, Vol. I.

41. Kitson Clark, op.cit. (23), pp.12-15.

42. Porter, op.cit. (24), pp.16, 18.

43. Orange, op.cit. (24), p.26.

44. Porter, op.cit. (24), pp.14-18.

45. Kitson Clark, op.cit. (23), pp.12-15.

46. Shapin, op.cit. (25), p.324. For the concept of performers and audience, see ibid, p.21 and Thackray, op.cit. (25), p.709.

47. Orange, op.cit. (24), pp.12-14.

48. First Report, op.cit. (35), Prospectus and lists of Patrons and Proprietors.

49. William Lempriere, Popular Lectures on the Study of Natural History... as Delivered before the Isle of Wight Philosophical Society, London, 1827, Dedication.

50. Gentleman's Magazine, 1823, 93i, pp.68, 163,

51. Laws and Regulations, op.cit. (36), p.1.

52. Ch.IV, Rule 9 of the Liverpool Literary and Philosophical Society. (See Minutes p.9).

53. The Philo-Union or Cambridge Literary Society 1826-1888, A Record, Cambridge, privately printed, 1890, pp.3-4.

54. Lempriere, op.cit. (49), p.vii, (note).

55. Annual Report of the Council of the Yorkshire Philosophical Society for MDCCCXXVII, York, 1828, p.14.

56. First Report, op.cit. (35), Prospectus.

57. Addresses delivered by the Presidents of the Liverpool Philomathic Society at the Royal Institution on the opening and closing of the sessions 1828 to 1831, Liverpool, 1832, p.3.

58. Annual Report of the Council of the Yorkshire Philosophical Society, for MDCCCXXVIII, York, 1829, p.11.

59. R.Detrosier, The Benefits of General Knowledge; more especially, the sciences of Mineralogy, Geology, Botany, and Entomology, London, [1834?] pp.4-5, 13.

60. Lempriere, op.cit. (49), p.vi, (Lempriere's emphasis).

61. First Report, op.cit. (35), p.15.

62. Annual report ... for 1828, op.cit. (58), pp.12-13; Report of the Council on the General State of the Leeds Philosophical and Literary Society, 1822-3, Leeds, 1823, pp.10-11,13. This is perhaps not surprising as many men were involved in both the Philosophical Society and the Mechanics' Institute,e.g. Edward Baines jnr. and Benjamin Gott (first president of the Mechanics' Institute); both were founder members of the Philosophical and Literary Society.

63. Annual Report ... for 1828, op.cit. (58), p.13.

64. For the Manchester Literary and Philosophical Society see Thackray, op.cit. (25). For Newcastle see Watson, op.cit. (24) and Roy Porter, 'The Industrial Revolution and the Rise of the Science of Geology', in M. Teich and R. Young, Changing Perspectives in the History of Science, London, 1973, pp.320-43. The discussion of the Liverpool Society is based primarily on my own research in the archives of the institution.

65. Thackray, op.cit. (25), pp.684-5, 690, 695, 697.

66. Ibid, p.705.

67. Quoted in G.M. Ditchfield, 'The Early History of Manchester College',

Transactions of the Historic Society of Lancashire and Cheshire, 1971, 123, 81-104 (96).

68. Thackray, op.cit. (25), p.709.

69. Tenth Report, op.cit. (30), p.7; Watson, op.cit. (24), Appendix B lists all the lectures delivered in association with the society.

70. Watson, op.cit. (24), p.226.

71. Porter, op.cit. (64), p.330.

72. Ibid, p.329.

73. Plan, op.cit. (2), p.15.

74. Tenth Report, op.cit. (30), pp.7-9; Eleventh Report of the Literary and Philosophical Society of Newcastle upon Tyne, Newcastle, 1804, pp.4-5; Twenty-second Year's Report, Newcastle, 1815, pp.2-3.

75. See I. Sellars, 'William Roscoe, The Roscoe Circle and Radical Politics in Liverpool, 1787-1807', Transactions of the Historic Society of Lancashire and Cheshire, 1968, 120, 45-62 (47-8).

76. Ibid, esp. pp.53-5; Vigier, op.cit. (10), pp.72-82.

77. Biographical information is mainly from the notes by J. Hampden Jackson in the Centenary Roll, vol.1, and DNB.

78. Minutes, p.19 (1 May 1812). The poem, by Rev. William Shepherd, was ordered to be printed, but no copies appear to have survived.

79. Houlbrooke's and Dixon's speeches were recorded in the minutes, pp.44,78-82. (5 Feb.1813, 6 May 1814).

80. This is my own analysis from the index and list of papers compiled by J. Hampden Jackson, ex-Keeper of the Records of the Society, held in the archives of the Society.

81. From a newspaper report of the annual meeting of the Society in 1868, included in the Centenary Roll, under the name of William Rathbone.

82. A. Thackray and S. Shapin, 'Prosopography as a Research Tool in History of

Science: The British Scientific Community 1700-1900', History of Science, 1974, 12, 1-28 (section II).

83. For the Manchester Royal Institution see Thackray, op.cit. (24), pp. 702-3, and Bud, op.cit. (33). For Liverpool see Resolutions, Reports and Bye-Laws, op.cit. (32), and H.A. Ormerod, The Liverpool Royal Institution, A Record and Retrospect, Liverpool, 1953.

84. Resolutions [etc.], pp.3, 25 in Resolutions, Reports and Bye-Laws, op.cit. (32).

85. Ibid, p.5.

86. Charter of Incorporation, p.4, in Resolutions, Reports and Bye-Laws, op.cit. (32).

87. Ormerod, op.cit. (83), p.11. (n.1)

88. Resolutions [etc.], p.11 in Resolutions, Reports and Bye-Laws, op. cit. (32).

89. Ormerod, op.cit. (83), pp.14, 20-6.

90. Resolutions, [etc.], p.26, in Resolutions, Reports and Bye-Laws, op.cit. (32); Ormerod, op.cit. (83), p.35. Compare the reaction of the Council to the School of Arts (below, ch. VII).

91. Ormerod, op.cit. (83), p.35; Report by the Secretary on 27 February, 1822, p.12 in Resolutions, Reports and Bye-Laws, op.cit. (32).

92. London Mechanics' Register, 1825, 1, 288.

93. Bud, op.cit. (33), pp.120-3. Bud also lists the (more varied) occupations of the first one hundred hereditary governors.

94. Thackray, op.cit. (25), p.702.

95. Ibid, pp. 702-3.

96. Thackray and Shapin, op.cit. (82), pp.8, 24 (n31).

97. Report of the Council, op.cit. (62), p.6.

98. Resolutions [etc]., p.22, in Resolutions, Reports and Bye-Laws, op. cit. (32).

Chapter Seven: The Mechanics' Institutes

A. The Early History of the Institutions

In October 1823 a manifesto was published in the Mechanic's Magazine calling for the establishment of a London Mechanics' Institution[1]. This event marked the beginning of the mechanics' institute movement in England.

Based upon already existing Scottish institutions, the Edinburgh School of Arts (1821) and the Glasgow Mechanics' Institute (1823), which in turn claimed their inspiration from the mechanics' class run by George Birkbeck in Glasgow at the turn of the century, the proposal quickly received the support of many members of the London middle classes[2]. As well as Birkbeck himself, now living in the metropolis, James Mill, Francis Place and the untiring Henry Brougham were amongst the most prominent backers. Preliminary meetings were held, and on 20 February 1824 the Institution was formally opened. Its object was stated to be "the instruction of the Members in the principles of the Arts they practise, and in the various branches of science and useful Knowledge"[3]. This was to be achieved by providing a library, a museum, a collection of apparatus, evening classes and, above all, lectures. In return for these facilities members would have to pay one pound per annum (usually in quarterly sums of 5s.); by the end of the first lecture course 1,200 members had subscribed, of which 800 were weekly wage earners.[4]

London was the first English institution, but it was soon followed by many others. In the same year, 1824, nine more were opened in England, seven of which were in the North, including those at Manchester, Newcastle and Leeds.[5] Also in 1824 Henry Brougham published an article in the Edinburgh Review praising these developments. The reprinting of this article as a pamphlet, in 1825, entitled Practical Observations upon the Education of the People, helped stimulate the enormous number of foundations of that year.[6] Over seventy institutions were established in Britain, and, of those in England, the greatest concentration was again in the north, including five in Lancashire and thirteen in Yorkshire, mainly in the West Riding. Others were founded particularly in seaports (including Bristol and Portsmouth) and in the suburbs of London.[7]

This was by far the highest number ever founded in a single year and, as some lasted for only a short while, there were actually fewer in 1831 than in 1826—101 as opposed to 104. After their initial two or three years of expansion the institutions went into a phase of stagnation or even contraction.[8]

Despite being scattered over the whole country the institutions often showed great similarities. Apart from a few of the smaller ones[9] all the institutions were founded by members of the middle classes, often medical men, lawyers, journalists, bankers, etc.[10] Frequently religious non-conformists, particularly Unitarians, nearly all were politically liberal, either Whigs or Radicals. In Manchester, for instance, over one-third of the committee elected on 7 April 1824 were Unitarians, by this time the smallest of the dissenting sects.[11] Benjamin Heywood, a banker and future Whig Member of Parliament, was first president of the Manchester Institution, while at Liverpool the committee included five medical men, the most influential of whom was Thomas Traill, soon to become Professor of Medical Jurisprudence at Edinburgh University. At Deptford Olinthus Gregory[12] was president while the London institute was opened by the King's brother and Whig supporter, the Duke of Sussex. Birkbeck,the first president, was a physician; Brougham, a driving force behind the institute, was a Whig representative in the Commons. Many similar examples of such connections could be given. Consequently the institutes were run for the working classes, not by them.

