The teaching of science in English dissenting academies 1662-1800

Thesis

THE TEACHING OF SCIENCE

IN

ENGLISH DISSENTING ACADEMIES

1662-1800

by

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Science! thou fair effusive ray
....
Through each progressive order, pass
To Instinct, Reason, God.

There, Science, veil thy daring eye;
Nor dive too deep, nor soar too high,
In that divine abyss;
To faith content thy beams to lend,
Her hopes t'assure, her steps befriend,
And light her way to bliss.

Mark Akenside (1721-1770), Hymn to Science

On the whole it may be observ'd, that the more philosophy is improved and enquiries pursued, the more is the harmony and regularity of the works of nature illustrated, and more evidently does it appear, that objections formerly made against them were owing to the ignorance of those that advanced them.

Philip Doddridge (1702-1751), A Course of Lectures

Natural philosophy is not only a noble science but one which offers the most interesting and profitable relaxations from the weight of severer studies .... [But ministers] are sent into the world, and into the academy, not to collect shells and fossils and butterflies or to surprise each other with feats of electricity but to win souls for Christ.

John Newton (1725-1807) Works.

ABSTRACT

This thesis attempts a new assessment of the place of science teaching in the English Dissenting Academies. It examines the approach to science teaching, seeking to account for the presence of science in the curricula of the Academies and its relationship to the wider educational aims. The content of science courses is examined together with the texts used and the relationships between the science taught and contemporary trends in scientific thought. Some attention is also given to the forms of teaching used in Dissenting Academies, and comparisons with the Universities.

Solutions to these problems have been sought in a variety of sources: lecture notes, correspondence, published texts, formal minutes, prospectuses. Chapter 1 introduces the subject, and Chapters 2 to 8 cover the Academies. As there are over 90 known Academies it is not possible to examine each one in equal depth, thus four (Northampton, Moorfields/Stepney/Hoxton, Warrington and Hackney) have been chosen as case studies. These Academies were selected because sufficient material survives, and their dates collectively allow continuous and overlapping coverage from 1701 to 1796. The remaining Academies are discussed rather more briefly. Chapter 9 draws together the findings of Chapters 2 to 8, and attempts an assessment of the Academies by their approach to and teaching of scientific subjects.

The most significant point about the science teaching in the Academies is the varied quality, which ranged from the exceptional to

the merely perfunctory. In almost one half, there is no evidence to suggest that science was taught at all. Generalisations cannot be made on the strength of the excellence of individual Academies or tutors, for example Priestley, Forster or Dalton, all of whom taught in these institutions. The reasons for including the subject on the curriculum also vary including specialist courses for students intending to follow medical or commercial careers, but in most Academies, the central reason is related to Christian belief, and the use of scientific knowledge to support the theological argument from design.

An antithesis between the Academies' aim to train ministers and at the same time, to offer a broad general education, can be perceived in attitudes towards science, and it is possible to suggest a more convincing reason for the decline of the Academies than those hitherto advanced.

CHAPTER 1

Historians have accorded Dissenting Academies an important place in English educational history, in spite of the fact that they had a relatively short life span and catered for a section of society that by definition was restricted. Founded by Dissenters as a result of the Test Acts[1] which excluded them from the English Universities, the Academies can be defined as institutions which offered a post-school level[2] education without, in almost all cases, a religious or political test on entry[3].

Many general histories of the late 17th and 18th centuries make large claims with regard to the academic standard of the Academies and the breadth and innovatory nature of their curricula. Roy Porter in one of the most recent of such histories writes:

> "Protestant boys from the trading classes, excluded by religious test from Anglican grammar schools and universities, generally went to Dissenting Academies. Many of these - such as Kibworth, Taunton, Daventry, Kendal, Warrington and Mile End - presided over by such distinguished scholars as Philip Doddridge and Joseph Priestley, became justly known, by sheer quality even attracting Anglican students. Mainstream Old Dissenters, and in particular Presbyterians, were not too precise to appreciate polite learning .... and they set out to blend canonical Classical studies with "useful" subjects such as geography, shorthand, arithmetic and science ..."[4]

A similar point is made by a distinguished historian of an older generation, T. S. Ashton, who also declared that the Academies

"...... did for England in the 18th century something of what the universities did for Scotland."[5] Ashton's work examined the development of the industrial revolution in England, and particularly mentioned the Academies as

> "... nurseries of scientific thought. Several of them were well equipped with "philosophical instruments" and offered facilities for experiment: their teachers included men of the quality of Joseph Priestley and John Dalton: and from them proceeded a stream of future industrialists, among whom were John Roebuck .. Mathew Boulton, John Wilkinson, Benjamin Gott..."[6]

In Reformation to Industrial Revolution, Christopher Hill claimed that the Academies provided "better" teaching than the universities of Oxford and Cambridge, with more science and modern subjects.[7] Hill made a particularly strong claim on behalf of Joseph Priestley's work in chemistry:

> "... Joseph Priestley, teacher at a dissenting Academy, picked up the science of chemistry where it had got bogged down at the Restoration."[8]

The importance of chemistry for the development of industrial techniques in the late 18th century cannot be overemphasised; the work of Joseph Priestley as chemistry tutor at the Hackney Academy will be considered in Chapter 8.

The main source of this view of the importance of the Academies can be traced to Irene Parker, from whose book Dissenting Academies in England (1914) comes the most often-quoted opinion on the Academies and the state of English education in the period between the Restoration and the end of the 18th century:

> "... without the story of the Dissenting Academies, the history of education for those 140 years [1660-1800] would be a dull and barren record..."[9]

Parker claims that the Dissenting Academies

> "... diverging from the main stream of education, drained off

> more and more of its life and vigour until the parent stream grew weaker and weaker ..."

> "... did their utmost to satisfy the needs of youth of this country..."

> "... trained men who filled the foremost places in every department of life and eventually developed into the most important educational system of their day"[10]

Parker's evidence in support of these statements was largely derived from the examination of a few selected, larger institutions, such as Rathmell, Northampton/Daventry and Warrington Academies. A more detailed study of the Academies was published 15 years later by H J McLachlan in English Education after the Test Acts (1931). McLachlan's book gave the first modern account of the history, curricula and staff of a large number of institutions, and largely substantiated Parker's view. More recently, J W Ashley Smith in The Birth of Modern Education (1954) has also supported the Parker/McLachlan view of the importance of the Academies. Parker's work has continued to be quoted by numerous authors to the present day. For example in her recent work Education and Society 1500-1800, (1982) Rosemary O'Day cites Parker as the standard work on the subject, drawing heavily on the Parkerian account of the structure, contribution and development of the Academies.[11] Parker's thesis was taken to extreme lengths in the work of E J Price, a non-conformist author.[12] Price stated that "...one effect of the legislation of 1662 was to commit national education to the care of Nonconformists"[13] and "the further fact that Anglicans often sent their sons to a Dissenting Academy as offering the best education available clearly shows that it was generally recognised that the standard of instruction in the Academies was higher than that in the

Universities."[14]

The basic Parker/McLachlan thesis on the contribution of Dissenting Academies to education was strongly challenged, if not demolished, by Nicholas Hans in New Trends in Education in the 18th Century (1951):

> "... both authors [Parker and McLachlan] exaggerated the opposition and contrast between the Church system and the system of the Dissenters ... both the old Grammar schools and the two Universities participated in the general educational movement towards a more scientific curriculum and the Academies, therefore, did not present an isolated instance..."[15]

Unlike Parker, McLachlan and Ashley Smith, Hans attempted to cover a wide range of 18th century educational institutions, from the universities to courses of public lectures and other less formal means of education. He attempted to evaluate the contribution of different institutions, and their relationship to each other, giving special attention to the nature of technical, scientific and mathematical education. Hans commented that not all Academies were as progressive as Parker appeared to believe and suggested that the religious dogma which governed some dissenting sects (for example Baptists, Calvinists)[16] could discourage an open and progressive attitude to learning.

Hans concluded that the intellectual and utilitarian reasons for educational reform had been put into full motion by secular bodies and teachers before the Dissenting Academies accepted them wholeheartedly. His broad assessment of their work was as follows:

> "The [Dissenting Academies'] contribution was very valuable and important, but it was not isolated in a "dull and barren" eighteenth century ..."[17]

In the first (1936) edition of the paper "Puritanism, Pietism and Science"[18] R K Merton relied heavily on Parker's thesis. But, in the revised 1957 edition, Merton accepted Hans' corrective assessment, as it was amply justified by available evidence.[19]

The Academies were not neglected by the early historians of dissent. Joseph Toulmin[20] devoted a chapter of his Historical View of the State of the Protestant Dissenters in England (1814) to the work of the Academies founded by ejected ministers in the later years of the 17th century.[21] Toulmin made the point that the Academies were the equivalent of universities for the dissenters:

> "... seminaries, which but for a malignant policy would never have existed, were opened in various parts of the kingdom to meet the wishes of such as would otherwise have sent their sons to the Universities."[22]

He considered Bishop Tillotson's suggestion that Academy tutors could be suppressed by prosecution under the Oxford and Cambridge Oath[23] as particularly important when considering the level of education offered by the Academies. However, Toulmin's chief concern was with divinity teaching, and the Academy's concern to turn out "good" men:

> "... convinced of the great importance, even necessity for the conduct of future life, of furnishing the youthful minds with principles of morality, he directed his particular attention to the improvement of his pupils' understandings in that part of learning."[24]

A more significant and substantial contribution to the history of Dissenting Academies was made in History of the Dissenters from the Revolution to the year 1808 (1808-12) by David Bogue and James Bennett[25] who gave some thought to what might constitute the "most proper course of instruction for a Christian ministry." They considered the study of mathematics and natural philosophy worthwhile as those subjects tended

> "... to improve the mind, and peculiarly to exercise its powers and call forth their energies, the general influence may be favourable to his future labours, and the hearers as well as the

preacher experience their good effects."[26]

However Bogue and Bennett sounded a warning note against the siren song of too much learning:

> "To a minister of the Gospel, every kind of knowledge will be useful: but as he is called to teach religion it should be his great aim to be a good divine: and theology should be his first and chief pursuit. Every other branch of knowledge should be valued and sought, in proportion as it bears upon theology and the sacred scriptures ...could he ...vie as a mathematician with Euclid or Sir Isaac Newton, how little would they all conduce to make him a good minister of Jesus Christ; for they all lye at the remotest distance from the knowledge of a Saviour, and the doctrine which is according to Godliness."[27]

The antithesis implied by Bogue and Bennett in the above quotations between the specific functions of Academies as institutions for the training of men for the dissenting ministry and as Academies offering broad general education, including scientific subjects (natural philosophy), is significant and is an implicit theme in many early works on the Academies. In the 1790s it was stated in relation to Dr Williams of the Rotherham Academy that the Dissenters' view of education and Academies was:

> "... not to extend the boundaries of human, but to diffuse more generally the benefits of divine knowledge. Without neglecting mental culture, far from despising it, dissenters have a higher purpose to accomplish. They view religion as the all important concern ... How desirable soever may be other objects to this they must defer their claims."[28]

When this limited objective was applied to the Academies it is interesting to note Bogue and Bennett's reaction:

> "It lowered the standards of general knowledge among dissenters, to that of the superior information of the old dissenting congregations which were often assemblies of divines, succeeded the comparative ignorance of the methodistic societies. In too many instances, the student never contracted enough of the habit, to acquire the love of study nor gained sufficient information to enable him to spend his future time to

advantage."[29]

Thus for some dissenters, the limits and purpose of education in the Academies were clearly defined. Scientific subjects attracted suspicion and occasionally particular opprobrium, for example the prohibition of mathematics at the Attercliffe Academy by Timothy Jollie (c1698) on the grounds that it led to atheism and infidelity. McLachlan comments[30] that this attitude was exceptional and that science was not neglected in any of the Academies, a point made earlier by Parker. During the period of the Academies' activity, the teaching of science was closely bound up with theology, for the term "natural theology" covered the study of living things, in the context of the "argument from design". Questions relating to these subjects, especially in the late 1600s and early 1700s were regularly discussed with reference to religious texts, the latter often quoted as references alongside Descartes and Newton. William Petty, the English economist, listed several objectives of such study at the time of the Restoration, as well as offering what was the underlying reason:

"God would be much Honoured

1. By finding out the use of the fixed stars
2. Of the matter wherewith the Globe of the Earth is fill'd
3. The use of Most animalls, vegetables and mineralls
4. The origins of man and animalls
5. Of animalls eating one another
6. Of the paines and evills which animalls suffer
7. Of generation by the way of male & female
8. Of the different ages & gestation of animalls
9. Of germination in animalls, vegetables & c."[31]

The study of natural theology in the Academies culminated with human anatomy studies, dealing with the most perfect "design" of the

Creator; this subject was also part of the preparatory medical studies undertaken at a few Academies. A number of the topics embraced by the term "physical science" as now understood were covered by "natural philosophy": theories of matter, the elements, astronomy, optics, statics, hydraulics and navigation.[32] Towards the end of the period a subject just recognisable as modern chemistry began to appear. Experiment occasionally featured in the teaching at the Academies and an indication of the experiments undertaken can be gained from references to the type of equipment available at the Academies. The study of natural philosophy could raise difficult theological issues, for example where observation did not accord with the received Biblical texts, or where the existence of animals or plants poisonous to man posed serious questions about God's benevolence.

It has been argued[33] that a relationship existed betwen Puritanism and scientific development, in that Puritanism encouraged an atmosphere of independent thought which in scientific matters led the student away from received opinion and towards greater reliance on observation from the primary source of nature. Thus, the teaching of science was potentially an arena of intellectual conflict. An examination of the Academies' attitudes to the study and teaching of science is therefore especially important in the assessment of the institutions as a whole.

The American scholar, Robert Schofield in The Lunar Society of Birmingham (1963) has put forward his view on the importance of the Academies with regard to science:

> "Dissenting Academies made up for their lack of prestige and refinement by the practicality of their curricula. They

> provided, for the first time in England, formal instruction in modern languages, in modern history, in practical commercial arithmetic, and most significantly in the new experimental science."[34]

Three specific claims on behalf of the Academies are made by Ashley Smith in The Birth of Modern Education[35] with regard to science: first, that they pioneered the "experimental" approach; second, that the Academies' general attitude and reasons for teaching the subject reflected a desire to find order and design in the universe; and third, that the teaching was up to date.

This thesis attempts to examine and reassess the role of the Academies. Evidence will be considered through four specific questions which will lead to a new assessment of the science teaching within the Academies:

a) how far was the teaching of science typical of the curricula of the Academies as a whole?

b) what were the reasons for teaching the subject?

c) how far did the actual material taught keep up to date with current trends and discoveries in science?

d) what form (theoretical, experimental) did the teaching take?

It is relatively easy to compile a list of all known Dissenting Academies, for many early listings exist, one example being the geographical listing compiled by Joseph Hill the Deputy Treasurer of Manchester Academy.[36] However some of these listings are incomplete and identification is not entirely straightforward as institutions are often referred to by the name of their principal tutor and not location. The institutions were of a transitory nature, few having a life extending beyond ten to fifteen years. The listings also provide numbers of students but these are rather unreliable when compared with other sources. Lists of students' names for individual Academies, sometimes with some biographical details, appeared in early 19th century issues of Monthly Repository[37] or the later Transactions of the Congregational Historical Society.[38] These have proved helpful in tracing students who undertook medical or scientific careers. A listing of tutors' names was published in the Congregational Yearbook 1851. A few Academies (for example Warrington, Attercliffe) have been the subject of monographs, some of which have student or tutor listings appended. A summary of information from these listings appears at Appendices 2.1, 3.1 and 6.1. The minutes and prospectuses which survive have also proved important sources for information on chosen texts, equipment and more broadly the aims of particular institutions.

In some instances records may have survived because the Academy or a group of Academies formed the antecedent of a 19th century theological college. In cases where well-known dissenters were associated with an Academy, (for example Priestley's connection with Hackney, Warrington and Northampton/Daventry, or Doddridge's with Northampton) additional information is also available from sources relating to the particular individual.

The importance accorded to scientific subjects in individual Academies can be judged by various means. A very important indicator is the choice of texts for study. Booklists, or student or tutor references to books read at the Academies occur in diaries, autobiographical memoirs, minutes, letters. However, it has sometimes been difficult to identify the precise text, as full references are uncommon; often the author's surname only or a "popular" title was given. Wherever possible these have been identified and the text examined.

Much of the published output of the tutors was theological in nature, mainly sermons on scriptural texts, but occasionally some touched upon aspects of the physical universe or the "argument from design". A few tutors prepared their own teaching material for scientific subjects, some of which was published but in other cases such material survives in manuscript form. These have been critically examined as have surviving student notes of their tutors' lectures. The latter present a special problem: Academy students were taught shorthand (one of the many systems then current), and the notebooks have remained untranscribed. However, in the instances where these exist, the majority contain phrases, proper names and dates which are written in longhand, and it has been possible to construct a summary of the content of these lectures by careful study. References to items of equipment have enabled an estimate to be made of the type and in some instances, the extent of experimental work carried out.

Another important indicator is the number of students from an individual institution who proceeded to a medical or scientific career, or the number of tutors whose scientific interests led them to publish scientific papers or books, or become members of a philosophical society. As far as possible these have been traced and listed in the Appendices.

In this thesis the Academies have been grouped in chronological bands (1662-1700, 1701-1750 and 1751-1800) without any assumption that the members of the groups have any particular factors in common, or that they form a continuous chain of development.[39] Within these time bands, the Academies have been subdivided into

a) those which taught science, and

b) those where the subject was unlikely, or known not to have been taught.

The availability of material played an important part in the decision upon which Academies this thesis should concentrate. The four chosen for an in depth study are:

Daventry/Northampton	fl.1730-1798
Moorfields/Stepney/Hoxton	fl.1701-1784
Warrington	fl.1757-1784
Hackney	fl.1786-1799

Some original material prepared by tutors for use in their scientific work is available for these Academies. For these four, the work of at least one tutor has been examined in depth, and the achievements and careers of the "scientific" or medical students of the institution summarised. The remainder of the Academies are given a more cursory examination, though it is possible in the majority of cases to reach a decision on what science (if any) was taught.

REFERENCES

1. A series of enactments between 1662 and 1689 which rendered practising dissenters liable to fines or imprisonment, and which strictly limited their legal, social and educational freedom. See references to Chapter 2.

2. A course of education which could only satisfactorily be studied after grammar school, or private coaching to equivalent standard.

3. An example of an Academy which imposed a religious test on entry is the Mile End/Hoxton 2 Academy, active from 1791. This institution, which was solely concerned with the training of ministers, required that entrants assented to Calvinistic articles, and that students renewed their declaration every six months.

4. Porter, R English Society in the 18th Century, (from The Pelican Social History of Britain Series), London, 1982, p.179

5. Ashton, T S, The Industrial Revolution 1760-1830, OPUS, first published 1948, reprint 1972, p.16

6. Ibid, p.16

7. Hill, C, Reformation to Industrial Revolution, (from The Pelican Economic History of Britain, 1530-1780, vol.2), first published 1967, reprinted 1975, London, p.194

8. Ibid, p.252. Bronowski is reported (by McLachlan, Joseph Priestley, Man of Science) to have made a similar statement relating to Priestley's discovery of oxygen.

9. Parker, I, Dissenting Academies in England, Cambridge, 1914, p.46

10. Ibid, p.45-46

11. O'Day, Rosemary, Education and Society 1500-1800, London, 1982. Other examples include Roderick and Stephens, Education and Industry in the 19th Century, 1978, p.83:

    "..in England, the nearest approach to higher education in the 18th century was to be found in the dissenting academies.."

    See also Simon, B, Studies in the History of Education 1780-1870, London 1960; Armytage, W H G, Four Hundred Years of English Education, Cambridge, 1970

12. Price, E J, "The Dissenting Academies: a neglected chapter in the history of education", TCHS, 1930, p.28-51

13. Ibid, p.38

14. Ibid, p.44

15. Hans, N New Trends in Education in the 18th Century, London 1951. Hans comments that his view of academies was generally supported by J. Thomas, MA Thesis, Dissenting Academies, London 1949, p.54

16. Calvinists accepted only the Bible as the rule of faith; believed in predestination, and denied the existence of free will, thus constructing a rigid intellectual framework which would not be conducive to general education. Other sects, Congregationalists, Arminians were more liberal in their outlook.

17. Hans, op cit, p.55

18. Merton, R K, "Puritanism, Pietism and Science", Sociological Review, o.s., 28, pt1, 1936

19. Merton, R K, "Puritanism, Pietism and Science", 1957 edition, (revised, originally printed in Merton, R K Social Theory and Social Structure, New York, 1957) reprinted Science and Religious Belief ed. C A Russell, 1973, p.47-9

20. Toulmin, Joshua (1740-1815) initially educated at St Paul's Academy from which he just escaped expulsion for his Arian and Socinian views. Later he opened own school in Taunton, though was forced to close this on account of his radical views. Awarded DD at Harvard in 1794. Published An Historial View of the State of the Protestant Dissenters in England, London, 1814

21. Sherrifhales, Taunton 1, Newington Green 1, Attercliffe, Islington 1, Sulby and Wickhambrook received detailed cover. Others less attention.

22. Toulmin, op cit, p.217

23. Toulmin quoted the Latin text of the Oaths which preclude graduates setting up as teachers of University learning. Tillotson is quoted as having recommended this as a way of dealing a blow to the Academies.