The London institute had a constitution which ensured that two-thirds of the committee was composed of subscribing members, and yet, despite this apparently democratic form of government, it was in fact the case that, as Blackwood's Magazine declared, the one-third of honorary committee members had "the management as exclusively in their hands, as though they constituted the whole committee"[13]. In Manchester there was no such pretence, and only honorary members were entitled to sit on the committee, which lead to the foundation of a rival institution run by the subscribing members, in 1829.[14] At Liverpool Traill believed that ordinary members of other institutions had "in some instances... made the most injudicious choice of teachers; and occasionally their attention has been directed more to amusing than to useful objects". The committee was therefore composed of one-third labourers, one-third master mechanics or master tradesmen and one-third general subscribers.[15]

Middle-class control resulted in a number of restrictions. The discussion of controversial politics or religion was nearly always officially forbidden, while the content of the library was closely supervised. Bolton, for example, reportedly banned novels and plays in 1825 while Leeds permitted "History, Biography, Travels and Antiquities" only from 1828. Even those like Manchester which were "promiscuous and not limited to scientific works" still retained a close control on the volumes admitted.[16]

Despite such restrictions, however, working men did join Mechanics' Institutes, at least initially.[17] The Mechanics Almanac for 1826 lists the occupation of the members of the committee of the London Institution, and the list gives a good indication of the primarily artisan composition of the early membership. Listed were two working-jewellers, two bookbinders and two opticians, with one each of machinist, brassfounder, plumber, mathematical instrument maker, carver and gilder, printer, veneer cutter, smith, tinman, carpenter, decorator and painter, clockmaker, turner, escapement-maker, metal-sash maker and silver spoon finisher. Also included were two men without a given occupation, and some members of the middle classes, a clerk, a schoolmaster, an ironmonger, an accountant, an actuary and a surgeon.[18]

At Liverpool members were listed according to the subscription paid (21s. or 16s. per annum) and whether they paid annually or quarterly. Amongst the lowest group, the forty-eight 4s.-a-quarter subscribers, were included millwrights, cabinet-makers and clerks, as well as artisans connected with Liverpool's life as a port, such as shipwrights and sailmakers.[19]

Evidence exists, however, to show that many working men soon left the institutes. Not only did total membership usually decline (London for instance, had an average membership of 1,477 in 1826 but only 950 in 1830) but also Hudson reports that by 1831 only 200 of the London members were working men;[20] at Leeds this differential decline in working-class subscribers was also commented upon in the 1827 report. It lamented the drop in total membership from 187 to 165, but especially the fall in the number of subscribers, "who are almost altogether of the working classes", from 161 to 94.[21]

The various mechanics' institutes were closely linked by personal contact. George Birkbeck was present at the opening or early meetings of the Hackney, Rotherhithe, Poplar, Spitalfields, Deptford, Hammersmith, Brighton and Hull institutions, and he wrote to other institutions, sending some of them copies of the London rules.[22] Brougham sent a questionnaire to the institutes in 1826 and himself wrote "ano nymous lectures" which were read out in many other institutions.[23] The London Mechanics' Register reported that Brougham and Birkbeck had been "freqently applied to by Mechanics' Institutions in the country, to send them a suitable lecturer..." and in at least one case this is known to have produced results, a Mr. Ogg lecturing at Reading on chemical and natural philosophy.[24] The institutions were clearly a national movement.

The mechanics' institutes were closely connected also with the activities of the Society for the Diffusion of Useful Knowledge, after the latter's foundation in 1826.[25] At the Leeds institute Brougham was praised for the Society's work on the occasion of the 1830 annual meeting. Brougham's work had resulted, it was reported, in "a University for the middle classes, and innumerable seminaries of scientific knowledge for the humbler ranks - and [Brougham] having excited an appetite for learning, has, in the prosecution of his patriotic enterprise, supplied it with appropriate aliment, in the formation of A Library of Useful Knowledge (Loud Cheers)".[26] Mill, Millington and Gregory were just some of those associated both with the London Mechanics' Institute and the Society.

Given the class and politics of the founders of these institutions, it is unsurprising that they received much criticism. "A Mechanic" wrote to the Mechanic's Weekly Journal in 1824, describing the London Institution as "a piece of contrivance among a few master tradesmen, who feel inclined to make as many journeymen as can be found foolish enough, pay for their amusement," while "W.D." claimed in the same journal that "if every mechanic had all the knowledge that the learned doctor [i.e. Birkbeck] possesses, it would be of little use to him in his own business. What has ever been taught at any of their institutions? nothing but to amuse women and children". A master objected that they "render[ed] the working classes in some degree dissatisfied with their masters, as if the latter wished to keep them in ignorance, and debauch their minds"[27] and one member of the upper classes complained that if the working men's "constitutions were weakened and debilitated by intense mental study... the time would arrive when the higher classes must sweep the streets."[28] Tories objected because they thought they were Whig institutions, Anglican clergymen because the institutions professed to teach no religion.

Such criticism had direct effects. At Liverpool the Corporation refused a grant of £500 "by a large majority", the Earl of Derby declined to subscribe, and an appeal fund received only "a marked lukewarmness".[29]

B. The Functions of the Institutes

The three major functions of the institutes were the provision of library facilities, evening classes and lectures (also held in the evenings).

The evening classes provided the most directly vocational education, teaching, usually comparatively small, numbers of men mathematics and drawing, both architectural and technical. Such classes or 'schools' existed at all the major institutions and many of the minor ones. At the London institute geography and French were also taught; at Leeds there was a formal chemistry class in 1826 taught by a Mr Whitehead. Only thirteen men subscribed to this class, however, which cost an extra 6d. a month; after Whitehead resigned the class was stopped,following a brief attempt to make it a mutual instruction class, because "some of [the Committee].. perhaps the best qualified to judge, entertain[ed] great doubts of the possibility of teaching this science in a Class".[30]

One tenth of the membership of the Liverpool Mechanics' School of Arts (as that institute was officially called) attended the drawing classes in 1828; at Leeds in 1826 the total membership of the mathematics class was forty-four, but the average attendance was only fifteen.[31] The classes were a minor part of most institutes' activities.

The libraries of the mechanics' institutes were probably some of their most useful facilities. Mention has already been made of the scarcity of library provision for the lower classes in the earlier years of the century, and even in the 1820s only a few libraries, such as the Sheffield and Liverpool Mechanics' and Apprentices' Libraries, existed. Particularly in London, however, the situation would probably have been better for the comparatively well-paid skilled craftsmen; one facility which did exist was the Silver Lion Coffee House at 12 Goodge Street. A "Mechanic's Coffee House" or "Economical Coffee House", its proprietor, J. Whitaker, offered "coffee and tea, in constant readiness, and not one minute in serving" to accompany the perusal of "Newspapers and Books, Literary and Scientific, in great variety". Whitaker mentioned the existence of other similar establishments.[32] There is no doubt, however, that it was difficult for most working men to obtain books to read of all but the cheapest and usually most basic kind. The libraries of the institutes must, for all the restrictions placed on permitted works, have expanded the possibilities of reading a wider variety of writings. The 1826 catalogue of the Leeds Mechanics' Institute has been preserved and it shows that, even though "History, Biography, Travel and Antiquities" were not permitted, readers had a fairly wide range of works to choose from. Fourteen reference works held included the Encyclopaedia Britannica, the Encyclopaedia Metropolitana and eighteen volumes of the Philosophical Transactions. Periodicals taken included the London Mechanics' Register, the Mechanic's Magazine, Brewster's Edinburgh Journal and the London Quarterly Journal.