24. Toulmin, op cit, p.217

*25. Bogue, D and Bennett, J, History of the Dissenters from the Revolution to the year 1808, 4 vols, London 1808-12.

26. Ibid, p.270, III

27. Ibid, p.271, III

28. Williams, W S, Memoir of the Life of E Williams, p.153

29. Bogue and Bennett, op cit, p.299

30. McLachlan, op cit, p.32

31. Mss of William Petty, in The Petty Papers, ed. Marquis of Lansdowne, 1927. Quoted Jennings, H (ed) Pandaemonium, ed. Jennings M and Madge, C, 1st edition, London 1985

32. Optics, statics, hydrostatics, navigation were often found in the mathematical curriculum. No clear cut divisions existed.

33. Merton, R K, "Science, Technology and Society in the 17th Century", Osiris, 4, 1938, p.360-632

34. Schofield, R E, The Lunar Society of Birmingham, Oxford, 1963, p.11. Others who have made similar comments are:
Mineka, F E, The Dissidence of Dissent (history of The Monthly Repository), 1944, p.12

    "In the Dissenting Academies at home, the emphasis upon natural science and upon the sufficiency of the Scriptures in the elucidation of Christian doctrine, led to the progress of independent, free inquiry".

    Hoppen, K T, The Common Scientist in the 17th century, London, 1970 p.54

    "After the conformity legislation of 1662 many of the best teachers were drained away from the old grammar schools into the new Dissenting Academies, some of which offered a sound grounding in natural philosophy."

35. Ashley Smith, op cit, p.246 et seq.

36. Odgers Papers, Dr Williams' Library, London

37. Monthly Repository, vols 8-10, 1813-15, contain the Warrington Academy student listing.

38. TCHS, vols 2-6 contain student listings for most academies.

39. Parker chose to group the Academies chronologically, but assumed some relationship or similarity in terms of size or government structure across each group, and a progression from simple to complex down the years. Ashley Smith's system of classification is based on the tutors' own places of education, and subdivided further into the sect (eg Congregational, Baptist) with which the Academy was most closely related. This is a more logical and rewarding system than Parker's but it is cumbersome and unnecessary for this thesis.

CHAPTER 2: ACADEMIES 1662-1700

The Dissenting Academies were founded following a series of Parliamentary Acts, collectively known as the "Clarendon Code",[1] which prevented dissenters from taking an active part in government and from participating in their own forms of worship; many social and legal rights were limited, including access to university education. An early enactment in this sequence, the 1662 Act of Uniformity, required that:

> "Every Schoolmaster keeping any public or private school and every person instructing or teaching any youth in any house or private family as a tutor or Schoolmaster .. should subscribe the declaration or acknowledgement following ...
>
> "I .. do declare .. that I will conform to the liturgy of the Church of England, as it is now by law established; and I do declare that I do hold .. from the oath common called, the solemn league and covenant, to endeavour any change or alteration of government either in church or state, and that the same was in itself an unlawful oath, and imposed upon the subjects of this realm against the known laws and liberties of this kingdom." "[2]

St Bartholomew's Day (24th August 1662) was the appointed date by which Dissenters had to agree or forego their livings. By 1662, 1760 ministers were "ejected" in the English counties,[3] of whom only 100 had means of their own in the form of private estates or money. The majority had been educated at Oxford or Cambridge.

In 1664 the First Conventicle Act[4] forbade the meeting together of more than five people for worship except in accordance with Church of England liturgy. This Act expired after the fall from power of Lord Clarendon, the then Lord Chancellor and chief architect of the Test Acts. However, a second Conventicle Act was passed in 1670 which covered similar ground to the first.[5] But there were some significant differences; the fines for worshippers were reduced but those imposed on ministers were raised. Magistrates who were reluctant to prosecute could themselves be heavily fined and "informers" received up to one-third of the fines collected. This Act therefore represented a serious attempt to silence the leaders of the Dissenting movement. The passing of the Five Mile Act[6] prevented Dissenters from living in or near to boroughs which elected members of Parliament. This Act had a continuous effect on the early Academies: the persecution of Richard Frankland ensured that the Rathmell Academy regularly moved its premises. In later years, Matthew Warren of the Taunton and John Shuttlewood of the Sulby Academy were also subject to harrassment under this Act.

The Dissenters' situation was temporarily eased by the issue of a Declaration of Indulgence at the instigation of Charles II in March 1672; as a result "all manner of penal laws in matters ecclesiastical" were suspended. For a short time Dissenters were able to meet freely for worship provided they had a licence for their meeting place and for their preacher. Unfortunately for the Dissenters, Charles' need for financial support forced him to succumb to pressure to withdraw the Indulgence in 1673.

A renewed outbreak of persecution followed the 1673 Test Act[7] which effectively debarred all Dissenters from public office though not from parliament.[8] The Act imposed the sacramental test, and those who failed to meet the requirements suffered severe penalties, financial, civil and personal. Prosecutions of Dissenters under the Acts in force increased in 1675 following a command issued by Order in Council, but the worst phase was to occur in the period leading to the accession of James II in 1688.

Dissenters appear to have remained hopeful throughout the 1660s, despite persecution, that the restriction on entry to the universities might be removed. Samuel Wesley, for example, stated that Charles Morton of the Newington Green Academy advised students to enter their names at the university but attend the Academy for the time being.[9]

The first breakthrough for Dissenters was the passing of the Toleration Act of 1689[10] which allowed carefully defined groups of Dissenters to be exempt from certain of the Test Acts. The universities, however, remained closed to them and no further improvements in their situation were gained for the rest of the century.

At this point, one modern writer comments, ended the heroic age of Dissent.[11] Yet another sums up the situation cynically as follows:

> "Dissenters faced the dilemma of being neither persecuted nor privileged. The letter of the Corporation Acts disqualified them from the trophies of office: yet in the absence of persecution Old Dissent lost zeal and minded its own business and grandchildren of revolutionary Puritans became quietist, inward-looking, and even lukewarm, as worldly in their own prim way as Anglicans."[12]

The first Dissenting Academies, Coventry, Sherrifhales, and

Shrewsbury, were founded in 1663 by ejected ministers. By 1700 some 28 Academies (details summarised in Appendix 2.1) had been founded; most had comparatively short lives, no more than 10-12 years. Of these 28 early Academies, there exists some evidence that scientific subjects were taught in about half of them:

Attercliffe
Bethnal Green/Highgate
Bridgewater
Nettlebed
Newington Green 1 [13]
Newington Green 2
Nottingham
Rathmell
Sherrifhales
Shrewsbury
Stourbridge/Bromsgrove
Taunton 1
Tubney
Wickhambrook

For the following six, detailed evidence exists, chiefly in the form of booklists, tutors' own works, and contemporary comment, enabling an assessment of the teaching of natural philosophy at these Academies:

Bethnal Green/Highgate
Newington Green 1
Newington Green 2
Rathmell
Sherrifhales
Shrewsbury

Much of this chapter is devoted to a discussion of the choice of texts (see Table 2.1) used in scientific subjects by the tutors of these Academies, together with any teaching materials they themselves devised. Methods of teaching, whether experimental or other are also considered.

The tutors of these six Academies chose widely for their natural philosophy and astronomy texts: most authors selected were broadly

TABLE 2.1

Summary of Texts
Academies, 1662-1700, discussed in Chapter 2

Academy	Authors listed (with Texts where known) for science[1]	Comments
Bethnal Green/Highgate	Le Clerc (Cartesian) (compared with Scholastics and other disciples of Descartes	For logic, Heereboord was main text but compared with Derodon and Smiglecius
Newington Green 1	de la Forge Traite de l'Esprit de l'homme (Cartesian)	
Newington Green 2	Morton, System of Physick	
Rathmell	Heereboord, Meletema Gassendi Suicer, Compendium (Scholastic/Cartesian)	Descartes read in general philosophy
Sherrifhales	Magirus (Scholastic) Descartes Principia Rhegius Fundamenta Physices (Cartesian, but with reservations) Heereboord (Cartesian) "de Staire" [de Stier] (eclectic) Rohault (Cartesian) "Clarke's Rohault" (Cartesian text with comment by an early Newtonian)	Gassendi read in mathematics
Shrewsbury	Le Clerc (Cartesian) Du Hamel (Cartesian) Gassendi Tallents, The View of Universal History	

[1] Excluding anatomy

Cartesian, but occasionally a Scholastic writer is listed. Scholastic authors however tended to predominate in logic and "philosophy" (as distinct from natural philosophy). At Rathmell,[14] according to R Tetlaw, who left a brief account of his studies there, Descartes' works were read in general philosophy. At Sherrifhales[15] Toulmin listed Descartes' "Principia" (Principia Philosophiae, 1644) as one of the natural philosophy texts. From the Principia Sherrifhales students gained a full account of Descartes' metaphysical and scientific theories, excluding the study of living creatures. Following Aristotle, the Scholastics had visualised and described the world in organic terms. Mind and matter, body and spirit were not considered separate parts, but every body was believed to absorb some characteristics of spirit or mind via an "active principle". Descartes on the other hand, divorced mind from matter and introduced the concept of dualism where body and spirit existed as separate entities. Sensory evidence was also rejected as the supreme test of actuality. God's role in the universe was reduced to that of creator only. For the more perceptive student, Descartes' works raised difficult theological questions, when contrasted with the evidence of revealed religion in the form of Biblical texts.

The philosophy of Descartes was popularised by a number of authors, some of whom modified or added to the original their own interpretations. Many such authors featured in Academy booklists: Rohault, Le Clerc, Du Hamel, Rhegius and Heereboord. In most instances no text was quoted, only the author's name listed. "Rohault" was read at Sherrifhales, but no specific work cited. The probable choice would have been Traité de Physique, first published in France in 1671, which was an introductory text on the Cartesian universe. Jacques Rohault (1620-1675) was a mathematics tutor in Paris who later turned to teaching Cartesian physics; the Traité was popular and covered most of the issues under discussion by Descartes' followers, but Rohault reported these theories rather than develop them further. This text was also in use at Rathmell alongside, later, the important edition of 1694 which contained a commentary by Samuel Clarke, an early disciple of Newton, in which he put forward his earliest Newtonian criticisms of Cartesian philosophy. An earlier Cartesian work Fundamenta Physices by Rhegius[16] dating from 1646 was also read at Sherrifhales; this covered similar ground to Rohault and was published in many editions. However, it contained a challenge to Cartesian dualism as Rhegius proposed a closer link between body and soul than Descartes had allowed. This shift in emphasis may have made the text more acceptable on theological grounds, but among Descartes' continental followers it aroused considerable opposition, eventually costing Rhegius his chair at Utrecht, and his friendship with Descartes.

No specific work by Heereboord[17] is listed for study at Sherrifhales. Converted to Cartesian philosophy in 1643, he thereafter devoted his life to an attempt to reconcile Scholastic and Cartesian philosophies. He published two texts on natural philosophy Parallelismus Aristoteliscae et Cartesianae Philosophiae Naturalis(1643) and Meletemata Philosophica (1654). The Meletemata was very popular and extremely useful for students, as it summarised Scholastic and Cartesian viewpoints on every scientific topic. It was in use at Rathmell, and probably also at Sherrifhales.

The work of a later Cartesian populariser, Jean le Clerc[18] was read at Shrewsbury[19] and at Bethnal Green/Highgate.[20] Le Clerc opposed some aspects of Descartes' philosophy, particularly in relation to God's role. No particular text was cited at either Academy[21] but an examination of a complete list of titles of Le Clerc's works, suggests that the most likely choices were either Opera Philosophiae, a four volume digest of the author's works published in 1697 or Physica sive de rebus corporeis Libri V. in quibus praemissis potissimis Corporearum Naturarum Phaenomenis ac proprietatibus veterum & Recentiorum de eorum Causis celeberrimae conjecturae traduntur,(1695) which dealt with the old and new philosophies in relation to the corporeal world. James Owen[22] at Shrewsbury introduced the work of Jean-Baptiste Du Hamel (1625-1706), a mathematician, philosopher and theologian to his students. Interested in chemistry and physics, Du Hamel was a prolific writer, publishing works on meteors, fossils, the history of the French scientific institutions, and several textbooks on the Scholastic and Cartesian philosophies which he seems to have attempted to synthesise. Owen probably chose one of the syntheses, for example, Philosophiae vetus et nova ad usum scholae accommodata in Regian Burgundia (1687) an edition of which was published in England.

Louis de la Forge's work Traitē de l'Esprit de l'Homme (1666) was read at Newington Green 1.[23] Another Cartesian, de la Forge concentrated on the relationship between body and soul for which he proposed a mutual interdependence in which the pineal gland played a central role in the exchange of sensations. His work contained nothing inimical to Cartesian philosophy.

At Rathmell and Shrewsbury, the works of Pierre Gassendi[24] were listed among the works read for astronomy. Gassendi offered an alternative theory of matter to that of Descartes, which was based on classical Greek theories of atomism. Where Descartes had argued that matter was infinitely divisible, Gassendi proposed that there existed units of matter which were indivisible. Gassendi rejected Descartes' notion of a plenum, favouring the existence of voids, totally empty of matter, an idea derived from the atomism of Democritus. Gassendi was led to propose a more prominent role for God in the universe; God alone could know the ultimate truths, while man could at best observe and describe phenomena. It is impossible to be certain which of his works was chosen, but a probable choice for Rathmell and Shrewsbury would be Gassendi's major work <u>Syntagma Philosophicum</u> (1653) which contained a lengthy if convoluted dissertation on all aspects of science - the universe, matter, astronomy, geography, living creatures. It represents a compendium of contemporary thought on each topic: but contradictory theories were put forward on selected issues with no attempt to reconcile the differences. The <u>Syntagma</u> was of lasting influence, despite its drawbacks, for its dissemination of Gassendi's corpuscular theory, which coloured English scientific thought through Robert Boyle, and much later, the continental theories of matter through Roger Boscovich. For astronomy, the portion of <u>Syntagma</u> headed "De Rebus Caelestibus", where the substance and structure of the sky and stars, types of star, their position, motion and light properties, comets, new stars, and astrology were discussed would have been of particular relevance. Gassendi was also read at Sherrifhales, but here was listed among the mathematical authors.

The works of "de Staire" (sic) were read at Sherrifhales. This name appears to be a corruption of "de Stier", a Scottish philosopher active in the 1680s. Stier took neither a Gassendian nor a Cartesian view wholly, and used a variety of sources ancient and modern, producing an eclectic philosophy of his own. Again no title is suggested, but the following text dealt with scientific matters and might have been chosen: Physiologia nova experimentalis in qua generales notiones Aristotelis, Epicuri et Cartesii supplentur enores deterguntur et emendatur atque clarae distinctae et speciales causae praecipuorum experimenntorum aliorumque phaenomenon naturalium aperientur ex evidentibus principiis quae nemo antea perspexit et prosecutis est.

A very basic text which appears to have offered a question and answer guide to the Scholastic and Cartesian theories is J H Suiceri's Compendium Physicae Aristotelico-Cartesianae methodo erotematica adornatum cui praefigiture theoreticae theatrum, published in Amsterdam in 1685. Used at Rathmell, the book's 455 questions covered general principles of physics and the properties of matter answered in Scholastic and Cartesian terms, with occasional reference to Gassendi's works.

One scholastic text is mentioned in use for natural philosophy, at the Sherrifhales Academy: Johannes Magirus'[25] Physiologiae Peripateticae, of 1597, which gave a thorough introduction to Aristotelian philosophy; Magirus rejected Copernican cosmology on scriptural grounds.

Anatomy was studied at Sherrifhales which listed three specialist texts. Bartholine's Anatomica Reformata (1619-20) was an early, well illustrated textbook dealing with each section of the human body including an extensive treatment of reproductive mechanisms. Blancardi's (Stephen Blanckaert) Anatomica practica (1688) was a medical pocketbook which described symptoms and provided an explanation of why they arose and seems to have been designed as a medical man's "crib" to help in the diagnosis of his patients' conditions. A text by Thomas Gibson (1647-1722) was also specified, and was probably The Anatomy of Humane Bodies Epitomised, published in 1682. Intended by the author as an introductory text, this was divided into "books" on different parts of the body, with chapters which dealt with individual organs in greater detail. Diagrams were included, as were many references. Gibson's and Blancardi's texts together would have provided grounding for intending medical students. Surviving records however suggest that Sherrifhales did not produce a large number of medical practitioners.

In two of the six Academies listed on page 20 (Newington Green 2 and Shrewsbury) tutors prepared their own material for specific subjects. The most comprehensive and notable in science is the work of Charles Morton[26] of Newington Green 2.[27] Morton gained a reputation as a mathematician of excellence and at Oxford had been "much esteemed by Dr. Wilkins, the head of his College".[28] He was personally interested in the practical uses of science and published a paper in Phil Trans[29] on the use of sea sand as fertilizer. Morton later took his teaching text, A System of Physicks or Naal [Natural] Philosophy by CM,[30] to New England whence he emigrated in 1685 to take up an appointment at Harvard College.[31] Morton's text was not available, as far as can be ascertained, in printed form in this country but a set of notes taken by a student, Joseph Hill, in 1684 has survived. The lectures covered matter, terrestrial phenomena, and living creatures, and were given in English, an early departure from the traditional language of instruction, Latin. Morton's view of the physical world was rooted in Aristotelian philosophy but he mentioned the new ideas of Descartes and Boyle where appropriate. The composition and structure of matter was explained by the Two Principles (sulphur and mercury) and the Four Elements (fire, air, water and earth):

> "Metall (they say) is a perfect mixt body generated in the veins of the Earth out of Sulphur (   ) [sic] and Quicksilver (☿) by virtue of the Heavens and Elements ... Gold, whose Chymical name is Sol and marked (☉) is said to be of the most pure and best prepared materials ... it has many attributes transcending other metalls."[32]

There are indications here of alchemical ideas, in the relationship of metals and heavenly bodies, as well as the more obvious use of alchemical symbols, but elsewhere in the work Morton gave short shrift to the central idea of alchemy, the transmutation of metals. A variety of terrestrial phenomena are covered, (including earthquakes, rain, wind) which were classified as different types of meteor, an idea derived from Aristotelian physics. Morton thought that heavenly bodies could not only influence the weather but also indirectly man by affecting the body and thus promoting or hindering the operations of the mind. Astrology, however, was considered an abuse of knowledge, probably because it dealt with prediction rather than scientific observation. Morton's discussion of the living world was quite extensive, almost one-half of the notes being devoted to the subject. A lengthy description of the circulation of the blood is included. Morton also covered commonsense, memory, "fancy", and moral judgement as if these were extensions of the physical senses. Morton's lectures were rounded off by a short chapter confirming the need for God as creator, and rejecting the Epicurean idea that all the wonders described in the lectures could have occurred as the result of chance. As an appendix, Morton's summary of John Wallis's theory concerning the ebb and flow of the sea as expressed in his letter of 25 April 1666, published in Phil Trans was attached. As two other identical versions of this text exist[33] it would appear that Morton's method of teaching involved the dictation of these notes to students.

Although not itself a scientific text, The View of Universal History (1681) by Francis Tallents,[34] principal and founder of the Shrewsbury Academy reveals that Tallents was fully aware of current developments in the scientific world. The View is a beautifully prepared set of tables summarising in English, world history from earliest times to c.1680. Religious history received the most extensive treatment as the work set out to systematise the subject, but under "miscellanies" scientific knowledge is included. The invention of logarithms by Napier, telescopes ("found by" Iac. Metius of Holland), Harvey's discovery of the circulation of the blood, astronomical discoveries of Galileo, Kepler and Cassini, Descartes' philosophy, and Boyle's various experiments are all recorded. The founding of the Royal Society also receives mention. It is brought up to date by references to Burnet's Telluris Theoria Sacra (published in 1681) and a reference to Nehemiah Grew's forthcoming work The Anatomy of Plants (published 1682). The View was well known amongst Tallents' contemporaries, for example, to Philip Henry, tutor of Broad Oak, and even some 50 years later it was recommended by Philip Doddridge of Northampton Academy.

In logic, Scholastic texts (by Smiglecius, Suarez, Burgersdyck, Fromenius[35]) were generally used but the predominant line of thought in natural philosophy was Cartesian. This posed particular difficulties for theologians, with the implication of a mechanistic universe in which God had a strictly limited place. In addition to Descartes' own works, these six Academies used a selection of commentaries which blurred, modified or challenged various issues in the original philosophy in an attempt to meet religious objections. Gassendi's works, in which he attempted to bring about a synthesis of scientific observation, atomism and religious belief as contained in scriptural text were also popular. At Sherrifhales, students studied the scholastic (Burgersdyck) in logic, Descartes and the scholastic Magirus in philosophy and Gassendi in mathematics, thus being presented with a bewildering array of contradictory theories. Other Academy students almost certainly faced a similarly confusing selection.