All natural sciences were represented, from Wakefield's Botany to Bryan's Lectures on Natural Philosophy, and other related subjects included an Abridgement of

Locke's Essay on the Understanding and Walker's Arithmetic. Works on French, stenography and architecture increased the variety, while well represented were books on arts and technology, e.g. Martin's Mechanical Arts, Tredgold on Rail Roads and Steam Carriages, the same author's Carpentry and, more domestically, Remarks on the Art of Making Wine.[33]

The lectures of the mechanic's institutes were their major function. As with the evening classes and the libraries they were not solely concerned with teaching science. At the London, Hull and Leeds institutions among others, lectures were given on political economy;[34] French was taught at the London institution in 1825 and in the same year members could hear lectures on mnemonics, stenography and eloquence. The majority of the teaching was, however, of physical science. In the twelve months from November 1824 to November 1825, of the seventy-three lectures given at the London institute, only six were unconnected with natural science; only four of the science lectures were not concerned with physical science.[35] This predominance of physical science was mirrored by other institutions. The 1826 report of the Leeds institute listed courses on: natural philosophy, chemistry, mechanics, electricity, geology, acoustics, optical instruments, and the use of globes. The next year saw lectures on chemistry applied to the arts, electricity, motion, and the division of labour etc. (i.e. political economy) from a course prepared for the London Mechanics' Institute.[36]

As time went on the proportion of physical science declined. In 1827 the London institute witnessed lectures on the antiquities of Rome and English grammar. The courses also tended to get shorter. A reform of the lectures in 1829 led to the introduction of systematic coverage of physical science. One evening a week would be devoted to lectures on motion, forces, elementary mechanism, astronomy, hydrostatics, hydrodynamics, pneumatics, optics, practical mechanics, heat, electricity and magnetism; the other lecture evening would be filled with discourses on chemistry and literary subjects.[37] This reform lasted only a couple of years, however, and in this decline in physical science content, coupled with a general increase in literary subjects, the institutes mirrored the changes occuring in the publications of the Society for the Diffusion of Useful Knowledge.

C. The Science Content of Mechanics' Institute Lectures

The science content of the lectures at the mechanics' institutes was not exclusively technological. Applied arts themselves received only occasional attention,[38] perhaps only a lecture or two on the steam engine, or other mechanical inventions, in a year. Fortunately, thanks to the practice of the London Mechanics' Register in reporting many of the lectures of the London institution at length, it is possible to look more closely at the content of the lectures for the years 1825-28. In addition it is known that these lectures were similar to those given at other institutions, both because it is recorded that some institutions read the lectures out from the journal,[39] and also because it is known that many of the London lecturers spoke at other institutes as well.[40]

From these reports it may be seen that, at this time, many of the courses were long, detailed, and systematic. Cooper's course on "Chemistry and its applicability to arts and manufactures" continued for two years. First, in 1825, he gave thirteen lectures on the simple combustibles (hydrogen, carbon, sulphur etc.); a year later he gave sixteen more on nitrogen, ammonia, the alkalis, alkaline earths etc; finally, in 1827, he gave a course of six lectures on metals. Other long courses included Tatum's twelve lectures on electricity of 1825 (repeated the next year), thirteen by Ogg on mineralogy and geology, twelve by Toplis on mechanics, and eight by Lewthwaite, also on electricity.

Very little of the science content could be applied in the members' trades. Cooper's first thirteen lectures hardly discussed applications and when they did it was a mere mention. In his lecture on sulphur, for instance, he merely informed his audience that sulphurous acid gas was "used with great effect for all purposes of bleaching".[41]

The lectures did contain, however, a substantial amount of information on social and religious attitudes. Cooper praised the wisdom and benevolence of God when discussing chlorine:

> "The Almighty Disposer of things has benevolently placed within the bowels of the earth, and in the vast regions of the air, properties which may be rendered useful to man by the exercise of science, but which, in their natural state, are rendered inactive, lest their action should be injurious to the human species".[42]

Such an extreme belief in the benevolence of God was also shown by Wallis in his astronomy course. After discussing the cause of the phenomena of dawn and dusk, (which occur gradually due to refaction of light, by the atmosphere), Wallis concluded it was "another proof that the more we investigate the sublime science of Astronomy, the stronger is our conviction of the infinite wisdom of the Great Artificer of the Universe". After discussing the laws of mechanics he remarked that "the perfection of a <u>law</u> marks the perfection of the <u>lawgiver</u>".[43] Similarly Ogg, in his geology and mineralogy lectures, "trusted that he had demonstrated, that the great design of the CREATOR was to promote the happiness of the inhabitants of the earth".[44]

The lecturers often showed a faith in the rational nature of physical science, and in the greater rationality of modern society than that of previous times. Criticising astrology, Wallis declared that study of astronomy would eradicate such beliefs;[45]

William Frend said that "Copernicus..., had he not died almost immediately after the publication of his work on the true motions of the planets, would, in all probability, have been put to death for his opinions." Indeed, he claimed that "some hundred years ago, a person would have been in danger of losing his life for promulgating such an opinion."[46]

Many lecturers also displayed their reformist and liberal political ideals. Frend argued against the opinion "that the black gentlemen are inferior to the white gentlemen" and congratulated "the Legislature, [which] to its immortal honour, abolished the slave-trade". He proceeded to applaud the openness, in China, of the "highest offices in the state... to every individual in the empire", and criticised the East India Company in satirical terms:

> "where would [a rajah of India] find the representative of the power which rules the destinies of a hundred millions of men? - Not seated upon a royal throne, but standing, with a small desk before him, and a hammer in his hand, knocking down a lot of tea to the highest bidder!"[47]

The characteristics of the science content of the London institute lectures thus showed many similarities with the content of the scientific treatises in the Library of Useful Knowledge. The belief in a providential cosmos was illustrated by Birkbeck's declaration that even the system of distribution of wealth was designed by God, and:

> "No system could be devised, calculated more extensively and effectually, to promote the happiness of a world peopled like our own".[48]

Faith in the advantages of machinery was displayed by Dr. Alderson at Hull Mechanics' Institution when he advanced "a variety of arguments, to prove that 'mechanical invention', rather than 'simple labour', properly constitutes the wealth of a nation".[49]

The faith in an empirical scientific method and in the greater rationalism of modern society was displayed by Frend when he declared that, "I scarcely ever knew an instance of an appeal to the wisdom of our ancestors, except from a want of argument, or for the purpose of supporting some falsehood or trickery".

'Neo-Baconian' methodology was lectured on by a Dr. Williamson to the Leeds Mechanics' Institution in 1825, in a discourse on "the method of obtaining knowledge by induction and its connection with the modern improvements of science".[50]

These similarities are less surprising when it is realised that of the authors of the first two volumes of Natural Philosphy in the Library of Useful Knowledge, Thomas Traill, Ogg, Millington, Brougham and Roget were all at one time lecturers at mechanics' institutes.

How was this rigorous, systematic and primarily pure science curriculum received by its intended audience? At Liverpool Dancer's lectures on electricity and magnetism were reported as proving "both amusing and instructive to a numerous and attentive audience".[51] Usually those lectures with good apparatus and demonstrations received most acclaim. At the Spitalfields institution Partington's lecture on pneumatics and the atmosphere was "rendered extremely interesting by the number and variety of the illustrative experiments introduced"; at Leeds Lockwood's last lecture on steam engines, with apparatus "excellent and in good order", attracted a hall "filled to overflowing".[52]

At the London institution electricity lectures were well attended, with around 1,000 people watching Tatum lecture on the subject on one occasion.[53] The audience at his course were rewarded with experiments in which tin foil was made to glow in the dark, electricity was passed through eggs, and hundreds of people experienced small electric shocks. Electricity was also used to inflame hydrogen gas, to break a Leyden jar filled with oil, to ignite gunpower, and, most spectacular of all, to make chains "glow with fire". When the Leyden jar was broken the "experiment excited much interest, and was loudly applauded",[54] while after Lewthwaite produced luminous effects with carbonate of lime the reporter for the London Mechanics' Register recorded that "the general applause [showed that] the whole of the members participated in our satisfaction". The electrification of the chains was so spectacular that the audience insisted it be repeated; after Mr. Cooper had inhaled hydrogen to alter the pitch of his voice "it was a long time before the applause, which had been elicited by the astonishment and amusement of the experiment, would permit him to continue".[55] Not so appreciated was the demonstration of the destructive abilities of electricity. Lewthwaite killed an eel and a frog before being prevailed upon by the members not to kill a guinea pig as well.[56]

Possibly most popular was Mr. Wallis and his lectures on astronomy. When he was engaged to lecture at Southwark institution it was reported that "many new members [were] added to the Institution", while at the London institution his first lecture was attended by "as crowded an assemblage of the members as we have ever witnessed." A "considerable portion" of the lecture room was reported to be occupied by his "extensive mechanical apparatus" (presumably a form of orrery), in addition to which he had a "brilliant transparency of the earth, about four feet in diameter" and a "magnificent scene representing the motion of a comet in its orbit".[57]

Some lectures were received less well. One of Cooper's later lectures was reported very briefly, because, it was said, "there are some subjects of immediate interest only to a few. Such appeared to us to be the case at Mr. Cooper's last lecture". Mr Wheeler's botanical lectures were concerned particularly with the physiology and diseases of plants. In the fourth lecture he listed all twenty-four of the Linnaean classes and their characteristics.[58] No audience reaction is mentioned in the reports and the lectures were not repeated; it seems fair to conclude that they were not very popular.

Spectacular courses were well supported, but the systematic science which lay at their heart seems not be have been. One must therefore ask why it was attempted to teach such science to members of the working classes at this time.

D. The Aims of Scientific Education of the Working Classes

To answer the question just posed, it must firstly be made clear that the education was to be primarily a moral, not a technical education. Those claims which were made for the economic utility of such an education, as when Ogg told Reading Institute that "By making them understand the scientific principles connected with their several occupations... [the working classes] will be rendered more skillful",[59] were claims designed mainly to encourage the patronage of manufacturers. Similarly, when Brougham proclaimed that: an "artisan, a dyer, an engine-maker, will gain the more in money or money's worth for being an expert chemist or mechanician",[60] he was attempting to entice workmen to attend the mechanic's institutes and read the publications of the Society for the Diffusion of Useful Knowledge. Yet it was not necessarily conscious deception for, as shown above,[61] science was believed to be the basis for all trades and, therefore, it seemed inevitable that learning science would aid technical production. This too, however, was in many senses a moral education, for utility had moral implications.

That in some cases it was at least conscious exaggeration, however, may be shown by a comparison of Birkbeck's thoughts on his own Glasgow physical science class with a comment he made in support of the London institute. Of Glasgow he said:

> "I am by no means sanguine in my expectation that, by a course of instruction such as I have proposed, any one artist will be directed to the discovery of any one thing which is essential or important in his particular department".

Of the latter he said, the "worth [of science to mechanics] in the most mercantile acceptation of the word, is now indisputably established".[62]

More important than direct economic benefit was the belief that, as Ogg said at Reading, "great moral improvement, and, consequently, increased happiness, must result from turning the attention of the working classes, to the pleasing and profitable pursuits of science".[63]

This moral education was to produce social benefits. As Brougham wrote, learning "elevates the faculties above low pursuits, purifies and refines the passions, and helps our reason to assuage their violence".[64] To Mr. Pelham, honorary secretary of the Rotherhithe Mechanics' Institution "if properly conducted [the institution] would produce (what alone the promoters had in view), moral and intellectual amelioration, subordination, and industry".[65]

Some efforts to "educate" the workers morally were more obvious than others. Institutes were established in areas of high population density and low incomes. This was particularly clear in London, for instance in the cases of Rotherhithe, Stepney, Poplar, Southwark and Spitalfields institutions.[66] Spitalfields had many poor people and also a community of weavers, a group which were being very hard pressed by changed production methods, including the introduction of power looms. When Birkbeck gave his opening speech to the institution he proclaimed that it would mean the weavers' "prejudice would give way when they came better to understand the advantages derived to the workmen by the introducton of machinery".[67] Little wonder then, that the Spitalfields weavers viewed the establish ment with "almost shuddering horror", as a review of a pamphlet, entitled An Exposure of the Sophistry that the Promoters of our Knowledge are endeavouring to thrust down the Throats of us Unintellectual Geniuses of the Loom, proclaimed.[68]

It seems that the weavers never found, as the London Mechanics' Register hoped they would, "that the institution is really designed for their advantage, and not, as they absurdly imagine for the emolument of the masters at their expense".[69] By 1832 it had changed its name to the Eastern Literary and Scientific Institution and was endeavouring to attract the middle classes. Hackney and Southwark also followed this course after finding too little favour with the local working population, while Rotherhithe and Stepney had both closed by c.1830.

The social and moral benefits were to be achieved in a number of ways. Attendance at mechanics' institutes would substitute "pure and harmless and cheap gratifications, in the stead of luxuries which are both grosser and more costly - hurtful to the health and wasteful of time".[70] As the London Mechanics' Register wrote:

> "The journeyman and the apprentice [will] no longer spend their leisure hours in the improvident dissipation of their gains, but in drinking deeply from the fountain of human knowledge".[71]

Regular habits would be encouraged by the very regularity of the meetings - the same evening every week, at the same time, throughout the year. This contrasted with the irregular holidays and working habits of many craftsmen at this time, and would therefore aid the development of work discipline. The institutes would "tend to make the operatives most regular in their habits" said Mr. Harvey at the Devonport Institution.[72] Extra provisions, such as the disqualification of members from all benefits at the Sheffield Mechanics' and Apprentices' Library if they entered prison or the workhouse, or the exclusion of members from classes at the Manchester institute if they missed four sessions,[73] were sometimes introduced to help. Yet membership still dropped substantially at the London institution in the summer quarter every year,[74] while the dedication of Mr. Tatum in lecturing on Christmas Eve was not reciprocated by the members, as the "lecture was but thinly attended in consequence of the festive nature of the evening".[75]

All these functions, however, would have been performed equally well by non-science based institutions. What was it about physical science which made it most suitable for such an education? The answer is hinted at by Brougham's statement to the fifth annual meeting of the Leeds Mechanics' Institution on 20 September 1830. "It is of high importance", he said, "that the bulk of the community should have sound and rational and safe views... it is my object to make the bulk of the people philosophers".[76]

The populace had to be made rational, and in the opinion of the middle-class reformists, physical science was the exemplar of rational thinking. If one could teach the working classes physical science one would be teaching them to reason.

This belief stemmed from a faith in the power of a Baconian inductive methodology. The first line of the manifesto for the London Mechanics' Institution called Bacon "one of the wisest men". To Birkbeck, Bacon was the "highest intellectual genius in this country";[77] to Toplis he was "immortal".[78] Brougham indeed modelled himself on Bacon when he too was Lord Chancellor, and was ridiculed for his "elaborate mimicry" by Disraeli.[79] The extremely high opinion of Bacon's worth shown here may be traced back to the influence of the Scottish Universities, particularly Edinburgh. Very many of those most closely associated both with the mechanics' institutes and with the Society for the Diffusion of Useful Knowledge had been educated at Edinburgh, including Brougham, Birkbeck, Traill, Heywood, Baines, Roget and Mill. Their ideas had been particularly influenced by Dugald Stewart's political economy lectures. Through him these modern professional men and intellectuals of English middle-class society had been influenced by the ideals of the Scottish Enlightenment. Brougham, particularly, had been fascinated by such topics, having studied with his friend and future colleague on the Edinburgh Review, Francis Horner, a curriculum which, in approximately descending order of frequency, consisted of methodology, moral philosphy, philosophy of mind, and chemistry. Most of all they studied Bacon.[80]

Anything which followed such a methodology - and this they believed included natural theology, political economy and even the correct form of history - was worthwhile both to learn and to teach, but physical science taught Baconian inductive methodology best of all.

William Henry, an Edinburgh-educated doctor, a Unitarian, a chemist with interests in manufacturing, a friend of Brougham's, a vice-president of the Manchester Literary and Philosophical Society and a supporter of the Manchester Mechanics' Institution (in other words a typical member of these middle-class rationalists) expressed this view in a letter to Benjamin Heywood, the president of the Manchester Institution, in 1824:

"[B]y diffusing [knowledge] among the lower orders, they will be rendered more

> substantially happy, less the slaves of vicious habits, and not only better fitted, but better disposed, to fulfill their several duties. I am fully persuded too that without entering at all in your course of instruction upon topics calculated to endanger that harmony among the promoters and members of such an institution [-a reference to Heywood's suggestion of teaching political economy?-]... the habits of reasoning correctly on subjects properly within its scope [i.e. physical science], will be beneficially extended to other subjects, and will tend, indirectly but powerfully, to root out fanaticism in religion, and visionary and impractical speculations in politics".[81]

Arnold Thackray, in quoting part of this passage,[82] has taken it as a use of science for conservative ends, but it seems more appropriate to view it as just the opposite. Henry was not politically active but shared many of the general ideas of the Manchester provincial middle classes, with their enthusiasm for political reform.

The conservative view of science and science education was ably expressed in the two most succesful conservative magazines of the period, the Quarterly Review and Blackwood's Magazine. The Quarterly described physical science as "no more than a number of well authenticated facts, addressed to our admiration, rather than our judgement... [It] will not instruct us in our own nature, nor furnish us with any of the talents, by which that nature is governed in our society, or fashioned within ourselves".[83] Science education was, they believed, rote learning of facts with no moral uses at all. John Wilson, writing in Blackwood's, was puzzled by the attidues of "writers on the Education of the People" who meant education which was "merely secular, that is, of the second order; and yet they often reason, as if it were to produce the effects proper to the very highest - unlimited effects on human happiness and virtue".[84] David Robinson, in the same publication, described what he felt to be correct moral education. It would consist of religious education, general history, biography, poetry, selections from the essayists, etc., and, significantly, "the descriptive parts of Astronomy, Geography, [and] Natural History".[85]

Wilson was correct. Education by the rationalists was to be primarily one of learning to reason, not learning facts, and to them the power of an education which taught how to reason had replaced a religious education as the most morally efficacious. Such ideas were shared by many working-class radicals, for instance William Lovett and Thomas Hodgskin. To see science as, and only as, subjects following an inductive methodology was not the prevailing view of science at this time. It was, rather, a form of science which suited the interests of those proclaiming it to be the true knowledge. Political economy was formed, as the Hammonds have noted,[86] on the model of physical and mathematical science, but not because most science was of this form, (for botany, geology and astronomy were none of them experimental and inductivist, and chemistry was only in the process of moving towards such a form), but because a science which resulted in laws, supposedly merely from examination of the natural world, was the sort of science required. It therefore had an authority based upon God's authority (as the design of the universe was dependent upon His will) but without relying on the supposedly less 'rational' scriptures.