As a method of teaching, "discussion", whether a debate between tutors before students or between students themselves, may have helped to bring some order in this plethora of ideas. It is known that at Rathmell this technique was adopted for some subjects;[36] in logic, for example, one tutor took the Aristotelian viewpoint another the Ramist (Peter Ramus, the French humanist (1515-1572) stressed the importance of deduction in scientific method). In natural philosophy, one tutor might have taken the Scholastic view while another countered with the Cartesian view of the universe. In two Academies (Bethnal Green/Highgate and Newington Green 1) students were left free to make up their own minds which philosophy, Scholastic, Cartesian or Gassendian, they wished to adopt. At Newington Green 1, Thomas Rowe[37] dispensed with "traditional" texts and introduced students to a "free philosophy".[38] This was evidently the study of different interpretations of Cartesianism, and later the views of the English philosopher, John Locke (1632-1704) who placed strong emphasis on empiricism. No pressure was brought to bear on students to adopt a particular philosophy. At Bethnal Green/Highgate students disputed the merits of the different systems themselves.[39]

The extent and level of practical teaching is difficult to judge on the evidence available. Two Academies (Sherrifhales, Newington Green 2) possessed equipment, which was used for practical demonstrations. According to the early historian of dissent, Joshua Toulmin, at Sherrifhales

> "All the students were obliged to read in natural theology ... Practical exercises accompanied the course of lectures, nd the students were employed, at times in surveying land, composing almanacks, making sundials of different constructions and dissecting animals ...."[40]

Although no other reference has been traced concerning the existence of equipment at the Academy, it is probable that Sherrifhales surveying equipment contained a Gunter's chain, Gunter's quadrant, a sector and compass. For dissection of animals, a selection of basic surgical instruments may have been used. As Moxon[41] was one of the authors read in mathematics at this Academy, some of the cheap globes he supplied along with instruction booklets may also have been available to students. Gunter's[42] works were also recommended in mathematics, one of the works being a reference book on the practice of surveying. At Newington Green 2 a contemporary writer remarked

> "This Academy was indeed the most considerable having annext a fine Garden, Bowling Green, Fish Pond and within a Laboratory and some not inconsiderable rarities with an air pump, thermometers and all sorts of mathematical instruments."[43]

Experimental work was not mentioned, but the air pump could have been used to copy Robert Boyle's experiments described in the Phil Trans and in Boyle's own New Experiments Physico-Mechanical, Touching the Spring of the Air (first edition, 1660): Morton's earlier contact with Boyle at Oxford makes such a departure a possibility. Mathematical instruments are difficult to identify but may have included measuring devices (such as Gunter's Chain) and Napier's Bones for calculation. The thermometer would have been either an "air and water" type or an alcohol-filled, sealed instrument. There are no records of equipment at other early Academies. Despite the description of the facilities at Newington Green 2 above, another ex-student and contemporary commentator Samuel Palmer acknowledged that facilities for the teaching of natural philosophy at the English Universities were superior to those available at Academies.[44]

Theophilus Gale, the first principal of Newington Green 1 did not denigrate the value of experimental work:

> "Experientia, quae utcunq sit aliquando minus certa non minima tamen species est Philosophiae. Dignitas Philosophiae Experimentalis ex ejus Qualitate & Natura demonstratur ... ejus ideae sunt magis congeneres est naturelles."[45]

> (While experimental knowledge may sometimes be less accurate it is not however of the least value. The worth of experimental philosophy is shown in its quality and nature ... its ideas are more logical and natural.)

> "Brevitur, ut in mundo visibili, sive libro Naturae, tot sunt visibiles characteres divinitas, ut quilibet occulatus possit Deitatem illic contemplari ..."[46]

> (In short, in considering the visible world with the book of nature, all divine characteristics are visible, while even though hidden anybody may contemplate the Divinity therein.)

The value of scientific experiment and observation was rooted in their ability to reveal divine workings within the physical world. But when the results of experiment and observation ran counter to the Biblical text, Gale was uncertain and unwilling to take a stand; the issue, he declared, must remain undecided.

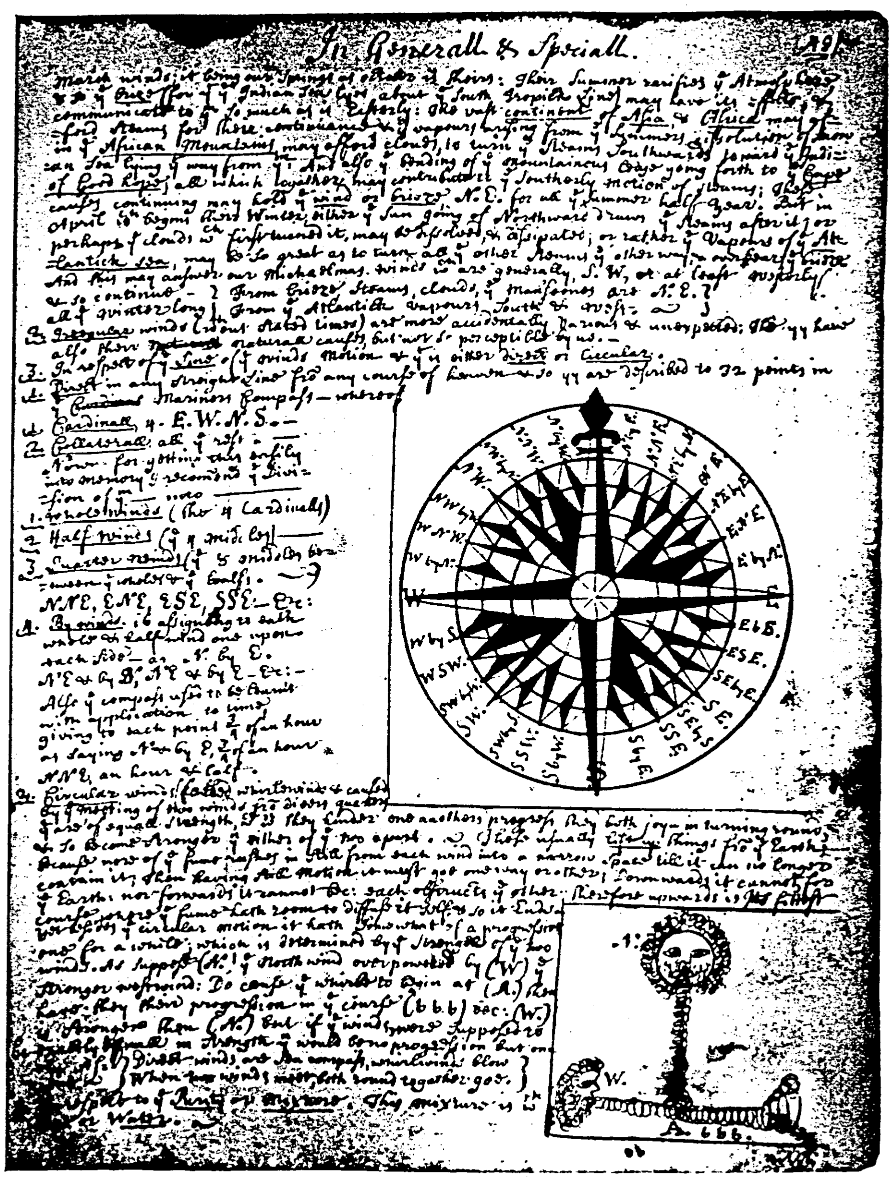
It seems probable therefore, that in those few Academies where equipment existed, some simple experimental work took place but for most Academies science was probably treated only theoretically.

The texts formally studied in these Academies (Bethnal Green/Highgate, Rathmell, Sherrifhales and Shrewsbury) were broadly comparable to those read at the English Universities. While an Oxford student in the late 1670s, Henry Fleming read the same works as students at Sherrifhales.[47] The Scholastic Magirus was read by Newton at Cambridge in the early 1660s.[48] A difference just becomes apparent from the late 1680s onwards, when the first informal discussion of Newtonian theory began at Cambridge, where Newton held the Lucasian Chair between 1669 and 1699. Bentley's Boyle lectures of 1692 drew heavily on Newton's work and encouraged discussion of the new philosophy. In the Academies, however the only clear hint of an interest in Newtonian science before the end of the century appears in the use of Clarke's edition of the Rohault text. Clarke's work, published 1694, incorporated his Newtonian critique of the Cartesian Rohault's view of the physical world.[49]

But confusion over the date of the introduction of Newtonian

FIGURE 2.1

Charles Morton's A System of Physicks or Natural Philosophy: this manuscript was entitled Compendium at Harvard. A sample page, which is very similar to the manuscript held at the Wellcome Institute is shown below.



From Morison, S E, Harvard in the Seventeenth Century philosophy into the early Academies has arisen. The casual reader of Ashley Smith's The Birth of Modern Education may be led to imagine that one Dissenting Academy (Newington Green 2) was among the earliest to adopt and teach the new philosophy. In connection with the scientific texts read at this Academy, Ashley Smith[50] quotes the authors "Newton and Khiel" cited in Daniel Defoe's The Compleat Gentleman.[51] Defoe, an ex-student of Newington Green Academy, published this work towards the end of his life in 1728/9. Defoe attacked the failings of the then educational system, and wrote of an ideal Academy for which he drew on his own experience and on the work of his tutor, Charles Morton, although unnamed. The tutor of the ideal Academy:

> "... set up his little Academy wherein he taught physicks, that is to say Natural Philosophy, with a system of Astronomy as a separate science, tho' not exclusive of the general system of nature; he taught also geography and the use of the globes in a separate or distinct class: in a word, he taught his pupils all the parts of academick learning, except Medicine and Surgery ... And all this he taught in English. He read his lectures upon every science in English, and gave his pupils draughts of the works of Khiel and Newton and others translated; also he requir'd all the exercises and performances of the gentlemen, his pupils, to be made in English."[52]

Morton left Newington Green for Harvard about 1685, which renders it impossible for "Khiel" (Keill's Introductio ad veram Physicam) first published in 1702 to have been used in his time. Similarly the first (Latin) edition of Newton's Principia was not published until 1687, too late for its ideas to have been used at Newington Green by Morton. Further, Morton's view of the universe as revealed in The System of Physicks... suggests that he did not closely follow developments in natural philosophy. It is unlikely that Francis Glasscock who carried on the Academy from 1685 until his death in

1706 introduced these texts, or taught from them, as his main interest lay in prophecy, particularly the books of Daniel and Revelations.[53] The other two tutors, William Wickens (d. 1699) and Stephen Lobb (d.1699) were not noted for any interest in natural philosophy.

From the evidence presented, it is possible to make a broad generalisation: if an Academy included science in the curriculum before 1700, then it was taught through a variety of conflicting and contrasting philosophies. Although the underlying philosophy was broadly Cartesian, some of the texts used introduced additions and adjustments by later Cartesian commentators, which modified and sometimes challenged the foundations of the original theory. Some Aristotelian/Scholastic ideas still survived, while other authors attempted a synthesis of old and new (Gassendi, de Stier). Scholastic authors predominated in logic, and their ideas on the physical universe would have been absorbed by students in the course of their study of this subject.

It would have proved immensely difficult for students to pick their way through this plethora of conflicting and contrasting ideas. Some tutors attempted their own synthesis (Cradock, Gale and Morton). Only the work of Charles Morton has survived, and here it can be seen that Morton's thinking was firmly rooted in Scholastic philosophy, introducing newer ideas where these seemed to explain particular phenomena more satisfactorily. It would seem that tutors also found the subject difficult to assimilate; in one extreme case, the tutor abdicated all responsibility, leaving students to decide for themselves which philosophy they wished to adopt. Similar texts were read at the Universities, and thus University students were also faced with a similar range of theories including, later, Newtonian philosophy which began to be discussed openly at Cambridge towards the end of the century. It can be stated with some degree of certainty that Newtonian science was not introduced into Academies before 1700. However in the Academies, a further influence on the study of scientific subjects can be detected: the statements on the physical world contained in the Biblical text. Divinity studies had a degree of importance in the Academies, because a strong vocational aim - the training of ministers - was always present. A close study of the Biblical text occupied a large proportion of the study time at Academies. Within the Biblical text were statements about the structure of the physical universe, and particularly God's role in it, which would inevitably have clashed with the mechanistic universe put forward by Descartes and his followers. The statements of Jollie, Cole and Flavell on the worthiness of scientific study in general may be seen as an indication that such tensions had been perceived.

Experimental work was undertaken at two Academies, but seems to have been directed towards practical skills (surveying) and of a rather basic level. Although much has been made of the facilities at Newington Green 2, Samuel Palmer's comment about the superior facilities at the Universities should be noted, as Palmer was by no means unsympathetic to the Academies.

For the following Academies, there is less evidence for the teaching of the subject but in each instance there is an indication that the subject was touched upon in the course of study:

Attercliffe
Bridgewater
Nettlebed
Nottingham
Stourbridge/Bromsgrove
Taunton 1
Tubney
Wickhambrook

There are very few references to printed texts for these Academies. At Taunton[54] the tutor, Mathew Warren, read both the Scholastic Burgersdyck and the Cartesian, David Derodon, who published works in the mid 1640s. Later in the mid-1690s Robert Darch, an assistant tutor, read Morton's System with the students. However, the Taunton students appear to have found their tutors' choice of texts somewhat outdated and unreflective of current thinking, for they turned to Le Clerc, a later Cartesian populariser, (already in use at Bethnal Green and Shrewsbury) and the works of Bishop Cumberland,[55] the anti-materialistic and anti-Hobbesian moral philosopher.

Reference to the teaching of "philosophy" occurs in connection with four of these Academies: Tubney, founded by Henry Langley[56] in 1668, Stourbridge/Bromsgrove founded by Henry Hickman[57] in 1665, Wickhambrook founded by Samuel Cradock[58] in the late 1670s and Nottingham founded by Edward Reynolds[59] c.1680, and continued by Thomas Hardy[60] until 1727. Although evidence is scanty, it may be speculated that the works of Descartes or his followers and some Scholastic texts were read in these Academies, and from which some knowledge of theories of the physical universe would have been gleaned. At Wickhambrook however, Samuel Cradock devised his own teaching materials, based on the works of a variety of authors:

"[Cradock] read upon systems that were of his own extracting out

> of a variety of writers, and all the young gentlemen with him were obliged to copy them out for their own use."[61]

The text of Cradock's work has unfortunately not survived.

The Bridgewater Academy was founded c1680 by John Moore the elder[62] and continued until 1747 with brief periods of closure, due to harrassment under the various acts limiting Dissenters' rights. Later, John Moore was assisted by his son John Moore the younger[63] who, it is claimed, acquired a reputation for scientific learning.[64] The possibility exists therefore that the study of natural philosophy was given a place in the curriculum from c1700. At two Academies, Nettlebed[65] and Attercliffe[66] a very different and more distrustful view of science is apparent. Thomas Cole[67] the founder of Nettlebed was clearly sceptical of the value of philosophy, and it seems unlikely that much science beyond the reading of a few classic texts was ever undertaken at the Academy:

> "I am ... persuading you from mingling vain philosophy and science, falsely so called, with the Mysteries of Faith, which are best understood in their own native simplicity as they are delivered to us in plain scripture language."[68]

The strength of Timothy Jollie,[69] the founder of Attercliffe, lay in the direction of religious studies and he

> "... forbad [his students] the Mathematicks, as tending to scepticism & infidelity, though many of them by stealth made a considerable progress in that branch of Literature"[70]

It was reported that "only the old philosophy of the schools was taught and that neither ably nor diligently".[71] This, and Jollie's reaction to mathematics suggests that Scholastic philosophy only was taught at Attercliffe. Mathematics in particular provided the evidence for a mechanistic universe, eliminating the necessity for a God with an active and continuous role. Mathematics did not require any reliance on God's existence, which in any case could not be proved by a theorem.

The available evidence indicates that Irene Parker's assertion in her work Dissenting Academies in England, that natural philosophy received some attention in all early Academies cannot be supported. Examination of the sparse surviving material indicates that it is unlikely that any teaching of scientific subjects took place at the following Academies:

Bedworth
Broad Oak
Coventry
Dartmouth
Exeter 1
Hungerford
Lincoln
Lyme Regis/Colyton
Ipswich
Islington 1
Islington 2
Penrith
Saffron Walden
Sulby
Wapping
Whitchurch

Some doubt has been expressed as to whether Philip Henry's institution at Broad Oak should be classified as an Academy at all.[72] From statements made by his son Matthew it appears that Philip Henry took in a few pupils in order to coach them for university entry. The records of a few such students have survived, and these continued their education either at a Dissenting Academy, or at a university. Philip Henry's diaries reveal that he had little interest in science beyond occasional medical matters or the husbandry of his own estates. There is no mention of instruction in scientific subjects within the Academy.

The Whitchurch Academy (c.1668-81) was founded by Philip Henry's friend, John Malden. It seems probable that this was a similar institution to Broad Oak where pupils (of whom only one has been traced) received an informal course of preparation before entry to another Academy or to university.

Bedworth,[73] Exeter 1,[74] Hungerford,[75] Ipswich,[76] Penrith,[77] and Saffron Walden[78] Academies were all institutions which prepared students for the ministry and unlikely to have taken any lay students. Lyme Regis/Colyton[79] however may have been open to both lay and ministerial students. No information about the curriculum at any of these Academies has been traced, and the name of only two students with any scientific connection has been discovered: Theophilus Lobb, MD, FRS, a medical practitioner whose education began at Saffron Walden, and was continued at Pinner Academy and Thomas Powell of Hungerford who is believed to have studied medicine at Leyden. Although the Sulby Academy[80] was described by Bogue and Bennett as "large and influential",[81] little information has survived. Its importance may be largely due to the fact that two other Academy founders (Julius Saunders of Bedworth, and Joshua Oldfield of Hoxton Square) spent some time there as students. One Sulby student, Thomas Emlyn, remarked on the lack of books available for study at this institution.[82] It is unlikely that any of these six Academies devoted much time (if any) to the teaching of scientific subjects.

The Coventry Academy was founded by John Bryan c.1663. Under its fourth principal, Joshua Oldfield this institution moved to Southwark, then Hoxton Square, London, some time after 1693, and before 1700. There does not appear to have been any interest in scientific subjects while the Academy remained at Coventry, but Oldfield may have introduced the subject. Oldfield is reported (in the Dictionary of National Biography) to have been a friend of Isaac Newton but as there is no mention of such a friendship in any other source on Newton consulted, including Westfall's comprehensive biography of Newton, Never at Rest, it seems unlikely that there was any significant relationship between the two men.[83] In An Essay Towards the Improvement of the Reason (1707), a scheme of learning but with no great emphasis on science, Oldfield made the earliest known reference to the possible teaching of Newtonian science in the Academies. As this work is dated 1707, and the Academy under Oldfield was active for many years after 1700, it will be considered in Chapter 3.

In the three Academies from this last group which were founded in the London area, it is unlikely that science was taught as no reference to the subject occurs in relation to any of them. They are: Islington 1, founded by Ralph Button,[84] Islington 2, founded by Thomas Doolittle[85] and Wapping founded by Edward Veal.[86] Islington 1 appears to have been similar to Philip Henry's institution at Broad Oak: mathematics may have been included as this subject was Button's particular interest.

The antithesis which Bogue and Bennett implied between the specific functions of Academies as institutions for the training of men for the dissenting ministry and as Academies offering a broad general education, including scientific subjects, can be seen developing during the first 40 years of the Academies' existence. Edward Reyner,[87] founder of the Lincoln Academy[88] valued education;

he warmly commended the study of scientific subjects, and left a full description of what he considered a reasonable course of learning for ministers in his Treatise of the Necessity of Humane Learning for a Gospel Preacher of 1663. In the Treatise Reyner recommended that the curriculum should include the following subjects: Languages, Rhetoric, Logic, Natural Philosophy, History, Chronology, Arithmetic, Geometry, Astronomy and Geography. Reyner suggested that natural philosophy was useful in two ways: firstly to understand the nature and function of all living creatures and plants, and non-living matter; secondly to understand their place within God's world:

> "To know the natures, properties, effects and operations of all sublunary creatures
>
> 1. of the form of the elements, as Fire, Air, Water and Earth
> 2. of Meteors in Air
> 3. of Minerals in the Earth
> 4. of all living creatures .....
>
> To make a fit application of the creatures ... to spiritual uses, as the Holy Ghost directs us in the scriptures; which have much philosophy in them; as Genesis, and other Books: and are full of Allusions to the Natures of all kinds of Creatures:
>
> of Beasts, as Lions, Wolves, Goats, Sheep, Lambs
> of Fowls, as Doves, Eagles, Ravens
> of creeping things, as Serpents, Worms, Ants
> of Gnats, Flies, Locusts, Caterpillars
>
> which we cannot make use of for ourselves, nor teach or unfold to others unless we have the knowledge hereof in some measure, which the study of Natural Philosophy may much help us to."[89]

Having considered these general uses, Reyner gave specific reasons why the subject was of value to ministers. An important reason, and first on Reyner's list was that knowledge of creatures is the knowledge of God within the creatures. Consideration of ends and means demonstrated the existence of an intelligent being, i.e. God. Reyner believed that Jesus's miracles were performed through a unique, exquisite knowledge of nature. Philosophy could make the minister "more fit and able to understand, discuss and determine some points of Divinity (though not without the assistance of God's spirit) especially those that have a physical term in them, as about the body of Christ." Biblical references were quoted to two purposes in the Treatise; firstly to show that man can learn "lessons" from Creatures, and that sound knowledge of animal natures and properties could only help man to appreciate the more such lessons; and secondly to show examples of the learning of the prophets in natural philosophy, thus leading to the conclusion that God himself was the fount of such knowledge.

Another theological reason offered by Reyner was that knowledge of Nature's creatures was within Adam before the Fall, when it became lost.[90] Reyner stated that this knowledge must now be recovered by observation, study and industry, Natural philosophy being a means towards this end. There was also a strictly useful application: the minister was expected to be a teacher within his community. To fulfil this role, he must be educated. Delightfully, Reyner also declared that natural philosophy was a very pleasant study, offering "much benefit, satisfaction and delight". Why, he asked, should not a minister partake of this?