Faith in physical science as a model for rational reasoning helps to explain a number of peculiarities. Firstly, Brougham's assertion that there were very few "elementary works that really answer the description".[87] As previous chapters have shown, there were some hundreds of such works, many easier to follow than the scientific treatises of the Library of Useful Knowledge. They were not considered suitable because they did not proceed systematically to lay clear the methodology of the science. The one non-original work issued by the society, an 'Introduction to Natural Philosophy', was really a reprint of Mrs. Marcet's Conversations on Natural

Philosophy, a work which expressly made clear that it proceeded "with some degree of regularity".[88] Many of the other works which also existed were on natural history, a science which many Edinburgh men were criticising at this time for being too concerned with classification by external factors and not enough with physiology - i.e. for not following experimental inductivist methodology sufficiently closely.[89]

Secondly, the decrease in physical science content of both the lectures at the mechanics' institutions and in the publications of the Society for the Diffusion of Useful knowledge was due to the switching of attention to the middle classes, who, while desiring and needing polite and improving subjects of study, did not, it was believed, need educating in the art of reasoning.

Thirdly, the concentration of the institutes upon the "higher classes of mechanics" which Blackwood's noted,[90] is illuminated. Tylecote has suggested that this was because the mechanic was "the new type of workman evolved by the new methods of industry",[91] yet the aim, certainly in London, was to attract artisan craftsmen, not workers in new industries. Rather, mechanics were chosen for two reasons. In the first place educating the higher sections of the working classes would help reform the attitudes of lower sections, because the artisans were in many ways the leaders of the working classes. As Mr. Elliot said, at Rotherhithe Institution, "a large body of uneducated people resemble the monster of Frankenstein... a huge body, with tremendous sinews, and powerful muscles, wanting mind to guide it to a good or provident purpose",[92] and an educated artisan class could provide such a mind. Also, mechanics were considered to be easier to educate because, as town dwellers, they were believed by the urban middle-class reformists to be more advanced. As Mrs Marcet wrote:

> "The knowledge of a ploughman is often remarkably distinct in his limited sphere; but yet I have usually found that in conversing upon general topics with

a ploughman and with a mechanic, the latter['s mind] .. has appeared more active and accustomed to reflection".[93]

Education of the working classes in this way was to have political and social benefits for the middle classes, above those of merely adjusting the working classes to the introduction of machinery. By convincing them that the middle classes shared their interests it was hoped to enlist their support in the battle for reform with the aristocracy. As Birkbeck wrote in 1830, "the more they [the lower classes] are really educated... the more perfect will the institutions of the state become".[94] Thus the main supporters of the institutions were liberal Whigs and Radicals rather than manufacturers.[95]

Social benefits included the display of patronage and philanthropy, activities essential to establish the middle classes as a socially established elite. This philanthropy was most obviously expressed in the large and impressive buildings many institutions hastened to erect. Such premises not only proclaimed that the activities within were respectable, but also that these middle classes had the money, social status and public spirit to fund them. Patronage of the institutes also provided a suitable destination for these funds at a time when the Malthusianism of the middle classes forbade orthodox chartiable activities. As Brougham wrote in his pamphlet, "the existence of a known and regular provision for the poor... has the inevitable tendency to bring forward not only as many objects as the provision will maintain, but a far greater number... the same money which is now not uselessly, but perniciously bestowed, might, by a little care... be made the means of at once educating all the children in the worst district of London, and of planting there the light of science among the most useful and industrious class of the community", (i.e. by founding three Lancastrian schools and a mechanics' institute).[96]

The education was often claimed to produce the desired effects. Claxton claimed at

Liverpool that few members of mechanics' institutes were also members of trade unions, while 'A Master' wrote to the Mechanics' Magazine during a strike that "not one of my men who is in the habit of taking your valuable little work, is among the disorderly. On the contrary, they endeavour... to prevail upon their fellow-men to return to their duty".[97]

E. The Rejection of the Mechanics' Institutes by Working Men

Modern scholars who have discussed the decline in working-class membership of the mechanics' institutes have normally not gone as far as contemporaries in blaming the working men themselves (Brougham, for instance, declared that the paucity of members at Leeds was "owing to a want of energy and exertion on the part of the body of the workmen of Leeds")[98] yet they have at the same time tended to provide the working classes with "excuses". As Mabel Tylecote writes, the price of membership, tiredness after long working days, the lack of elementary education and the too sophisticated level of teaching were the main factors responsible for the non-attendance of workmen.[99] Even those writers who have recognised the middle-class attempts at acculturation which the institutes embodied have associated the rejection of the institutions with circumstances surrounding the education, thus implying the education itself was worthwhile and value-free.[100] This chapter has attempted to show that the science education itself, which lay at the heart of the institutions' early activities, was intended to be a major 'reforming' element.

It is probably true that the circumstances surrounding the education were responsible for much of the lack of response of the working classes, particularly for the exclusion of nearly all but the artisan elite. Yet the difficulties should not be exaggerated. Leeds Mechanics' Institute, with the very small membership of 116 subscribers in 1830 had one of the lowest annual subscriptions in the country, 10s.

Conversely, the New Manchester Mechanics' Institution, a rival set up when working members were not allowed to participate in the government of the Manchester Institution, had a 16s. subscription, only four shillings less than the original institution. The idea that workmen were too tired after work must be compared with Charles Smith's statement of the 1840s (before the ten hour Act) that, "To talk of a mechanic or an artizan of London, Bristol or Birmingham of working more than ten hours a day was to risk being set down as a mad-man".[101]

Censorship of libraries and discussions, often by one's daytime bosses, the need to appear respectably dressed, irregularity of habits both by tradition and, in bad years, by necessity, lack of expectation of material reward from the education and the ostentatious display of patronage in the buildings of many institutes would all no doubt have discouraged working men from subscribing. Despite all these factors, however, those who shared the ideal of a rational, fairly secular, society, such as William Lovett, were able to attend "very regularly".[102]

Perhaps one should ask rather why working men should attend. Recent work has shown the existence of a wide ranging and varied popular culture at this time, encompassing circus, theatre, sports, pantomine, menageries, etc.[103] By establishing the Society for the Diffusion of Useful Knowledge and the mechanics' institutes as free market competition with these attractions the lack of demand may be explained by suggesting that the other attractions proved more exciting. From the consideration above it seems that many of the members of the audience at mechanic's institute lectures - were most impressed by the spectacular demonstrations, i.e. they treated the institute as an alternative to other theatrical and spectacular events.

Was there, however, also something in the nature of the science education itself which would have proved uncongenial to members of the working classes? Two features seem to have been relevant. Firstly the mechanics' institutes often specifically linked science to technological developments. In 1823, for instance, Birkbeck told the London institution that James Watt's inventions were "an instance of the applicability of science to the ordinary purposes of life". In 1826 he lectured on the power loom, (one of which he actually had present in the lecture theatre), and claimed that "with this machine, I could manufacture a piece of gros-de-Naples as well as any Spitalfields weaver".[104] This same year, 1826, was a year of great social disturbance, which saw the breaking of many power looms throughout the country. As Birkbeck knew, his lecture was to be reported by the London Mechanic's Register and was therefore potentially to be read throughout the country; he seems to have clearly been attempting to influence loom breakers in many areas.

In a similar way the Davy lamp was described by Brougham in his 1825 pamphlet as Davy's "most useful, perhaps most philosophical discovery".[105] The workers who actually experienced this "most philosophical discovery" had a somewhat different opinion. The miners' of the Tyne and Wear complained in 1825 that they now had "to suffer the most awful agony in an exceedingly high temperature".[106] The number of mining accidents actually increased in the years after the lamp's introduction as mine-owners took advantage of it to exploit seams previously considered too dangerous.

The mechanics' institutes, therefore, publicly associated "science" with, often unwelcome, technological change. They also equated political economy and "science". Birkbeck's lecture on the power loom soon moved from describing the loom itself to discussing political economy. Quoting from Marshall's The Economy of Social Life (which, at only 6d., he recommended the audience to purchase) he declared that the science of political economy proved that "whatever abridges and facilitates labour, will eventually increase the demand for labourers".[107]

The form of science taught at the early institutes and presented in the early publications of the Society for the Diffusion of Useful Knowledge was therefore associated by these educational enterprises with technology and political and economic theory which must have proved unwelcome to sections of the working classes. More than this, however, the type of science taught was inimical to the interests of large sections of the working classes. It has already been shown[108] that much of the community believed, and wanted to believe, that "science" or "philosophy" was connected with prediction and control. Those sciences which members of the working classes did indulge in dealt with natural objects and their interconnections, not with experiments and the induction of general laws. As Birkbeck said to the Spitalfields institution, "[he understood that] botany and entymology [sic] were favourite pursuits among the inhabitants of this district, and, indeed, he had been told, that many of the most rare specimens in these sciences had been found, and were only to be found, in the collections of Spitalfield's weavers".[109] Manchester working men founded a natural history society, the Banksian Society, shortly before the foundation of the New Mechanics' Institution. These subjects did not, however, suit the requirements of the rationalist middle classes and very little botany, entomology, etc. was taught either at the Spitalfields or Manchester Mechanics' Institutes. Thus, rejection of the education by the working classes could have come from their lack of interest in the type of science taught, a lack of interest due to the conflicting interests of the social groups involved.

Notes to Chapter 7

1. Mechanic's Magazine, 1823-4, 1, 99-102 (11 October 1823).
2. For mechanics' institutions see especially T. Kelly, George Birkbeck, Pioneer of Adult Education, Liverpool, 1957, book I, chs. V-VII, and book II. See also M. Tylecote, The Mechanics' Institutes of Lancashire and Yorkshire before 1851, Manchester, 1957; J.W. Hudson, The History of Adult Education, London, 1851; reprinted London, 1969, is the most valuable nineteenth-century source.
3. Quoted from the Rules and Orders of the institution in Kelly, op.cit. (2), p.88.
4. Hudson, op.cit. (2), pp.49-50.
5. The others which opened were at Lancaster, Eyam, Kendal, Alnwick, Ipswich and Bury. Kelly, op.cit. (2), p.209.
6. [Henry Brougham], 'The Scientific Education of the People', Edinburgh Review, 1824-5, 41, 96-122; Henry Brougham, Practical Observations upon the Education of the People, addressed to the Working Classes and their Employers, 13th edn., London, 1825.
7. Kelly, op.cit. (2), Appendix vi, p.313, lists Camberwell, Peckham and Kennington Mechanics' Institute, but this seems always to have been a "Literary Institution", see London Mechanics' Register, 1825, 1, 224.
8. Kelly, op.cit. (2), pp.222-3.
9. Kelly lists Keighley, Wilsden, Stalybridge and Halifax as working-class institutions, ibid, p.215.
10. Tylecote, op.cit. (2), pp.57-9 shows this for Lancashire and Yorkshire.
11. Ibid, p.130.
12. For Gregory's activities in other London societies see above, ch.V.
13. [David Robinson], 'Brougham on the Education of the People', Blackwood's Magazine, 1825, 17, 534-51 (548).
14. For the New Manchester Mechanics' Institution see R.G. Kirby, 'An Early

Experiment in Workers' Self-Education: The Manchester New Mechanics' Institution, 1829-35', in D.S.L. Cardwell (ed.), Artisan to Graduate, Manchester, 1974, pp.87-98.

15. Quoted in Tylecote, op.cit. (2), p.62 (n2). The division of membership is given in T.S. Traill, Address delivered by Thomas Stewart Traill... and Resolutions adopted at a General Meeting of the Inhabitants held on the 8th June, 1825, Liverpool, 1825, p.ix.

16. Tylecote, op.cit. (2), p.109; Annual Report of the Leeds Mechanics' Institute, Leeds, 1829, pp.4-5; Tylecote, p.153.

17. It is only working men and youths referred to in this chapter. Women were nearly always excluded from mechanics' institutes at this time. This could pose problems when the failure to attract working men meant that the middle classes were included in a society's aims. To be 'respectable' such institutions were felt to need 'lady members'. One instance is that of Southwark institution. Founded only in 1826, "the recent [financial] distresses" were soon blamed for preventing sufficient working men from joining. In the second report President James Horne recognised "that, in the present times, it is not by mechanics alone that such Institutions can be supported". Consequently, thirty-five 5s. transferable tickets were issued "principally for the admission of ladies". Thus "the incongruity of having ladies as members of a Mechanics' Institution... [was] avoided". Unfortunately such expedients were not sufficient to prevent it closing in c.1830. See London Mechanics' Register, 1826, 4, 412-3; New London Mechanics' Register, 1827, 1, 172-3.

18. Mechanics' Almanac, London, 1826 (folio sheet B.L. Tab. 597.c.1(57)).

19. Liverpool Mechanics' School of Arts, Minutes, 4 September 1828.

20. Hudson, op.cit. (2), pp.51-2.

21. Annual Report of the Committee of the Leeds Mechanics' Institution, Leeds, 1827, p.4.

22. See reports of these early meetings in the London Mechanics' Register, 1825-6.

23. C. New, The Life of Henry Brougham to 1830, Oxford, 1961, pp.341-2.

24. London Mechanics' Register, 1826, 3, 152.

25. See above, chapter II, section Cii.

26. Report of the Proceedings at the Annual Meeting of the Leeds Mechanics' Institution on the 20th September, 1830, Leeds, 1830, p.2.

27. Mechanics' Weekly Journal, 1824, 1, 141; ibid, p.48; ibid, p.76.

28. Quoted in New, op.cit. (23), p.343.

29. Liverpool Mechanics' School of Arts, Minutes , 4 Aug. 1825, 7 Sept. 1825, 14 March 1827.

30. Annual Report of the Committee of the Leeds Mechanics' Institution, Leeds, 1826, p.10; Report, op.cit. (21), p.8.

31. Report and Proceedings of the Liverpool Mechanics' School of Arts, Liverpool, 1828, p.6. Total membership was actually 1,090 but 250 were estimated to attend, of whom 25 attended the drawing class; Report, Leeds, 1826, op.cit. (30), pp.8-9.

32. See the advert for this coffee house in Place MSS at the British Library, Add. MSS 27824.f.39.

33. Catalogue of Books in the Library of Leeds Mechanics' Institution, Leeds, 1826.

34. See e.g. London Mechanics' Register, 1826, 4, 340; ibid, 1826, 3, 41; Annual report, 1827, op.cit. (21), p.6.

35. London Mechanics' Register describes lectures given at the London Mechanics' Institution in 1825-6. The four lectures not on physical science were on botany.

36. Annual Report, 1826, op.cit. (30), p.8; Annual Report, 1827, op.cit. (21), pp.5-6.

37. Kelly, op.cit. (2), pp.112-3.

38. Tylecote, op.cit. (2), p.149.

39. Bury Mechanical and Scientific Institution, for instance, heard "a lecture

previously delivered at the London Mechanics' Institution, or extracts from some scientific work" every other Tuesday evening in the summer of 1825. London Mechanics' Register ,1825, 2, 43.

40. Partington, Wallis and Birkbeck lectured at Spitalfields, Lewthwaite and Wallis at Southwark, Partington at Hackney and Ogg at Leeds, for instance.

41. London Mechanics' Register, 1825, 1, 115.

42. Ibid, 1825, 1, 8

43. Ibid, 1825, 2, 119, 155.

44. Ibid, 1826, 4, 197.

45. Ibid, 1825, 2, 155-6.

46. Ibid, 1826, 3, 278.

47. Ibid, 1826, 3, 308-9, 356, 358.

48. Ibid, 1826, 4, 121.

49. Ibid, 1826, 3, 41.

50. Ibid, 1826, 3, 339; ibid, 1825, 1, 332.

51. Report... of the Liverpool Mechanics' School of Arts, Liverpool, 1826, p.6.

52. London Mechanics' Register, 1825, 1, 332; ibid, p.279.

53. Ibid, 1825, 1, 24.

54. Ibid, p.41.

55. Ibid, 1825, 2, 51; ibid, 1825, 1, 42-3.

56. Ibid, 1825, 2, 37.

57. Ibid, 1826, 4, 384; ibid, 1825, 2, 85-7, 154.

58. Ibid, 1825, 1, 137-8; ibid, 1825, 1, 322, 342, 358, 392 are the first pages of the reports of Wheeler's four lectures.

59. Ibid, 1826, 3, 152.

60. Brougham, op.cit. (6), p.12.

61. See ch. III, (Section on Chemistry).

62. Quoted by 'E.W.' in his letter, hostile to Birkbeck, to the Mechanics' Weekly

Journal, 1824, 1, 76; Kelly, op.cit. (2), p.82.