Not all of the contemporary dissenting community agreed with Reyner's views on the subject, and he provided counter arguments to two main types of objection. The first objection emanated from the teachings of the apostle Paul whose warning to beware of those who might spoil the Christian with philosophy was often quoted verbatim from the Biblical text. Reyner interpreted Paul's words as an attack on what was vain and deceitful, not true philosophy - a word which, Reyner commented, has several interpretations. A second form of objection might be based on quotations from the "Ancients" particularly Tertullan: this criticism arose from the abuse of philosophy by heretics.

In relation to astronomy, Reyner believed this to be a "sublime part" of natural philosophy which was lost to humans at the fall of Adam. It was helpful because through it man could know

> "... the Nature, Light, Motions, Magnitudes, Influences, and Operations of the Celestial Bodies ... and how they serve (according to God's appointment) for signs and seasons, for days and years.
>
> [and] ... know the Ordinances of Heaven, the various motions and the marvellous and Unspeakable Order of the Heavenly Bodies, which they keep as constantly as if they walked by a Rule."[91]

It also helped man to understand such phenomena as eclipses: this was considered especially significant as only those with astronomical knowledge could demonstrate the miracle of the eclipse of the sun at the Crucifixion. Astronomy also helped in understanding the Jewish Calendar, which was important for dating Biblical events. The significance of so many astronomical references in the scriptures could be explained by the contemplation of the text "... the Heaven's declare the Glory of God". Arithmetic too was valuable in understanding and computing scriptural numbers and accounts, and for searching into the mysteries, for example the number of the Beast. Geometry helped with Biblical weights and measures, and generally the works of God, " who hath ordered all things in number, measure and weight".

Reyner generally set a high value on learning as a help in matters religious. "Religion flourished when learning abounded." In his closing comments he tried to cover all possible objections to learning, citing a long history (back to the Biblical prophets) for the establishment of universities and colleges; he affirmed that learning enabled man to discuss religion confidently and to be able to detect the false teacher and the false argument.

A more limited view of the need for education was put forward by John Flavell,[92] founder of the small Dartmouth Academy. Flavell denounced theoretical or philosophical study which did not base itself on a moral or religious framework. This view echoes that of Cole (Nettlebed) and Jollie (Attercliffe), who both expressed doubts about where the study of scientific or mathematical matters might lead. Flavell has, however, left a series of works, the most interesting from the point of view of science being <u>Husbandry Spiritualized</u> and <u>Navigation Spiritualized</u>. Unlike the considered, cultured opinions of Reyner, Flavell's views on education contain an anti-intellectual element:

> "And shall we spend our precious time in frivolous controversies, philosophical niceties, dry and barren scholastic notions?"
>
> "It should both amaze and grieve a pious mind, to see how some ingenious persons can sit with unwearied patience and pleasure, racking their brains upon some dry schools problem, or some nice mathematical point; whilst no reasons or persuasions can prevail with them to spend one serious hour in the search and study of their own hearts!"[93]

However, it is clear from his works that Flavell himself had considerable knowledge of the naural world. These works were popular for about a century and were known in other Academies. <u>Husbandry Spiritualized</u> is divided into brief chapters, each headed by a "proverb", for example:

"Corn-land must neither be too fat nor poor

The middle state suits best with Christian sure"[94]

This is followed by a brief factual description of some task associated with farming, the first chapter containing a list of various tasks the farmer might carry out:

> "... in his fields, dressing, plowing, sowing, harrowing, weeding or reaping; and sometimes in his barn, threshing or winnowing; sometimes in his orchard, planting, grafting or pruning his trees; and sometimes among his cattle..."[95]

Flavell's practical knowledge is immense; and his ability to describe clearly complex tasks is remarkable:

> "When the husbandman hath prepared his grafts in the season of the year, he carries them with the tools that are necessary for that work, to the tree or stock he intends to ingraft; and having cut off the top of the limb, in some straight smooth part, he cleaves it with his knife, or chisel a little beside the pith, knocks in his wedge, to keep it open: then having prepared the graft he carefully sets it into the cleft, joining the inner side of the barks of graft or stock together (there being the main current of the sap) then pulls out his wedge, binds both together (as in barking) and clays it up, to defend the tender graft and wounded stock from the injuries of sun and rain."[96]

Having thus carefully described a familiar task, Flavell went on to relate the task to religion, drawing a parallel between the farmer's or the husbandman's work, and God's work among men. Flavell's knowledge is of the kind based on experience and practice rather than on experiment. Although his observations of natural life were extensive his main concern in the two books is not the scientific but the spiritual, and he successfully drew together themes from Christian theology with the practicalities of daily life in the country.

Navigation Spiritualised is ordered in the same way, but here Flavell needed to rely more heavily on report than direct observations. Again he found belief in God's regular intervention in the workings of the universe:

> "It is a wonderful work of God to limit and bound such a vast and furious Creature as the Sea, which according to the judgement of many learned men is higher than the earth; and that it hath a propension to overflow it is evident, both form its nature and motion; were it not that the Great God had laid his law upon it. And this is a work wherein the Lord glories, and will be admired."[97]

> "The Waves of the Sea are sometimes raised by God's commission, to be Executioners of his Threatnings upon Sinners."[98]

Flavell also drafted a scheme of education[99] which was strongly Christian in character, the only place for science in such a scheme being where it could complement and support religious belief.

The English Universities clearly exerted a strong influence on some aspects of these earliest Academies. Apart from a similar range of texts, Latin appears to have been the teaching medium for at least part of the course at Sherrifhales, Rathmell and Newington Green 1 Academies. Latin exercises of the "Question and Answer" type were practised at Newington Green 1 and at Sherrifhales, where Frankland's "tables" were in the form of Latin questions. At Rathmell and Highgate candidates were examined by Latin thesis. The continued use of the language at this period is not surprising, for many of the texts studied were themselves in Latin, making it essential both in the Universities and the Academies. Another strong influence were the early Academy tutors; the majority of these tutors had received their education at one of the two English Universities and in setting up their own Academies appear to have drawn on their own experience of education as a model. In the one instance where a contemporary account of the curriculum exists (Bethnal Green/Highgate), the study of natural philosophy was placed in the final year of Academy study; this may have been a general pattern, for in later Academies it occurs towards the later rather than the earlier stages of study. Although the Academy course was shorter in years than the univesity MA course, the position of the subject in the curriculum is not dissimilar.

From Appendix 2.1 it can be seen that very few students pursued scientific or medical careers following their education at an Academy, and none of those who did can be recognised as having made a significant input to scientific knowledge. At their best, the Academies were roughly comparable to the Universities; by the end of the period (1700) even the most dynamic had fallen somewhat behind.

REFERENCES

1. A series of Acts, also known as the Test Acts, initiated by the then Lord Chancellor, Lord Clarendon, which limited the rights of the Dissenters following the Restoration of 1660. The main Acts were The Corporation Act (1661), the Act of Uniformity (1662), the First Conventicle Act (1664), the "Five Mile" Act (1665), the Second Conventicle Act (1670), the First Test Act (1673), and the Second Test Act (1678). Some Acts restricted legal rights, all sought to impose a religious test before certain offices or professions could be taken up, and applied penalties in case of default.

2. The Act of Uniformity (1662), 14 Charles II, Cap iv, 1662

3. Of the English counties, Devon,Yorks, Essex, Suffolk and London had the highest and Cumberland, Westmorland, Beds, Channel Islands and Hunts the lowest number of ejections.

4. The First Conventicle Act, 1664, 16 Charles II, Cap 4, 1664

5. The Second Conventicle Act, 1670, 22 Charles II, Cap 1

6. The Corporation Act No.2,17 Charles II, Cap 2, 1665

7. The Test Act no.1, 1673, 25 Charles II, Cap 11, 1673

8. In the early 1660s some 50-70 Presbyterian MPs sat in the Commons but by 1674 numbers had reduced to 15, with a further 10 MPs as potential supporters.

9. Wesley, S, A Letter from a Country Divine on the Education of the Dissenters in the private academies in several parts ofo this nation, 1704

10. The Toleration act, I Will. & Mar, Cap 18, 1689

11. Watts, M The Dissenters, Oxford 1978, p.261

12. Porter, R, English Society in the Eighteenth Century, p.195

13. In this thesis, where there is more than one Academy connected with a locality, each has been numbered 1,2,3 etc in chronological order to aid identification.

14. Rathmell was founded by Richard Frankland, c1665, the Academy was forced to move several times after Franklands persecution under various Clarendon Code Acts. Frankland (1630-98), DNB, educated at Cambridge may have been a marked man, as he had held an appointment at Cromwell's Durham College. During its lifetime, students totalled 303 (a complete list is given in Heywood's Autobiography, 1895 edition) of whom 110 became ministers the remainder entering trade of lay professions. Information of about texts comes from R Tetlaw, ex-student, reported Ashley-Smith op cit. On Frankland's death in 1698 the Academy closed and the remaining students went to John Chorlton at Manchester 1 or to Timothy Jollie at Attercliffe.

15. Sherrifhales Academy founded 1663 near Shifnal, Shropshire by John Woodhouse (1627-1700) fellow commoner of Trinity, Cambridge; ejected), open to both lay and ministerial students. A second tutor, the elderly Samuel Beresford (d.1698 also a Cambridge graduate (Queens), ejected) was appointed.

16. Rhegius, Henry (1598-1679), professor of philosophy, Utrecht.

17. Heereboord, Adrian, (1614-1659), professor of logic, Leyden

18. Jean le Clerc (1657-1736) French Protestant, living in Amsterdam (from 1683), a tutor at the Arminian College there; visited England and was strongly influenced by English intellectuals. An important agent in the transmission of English ideas to the Continent, through the medium of philosophical journals with which he was involved.

19. Shrewsbury/Oswestry Academy, founded c.1676-80 by Francis Tallents (1619-1708, educated Cambridge; ejected, sometime Vice-President of Magdalene College, Cambridge; said to have visited France in 1671-4 with John Hampden the Younger (see DNB and Gordon,Autobiographical Addresses, London, 1922, p.364)

20. Bethnal Green/Highgate Academy founded c.1680 by Thomas Brand (1635-91, educated Oxford; ejected; DNB). McLachlan decribed Brand as an "educational philanthropist" who ran many schemes including one for the occupational training of paupers, and therefore had little to do with the running of the Academy. (McLachlan, op cit, p.85-6). The tutor who is generally associated with the Highgate Academy is John Ker, who is known to have had scientific interests. Employed as a private tutor in Dublin before joining the Academy, Ker was in contact with the Dublin Philosophical Society and became involved in an an argument over the nature of lines of longitude. He left Bethnal Green Academy in the care of John Short, from 1692-7, to read medicine at Leyden.

21. Most of the information regarding Highgate/Bethnal Green emanates from an ex-student's (Samuel Palmer) response to Samuel Wesley's attack on Dissenting Academies, an acrimonious debate which occurred against the background of renewed repression of

dissenters, associated with the early years of Queen Anne's reign. For Shrewsbury, see DWL ms 25, dated c.1700.

22. Owen, James (1654-1706) educated at (Welsh) Brynllwarch Academy by Samuel Jones. Owen had been a schoolmaster in Oswestry.

23. Newington Green 1 was founded by Theophilus Gale in 1665. Gale (1628-1677/8) had been educated at Oxford where he became a Fellow. Ejected, became tutor to Lord Wharton's son, spending some time with them at the Protestant College at Caen in France. His works indicate that he read widely, consulting amongst scientific/ philosophic authors: Descartes, Gassendi, Boyle, DuHamel, and the earlier mathematician and astrologer, Cardan, Lydiat and Willis. Thomas Rowe continued the Academy after Gale; it moved to Clapham and Little Britain, closing on Rowe's death in 1705.
Reference to de la Forge occurs in the notebooks of Isaac Watts, dated 1691/2

24. Gassendi, Pierre (1592-1655) professor of philosophy at Aix from 1617, then professor of maths at College Royal, paris, from 1645. For information see Jones, H Pierre Gassendi 1592-1655, Canada, 1981. Note also a recent Ph.D thesis Makin, W "Gassendi's scientific work in its social and religious context", OU Ph.D thesis, 1987

25. Magirus, Johannes, Professor of Physics, Marburg, d.1596

26. Morton, Charles (1627-1698), educated Wadham, Oxford, later went to Harvard College, USA as Vice President. Ejected from Blisland, Cornwall. DNB. See Humphrey, D C "Colonial Colleges and English Dissenting Academies" History of Education Quarterly, XII, 2, Summer 1972

27. Newington Green 2 precise date of opening unknown, varies - 1665/6, 1662, 1675. Open to lay and ministerial pupils, no specialist courses devised to meet needs of particular professions. No particular emphasis on science studies as such.

28. Quoted McLachlan, op cit, p.76. See also Samuel Wesley, op cit, p 5

29. Morton, C Phil Trans
See also Toulmin, op cit, p.234

30. Taken down by "IH" (Joseph Hill), dated 12 December 1684. Ms 3635, Wellcome Institute.

31. See Humphrey, D C "Colonial Colleges and English Dissenting Academies: A Study in Transatlantic Culture" History of Education Quarterly, VIII, 2, Summer 1972 for a brief discussion of Morton's influence on New England education. See Guerlac, H Essays and Papers in the History of Modern Science, Baltimore 1977, p.269 for other references to the System ... and Mayow.

32. Morton, A System of Physicks or Naal Philosophy, (1684 ms edition) Chapter 18.

33. Held at the Wellcome Institute,London

34. Tallents, Francis (1619-1708), educated Cambridge; ejected from living in Shrewsbury; sometime Vice-President of Magdalene College, Camb. Said to have visited France in 1671-4 with John Hampden the younger (Gordon op cit, p.364) DNB. The View may have been prepared for these private pupils; Henry, M, Two Funeral Sermons.

35. Burgersdyck, F (1590-1636), educated Leyden, tutor at Saumur, then returned to Leyden as professor of logic

36. From James Clegg (1679-1755), a student at the Academy. See Kirke, H (ed) Diary and Autobiography of James Clegg

37. Rowe, Thomas (1657-1705) educated at Islington Academy by Doolittle, and Gale at Newington Green 1.

38. Gordon, A Addresses Biographical p.203-4, quoted McLachlan, op cit, p.51

39. Palmer, S A Defence of the Dissenters Education in their private academies, 1703, p.4

40. Toulmin, op cit, p.226-8

41. Moxon, Joseph (1627-?1700) FRS, an instrument maker. Mathematics made Easie (1679) an early mathematical dictionary in English was prescribed for maths at Sherrifhales. Moxon also published other "tutors" - in astronomy, navigation, but these were not mentioned in connection with Sherrifhales.

42. Gunter, Edmund (1581-1621) minister, later Gresham Professor of Astronomy (from 1619), believed to have invented the surveyor's table and chain, and to have devised a type of slide rule.

43. Wesley, S, A Letter from a Country Divine to his friend in London, concerning the education of the Dissenters, London, 1704, p.6

44. Palmer, S, A Vindication of the Learning, Loyalty, Morals and Most Christian Behaviour of the Dissenters towards the Church of England, 1705, p.25

45. Gale, Philosophia Generalis, London, 1676, p.763

46. Gale, Idea Theologicae., p24

47. Quoted by Parker, op cit, p.74

48. Westfall, R S Never at Rest, Cambridge, 1980, p.84

49. Clarke, S (1675-1729), English metaphysician and theologian.

50. Ashley Smith, op cit, Appendix A, p.273, suggests that Defoe's list of books was "probably used" at Morton's Academy.

51. Defoe, Daniel (1660-1731). Attended Newington Green 2 c.1674-79. DNB. The Compleate Gentleman, c. 1728/9. The "modern" editor, KD Bulbring of the 1890 edition ascribes this date from internal evidence, p x of the introductory essay.

52. Defoe, D, op cit, p.218-9

53. Ashley Smith, op cit, p.288

54. Taunton Academy was founded by Matthew Warren c.1665. The Academy continued well into the 1700s, see Chapter 3.

55. Cumberland, Richard (1632-1718), Bishop of Peterborough from 1691. Most noted work De Legibus naturae (1672) in which he maintained that the laws of nature were ethical and immutable, and emanated from the principle of "Universal Benevolence". Reference to such "closet" reading is made in Amory's preface to Grove's Posthumous Works, ed. Amory

56. Langley, Henry (1611-79) educated Oxford; MA; "intruded" Master of Pembroke, and canon of Christ Church. Ejected. According to the historian Edward Calamy's record, Langley left under a cloud, having been accused of removing plate and documents and failing to keep proper accounts. Langley was a friend of Hartlib, and took active interest in Comenius and in schemes for the reform of education. DNB.

57. Hickman, Henry, (d.1692), educated Oxford, BD, ejected, DNB. This Academy closed in 1675 when Hickman went to Leyden as a medical student, or according to Wilson, History and Antiquities of Dissenting Churches,1808, p.70, went as pastor to the English Church at Leyden.

58. Cradock, Samuel (1621-1706); educated Cambridge, BD, also MA Oxford, DNB

59. No details available, no entries in DNB, etc.

60. Hardy, Thomas, educated at Oswestry, conformed 1727.

61. Calamy, Life, I, p.132 quoted Toulmin, op cit, p.240, and Ashley Smith, op cit, p.41

62. Moore, John (1642-1717), educated at Oxford, did not graduate.

63. Moore, John, the younger (1673-1747) educated at Oxford, did not graduate.

64. Quoted by McLachlan, op cit, passim; no further information given.

65. Nettlebed Academy was founded by Thomas Cole in 1666, and closed on his removal to London in 1672.

66. Attercliffe Academy was founded by Timothy Jollie in 1690 initially to complement Frankland's institution at Rathmell, and on the closure of the latter, became its successor.

67. Cole, Thomas (?1627-94), ex-tutor at Christ Church, Oxford; Principal of St Mary's; ejected, was one of Locke's tutors. DNB.

68. Cole, T, Regeneration Scripturally Considered, London, 1845, p.92

69. Jollie, Timothy (1659-1714), educated at Rathmell, with Frankland.

70. DWL ms 6.31-3; cited J W Ashley Smith, op cit, p.109

71. CHEL, IX, p393; quoted Ashley Smith, op cit, p.110

72. TCHS, II, p.422-5; J W Ashley Smith, op cit, p.21

73. Bedworth: date of founding uncertain, but likely to be between 1680 and 1690, as the founder was educated at Sulby c1680-90.

74. Exeter 1, founded 1690 active till 1722. Founded by the Halletts at least one of whom was anti-deist; closed following religious controversy.

75. Founded by Benjamin Robinson (1666-1724), an ex-student of Sherrifhales.

76. Ipswich, c1688-1703; founded by John Langston (1640-1703/4); ejected; educated at Oxford but unknown if he graduated. DNB. Students transferred to Chauncy at Moorfields on Langston's death. From his publications, classics appear to have been his interest.

77. Penrith, active c1696-1700

78. Saffron Walden ?1690-96, founded by William Payn (Paine), no details

79. Lyme Regis/Colyton 1680-1716?; tutors were John Short and Mathew Towgood

80. Founded by John Shuttlewood, active c 1680-88. Shuttlewood (1631/2-1688/9) was educated at Cambridge, but did not graduate; ejected; frequently prosecuted under the Test Acts. DNB

81. Quoted McLachlan, op cit, p.14

82. Quoted McLachlan, op cit, p.43

83. The DNB indicates that the friendship originated in the 1700s, after Oldfield arrived in London.

84. Button, Ralph (d.1680) educated Oxford, fellow and tutor at Merton, 1642; later Professor of Geometry at Gresham. DNB. The Academy appears to have consisted of a few students coached at Button's house.

85. Doolittle, Thomas (?1630-1707) educated at Cambridge; ejected; DNB. Doolitle's Academy travelled around Wimbledon, Battersea, Clapham and Clerkenwell to avoid prosecution. Highly considered as a divine, Doolittle was not thought highly of for any breadth or depth of knowledge (Toulmin, op cit, p.38). He was assisted by Thomas Vincent (16334-1678) educated at Oxford, possibly later a tutor there.DNB

86. Veal, Edward (1632-1708) educated Oxford, MA, fellow of Trinity College, Dublin. DNB. The Academy was opened in 1670, but closed in 1680/1; Veal was harrassed by local magistrates under the provisions of the Test Acts.

87. Reyner, Edward (d.1663?) educated at Cambridge; ejected; DNB. Followed by his son, John, d.1697, ed. at Cambridge, MD.

88. The Lincoln Academy was founded by Edward Reyner, whom Bogue and Bennett state

> "..devoted a portion of his time to the instruction of young men for the dissenting ministry; but the extent of his labours cannot be ascertained."

Other sources, where a reference to the Academy might have been expected, are silent (eg TCHS and DNB entry on Reyner) and the size and precise date when the institution was active are therefore unknown. John Reyner, son of the founder is said to have carried on the institution after Edward Reyner's death in c1663.

89. Reyner, Treatise of the Necessity of Human Learning for a Gospel Preacher, 1663, p.90

90. See RF Jones, Ancients and Moderns, for comment on this idea which had ancient origins.

91. Reyner, op cit, p.151

92. Flavell, John, (1630-91) educated at Oxford but did not graduate. DNB.

93. Flavell, Works, I, first extract, p.40, second p.510.

94. Flavell, _op cit_, p.60

95. Flavell, _op cit_, p.39

96. Flavell, _op cit_, p.214

97. Flavell, _op cit_, p.82

98. Flavell, _op cit_, p.99

99. Flavell, "Fountain of Life"_Works_, _I_, p.40

CHAPTER 3: ACADEMIES 1701-1750

In the first two decades of the 18th century, the number of Dissenters was estimated at 5% to 6% of the national population, approximately 338,120 persons.[1] During the reign of Queen Anne (1702-1714) Dissenters found the political climate increasingly hostile and particularly after the 1702 Tory victory, a hardening of attitudes towards them can be detected. Attempts to ban "occasional conformity" (the practice of receiving the sacrament in order to qualify for civil or military office) which had been permitted under earlier Acts, began. Three unsuccessful attempts at such legislation (1702,1703 and 1704) were made, followed by a fourth successful attempt after the 1710 Tory victory.[2] During the Whig parliament of 1705-10 there was some easing of pressure on Dissenters, and a few new Dissenting Academies were opened. Tension remained, and in 1709, towards the end of the Whig parliament a civil crisis was precipitated by the impeachment of the Anglican theologian, Henry Sacheverell, on publication of his sermon The Perils of False Brethren. Preached on the Anniversary of the "Glorious Revolution" of 1688, this was an attack on the 1688 settlement, upon the current

Whig government and their policy of toleration towards Dissenters. Disorder and attacks upon the meeting places of Dissenters followed. Academies were denigrated by Sacheverell who described them as a breeding place for:

> "Atheism, Deism, Tritheism, Socinianism with all the hellish principles of Fanaticism, Regicide and Anarchy"[3]

and Dissenters as:

> "miscreants begat in rebellion, born in sedition and faction"[4]

Earlier attempts of Academy tutors to demonstrate their loyalty were forgotten, for example Samuel Benion's attempts to instil loyalty to the Crown into his students at Tewkesbury/Gloucester, or the paeon of praise to Queen Anne in the preface of the book An Essay Towards the Improvement of Reason by Joshua Oldfield of Hoxton Square.
One response to Sacheverell came in an anonymous tract[5] which tried to assure the Anglican Bishops (to whom it was addressed) that the Dissenting Academies were as loyal as the universities, and that it was better to allow Academies to flourish at home than to encourage dissenters to send their sons to universities abroad where Republicanism was rife.

No new Academies were opened during the last years of the Queen's reign when harrassment of dissenters increased under the Tory government. Prosecution of tutors at existing Academies under the "Oxford Oath" continued. The last enactment of the reign, the Schism Act of 1714[6] was aimed at preventing the perpetuation of an educated dissenting ministry by requiring all tutors to declare their conformity to the established church. At least one Academy tutor, Samuel Jones of Tewkesbury Academy, was threatened with prosecution under its provisions.

The Whig majority of the first parliament of George I's reign (1714-1727) immediately set about redressing the Dissenters' grievances.[7] However attempts to repeal the Prevention of Occasional Conformity and Schism Acts proved more difficult than arranging recompense for damaged or confiscated property. The issue generated violent emotions but following great secrecy over the preparations, the two Acts were repealed in 1718, although the requirement for the sacramental test remained for appointment to civil or military office. The Dissenters' position was further improved by Acts of Indemnity[8] the first of which was passed in 1727: these Acts allowed dissenters to postpone the taking of communion until after instead of before election to civil office.

Nevertheless, despite the regular Acts of Indemnity and the generally more tolerant climate, prosecutions of Academy tutors for not holding an appropriate episcopal licence for teaching still occurred. Philip Doddridge of the Northampton Academy suffered such harrassment in 1733. and the issue came before the ecclesiastical courts in Westminster Hall on 31 January 1734. However, Doddridge was able to report that:

> "our cause was gained without any opposition worth naming. The judges order'd a prohibition to be issued which secures me from all further Trouble ..."[9]

An attempt was made to reopen the case in June 1734 but was prevented by the direct intervention of George II who insisted that during his reign (1727-1760), dissenters were to be free from persecution on the grounds of their faith.[10]

Further attempts in 1736 and 1739 to repeal the Test and Corporation Acts failed; the question of repeal was not to be revived in parliamentary circles until the 1770s. Any further easement in the dissenter's legal condition was acquired via the courts in the intervening years.

Between 1700 and 1750 23 new Dissenting Academies were founded (details are summarised in Appendix 3.1). In addition the following founded before 1700 were still active in the early years of the new century:

Attercliffe	closed 1714
Bedworth	1710
Bridgwater	1748
Broad Oak	1706
Exeter 1	1722
Hoxton Square	1729
Ipswich	1703
Islington 1	1702
Newington Green 1	1705
Newington Green 2	1706
Nottingham	1714
Shrewsbury/Oswestry	1715
Taunton 1	c1759

Of the 23 new Academies, 16 are known to have included science subjects in the curriculum:

Bristol Baptist Academy
Findern/Derby
Kendal
Kibworth
King's Head Society/Homerton
Manchester 1
Moorfields/Stepney/Hoxton
Northampton/Daventry
Tewkesbury/Gloucester
Whitehaven/Bolton

For 6 of these Academies, detailed evidence exists, again in the form of booklists, tutors' own works, and contemporary comment, to enable a picture of the teaching of scientific subjects to be constructed:

Findern/Derby
Kendal
Kibworth

TABLE 3.1

Summary of Texts
Academies, 1700-1750, discussed in Chapter 3

Academy	Authors listed (with Texts where known) for science[1]	Comments
Findern/Derby	Le Clerc Rohault 'sGravesande	
Kendal	Caleb Rotheram's own lectures	
Kibworth	Le Clerc Rohault Jones (of Tewkesbury) lecture notes Varenius Nieuwentyt, The Religious Philosopher Derham, Physico- and Astro-Theology Jennings, Miscellenea Harris, Technicum Lexicon Eames (of Moorfields/Stepney) lecture notes	
Moorfields/Stepney	Eames's own lectures Jennings, An Introduction to the Globes and Orrery	See Chapter 5
Northampton	Nieuwentyt, Derham, Mather, Watts, Ray, Rowning, Clare Doddridge, A Course of Lectures on the Principal Subjects in Pneumatology, Ethics and Divinity	See Chapter 4
Whitehaven/Bolton		No booklists survive

[1] Excluding anatomy

Moorfields/Stepney/Hoxton
Northampton/Daventry
Whitehaven/Bolton

Two from this group have been chosen for in depth study: Northampton/Daventry (Chapter 4) and Moorfields/Stepney/ Hoxton (Chapter 5).

Academy tutors in this period chose textbooks from a wide range, including continental as well as English works (see Table 3.1). The most significant feature of this period was the transition in scientific philosophy from a Cartesian to a Newtonian universe. In Principia published in 1687, Newton put forward a systematic description of the universe, in which the heavenly bodies as well as earth were subject to the same laws of motion and attraction, an hypothesis the truth of which could be demonstrated mathematically. God retained a clear role as Creator but his daily participation in the life of the universe was limited to correcting apparent aberrations from the mathematical laws. Newton however was very clear about the relationship between religion and science:

> "The main business of natural philosophy is to argue from phenomena without feigning hypotheses, and to deduce causes from effects, till we come to the very first cause, which certainly is not mechanical .... does it not appear from phenomena that there is a being incorporeal, living, intelligent, omnipresent, who, in infinite space, as it were in his sensory, sees the things themselves intimately, and thoroughly perceives them; and comprehends them wholly by their immediate presence to himself?"

to which question his response was:

> "This most beautiful system of sun, planets, and comets could only proceed from the counsel and dominion of an intelligent and powerful Being. This Being governs all things, not as the soul of the world, but as Lord over all."

Descartes had denied the existence of forces which acted between particles of matter. Newton, although he did not know the precise nature of such forces as gravity, attraction or repulsion, was convinced that they existed. To deny their existence would be to deny the existence of God. Thus Newton's universe left a clear role for God in the natural world, and demonstrated clearly some of the essential elements of the "argument from design".

In the early years, up to the mid-1720s, Cartesian texts are known to have been in use at two of the new Academies: Findern/Derby[11] and Kibworth.[12] At Findern/Derby the founder, Thomas Hill, taught natural philosophy using texts by Le Clerc and Rohault.[13] For logic, Le Clerc's Ars Cogitanda[14] was listed but no text from the same author was cited for natural philosophy. A probable choice would be Physica sive de rebus corporeis Libri V. in quibus praemissis potissimis Corporearum Naturarum Phaenomenis ac proprietatibus veterum & Recentiorum de eorum Causis celeberrimae conjecturae traduntur, a work which may also have been used at Shrewsbury and Bethnal Green/Highgate. Rohault was a popular author in the earlier Academies. His work in its original form was Cartesian and there is no suggestion that the version Hill used contained Samuel Clarke's Newtonian commentary. It can thus be assumed that Hill's natural philosophy teaching had a strong Cartesian bias. Ebenezer Latham, Hill's successor at Findern/Derby from 1719/20 onwards, is known to have used parts of Le Clerc's Physica but introduced alongside it, at an unknown date, an early Newtonian text by s'Gravesande,[15] probably Mathematical Elements of Natural Philosophy.[16] s'Gravesande's text was an early attempt to present Newton's system in a non-mathematical form. The text (of which there was a 1720 English edition) covered the three Newtonian laws of motion, argument about the infinite divisibility of matter and the principles of attraction and repulsion. s'Gravesande's work included a series of experiments (some drawn from Newton's Opticks (1704)) by which the basic principles of the system could be seen to be confirmed. There is no indication that any of these experiments were demonstrated at Findern/Derby.

Much information on the curriculum of the Kibworth Academy, founded by John Jennings, has survived. Philip Doddridge founder of the prominent Northampton/Daventry Academy (see Chapter 4) was educated there, and a full account of his studies is given in his correspondence.[17] The study of natural philosophy began in the second year of the four year course; mechanics, introducing the essentials of the lever, screw, wedge, pulley and so on was followed by hydrostatics, physics, astronomy, anatomy and chronology. Mathematics was taught in the first year, using Barrow's version of Euclid, and Jennings' own material for the teaching of algebra. Astronomy and chronology were studied in the second year, using a system devised by Jennings himself and "the Globes" using one devised by Samuel Jones of Tewkesbury. Geographical and cosmological texts by Bernardus Varenius (fl.1649-72) may have supplemented Jones' system. Varenius' works appear to have been a rather curious hybrid: in the later editions (which were probably used at Kibworth) editors had attempted to bring the work up to date by adding a Newtonian gloss to the original scholastic philosophy.

Although works by the Cartesian authors, Le Clerc and Rohault, were read at Kibworth, a much greater emphasis was placed on the works of Newtonian authors. Harris's Technicum Lexicon (1704-14) one of the very earliest technical dictionaries of science, was chosen as a work of reference. Harris[18] especially praised Isaac Newton and summarised sections of Opticks and Principia where appropriate. A good feature of this text is the reading list appended to some entries, which gave additional sources for important topics. The work had a strong mathematical bias and contained details of the scientific theories and machines of the day.

The underlying philosophy of the science teaching at Kibworth was very closely related to theology. This is strongly brought out by consideration of two of the authors studied by Doddridge: Neiuwentyt and Derham. Derham, a Newtonian, followed broadly the lines set by John Ray in The Wisdom of God (1691) which put persuasively the "argument from design" in contemporary terms. Originating with Aristotle, and adapted by medieval scholastics, the "argument from design" proposed an omnipotent Creator, benevolent to man, and an ordered creation with man at its pinnacle. The principle of causality or First Cause in the form of God, was of prime importance. Derham's Physico-Theology[19] was a compilation of the Boyle lectures which he gave in 1711 and 1712. These lectures, though not specifically scientific, were funded from Robert Boyle's will and were intended to allow theologians to demonstrate the truth of the Christian religion to non-believers. The "argument from design" was often featured as it showed a means whereby scientific facts could be used to support theological precepts. A naturalist, Derham's own studies dated from pre-Newtonian days and his sources for the work were mainly Hooke, Boyle and Wallis, but occasional references to Newton and his followers occur.[20] Physico-Theology retained its popularity, running to several editions and translations, a new edition being published as late as 1798. However, where Ray recognised difficulties posed by the "argument from design",(for example the presence on earth of creatures noxious to mankind) Derham did not allow such concern to distract him from the theme.

A later text by Derham, Astro-Theology was probably used in the study of astronomy at Kibworth. Again the same theme was heavily emphasised: every conceivable assertion from the magnitude of the universe to the size, shape and motion of its bodies was used as evidence of the existence of a benevolent God. Much of the detail of Astro-Theology was based on Newton's Principia. The Copernican solar system was taken as the central point of the universe and extended into indefinite space, with the suggestion that the fixed stars were suns with planetary systems of their own. Derham supported this proposition by four arguments, three were culled from theology and the works of Bentley and Huygens, but the fourth was his own unique suggestion that the planetary system encircling fixed stars would explain the appearance of new stars. The movement of a planet around and its emergence from behind its sun would give the impression of a "new" star. Derham also noted that fixed stars were too distant to shine with reflected light from the sun, and must therefore generate their own light.

Derham's work offered scope for discussion on the possible existence of other populated worlds without transgressing the limits of the argument from design.[21] Thus he could write:

> "... an inifinite Creator, whose power and wisdom, as they are without bounds or measure, so may in all probability exert

themselves in the creation of many systems as well as one."[22] This idea did not originate with Derham, but had already been discussed by the French philosopher, Fontenelle, in Conversations on a Plurality of Worlds, first published in 1686 and by Huygens in Cosmotheoros (1698), a work with which Derham would have been familiar. No modern writer holds Derham in high repute[23] or indeed Nieuwentyt, whose work The Religious Philosopher[24] was read at Kibworth, and was another in this genre. "Designed for the conviction of atheists and infidels", The Religious Philosopher was Nieuwentyt's main work, and its three volumes cover (1) animal bodies, particularly man, (2) the elements and their various effects upon animal and vegetable bodies, and (3) "the most amazing structure of the Heavens with all its Furniture". Nieuwentyt's text was very popular with contemporaries, the British experimental philosopher, J T Desaguliers, describing him as the Dutch Ray or Derham. It contained a jumble of ideas culled from a variety of sources among them Descartes, Boyle, John Keill and Newton (particularly the portion of Opticks entitled Queries). The inconsistencies thus brought about seem not to have been noticed by Doddridge, or by Isaac Watts the hymn writer both of whom recommended the work to others. Both were probably attracted by the strength of Nieuwentyt's support for the argument from design. However, Nieuwentyt had lasting influence on one aspect of science: his statements on the material nature of fire. Nieuwentyt declared that heat was attributable to particles of fire adhering to a body; he made a detailed case for this theory, and was cited as the authority on the subject during the 18th century. Musschenbroek praised The Religious Philosopher for this aspect of his work, and it seems likely that s'Gravesande and Boerhaave were influenced by Nieuwentyt in this respect.

John Jennings of Kibworth was one of a small number of Dissenting Academy tutors of this period who prepared and published (or for whom work was published posthumously) their own texts for the teaching of scientific subjects. (The others, David Jennings of Hoxton, and Philip Doddridge of Northampton/Daventry are discussed in Chapters 4 and 5.)

John Jennings published Miscellanea (1721) in which he collected together material useful for teaching the "young". Bound in with the Miscellanea is a section in Latin which details the logic syllabus. The Miscellanea is a curious collection of notes some in English, others in Latin, on a variety of subjects. Sections include "Psalm Singers Guide", "Ars Raymundi Lulli", "Dialectica Petri Rami", "Fortifications", "Conic Sections", "Heraldry" and one on herbs with proven medical use. Those sections on scientific matters "Mechanics", "Hydrostatics", "Physiognomia" and "De Sphaeris nostris Newtonianis sive astronomica" are in Latin and for the most part consist of brief notes of the "aide memoire" type. For example, the section on the Newtonian universe contains subheadings on (i) phenomena visible during the Earth's year, (ii) phenomena apparent only over the course of several years, (iii) the moon, (iv) eclipses, (v) planetary tables and (vi) planets, comets, sun and fixed stars. The description of the Newtonian universe given here is cursory and consists of measurements of the known solar system (globes, orbits), and single sentence descriptions of, for example, the earth's orbit around the sun. Very few references are given. This points to the strong possibility that students were required to understand the basic elements of the Newtonian system only. The amount of Latin within Miscellanea suggests that at least for some subjects this language was the teaching medium at Kibworth.

In his choice of texts Jennings' concern was to select those which buttressed the Christian God's role in the universe, and for this Derham and Nieuwentyt were natural choices. Jennings was probably strongly influenced by his own tutor, Timothy Jollie, who expressed reservations about mathematical study, which he believed led to atheism. The importance of the work of Derham and Nieuwentyt lay in the theological argument, rather than scientific content. Jennings own work the Miscellanea indicates that the core of the scientific teaching was concerned with simple machines, and the learning of essential facts rather than a thorough study of the Newtonian universe.

For the last two new Academies in this group, where it is known that science was taught, Whitehaven/Bolton and Kendal, no booklists survive. The earlier of the two, Whitehaven (later moving to Bolton) was active from c1708 to 1729. The Academy was founded by Thomas Dixon[25] who was assisted by the mathematician, John Barclay, about whom little information has survived other than an indication that he might have been an Edinburgh graduate. One set of lecture notes (taken down by the student Henry Winder) survives.[26] These are dated 1708-12 and show that at that time the scientific curriculum covered astronomy and globes, and mathematical subjects - arithmetic, logarithms, algebra and trigonometry. The astronomy lectures were recorded in Latin (suggesting that this language was the medium for some of the teaching). While two volumes of notes can be assigned precisely to the period 1708-12, the date of a third, in the same hand is uncertain. This volume contains references to Newton amongst others. It is known that Winder prepared a course of instruction for his stepson in the mid 1730s and it is probable that these notes form an outline for this course. There is no reason to believe that Dixon would have taught Newtonian science at this early period. Winder later used the outline of the course as the basis for an unsuccessful book A Critical and Chronological History of the Rise, Progress, Declension and Revival of Knowledge, chiefly Religious which was published in 1745.

There are many testimonies to the scientific interests of Caleb Rotheram, the founder of the Kendal Academy.[27] Typical of these is the following:

> "Dr Rotheram was a considerable scholar in many branches of literature. But he chiefly excelled in mathematics and natural philosophy which he taught at Kendal for many years with great reputation."[28]

The Kendal Academy, active 1733-1751, offered a course which included natural philosophy, with higher mathematics as an additional extra.[29] Many of Rotheram's students followed lay careers including medicine, and his influence in the Academy world continued through John Seddon the founder of the Warrington Academy (Chapter 7). Little information exists about the natural philosophy taught but it would certainly have covered both Cartesian and Newtonian theory. It is probable that the scientific subjects which Rotheram taught in the Academy were very similar in range to the public lectures which he gave on natural philosophy. One such course[30] given in 1743 in Manchester covered the nature of matter, attraction and repulsion, mechanics and electrical attraction, and specifically mentioned Newton's work on optics. The lectures were illustrated by practical demonstrations.

A few of the new Academies in this group are known to have acquired equipment: Northampton/Daventry and Hoxton (see Chapters 4 and 5), Kendal and Kibworth, though in the latter case the equipment may have been limited to the globes and some simple devices to demonstrate the pulley, lever and other elements of basic mechanics. Kendal had a fairly large collection of instruments which Rotheram purchased for the Academy from the estate of John Horsley.[31] At Rotheram's death the equipment included a new orrery, a complete air pump with receivers, and many others (amongst which globes and surveying instruments were almost certainly to be found).

Anatomy was taught at Kibworth, Findern/Derby and Northampton/Daventry. At Findern/Derby, the tutor Ebenezer Latham, was also a minister and medical practitioner (which gave rise to some criticism about the amount of attention he was able to devote to the Academy). Latham's interest in anatomy and its inclusion in the curriculum can no doubt be partly explained by his interest in medicine, confirmed by his medical work for the community in which he lived. At Kibworth, a variety of texts were read for this subject: Nieuwentyt, Keill, Cheselden, Drake and extracts from the lectures of John Eames of Hoxton. The works of the surgeons Drake and Cheselden were standard anatomical treatises, Cheselden's <u>The Anatomy of the Humane Body</u> (1713) being particularly well-illustrated. "Keill", used at Kibworth, can be identified as the text <u>The Anatomy of the Humane Body</u> of 1698. James Keill, a medical practitioner, described his work as a "small pocketbook, in which one, upon any occasion, without much reading might have a full view of the structure of any part".[32] It contained no diagrams, however. Keill's work was of a mechanistic nature and fitted well with Newtonian philosophy, as it rejected Descartes' "aetherial, subtile matter" and continuously attempted to quantify data. Keill's own theories of the transfer of air to the bloodstream across the lungs, and muscular motion and glandular activity were clearly explained. Keill believed that a thorough knowledge of the workings and structure of the body was essential for the proper administration of medicines. He also drew an interesting analogy in asserting that knowledge of the working of the eye prepared the way for the invention of the microscope, and joints for ways of joining materials. Nature, he believed, offered the best examples of structure and economy; study of natural bodies might direct the philosopher to further useful inventions for mankind. Anatomy was also taught at Northampton/Daventry, here with the emphasis on the theologically based "argument from design".