63. London Mechanics' Register, 1826, 3, 152.

64. Quoted by New, op.cit. (23), p.352.

65. New London Mechanics' Register, 1827, 1, 104.

66. It is noticeable that all these local foundations occurred in 1825-6. After the London Institution was founded two or so years passed before any more were initiated. Yet in 1825-6 at least nine more were founded, and generally in poorer districts of London. This is easily explained if it is accepted that moral reform was the prime aim of the institutions. The central institution was seen, after two years, not to be attracting men from the outlying areas. With the trade distress of 1825-6 it became, in the minds of the patrons, more important than ever to 'educate' the working people. Therefore, if they would not come to the mountain, a whole range of mountains would have to be built in the areas most at risk, the poorest areas. For information on Spitalfields see P. McCann, 'Popular Education, Socialization and Social Control: Spitalfields 1812-1824', in P. McCann (ed.), Popular Education and Socialization in the Nineteenth Century, London, 1977, pp.1-40.

67. The Circulator of Useful Knowledge, Amusement, Literature, Science, and General Information, 1825, 1, 188.

68. Reviewed by The Scientific Gazette; or, Library of Mechanical Philosophy, Chemistry, and Discovery, 1826, 1, 34-6 (35).

69. London Mechanics' Register, 1825, 1, 411.

70. Brougham, op.cit. (6), p.12.

71. London Mechanics' Register, 1825, 1, 8.

72. Ibid, 1825, 1, 351.

73. Brougham, op.cit. (6), p.26, praised this first provision; Hudson, op.cit. (2), p.127.

74. In the year 1825-6 the four quarterly membership figures were (winter first)

1522, 1772, 1266, 1347 (Kelly, op.cit. (2), p.109).

75. London Mechanics' Register, 1825, 1, 139.

76. Annual report, 1830, op.cit. (26), pp.10-11.

77. The Circulator of Useful Knowledge, 1825, 1, 188.

78. London Mechanics' Register, 1826, 4, 72.

79. He was thus criticised in 1836: see F.A. Cavenagh, 'Lord Brougham and the Society for the Diffusion of Useful Knowledge', Journal of Adult Education, 1929, 4, 3-37 (14). That teaching right reasoning was one of the functions of a science-based education is suggested in E.A. Storella, '"O, What a World of Profit and Delight": The Society for the Diffusion of Useful Knowledge', Brandeis University PhD Thesis, 1969, p.60.

80. T.H. Cook, 'Science, Philosophy and Culture in the early Edinburgh Review, 1802-1829', University of Pittsburgh PhD thesis, 1976, pp.74-5.

81. Quoted in W.V. Farrar, K.R. Farrar, and E.L. Scott, 'The Henrys of Manchester, part II', Ambix, 1974, 21, 179-207 (197).

82. A. Thackray, 'Natural Knowledge in Cultural Context: The Manchester Model', American Historical Review, 1974, 79, 672-709. (688).

83. Quarterly Review, 1811, 6, 182.

84. [John Wilson], 'Education of the People', Blackwood's Magazine, 1830, 27, 1-16(8).

85. [Robinson], op.cit. (13), p.550.

86. J.L. and B. Hammond, The Town Labourer, London, 1978, p.140.

87. Quoted by New, op.cit. (23), p.349.

88. Mrs. Marcet, Conversations on Natural Philosophy, 10th edn., London, 1843, p.3.

89. See above, ch.III (Section on Natural History).

90. Blackwood's Magazine, 1825, 17, 538.

91. Tylecote, op.cit.(2), p.35.

92. See report of November 1825 meeting of the institution in B.L. Add MSS 27824, f.89.

93. [Mrs. Marcet], Conversations on Political Economy, London, 1816, p.77. Thus the education was to be to reason, not just teaching 'truths'. Cf.B. Simon's interpretation in his Studies in the History of Education 1780-1870, London, 1960, esp. pp.137-48. In a related sense, and as shown by David Robinson's comment (ref. 85), the concept of the education displaying the design of the universe, while undoubtedly present, was not the main reason for teaching science. Such a use of science was acceptable to the conservative mind, but was considered of only secondary importance by the reformists, cf.S.Shapin and B. Barnes, 'Science, Nature and Control: Interpreting Mechanics' Institutions', Social Studies of Science, 1977, 7, 31-74.

94. Quoted by Kelly, op.cit. (2), p.119.

95. At the Liverpool Institution, for instance, despite the presence of glass, china and soap manufacturers in the town, as well as dyers and tanners, the occupations of committee members included none of the above trades, most of the patrons being liberal merchants. Rules and Orders of the Liverpool Mechanics' School of Arts, for the Promotion of Scientific Knowledge Among the Working Classes, Liverpool, 1825, p.2.

96. Brougham, op.cit. (6), pp.30-1. It was said to be after his defeat over the question of whether or not to build large premises that Robertson (editor of the Mechanics' Magazine) finally turned against the project of the London Institute: Storella, op.cit. (79), pp.70-1.

97. Claxton is referred to, and Hindley quoted, in Tylecote, op.cit. (2), pp.48-9.

98. Annual Report, op.cit. (26), p.8.

99. Tylecote, op.cit. (2), pp.88-93.

100. See, for instance, H. Cunningham, Leisure in the Industrial Revolution c.1780-c.1880, London, 1980, p.91.

101. Quoted ibid, p.64.

102. W. Lovett, The Life and Struggles of William Lovett in his Pursuit of Bread, Knowledge, and Freedom, 2 vols., London, 1920, I, 36.

103. See Cunningham, op.cit. (100).

104. Reported in Mechanics' Weekly Journal, 1824, 1, 11; London Mechanics' Register, 1826, 4, 118.

105. Brougham, op.cit. (6), p.14.

106. Quoted in J.L. and B. Hammond, The Skilled Labourer, 1760-1832, London, 1919, p.28.

107. London Mechanics' Register, 1826, 4, 120.

108. See above, ch.II, section C.

109. Address is reported in B.L. Add. MSS. 27824 f.63.

Chapter Eight: Conclusions

One significant fact that this study has helped to confirm is the existence of many media popularising science in the early nineteenth century. At a time when science had very little economic utility it was still considered as an entity of some intellectual importance. Books, periodicals, institutions, lecturers, museums; all existed in profusion. The 'science' presented by these media was, however, very heterogeneous. Science could be a collection of singular phenomena, a part of literary culture, an aid to agricultural improvement, a set of causal laws. The nature of science varied with the popularisations.

Links between these media were multiple. Lecturers spoke in institutions, journal editors helped found societies, a museum owner wrote for the Society for the Diffusion of Useful Knowledge, mechanics' institute lecturers were members of Literary and Philosophical Societies, authors lectured and tutored etc. Yet there was not simply a passive audience and a smaller set of performers, for science was also practised. Collecting, experimenting, studying plants and animals in the wild and at menageries or in herbariums; all broke down this distinction.

There was no need, however, to have one's view of the world changed or even expanded when one visited a menagerie or mixed two liquids to produce, as if by magic, brilliant colours or boiling heat. The popularisation of science was sometimes an effort to impose views (i.e. to 'educate') other members of society by sections of the middle classes, yet those at whom this cultural broadside was aimed already possessed a concept of the natural world which spectacular lectures, etc. did very little to change.

The many institutions and publications treated science as of varying importance. To the Westminster and Edinburgh Reviews it was crucial, but by most general media it was treated as a part of literary culture of no more than equal, and often of less importance, than many other parts.

The image of science has been shown to have varied with social groupings. For the upper classes science was presented in almost a fine art mould. Davy's lectures at the early Royal Institution were reported in a journal, The Director, which concerned itself with painting and poetry. Davy, the individual genius, was an artist who happened to work with the material world, not just a participant in a co-operative process. The upper classes, however, also seem to have been prepared to consider actually utilizing science, e.g. for soil analyses, if there was the possibility of economic profit. This was of course the traditional role of aristocrat as patron and employer of craftsmen, yet some members of these classes treated science also as a hobby, either to practise or just to read about. Science was a, usually minor, part of a non-controversial and therefore socially-unifying general culture.

The rural gentry and most of the middle classes shared a broadly similar view of science. It was of very little economic use to them but morally very useful. It was rational and private recreation; the order of the universe, revealed by astronomy in the heavens and by collecting and taxonomy on earth, was a comforting validation of the naturalness and stability of the social order which served them so well. The ability to see the hand of God behind all the phenomena of nature was an essential metaphysical guarantee of this stability; natural theology, in this sense, pervaded practically all middle-class science works. The evangelical revival seems to have had a minimal effect on such authors, beyond a slightly greater emphasis upon the scriptures than may have been found in the eighteenth century. The Bridgewater

Treatises of the 1830s were clearly not anachronistic or peculiar, but merely an expression of the prevailing tenor of the times, at least among those concerned with study of the natural world. Even those who were consciously 'progressive' and reformist, such as Henry Brougham and his fellow authors in the Society for the Diffusion of Useful Knowledge, maintained a firm allegiance to natural theology.