Some Academies which had opened before 1700 and where scientific subjects were known to have been taught continued in operation: Bridgewater, Newington Green 1, Newington Green 2, Nottingham, Shrewsbury/Oswestry and Taunton 1. At Taunton 1, Robert Darch's[33] responsibility for the teaching of natural philosophy and mathematics was taken over by the principal, Henry Grove,[34] in 1716. It is unlikely that Darch's teaching had kept up-to-date, for in the mid-1690s he continued to use Morton's <u>A System of Physics</u> as the basis of his teaching, a work rooted in scholastic philosophy. Grove had studied Cartesian philosophy with Thomas Rowe (at Newington Green

2) but it is clear that he had also read Clarke's (Newtonian) criticisms of Cartesian Rohault, as he appreciated Clarke's

> "... excellent use... of the Newtonian philosophy, particularly the law of Gravitation, to demonstrate the continual Providence and Energy of the Almighty"[35]

It is known that Grove was in contact with Clarke in 1708 over a religious controversy and it is interesting to speculate whether he was introduced to Newton's theories at the same time.

Grove is reported to have been a good teacher of natural philosophy, and before beginning to teach the subject made an attempt to bring himself up to date:

> "Mr Grove was obliged to renew and increase his acquantance with natural philosophy and mathematics in which he made a great proficiency as could be expected; the vast extent of those subjects, and his other ingagements being considered."[36]

It is possible therefore that Grove introduced Newtonian philosophy to this Academy as early as 1716.

At Shrewsbury/Oswestry, Samuel Benion[37] had brief control of this Academy, 1706-8. Benion was a qualified physician and he customarily gave medical advice charitably to members of his own congregation. He prepared his own teaching material "Schematismus" which "presented the Young Travellers with a general map of the country they were to survey."[38] This work included physics and mathematics, but no copy has been traced. In his teaching method, he seems to have preferred to compare and contrast different philosophies, rather than allowing one to dominate the teaching.

No information on the Bridgewater curriculum has been traced, but this Academy produced a few medical men, some of whom continued their studies at Leyden with Boerhaave, most notably Thomas Morgan[39] and Samuel Chandler, DD, FRS[40].

The study of Descartes' scientific philosophy was not immediately usurped by Newtonian science in the Academies, for it continued to be taught in parallel at least during the first two to three decades of the 18th century. Nor indeed was Cartesian philosophy ousted by the Newtonian at the two English universities. However the indications are that Newtonian philosophy was a subject of discussion in the universities rather earlier than in the Academies. Richard Bentley's Boyle lectures, which drew heavily on Newton's work were given in 1692, printed and adapted for tutorial use in colleges in the teaching of moral philosophy. They were however insufficiently detailed for use in natural philosophy. John Keill lectured on Newton's work and published the text of his lectures as Introductio ad Veram Physicam in 1702. Newtonian propositions were being defended in some of the Cambridge schools from 1707.[41] Readings from Newton and Keill were prescribed by other university tutors alongside Cartesians such as Rohault. Courses on the new philosophy were offered at both Cambridge and Oxford, by Whiston and Cotes, c1700-10, by Friend, and by Keill (with Desaguliers' help). An interesting example of an early Cambridge scheme of study in natural philosophy is that of Robert Greene, a Clare College tutor. Greene's wide-ranging booklist[42] included Newton's works on optics, mechanical philosophy, fluxions and astronomy, together with texts by Descartes, Boyle, Gregory, Harvey and Grew. (Greene's own text, describing his own anti-Newtonian philosophy also featured). A later booklist (dating from c1730)[43] for use of students at Cambridge suggests that Newton's own writings as well as those of his interpreters were set texts alongside the older Gassendi, Rohault and Burgersdyck. However, the teaching of Newtonian science at the Universities appears to have declined after the departure of the first generation of Newtonian tutors. Nevertheless during the first half of the century, Oxford and Cambridge educated university tutors of natural philosophy, for example Smith, Rutherforth, and Gregory, all of whom published scientific textbooks later used in Academies.

It is difficult to be precise about the date when Newtonian science became the dominant scientific philosophy in the Academies. Joshua Oldfield of Hoxton Square Academy was aware of Newton's work as early as 1707 though it is by no means certain that his curriculum included science subjects. At Kibworth (active 1715-23) Newtonian texts (Nieuwentyt and Derham) were in use. At the Hoxton Academy, John Eames (who may have had some direct contact with Newton in the early years of the 18th century) had joined that Academy as tutor by 1716. At Findern/Derby, Ebenezer Latham introduced a text by s'Gravesande alongside the late Cartesian, Le Clerc. It seems probable that the teaching of Newtonian science became common in the Academies by early 1720s, a date which coincides with the availability of the first textbooks in English based on Newton's philosophy, for example s'Gravesande's Mathematical Elements of Natural Philosophy. In contrast with the Universities, Newton's texts do not appear to have been used directly. Thus the introduction and teaching of Newtonian theory was slower than at the universities.

The following Academies probably taught scientific subjects but the evidence for such teaching is less conclusive:

Bristol Baptist Academy
King's Head Society/Homerton
Hoxton Square
Manchester 1
Tewkesbury/Gloucester

Joshua Oldfield[44] of the Hoxton Square Academy, set out his scheme of education in a work published in 1707 An essay towards the Improvement of Reason. This was a logic course, which contained an outline of the "map of knowledge" of the day. A very brief section, (11 pages out of 424) gives a summary of scientific knowledge, covering animal life, other living organisms of the earth, and speculation on the different races of men. This Oldfield intended to be an introduction to the subject. God's providence was clearly indicated, not only in the creation, but particularly in providing Man with reason:

> "By this our Creator teacheth us more than the Beasts of the Earth and makes us wiser than the Fowls of Heaven. By this we are capable of examining more thoroughly the Appearances of things to rectifye or confirm our Apprehensions about them. We can hereby form abstract and general notions, reflect upon the operations of our Mind, and go beyond the sphere of sense and imagination, so as to carry our Tho'ts upward to God and forward to a future life."[45]

The pages on science contain statements couched in the language of Scholasticism: the Moon's motion is described in terms of an epicycle, and the structure of the Heavens in terms of higher and lower spheres. Yet Oldfield was aware of Newton's work, mentioning some observations of the "justley celebrated Author of the Principia Mathematica". (It is not known whether Oldfield had personal contact with Newton, as has been claimed.[46]) Oldfield described Newton's work as follows:

> "... that the several inanimate Bodies of the Visible World are mutually attracted by each or do gravitate and incline towards each other, in proportion to their Bulk and Distance; so much

> that more as the former is greater and the other less; that is according to the Cubes of their Diameters; which give the proportion of the Matter they contain (supposing them equally dense or compact) and the Squares of their Distances, the increase of which does accordingly lessen their Gravitation. This Natural Conatus or preprension communicated by the Divine Power and Wisdome, may seem to determine the respective places of the several parts of the Universe, particularly the Orbs of the heavenly Bodies with their various Motions and the Lines wherein they move as that admirable Treatise shows."[47]

If this document of 1707 represents a summary of part of the content of Oldfield's teaching at Hoxton Square, then this is the earliest clear indication of the teaching of Newtonian science in the Academies.

At the Manchester Academy[48] natural philosophy was taught but little information has survived. Students are reported to have made use of Chetham's Library.[49] At Tewkesbury/Gloucester Academy[50] (active c1712-1719) Samuel Jones taught logic using Heerebood's texts, with a work by Le Clerc, probably Logica, from which students would have gained some knowledge of Aristotelian and Cartesian natural philosophy. A set of notes of lectures[51] survives, entitled Notae Gronovi et viri clarissima, and based on lectures Jones had heard whilst he attended the University of Leyden and which he read to his Tewkesbury/Gloucester students. "Gronovi" indicates that these were given by Jacob Gronovius (1645-1718), Professor Belles Lettres at Leyden. The subject matter covered a description of the earth, its character and movement. From the list of Gronovius's works in the British Library catalogue, it is clear that he was a classical scholar and any scientific material in these lectures would be likely to relate to the theories of classical Greece. It appears that science was not a subject in which Tewkesbury/Gloucester specialised; at least one student[52] is known to have transferred to

Hoxton to join Eames' course. Basic mathematics was also taught at Tewkesbury.

Lecture notes taken at Bristol Baptist Academy[53] indicate that some teaching in natural history and physics was given although existing references are slight. In the first year of the course, the works of Isaac Watts and Gordon's Geographical Grammar, were studied alongside Benjamin Martin's Philosophical Grammar, a basic textbook of the physical sciences.[54] Circa 1730, the principal tutor, Bernard Foskett was assisted by Andrew Gifford who used the notes of Samuel Jones' lectures which he had taken at Tewkesbury/Gloucester, and which would probably have given further grounding in the study of the "globes".

Some science appears to ahve been taught at King's Head/Homerton from its inception in 1730 but comment has been deferred to Chapter 6, as from the 1750s onwards the subject received rather more attention than in the early years of the Academy's existence.

In the following Academies it is uncertain from existing evidence whether any science subjects were taught:

Alcester
Bridgnorth
Mixenden
Pinner
Stratford
Tiverton
Trowbridge 1
Warrington 1

Of these, it is unlikely that any significant work in natural philosophy took place at Alcester, Bridgnorth, Mixenden, Pinner, Stratford and Trowbridge. At Stratford, the founder John Alexander, was interested in oriental studies, and was recognised as an excellent linguist and patristic scholar. Only Pinner and Tiverton produced any students who followed medical careers.[55] At Trowbridge, the tutors John Davisson (d.1721) and Thomas Lucas (d.1743) were expressly concerned with the training of ministers: Lucas displayed a mistrust of all books other than the Bible. At Mixenden, the founder Mathew Smith (1650-1746) prepared students for the ministry.

Warrington 1 was founded by Charles Owen[56] about 1700 and continued, with a brief closure in 1714, until 1746. Although no details of the curriculum have survived, it appears that Owen was interested in natural philosophy as he published An Essay towards a Natural History of Serpents in 1742. In the book, dedicated to Hans Sloane, Owen wrote:

> "..I don't Pretend to new Discoveries but only to collect and bring into one View what has been said by different Persons, which is not to be found without many books, and much Time; and which without the present English Dress would not be understood by others at all.
> ...
> I have endeavoured to give it some agreeableness by a variety of passages from History and Reflections of many kinds ..."[57]

Not intended for use in the Academy as a text[58] this volume appears to be a forerunner of the modern "coffee table book". The title page proclaims that the work was "illustrated with copper plates, engraved by the Best Hands". Divided into three parts, the first dealt with the attributes of serpents in general but digresses to include anecdotes not always related to the subject matter; (an account of snake venom led into a discussion of various other naturally occurring poisons but also included some comment on industrial waste arising from the exploitation of lead ore). Myths, such as Pliny's report of a plant which killed mice by its smell, were also included. Descriptions of various snakes, illustrated by beautifully prepared drawings appear in part 2 (Figure 3.1). Here again there is a mixture of fact and myth: compare the entry, for example, on the viper or adder, a domestic snake which Owen had probably seen, to the description of the mythical basilisk or cockatrice:

> "The Viper, or Adder a subtle and poisonous creature, slender in body about the foot and a half long, with fiery and flaming eyes, a long and cloven Tongue which when irritated it darts forth with Violence, and looks like a glowing Fire-brand; has a big Head, and Flattest of the Serpentine kind."[59]

This is a vivid description of the nature of the snake, but insufficient physical data is included to make identification easy.

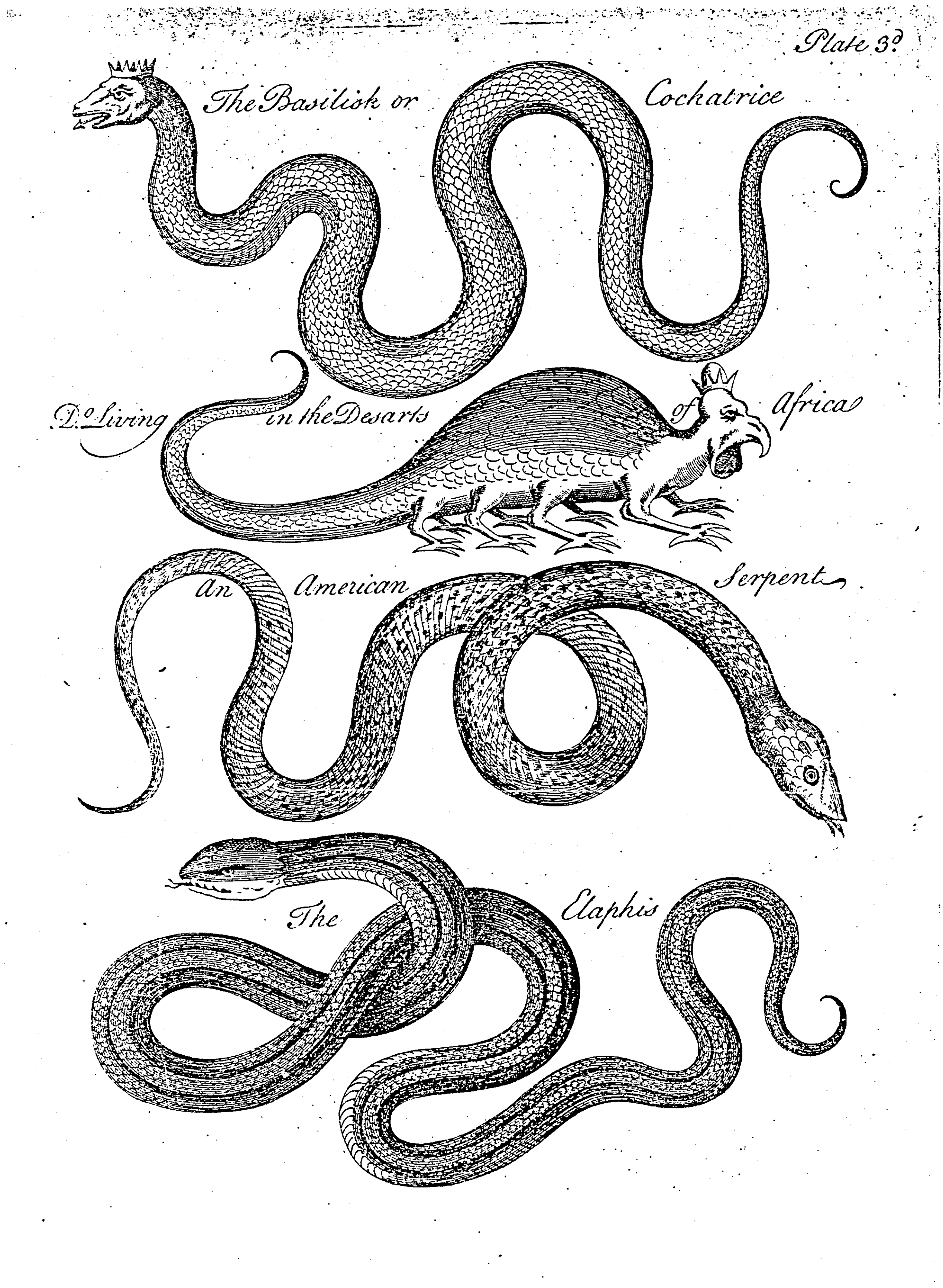
> "The Basilisk or Cockatrice is a Serpent of the Dragonick Line, the Property of Africa, says Aelian, and denied by others; in shape, resembles a Cock, the Tail excepted. Authors differ about its extraction; the Egyptians say, it springs from the eggs of a Cock; the bird Ibis, others from the Eggs of a Cock... Nor are they agreed whether it inclines to the black or yellow colour ....
>
> It is gross in body, of fiery eyes, and sharp head, on which it wears a crest, like a Cock's Comb ... Tradition adds that his Eyes and Breath are killing; that is, I presume, when he grasps the Spoil."[60]

Here, Owen has taken a variety of sources and included information from all, causing confusion rather than leading to elucidation.

The Serpent category was widened to include a number of other animals, the Salamander, Chameleon and Crocodile, and those with venomous bites or stings: bee, wasp, hornet and tarantula, the latter a particularly fascinating subject as it enabled Owen to discuss at some length the use of music as a cure for certain disorders. Part 3 of the work contained essays on serpents with a Biblical connection, commencing with the Genesis account of the serpent in the Garden of Eden. Owen's intention throughout the work was clearly to provide evidence of the wonders of God's creation, in this case in a

FIGURE 3.1

A plate from An Essay towards a Natural History of Serpents by Charles Owen.



creature that was noxious to man, and which raised difficult questions for the "argument from design". Owen's viewpoint was expressed succinctly in the Preface:

> "The Divine Wisdom so variously displayed in the Works of Nature, even the lowest Order of them entertains the human Eye with Prospects exquisitely beautiful and pleasurable ... if we consider the Noxious [animals], we shall find it not an Argument why they should be made, yet we shall be able to discern no Reason why they should not, because their Noxiousness is not so unavoidable, but that we may, and almost everyone does avoid it ..... in cultivating this Subject, I have attempted to give a short Display of the Divine Perfections, which, as they appear eminent in the System of Creation in general, so in the Serpent they may be seen in particular."[61]

This is an elegant argument for the existence of poisonous creatures, which does not require transgression of the basic framework of the argument from design.

The most important issue in the scientific world in the first half of the 18th century was the debate between Cartesian and Newtonian philosophies. It has been shown that Academies introduced the teaching of Newtonian science to their students later than the two English universities. Joshua Oldfield's reference to Newton's work in 1707 is the earliest known, but it remains uncertain whether science was taught at Oldfield's Academy. But by the mid-1720s, the new philosophy was commonly taught. Unlike the mechanistic universe of Descartes, in Newton's there was a central place for God whose presence was manifested in the essential forces, such as gravity and elasticity. Newton's universe could be used to provide further evidence to support the "argument from design". However, as the French philosopher Malebranche (1638-1715) pointed out, the idea of force as Newton conceived it was valid with or without God for

Newtonian forces could be as easily explained through the mechanical workings of the "machine" itself. The teaching of Newtonian ideas was thus entirely possible without reference to theology. Kendal, where there was strong interest in experimental philosophy and a "free-thinking" approach, may have followed this path. Other Academies (notably Kibworth and Northampton/Daventry) were to place a strong emphasis on theological interpretation - to such an extent that the science became subservient to the theological argument. This trend can be seen in the selection of such works as Derham and Nieuwentyt at Kibworth and at Northampton/Daventry, as will be seen in Chapter 4.

Although the political and legal climate was more tolerant of Dissenters after the death of Queen Anne there were two challenges to Dissent (and thus the Academies) from very different sources in the period: Methodism and Deism. By the 1740s interest in Dissent was declining noticeably and the numbers of Dissenters had fallen to approximately 50,000. Eminent Dissenters expressed concern about the decline, including Philip Doddridge who, in 1730, remarked the failure of Dissent generally to cater for the spiritual needs of "plain people of low education and vulgar taste". In contrast, from the 1740s Methodism was gaining a foothold among groups described by its founder, John Wesley, as "low, insignificant people". Although some theological beliefs were common to both Dissenters and Methodists, the emotional overtones of Methodist worship were foreign to the more sober Dissenters but appeared to be attractive to the less sophisticated. The followers of Methodism were protected from the legislative penalties imposed on Dissenters, as Wesley formed the movement within the established church, thus safeguarding them from prosecution. The success of Methodism was to force some Dissenting sects to adopt some of its characteristics, and to enter the race for new converts. This was to have effect on the Academies, as will be seen when those founded after 1751 are considered in Chapter 6.

The second challenge sprang from Deism. During this period (1700-1750) the Deist movement flourished and faded in England.[62] The Deist assault on revealed religion and its championship of the power of human reason met with a vigorous challenge. The debate impinged on the Academies, some tutors taking a vigorous part. Deists allowed God a role as designer and creator of the universe, and as the source of all physical laws, such as those discovered by Newton, but elevated the value of human reason so that only those Christian doctrines which could be defended by reason were considered valid. Some deists, for example the 18th century moral philosopher David Hume, were to go further and deny the principle of causality on which the "argument from design" was built. Academy tutors of the period on the whole opposed deism: Joseph Hallett the younger of Exeter 1 vigorously attacked Deism and belittled the role of human reason. Henry Grove of Taunton 1 expressed a high opinion of human reason but held reason of itself to be insufficient to reach all truths:

> "... a more perfect knowledge of those things, which reason gives but obscure notices of, with the knowledge of other things entirely new, is the immediate end of revelation ..."[63]

Grove saw no antithesis between "reason" and "revelation". His successor, Thomas Amory, noted that a particular text (Andrew Baxter's <u>Enquiry into the Nature of the Soul</u>) was

> "... a book which makes the attentive mind clearly discern the presence of the Deity everywhere and demonstrates that we cannot

> account for a single motion without his constant influence executing these laws of nature which his infinite wisdom had established."[64]

This is clearly the opposite of the Deist view of God, which assigned him the role of the Creator or First Cause, who then stood aside from his creation, which ran its course according to its own rules. Some tutors, for example, Caleb Rotheram were known to be openminded, in his case encouraging his students "to think freely upon every subject of natural and revealed religion".[65]

In the life of the Academies themselves few changes had taken place. Almost all tutors in this group of Academies were alumnii of earlier ones, some having also spent time at a Scottish or Continental University. A few had been students at Oxford or Cambridge. Yet practices common to the English Universities persisted. The wearing of gowns appears to have been required in some rare instances, but more widespread was the use of Latin which still seems to have been a medium of instruction in a few Academies. The continued use of Latin would have been helpful as it remained the academic "lingua franca" during the early years of the 18th century, and knowledge of it eased the path of those students who transferred to a continental university to complete their studies.