Science had other benefits for the middle classes. Women found, particularly in botany, a permissible outlet for intellectual endeavour, giving interest to country walks, and occupying indoor leisure hours by the making of collections and reading. The men, particularly those of the urban middle classes, could similarly interest themselves and impress their friends by indulging in the more masculine and seemingly profound sciences of geology and chemistry. For children, learning science was both a moral education (through natural theology and by occupying idle hours both rationally and in private) and an intellectual one (through practising observation and judgement).

All sections of society delighted in spectacular and theatrical scientific lectures, particularly those on chemistry, electricity, and astronomy. Most of the population experienced the scientific ideas of the middle classes mainly through such events. Otherwise they maintained the traditional ideas on the natural world that penetrated throughout society. Many members of the upper and middle classes shared with the majority of the lower classes ideas which had been passed down for many generations. The concept of interconnection of all things, beliefs in the powers and uses of herbs, faith in astrology and the influence of planets, the formation of collections of miscellaneous objects, belief in ghosts and spirits etc., were widespread (although of course not uniform). The middle classes who took an interest, saw this as evidence of 'rational' thought, picking out, like Whig historians, those bits with which they agreed but ignoring their context. The mass of the people, however, preferred to maintain faith in their own superstitions rather than transfer their allegiance to a divinity who maintained the social order and whose 'invisible hand' seemed to be responsible for so many of their economic troubles.

Significant differences have been shown to exist in the treatment of individual sciences. Undoubtedly natural history was the most favoured of sciences in these years, particularly botany. Chemistry challenged this supremacy briefly in the early years of the century, geology did the same from the 1820s, but neither overtook the study of animals, plants and minerals. The most popular sciences were therefore natural history in Foucault's sense of the term, i.e. sciences of singular phenomena ordered into hierarchical tables. These had the benefit not only of displaying the order of the universe but also, in popularised form at least, of posing no challenge to authority. The classification had already been laid down, e.g. by Linnaeus, Hauy etc., and the practice of the science consisted of locating specimens in this hierarchy. Neither was the science making far-reaching truth claims. One could verify the existence of stamen and pistils by examining any flower, and therefore fit it into the, admittedly artificial, classification. This was the form of science espoused in the Gentleman's Magazine, in the natural history periodicals and in most of the higher-class cultural settings of science, such as the Literary and Philosophical Societies.

The beginnings of 'modern science', with its concern with general laws, with historicality and with spatial distribution, were evident in the popularisation of science in these years. This was the form of science which the urban middle classes were interested in, as demonstrated by the content of the Westminster and Edinburgh Reviews, and which they used as the basis of the moral education of the working classes (in mechanics' institutes) and of young men of the middle classes (in Literary and Scientific Institutions and in the London University). With this development arose problems about guaranteeing the truth of these general laws. Where popularisation had been a process of censorship (particularly for female or young audiences), of pointing out the moral lessons which could be drawn from the facts presented and, sometimes, of using a literary style and format, now a new problem presented itself: how to convince an audience of the truth of the information given. Interestingly, simplification was very seldom a part of the popularising process (other than in the general exclusion of mathematics). Indeed the S.D.U.K. and lecturers at mechanics' institutes were criticised (not least by modern historians) for not successfully matching their expositions to the supposed capacities of their desired audiences.

The answer to the problem of making the audience believe the 'truths' of modern science lay usually in stressing the methodology of the science. Astronomy, geology and chemistry were all explained to rest upon inductive methodology. In chemistry, experiments could be performed to verify the results but, particularly in geology and astronomy, forms of almost scholastic arguments were used, using the authority of Bacon, Newton etc. as justifications of the effectiveness of induction, the validity of the laws of gravity, etc.

Thus, as science changed, so popularisation altered. Why, then, has popularisation come to be seen as downgrading science, as diluting and distorting the truth? In the early years of the century popularisation to the lower classes had been seen as dangerous, but not as demeaning. There were no doubt many reasons for this change. Theatrical lectures could teach natural philosophy of the eighteenth century because that enterprise was concerned with singular happenings. Its object was not to form general explanatory laws. For modern science such a method of teaching is much inferior to formal studies because modern science depends upon learning large amounts of information and believing it; spectacular lectures are conducive to neither of these. Secondly, as science became successful, i.e. as it built upon knowledge claims, specialisation occurred more and more until simplification became absolutely necessary if an idea of a subject area was to be given to a layman in a lecture or a book etc. Thirdly, the growth of formal education meant that most people learnt about subjects which particularly interested them in prolonged class room study. Popularisation therefore became not the prime means by which people learnt of subjects not taught at school, but the imparting of a smattering of knowledge of a subject to that greatly enlarged category of people, 'laymen' (and women). Popularisation thus came to be seen as an intellectually inferior form of education, particularly so if one had to corrupt the 'purity' of the subject by adapting it to the interests of the expected audience.

All this contrasts strongly with the early nineteenth century when the very concept of formal education, and of the sections of society felt to be in need of it, was undergoing great change, particularly under the influence of an intellectual vanguard of urban middle-class men, themselves heavily influenced by the ideas of Scottish intellectuals.

It has been argued that popularisation of modern physical science occurred primarily with moral and social motives, emanating from this urban vanguard and directed at the working classes (through the S.D.U.K. and mechanics' institutes) and at other sections of the middle classes (through a variety of media including the London Institutions of the 1820s, Literary and Scientific Institutions, the Edinburgh Review, etc). This vanguard was characteristically politically reformist and of 'rational' (i.e. often Dissenting) religious views.

Recent historians who have examined science in its social context in these years have over-emphasised the separateness of science. Inkster, for instance, has suggested that science was "the popular cultural pursuit of the middle classes" and that societies like the City Philosophical Society, etc., were wholly scientific.[1] This study has shown that science can not be so clearly marked off from general culture at this time,[2] yet to some sections of the middle classes, science, of a particular kind, was of crucial importance, especially when taken to include (as was the case at the time) the discipline of political economy. For most sections of the middle classes science was but one component of their popular culture. Thus the very marking off of science becomes a historical problem.

This study of popular science may be claimed to have thrown some light upon the problem. Science was differentiated and emphasised by the middle-class rationalists.[3] Education was to be based upon a science of causal laws because they believed this, rather than in natural hierarchies, was how the world was (divinely) ordered. Thus the inductive methodology of 'modern science' was the only way to attain the basic truths of the universe. Post-Lavoisian chemistry, for instance, was the way in which God ordered much of the world.

The attractions of such beliefs for these men are fairly clear. The development of the middle classes was itself seen as an historical process; in the political arena they were attempting to displace the hierarchy of the aristocracy, which was traditionally presented as the natural social order, analogous to the natural order of animal, vegetable, and mineral 'kingdoms'. Causal laws also held out the promise of technological improvement via more accurate knowledge of the functioning of the universe and, as importantly, they justified the existence of all forms of technology. If God had ordered the world so that man could ferment beer, work metals, dye cloth etc., then any technological device which worked must have the sanction of God. Machine-breaking thus became not only economically bad but almost blasphemous; men had the duty to invent and employ new machines.

This, then, was the reason empirical inductive methodology was emphasised. It has been suggested that such emphasis was a technique to avoid social control over investigations in the sciences,[4] yet it is a legacy of the success of this methodology which allows us to believe such a method to be non-controversial. The attacks on the S.D.U.K. and the mechanics' institutes, and the explicitly liberal lessons in economics and industrial relations drawn from the teaching in the institutes and by the Society demonstrates that this was clearly not so in the early nineteenth century.

This study has therefore helped to show not only what 'science' was in the early nineteenth century, but also how and why this changed. The history of science should not and cannot be limited to consideration of the ideas within science, for the development of the historical construct of science is itself a historical problem which can only be illuminated by a consideration of society and the place of scientific activities within that society.

Notes to Chapter 8

1. Ian Inkster, 'The Social Context of an Educational Movement: A Revisionist Approach to the English Mechanics' Institutes, 1820-1850', Oxford Review of Education, 1976, 2, 277-307 (301,n 41); idem, 'London Science and the Seditious Meeting Act of 1817', British Journal for the History of Science, 1979, 12, 192-6 (194).
2. Thackray's claim for a (physical) science-based culture in the Manchester Literary and Philosophical Society also seems to over-emphasise the physical sciences. Certainly this was not the case in all the Literary and Philosophical Societies (see above, Chapter VI, section F).
3. Not all were middle-class, although those who came from the lower classes and took up these rationalist ideas usually became firmly middle-class, e.g. Francis Place, William Hone, William Lovett and others.
4. e.g. R. Porter, 'Creation and Credence: The Career of Theories of the Earth in Britain, 1660-1820', in S. Shapin and B. Barnes, Natural Order: Historical Studies of Scientific Culture, London and Beverly Hills, 1979, pp.97-123 (115-6).

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