REFERENCES

1. The main groups were

Presbyterians	179,000
Independents/Congregationalists	59,000
Baptists	55,000
Quakers	38,000

See Porter, R English Society in the 18th Century, p195, and Gilbert, A D Religion and Society in Industrial England, p.16.
The John Evans List of 1715-18, estimated 338,120, 6.21%. So called from the name of the secretary of the Committee of Three Denominations a group set up to protect the interests of dissenters against the Tories in Queen Anne's reign. The John Evans Survey was undertaken in 1716-18 (with subsequent additions to 1728) and aimed to provide a listing of every dissenting congregation in England and Wales.
The John Evans List indicated a heavy concentration of Presbyterians in the North of England, Lancashire and the South-West, excluding Cornwall. The heaviest concentration of Independents occurred in Essex, and of Baptists in the Northern Home Counties and Devon. Taken with other records, for example episcopal visitation returns, Quaker Burial records these sources show that a greater proportion of dissenters lived in towns than in rural areas. Congregations in the larger centres of population often drew a proportion of their members from the surrounding countryside.

2. The Occasional Conformity Act, 10 Anne Cap 6, 1711

3. Sacheverell, H The Perils of False Brethren, 1709, reprinted 1974, p.25. Sacheverell was a high Anglican, and a descendent of a dissenting minister.

4. Sacheverell, op cit, p.30

5. Anon., A Defence of the Private Academies, 1714; author identified as James Owen, but not Owen the tutor.

6. The Schism Act, 13 Anne, Cap 7, 1713

7. The 1723 Regium Donum, under which grants of £500 p.a., then £1000 were made to the widows of dissenting ministers. The 1718 Act for Quieting and Establishing

Corporations placed a limit of 6 months for prosecutions under the Corporation Act. Therefore, if a dissenter held office for 6 months unchallenged, he was safe from prosecution.

8. The Act of Indemnity; first passed in 1727, thereafter almost annually. The Acts suspended legal effects of disqualifications against Dissenters.

9. Doddridge to Mercy Doddridge, 31 Jan 1733/4, quoted Humphreys, J D, The Correspondence and Diaries of Philip Doddridge, n.p., 1829, III, p.139

10. Gasquinone, T et al, History of Castle Hill Church, Northampton, Northampton, 1896 p.21-2

11. Findern Academy was founded by Thomas Hill in 1700, its location initially at Derby. Hill, educated at Cambridge, died 1719/20 and was succeded by Ebenezer Latham(1688-1754). Latham had been educated by Samuel Benion at the Shrewsbury Academy and at Glasgow University. He ran the Academy until his death in 1754. Total number of students passing through Academy is estimated to be of the order of 300 to 400.

12. Kibworth Academy was founded by John Jennings (? - 1723), educated at Attercliffe with Jollie; elder brother of David Jennings, tutor at Hoxton Academy (Chapter 4). The Academy was active 1715-23, closing on the death of its founder.

13. Dr Williams Library ms.55

14. Ars Cogitanda: no work written by Le Clerc matches this name: there is however Logica sive ars ratiocinanda, which was most likely the chosen text.

15. Dr Williams Library ms.55.9 quoted McLachlan, English Education Under the Test Acts, Manchester, 1931, p.132

16. s'Gravesande incorporated John Keill's most recent work form the 1715 edition of Introductio ad veram Physicam, another early text popularising Newton's philosophy which occasionally introduced the author's own ideas, particular over the size and shape of fundamental particles.

17. Doddridge to Thomas Saunders, Nov 1728, quoted Humphreys, op cit, II, p.463. See note 35 of Chapter 4, where the natural philosophy teaching is described.

18. Harris, John (1666-1719) FRS (1696), minister, Boyle lecturer (1698), DNB

19. Derham, W Physico-Theology; or a Demonstration o f the Being and Attributes of God from his Works of Creation, London, 1713

20. Later editions included material from Newton's works Principia (1713) and Opticks (1717)

21. See Dick, S J Plurality of Worlds, Cambridge 1982, for further discussion of Derham's contribution to the debate.

22. Derham, op cit, pxxvii-xxviii, Edinburgh 1777 edition.

23. Derham has been described as a "vulgar apologist", AMST283, Unit 9, p.26) and Schofield, R E (Mechanism and Materialism, Princeton, 1970, p.22) has commented "Few treatises become flat and unprofitable sooner than a theologians apologetics but Derham's seem even staler than most."

24. Nieuwentyt, B The Religious Philosopher, or the Right Use of Contemplating the Works of the Creator, 3 vols, translated by J Chamberleyne with an Introduction by J T Desaguliers 1718-19. Nieuwentyt (1654-1718) was educated for the ministry but chose to take up science, following the teachings of Descartes. Schofield described Nieuwentyt's work as "dry, prolix, pompous and occasionally silly" Mechanism and Materialism, p.138

25. Dixon, Thomas (1680-1729); MD, practising physician, honorary MA of Edinburgh; educated Manchester Academy.DNB

26. Notes were taken by Henry Winder, a student at the Academy, and later at Dublin University

27. Kendal was founded by Rotherham in 1733, remaining active until 1751. Students included both lay and ministerial, a large proportion of whome continued their studies at Leyden or Edinburgh. Rotherham was assisted by Richard (Robert) Simpson, an ex-student of Doddridge at Northampton, who carried on the Academy for a few months after the founder's death. Rotherham (1694-1752) was educated at Whitehaven/Bolton, awarded Edinburgh DD in 1743.DNB.

28. Benson, G, Memories of Winder, p.13

29. The course is briefly described in "Assistance in preparing for death and judgement. A discourse occasioned by the sudden death of the Revd. John Ashe", Clegg, J, p.53-6

30. The ms. are at Chetham's Library, Mun.A.2.68., Mun.A.2.81.; see also Mumford, The Manchester Grammar School, 1919, p.157-8 for a list of lecture titles.

31. John Horsley was a natural philosophy lecturer who kept a school at Morpeth, Northumberland

32. Keil,J, The Anatomy of the Humane Body,1698, Preface. Modelled on earlier works, the text was divided into chapters covering (i) the component external and common parts of the body (ii) the lower belly, (iii) the thorax, (iv) the head, (v) the bones, (vi) the muscles (including a table of muscles) and (vii) the nerves, veines and arteries.

33. Darch, Robert (c1672-c1737/8), no further information available: no DNB entry.

34. Grove, Henry (c1683-1737/8), ed. at Taunton 1, and by Rowe and Eames at Hoxton. DNB.

35. Amory, ed. Grove's Posthumous Works, xix, xxviii

36. Amory, op cit, xxx

37. Benion, Samuel (? -1708)

38. Henry, M, Two Funeral Sermons; one on Dr Samuel Benion and the other on the Reverend Mr Francis Tallents, Minister of the Gospel in Shrewsbury, with a short account of their lives, London 1709

39. Morgan, Thomas, MD (d.1743); became free-thinker, described himself as a Christian Deist. Opposed Samuel Chandler (see below). Morgan wrote works on medicine, but was interested in problems relating to the free-will. Morgan's Physico-Theology (1741) tried to give God a more "active" role in the universe than simply that of "Clockmaker".

40. Chandler, Samuel, DD, FRS (1693-1766), prolific theological writer. Anti-deist; educated Bridgewater and Oswestry Academies, and at Leyden. No known scientific works or publications.

41. Schofield, R E and Allen, Stephen Hales: Scientist and Philanthropist, London, 1978, p.11

42. See Wordsworth, C Scholae Academicae, 1877, p.338 for full listing

43. Waterland, D Advice to a Young Student, initially drawn up by Waterland, a Magdelen College, Cambridge tutor in 1706. Another edition 1740. A later listing,

published in Wordsworth, Scholae Academicae, p.78-81, is dated 1730, and is derived from Waterland and Johnson. The first contains one of Newton's mathematical works, but the list in Scholae Academicae gives a very wide range of scientific and mathematical works.

44. Oldfield, J (1656-1729), student at Oxford and Cambridge, did not graduate; also attended Sulby Academy.

45. Oldfield, J, An Essay Towards the Improvement of the Reason, 1707, Introduction

46. There is no reference to contact in Westfall's comprehensive biography of Newton Never at Rest. Oldfield was however known to have made the acquaintance of John Wallis at Oxford.

47. Oldfield, op cit, p.19.

48. Opened in 1698, and closing in 1713, founded by John Chorlton (1666-1705), educated Rathmell. Chorlton had been invited to take over Frankland's Academy on the latter's death in 1698 but refused, opening his own institution. As at Rathmell lectures were given in Latin, course lasted for five years; from 1700-05, Chorlton was assisted by James Coningham (1670-1716), ex Edinburgh and who continued Academy after Chorlton's death.

49. Clegg, Diary of James Clegg, ed. by Kirke, p.23

50. The early history of this Academy is somewhat confused, as different dates are given by different authorities. It is certain that Samuel Jones (a product of several Academies) was principal of an Academy in Tewkesbury from 1712-1719. The Tewkesbury course was of four years' duration, and Latin was the formal teaching medium.

51. Notes taken by Andrew Gifford, a student.

52. Secker, Archbishop Thomas (1693-1768), DNB

53. Founded 1720; first tutor Bernard Foskett; notes taken by Andrew Gifford and relate to Pneumatology. The academy will receive further consideration in Chapter 6.

54. Quoted Ashley-Smith, op cit, p.211-212, from the diary of John Collet Ryland published in the Baptist Quarterly, II, p.249

55. Theophilus Lobb MD, FRS (1678-1763), was an ex-Pinner student, but his medical interest arose from contact with a doctor in Guildford, where Lobb was minister and not through his studies at Pinner. Tiverton Academy was founded by John Moore (d.1740,DNB) whose library was noted for its collection of books on surgery and medicine. Thomas Glass MD (1709-86) was an ex-student. Glass graduated from Leyden University, MD in 1731, and was a physician at Tiverton and Exeter. Invented a method of preparing magnesia alba which he passed to his brother; cause of controversy when published and later sold to manufacturer. Glass was an authority on smallpox and innoculation.DNB.

56. Owen, Charles(? - 1746), educated at Bethnal Green Academy. Awarded honorary DD of Edinburgh University in 1728.

57. Owen, C An Essay towards a Natural History of Serpents, 1742, p.vii

58. It received a wide circulation, a large list of subscribers being appended. The book may have found its way into some academy libraries, for the names of Amory (Taunton), Doddridge(Northampton), Eames (Hoxton) and the Halletts (Exeter) are included.

59. Owen, op cit, p.51

60. Owen, op cit, p.78

61. Owen, op cit, preface

62. Clarke, J C D English Society 1688-1832, Cambridge, 1986, p.280

63. Grove,H, Some Thoughts Concerning the Proofs of a Future State from Reason, 1730, p.195

64. Amory, T, Preface to Grove's Posthumous Works,I, 1745, xix

65. Ashley Smith,J W, The Birth of Modern Education, p.108, quoting Nicholson and Axon, The Older Nonconformity in Kendal, 1915, p.315

CHAPTER 4: CASE STUDY - PHILIP DODDRIDGE AND THE NORTHAMPTON ACADEMY

In a letter to a fellow minister, Samuel Clark, dated 1727/8[1] Philip Doddridge first mentioned the idea ".... of renewing Mr. Jennings Academical Course". The reference was to the Kibworth Academy which had closed on John Jennings death in 1723, and of which Philip Doddridge was an ex-student. A year later, in April 1729, Doddridge sought opinion on the same matter of other dissenting ministers including Edmund Calamy[2]. Events then moved swiftly and in July 1729 Doddridge opened a new Academy in Market Harborough, Leicestershire, with seven students.[3] For the next sixty years, the Academy was open to both lay and theological students. The openness of the new Academy was an issue which Philip Doddridge considered in 1732; he took the advice of his friend David Jennings, and continued to accept both lay and ministerial students. Jennings reminded him that:

> "The support of our interest comes from the layity,[sic] and they will not be obliged to bring up all their sons ministers or dunces."

Jennings added that there was no sense in forcing the sons of dissenters

> "... who are designed for physicians, lawyers or gentlemen to Oxford or Cambridge, or to make them rakes in the foreign universities."[4]

Jennings himself was to become the principal of Hoxton Academy (Chapter 5), of which he was an ex-student. This Academy was open to lay students, and acquired a high reputation for its teaching of scientific subjects under John Eames. Jennings had thus matured in an atmosphere which favoured a broader approach to education than had been the case in many early Academies.

Soon after it opened, Doddridge moved the new Academy to Northampton where it remained for the next twenty years. By 1732, numbers had risen to 40 students, and were to remain stable at 40 to 50, occasionally rising to above 60, during Doddridge's lifetime,[5] approximating a medium-sized college at Oxford or Cambridge. Some of the students were helped financially by charity, and later by the Coward Trust in particular, which was to become involved in the Academy's management.[6] The fees were not inexpensive, and a student could expect to pay a minimum of £20 per annum with additional payments towards upkeep of the scientific equipment and the library.[7] The evidence suggests that Doddridge ran the Academy independently in the early days and was free to make decisions concerning his institution without the need to consult or gain the permission of Trustees or a Management Committee. For example, the Rules of the Academy[8] make no reference to any higher authority to whom students and staff were answerable over disciplinary matters, or issues concerning the day to day management of the institution. Doddridge also undertook the major portion of the teaching, assisted from time to time by ex-students.[9]

The Academy offered a wide range of subjects for study (Table 4.1). It is clear from ex-student Job Orton's account[10] of life at

TABLE 4.1

The Curriculum of the Northampton Academy during Philip Doddridge's lifetime

Year 1	Year 2	Year 3	Year 4
Logic	Trigonometry	History	Civil Law
Rhetoric	Conic Sections	Anatomy	Mythology and Heiroglyphics
Geography	Celestial Mechanics	Jewish Antiquities	English History of Nonconformity
Metaphysics	Natural and Experimental Philosophy	Divinity	Divinity
Geometry	Divinity	Orations	Preaching and Pastoral Care
Algebra	Orations		

Extracted from Orton, J Memoirs of P Doddridge, 1766, passim.

the Northampton Academy, that for all students a major part of study time was devoted to divinity and associated historical studies. Divinity, moral law and analysis of biblical texts (which incorporated "Jewish Antiquities" in the last year of study) occupied a large part of each day, together with background studies in church history, including the history of nonconformity. Studies of classical and other antiquities such as hieroglyphics and mythology supplemented this part of the curriculum. Modern studies such as scientific subjects, general history, literature, English, and French were also included. In the last year, specific training in preaching and pastoral care was given, which was clearly practical and vocational in nature. All students were expected to practise their skills as preachers, or prayer leaders, in the Academy and in the neighbourhood. A small measure of course specialisation was permitted but Doddridge was careful not to allow the development of specialist interests to become paramount. The criterion was whether the subject would be useful or necessary in the student's future career. Thus lay students could be excused from the practical exercises in preaching, and in some instances might receive an individual course of instruction devised from the most suitable segments of the whole curriculum.

Lectures at Northampton were read in English, and Doddridge outlined a method to help students obtain the most from them.[11] The notes taken at each lecture were to be re-read carefully afterwards, together with the recommended references from which the main points were to be abstracted, some portions to be copied as a whole. The student was then advised to review the material, and to seek the tutor's guidance should anything remain unclear. Scientific and mathematical subjects were taught to all students in the first three years of the four year course at Northampton.[12] In the first year, students concentrated on geometry and algebra, and were introduced to the subjects of logic and metaphysics. For studies in algebra, Doddridge prepared a treatise especially for the Academy students. In the second year students moved on to more complex mathematics, trigonometry, conic sections, and celestial mechanics, and natural and experimental philosophy was given a regular place in the programme. An important attempt was made to teach science experimentally at the Academy from the earliest days: this however appears to have been limited to demonstrations, in which a student's help was necessary.[13] The use of the apparatus in Doddridge's time seems to have been unadventurous, as Doddridge himself admitted:

> "... we did little more than make experiments in philosophy, adding a short account of the purpose they are intended to serve"[14]

In the third year, anatomy studies only were featured. As time went on, the pattern was modified:[15] by the 1780s, the teaching of natural philosophy was spread across the third and fourth years of the course, with the various mathematical disciplines being covered in the first two years. Table 4.2 shows the position of science studies in the curriculum in Doddridge's time and this can be compared with the 1780s (Table 4.3). Natural philosophy not only occupied a secure place in the Northampton/Daventry Academy curriculum, but an increasingly important one as time went on.

The work of Philip Doddridge only will be examined in this chapter. The other tutors of science subjects at

TABLE 4.2

Extract from Northampton Academy Timetable relating to scientific and mathematical subjects only dating from Philip Doddridge's time as principal[1]

Subject	Year of Course 1	2	3	4
Geometry	x			
Algebra	x			
Trigonometry		x		
Conic Sections		x		
Celestial Mechanics		x		
Natural & Experimental Philosophy		x		
Anatomy			x	

TABLE 4.3

Northampton/Daventry Academy timetable for scientific and mathematical subjects only during Timothy Kenrick's time as principal (c.1780)[2]

Subject	Year of Course 1	2	3	4
Geometry: Euclid, Books 1-6	x			
Books 11-12		x		
Algebra		x		
Trignometry		x		
Conics			x	x
Natural Philosophy (including hyrdostatics, pneumatics, astronomy, electricity)			x	x

[1] from Orton, J, Memoirs of Philip Doddridge, p.86-122, quoted Parker, I, Dissenting Academies, p.86

[2] From a letter by Thomas Belsham to Samuel Heywood, 1781.

Daventry/Northampton were:

Caleb Ashworth	1751-75	Natural philosophy
Samuel Clark	c1756-69	Experimental and Natural Philosophy
Timothy Kenrick	1779-84	Natural philosophy and Mathematics
William Broadbent	1784-91	Natural philosophy and Mathematics

According to McLachlan's list of texts and manuscripts in use at the Academy[16] Thomas Belsham should be added to this list, as a set of lecture notes on electricity are included which he believed Belsham read at Daventry in 1781. On examination of Belsham's notes, internal evidence indicates that these lectures were given after 1794. It seems possible that Belsham read these lectures in his last year at Hackney, or even more likely to the private pupils he continued to take after Hackney's closure. Belsham's notes are therefore considered in Chapter 8 which deals with Hackney Academy.

The work of the other tutors listed above will be discussed in Chapter 6, which deals with Academies active during the period 1751-1800. As will be seen in Chapter 6, between 1751 and 1789 (when the Academy was closed to lay students), a variety of scientific subjects were present on the curriculum, including electrical studies, chemistry and zoology. The lectures on chemistry and electricity dating from the 1780s gave reasonable grounding in these subjects but seem to have been narrative rather than analytical in nature.

Philip Doddridge

Philip Doddridge made a substantial effort to teach various aspects of natural philosophy, both philosophical and practical. For the philosophical element, he prepared his own course, published as Course of Lectures on the Principal Subjects in Pneumatology, Ethics and Divinity,[17] which formed the central core of the Northampton curriculum, during his lifetime (to 1751) and continued in use long after the author's death, almost to the closure of the Academy in the 1790s. The Lectures reveal much of Doddridge's personal philosophy of the natural world.

Doddridge's interest in science appears to have absorbed much of his time; he visited exhibitions concerned with science or medicine, and exchanged information on scientific phenomena with a wide circle of correspondents. Doddridge was to assert in the Lectures his conviction that the more information became available, the more harmony and regularity could be observed in nature, confirming the existence of a benevolent Creator. Thus his continuing interest in the collection of phenomena combined for him both scientific and theological interests. Doddridge was confident that the "book of nature" would disclose a universe which demonstrated the truth of the argument from design, the framework within which scientific theory of the time was generally discussed and which formed the background to the Northampton studies in the subject.

The Lectures follow a mathematical format, with axioms, scholia, definitions and corollaries. Samuel Clark, the first editor, commented that this form and some of the material was derived from Doddridge's own tutor, John Jennings of Kibworth. Clark did not indicate in detail which material was so derived, except that it fell into the "former" part, which covered pneumatology.

The main purpose of the Lectures was to demonstrate that the universe was created by an Omnipotent Being, benevolent towards man, in other words to reaffirm the truth of the argument from design. Doddridge adduced many persuasive arguments to confirm that the world had been created about 6,000 years earlier, an estimate close to the date (4004 BC) proposed by Archbishop Ussher, and was not infinite in terms of time but of a fixed duration. Doddridge affirmed the basic proposition to which he was committed; namely that the universe needed to be maintained by its Creator. A significant proof of this proposition concerned the "projectile force" of the planets which was continually diminished by the resistance of the fluid (aether) through which they were believed to pass. Logically, therefore, a point must be reached when this "force" would burn itself out. If the earth were eternal and the laws of nature applied, then he believed, the "force" would have been long since destroyed and the planets fallen into the sun. (This was a problem encountered in the Cartesian plenum with its associated vortex theory, by which Descartes attempted to explain the movement of the planetary bodies.) Here Doddridge turned to Newton's work, in which it was proposed that the "Creator" set the system in motion after which natural laws took over. In Doddridge's view the smooth working of these natural laws required continual oversight from God, an interpretation of Newton's work which differed from some others, and which was the most readily compatible with strong religious faith. An alternative interpretation allowed only a limited role for God, and raised questions for theologians which seemed to threaten the very roots of their faith. In Doddridge's view, an harmonious relationship between science and religion was created, where scientific discovery could be clearly seen to affirm the validity of faith. In this context, the nature of the sun was discussed; if it were temporal, and if there were no continually watchful Creator, then the sun itself would be subject to eventual decay and burn out. On the question of whether fuel was added, Doddridge could make another point helpful to the argument from design:

> "... fewel is or is not exactly adjusted to the expence of his flame: if it is not exactly adjusted, if too little, the consequence urged above will at length though still more slowly follow; if too much, the sun must have been burnt up, and so an argument against its eternity will arise in another form, from the ever-growing heat of the sun; but if the adjustment be exact, it will be such a proof of design and government in the works of nature as would be so greatly serviceable in another view, that any friend of religion might willingly spare this argument against the world's eternity, when there are so many others unanswerably strong."[18]

In Doddridge's scheme, God had a clear and continuing role in maintaining forces (centrifugal and centripetal), equilibrium, and the general diversity and balance of life on earth. A further "proof" of a created world existed in the position of the fixed stars: Doddridge suggested that the attraction between fixed stars and the sun would have resulted in a meeting of such stars in the common centre of gravity in the universe. This idea was extended to the solar system, where Doddridge suggested gravity would eventually cause collisions.[19] Population growth (here Doddridge cited Sir William Petty's political statistics), the formation of rocks, mountains, and periodic return of comets were also offered in evidence of a temporal rather than eternal world. Finally the world-wide prevalence of the creation tradition suggested that this in itself was further supporting evidence; the fallacy of this argument was either unperceived or ignored by Doddridge.

In Lectures 30 and 31[20] Doddridge attempted to demonstrate God's existence from the works of nature. He described the perfection of creation: for example the situation of heavenly bodies, so placed that they did not collide with each other; the vegetable life "with which the earth is furnished, so various, beautiful and useful", "in the inferior animals, it is wonderful to observe, how their different organs are fitted for those different circumstances in life for which they are intended, and especially to the elements in which they are chiefly to live." Such beauty and such order could not have come about by mere chance which, Doddridge believed, would have produced a very confused and imperfect system.

Confident of his thesis, Doddridge inserted a generalisation:

> "On the whole it may be observ'd, that the more philosophy is improved and enquiries pursued, the more is the harmony and regularity of the works of nature illustrated, and the more evidently does it appear, that objections formerly made against them were owing to the ignorance of those that advanced them."[21]

However he did not deal with the counter arguments to the idea of a benevolent Creator which raised awkward questions about the existence of poisonous plants or disease. He dismissed such counter-arguments as weak and easily refuted, referring the reader to a selection of other authorities which included Bentley, Ray, Keil, Wilkins and Clarke. Doddridge chose to reaffirm the point that a perfectly ordered beautiful and harmonious world must have been created by God.

Doddridge imagined the creation in the form of an heirarchy. On earth, man was at the pinnacle, and it therefore became necessary to clarify man's position in relation to animals, particularly where moral questions about the use of animals as food were concerned.

Although animals shared some characteristics with man (perception by sight, hearing, memory, ability to exert free will, emotion) there was a distinction. While man had the power of abstract thought, and the ability to reason, animals had not. Doddridge dismissed the Cartesian view that animals were mere machines because the phenomena distinguishing the animate from inanimate could not be explained by any mechanical laws or principles. He also rejected the view that man was no different from an animal as man was evidently ".... a creature superior to the brutes...". He was also unconvinced by a theory that plants were a species of animal.[22] Doddridge believed animals to be governed by instinct, and cited Derham[23] and de la Pluche's Nature Display'd[24] in support of his view.

Doddridge saw no objection to the use of animals as human food. He argued:

> "The instinct which brought fish in shoals to the shore seems an intimation that they are intended for human use."[25]
>
> "The agreeable variety of tastes which God has given to the flesh of many birds, beasts and fishes, is a further presumption that he designed them for our food, and consequently meant to give us a liberty of taking away their lives."
> ...
>
> "that by appointing it ... that they should multiply so fast, God has made it necessary that many of them should be slain, from where we may reasonably argue, that he allows us to kill them for food."[26]

On the difficult question of depriving animals of their life for human food, in apparent contradiction of the rest of God's laws, he wrote:

> "The happiness of the brutes is not on the whole diminished but rather promoted by this means: for violent death does not seem to be near so painful as a natural death, coming upon they by slow advances of a disease: their life though it be shortened, yet is not embittered with fear and expectation of death, of which they seem not capable: to which we may add, that out of regard to our own advantage, we take care to feed and defend them which renders their lives much happier than they would otherwise be; whereas were they not to be used for food, we must either destroy them without eating their carcases, to prevent their multiplying too fast upon us, or they would destroy each other, consume the vegetable creation, and perhaps grow dangerous to us for want of sufficient food."[27]

Doddridge warned against abuse of the animal world, remarking that man should not add unnecessary terror and pain to animals' deaths, nor should he make sport with their lives. However, in the final analysis, his opinion was that the rights of animals must give way to those of humans:

> "... as they are capable of but small degrees of happiness in comparison with man, it is fit that their interests should give way to that of the human species, whenever in any considerable article they come in competition with each other."[28]

Some of the lectures were devoted to discussion of the physical universe, for example lectures 46 and 47 on space, place and time. Doddridge's personal library contained Newton's <u>The System of the World</u>, the non-mathematical summary of a portion of <u>Principia</u>, which was probably his most important source of reference. No Cartesian texts were used by Doddridge in the teaching of natural philosophy; for him the framework of the physical universe was Newtonian; some Cartesian theories were discussed and refuted by drawing on Newtonian ideas. Space, Doddridge proposed, was a "mere abstract idea; and does not signify any thing which has a real and positive existence without us." Space was neither a "mode" nor a substance, nor was it God. Students were referred to a work by an Oxford theologian, Dr

Daniel Waterland, to discover how the idea of space was formulated, and how the mistake of believing it to be "something real" arose. Further discussion of whether space was a simple idea and whether it forced its existence upon the observer led to a consideration of motion in relation to space:

> "If space were not real, it is said there could be no motion, because no space to move in.
>
> Ans. A body might move on to infinity; for there would be nothing to stop it: and since motion is only a change of place ... there needs no such medium through which the change should be made."[29]

Doddridge gave as a references Jackson, Law, Clarke, Watts and Leibnitz.[30] He clearly found the philosophical discussion of physics difficult and irritating, for he rather testily concluded his discussion of space as follows:

> "It is a matter of humiliation, to think that there should be such weakness and darkness in the mind of man, that some of the greatest geniuses should dispute whether space be God, or whether it be nothing."

Doddridge believed time to be an abstract idea similar to space, though he did not elaborate.

The Newtonian notion of the universe as God's sensorium was briefly touched upon. Initially in a discussion of whether an immaterial being can enter a material body, he commented that

> "If the penetration mean no more, than that God can act in and upon every particle of matter where or however situated, this will be readily granted ... "[31]

Doddridge was aware that not everyone accepted this position, and mentioned a recent work by Samuel Colliber, a writer of religious tracts, who seems to have held the view that God was finite. In a footnote, the editor of the Lectures commented that when Doddridge was preparing the lectures, Colliber's Enquiry[32] excited much interest but had later "sunk into oblivion". Doddridge was puzzled by Colliber's views but was so assured of his own position and beliefs that he felt no need for further refutation.

The Lectures clearly set out a philosophy of science which was firmly based in the argument from design, and strengthened the links between the subject and theology. That the newest research in scientific matters could be helpful to theology would have been evident from Doddridge's use of Newton's work which he used to support and confirm the idea of a created, maintained universe. The Lectures continued in use at the Academy for several years, and in their published form, from 1763 onwards reached a much wider, general audience exerting an important influence, particularly among the educated dissenters.

Although the Lectures were central to the natural philosophy syllabus at Northampton, Doddridge also used some supplementary texts. When his opinion of study texts was sought by John Wesley (before the foundation of Kingswood School for Methodists) Doddridge recommended those which reinforced various themes which he had covered in the Lectures. Thus works by Nieuwentyt, Ray, Watts, Cotton Mather and Derham,[33] were recommended, which were texts in use by the Northampton students. These works were all similar in their very positive use of natural phenomena to support religious arguments for the existence of a created, ordered universe. Of this group, Doddridge appears to have thought most highly of Derham, for against a reference to this author in a letter to John Wesley he adds "above all". The works of Derham and Nieuwentyt[34] would have become known to Doddridge at Kibworth where, as already noted in Chapter 3, these texts had been used.[35] Of the others, John Ray's Wisdom of God,[36] is the best known and the most perceptive. Published originally in 1691, it was based on lectures given at Cambridge in the 1650s, but the early printed editions contained new material added under Ray's supervision. Divided into two parts, the first covered a study of inanimate bodies, animal and vegetable life. In the second, the earth itself was considered as a physical body while man was given most attention as the highest form of life. Ray clearly set out his purpose in the Preface:

> "The particulars of this discourse serve not only to demonstrate the being of a Deity, but also to illustrate some of His principal attributes, as namely His infinite power and wisdom. The vast multitude of creatures ... are effects and proofs of His almighty power ... The admirable contrivance of all and each of them, the adapting all parts of animals to their several uses, the provision that is made for their sustenance ... and lastly their mutual subserviancy to each other and unanimous conspiring to promote and carry on the public good are evident demonstrations of the sovereign wisdom."[37]

Ray's philosophy fitted well with Doddridge's in confirming the centrality of the argument from design, denying a "chance" cause for the Universe, and asserting that such phenomena as uniformity of motion could not exist unless "providence" had overruled chance. Spontaneous generation was impossible in Ray's view, for a conjunction of mechanical circumstances could not generate life. The number of species was fixed by the creator and after the "sixth day" life was dependent on generation from the original ancestors. The possibility of the existence of other inhabited worlds strengthened the case for the existence of a creator: to Ray the "immeasurable great" number of creatures in the universe afforded "demonstrative proof of the unlimited extent of the creator's skill and the fecundity of his Wisdom and Power".[38] Doddridge briefly touched on this point in Lecture 98 of the Ethics series[39] suggesting that a consideration of the variety of life that exists, and which can be ordered in terms of superiority led one to the conclusion that

> "we, who are in part allied to the beasts that perish, and who are placed in so imperfect a state of being are not the highest order of spirits and the most glorious creatures of our almighty creator: but rather, that the scale of created beings rises abundantly higher".[40]

In this passage, Doddridge imaginatively expressed the idea of the "Great Chain of Being" which placed man in relation to fellow creatures on earth, and also in his cosmic context.

Ray's original lectures, on which the book was based, were read at Cambridge (in the 1650s) at a time when discussion centred on Descartes' philosophy. Descartes had stated that man could not discover the creator's purposes, and must therefore exclude any search for final causes from philosophy, thus disposing of the fundamental basis of the argument from design. Ray countered with three arguments: firstly that the purposes of some things were obvious and unmistakable (for example the eye); secondly Ray asked how man could praise God for the use of limbs or for providing food, if he didn't know that they were intended for such use, and thirdly he asked how may the existence of God be proved if a denial of final causes destroyed the best demonstration of his existence? This last question of Ray's touches the fundamental difference between the Cartesian mechanistic universe and the universe of the theological argument from design. Ray's arguments were not only useful in refutation of Descartes' mechanistic philosophy but were also of help in supporting the argument from design.

Unlike many writers on this theme (particularly Derham and, later Paley), Ray was aware both of dissent from and weaknesses in the argument from design and did not lightly dismiss such views:

> "It is a generally received opinion that all this visible world was created for Man [and] that Man is the end of creation, as if there were no other end of any Creature but some way or other to be serviceable to man .... But though this be vulgarly received, yet wise men nowadays think otherwise"[41]

Ray's work was an excellent example of its kind: having rejected chance in the formation of the earth, the only alternative hypothesis was fully developed.

"Watts" can be identified as the hymn writer, Isaac Watts, (1674-1748) author of the textbook Knowledge of the Heavens and Earth Made Easy (1726) which covered both elementary astronomy and geography with emphasis on the terrestrial globe.[42] Readers were reminded of the underlying philosophy of the argument from design, and God's central role as Creator, often in language reminiscent of Watts' hymns:

> "If we look upward with David to the Worlds above us, we consider the Heavens as the Work of the Finger of God, and the Moon and stars which he hath ordained. ...Nor was there ever anything that has contributed to enlarge my apprehensions of the immense Power of God, the Magnificence of His Creation, and his own transcendent Grandeur, so much as that little portion of Astronomy which I have been able to attain.[43]

Watts here suggests how a little knowledge of the physical universe could enhance and strengthen religious faith.But the book also offered a very clear and straightforward introduction to geography, and offered some exercises for students to test their understanding of measurements of the globe, and calculation of longitude and latitude.

Cotton Mather's The Christian Philosopher[44](1721) was based on the work of Ray and Derham with occasional references to a Newtonian textbook, such as Cheyne's.[45] Mather clearly wished to popularise the study of science and to show that there was no conflict between science and religion:

> "The Essays now before us will demonstrate that Philosophy is no enemy but a mighty and wondrous Incentive to Religion ..."[46]

Of the five texts of this group, Cotton Mather's is the least scholarly and most unreliable on scientific matters. It is a compilation of ideas and information gleaned at random from various sources, including Islam, and welded together to form support for the argument from design. Occasionally nonsense is included as fact: for example a reference to snow which fell with a "woollen consistence" so that it could be called nothing but wool.[47] Mather's work would, however, have provided much useful material for inclusion in sermons, as the following example shows:

> "The Telescope, invented the Beginning of the last Century and improved now to the Dimensions even of Eighty Feet, whereby Objects of a mighty distance are brought much nearer to us: is an Instrument wherewith our Good God has in a singular manner favoured and enriched us: A Messenger that has brought unto us from very distant regions, most wonderful discoveries. My God, I cannot look upon our Glasses without uttering thy Praises: By them I see thy Goodness to the Children of Men! By this Enlightener of our World, it is particularly discovered that all Planets at least, excepting the Sun, are dense and dark bodies; that what Light these opake bodies have is borrowed from the sun ..."[48]

Doddridge also recommended some texts for students which concentrated on basic descriptions of forces, elements and so on, but which placed little or no emphasis on the religious philosophy of the argument from design: Rowning, s'Gravesande/Desaguliers, Clare, Keill, Jennings and Wells.

"Rowning" and "s'Gravesande or Desaguliers" offered an individual interpretation of Newton's universe. "Rowning" may be identified as the popular textbook by the Cambridge tutor, John Rowning,[49] A Compendious System of Natural Philosophy. Published in two volumes, 1735-43, it was used as an introductory natural philosophy text at Cambridge until the 1740s, and at Oxford until the 1790s, as well as at other Dissenting Academies.[50] Rowning's main interest lay in the field of attractive and repulsive forces, which he developed further than any contemporary writer.[51] Doddridge's recommendation of s'Gravesande's or Desaguliers' Philosophy is confusing. This recommendation could refer to either s'Gravesande's Physices elementia mathematica[52], first published in Latin in 1720/1 and shortly afterwards in English, an early translation being one by Desaguliers, or to Desaguliers' own Experimental Philosophy. It has already been noted that s'Gravesande's work represented an early attempt to present Newton's ideas non-mathematically. In Desaguliers' own Experimental Philosophy[53] of 1734-44, students would have had to cope with a text which focussed on the problems of the Newtonian universe, and which injected elements of doubt into the stable world which Doddridge sought to portray, where scientific fact supported theological precept. This, however, is unlikely as Doddridge makes reference to the work in 1741, before the complete work was available.

Clare's The Motion of Fluids[54](1738) contains no overt reference to the religious arguments. This text was based on lectures "privately read to a set of gentlemen"; the "set of gentlemen" were probably Clare's students at the Soho Academy[55] which offered a broad general, but not religious, education to youths. Clare also appears to have had contact with the experimental natural philosopher, J T Desaguliers, whom he consulted during preparation of the book. This introductory text covered "staticks", "hydrostaticks", and human biology, the latter under the heading "Pneumaticks" and built around the nature and properties of air. Theory was generally included only where it was necessary to explain particular principles. Thus there were introductory sections on the nature of fluidity, the Cartesian plenum and "specifick" gravity which were chiefly straightforward descriptions, quoting from Newton, Keill and Descartes as the main references. The theory underlying Clare's work thus consisted of an amalgam of theories old and new. However the main thrust of the book was towards the practical, and in many instances the experiments described could be easily reproduced by the reader, as little in the way of special equipment was needed. "How things work" was also an important theme, and descriptions of the workings of a fire engine and a steam operated water pump, similar to Newcomen's, were included.

Particular aspects of human biology were touched upon. For respiration Clare supported Mayow's aerial nitre theory[56] at a time when it was under increasing attack. He also discussed muscular motion, digestion, the working of the heart (illustrated diagrammatically) and the venous system. For the heart, the mechanical metaphor of the pump was suggested as a helpful way of grasping the principles involved. Clare's text would thus have been useful in the teaching of anatomy, a subject which Doddridge introduced into the curriculum at an early date. (The main teaching text used for this subject was James Keill's <u>The Anatomy of the Human Body</u>, already in use in other Academies.) Clare's work also covered atmospheric phenomena (thunder, lightning and meteors), and a chapter on deep water diving with details on the construction of diving apparatus.

Further exercises in astronomy were offered in two basic primers by Wells and Jennings. Wells' Young Gentleman's Mathematical Recreation (1714) covered the main branches of mathematics[57] with emphasis on usefulness and ease of assimilation. In addition to astronomy, exercises on optics were provided. A homily on the duty of wealthy young gentlemen to learn was included in the preface:

> "And since God sends no one into the world to be idle, or only to take his pastime therein; but the more he has free'd Gentlemen from bodily labour, the more he expects they should exercise the Faculties of their Minds in order to his greater Glory, by raising their minds to more clear and sublime apprehensions of his divine perfections ..."[58]

The reference to Jennings' text Introduction to the Globes and Orrery is interesting as its quotation in the letter to Daniel Wadsworth (sometime pastor of the First Church of Christ, Connecticut) dated 1740/1 indicates that Doddridge must have known of this text, prior to its publication in 1747. Some points from Jennings work were discussed, and questioned in Doddridge's own lectures.

The teaching of scientific subjects had a place in the Northampton curriculum for all students of the Academy during Doddridge's lifetime. Doddridge's ideas on the purpose and value of science were clear, and students were shown clearly the interlinking of scientific studies with theology. An important function of science was to provide material which could be used for theological purposes, and as an early biographer, Job Orton noted, Doddridge

> " .. tended to promote [the students'] veneration and love for the great architect of this amazing frame whose warders of providential influence are so apparent in its support,

> nourishment and motion; and all concurred to render them agreeable and useful in conversation, and to subserve their honourable appearance in the ministry."[59]

and:

> "[Doddridge] took occasion to graft some religious instruction on what he had been illustrating, that he might raise in the minds of his Pupils to God and Heaven."[60]

There was no attempt to offer specialist courses in any aspect of the subject of natural philosophy, but students received an introduction to experimental philosophy, albeit in the form of demonstrations in which a student assisted the tutor. For the students, Doddridge was an exemplar who could combine theological and scientific interests, and use both to serve the local community.

Criticism has been levelled at Doddridge from some sources, including the historians Bogue and Bennett[61] for adopting an attitude of such impartiality towards the teaching of controversial subject matter that students could not distinguish the erroneous, and for including so many conflicting theories that students were left in confusion. While there may be some truth in these criticisms for Doddridge's teaching of other subjects, it is not so within natural philosophy: here Doddridge had a clear framework, and taught competently within it. However, a weakness in Doddridge's view of science can be perceived. In his selection of scientific texts, he was uncritical. His preference for Derham "above all" and Nieuwentyt displays a lack of intellectual rigour, not to mention his choice of the (in scientific terms) ridiculous Mather. These texts are however marked by the strength of their theological argument. Unwilling to devote more of his time than strictly necessary for his own study of science[62], Doddridge betrayed some impatience with those who contemplated the more abstruse aspects, for example the nature of space and time, of the Newtonian universe. This in turn suggests that his understanding of the significance of these issues did not run very deep.

Outside the Academy, Doddridge was involved in scientific and medical interests, the most notable being his involvement with the founding of the County Hospital at Northampton, and of the Northampton Literary and Philosophical Society. He gave generously of his time in planning and gaining public support for the hospital. This project was discussed in his correspondence with the Headmaster of Winchester School, where the latter gave advice based on experience at Winchester Hospital. In 1743 Doddridge preached a sermon on the benefits of a hospital (Compassion to the Sick Recommended and Urged) which he later had printed and circulated to help the cause.[63] In it Christian charity was stressed, but Doddridge also put forward arguments which supported the cost-effectiveness and utility of such an institution. He had carefully studied the success of hospitals recently established (Winchester, Bath, Exeter, York, Bristol, London and Westminster, all of which had opened since 1740) and his summary of reports from these new hospitals revealed 7330 persons known or believed to be cured, 784 dead or discharged incurable. Doddridge reported that such diverse ills as palsies, dropsies, consumptions, fevers, leprosies, rheumatisms, cholics, stones, as well as ulcers, fractures and dislocations had been relieved, sometimes after several years of suffering. Doddridge also made the point that efficiency was improved by treating groups of people rather than disbursing small sums of money to individual families.

Another medical interest was innoculation against smallpox. Following an outbreak of the disease in local villages in 1750, Doddridge saw variolation as the only means of limiting the spread of infection. He published a paper by David Some[64] on the efficacy of variolation. (The use of the safer method of vaccination, promoted by Jenner, lay some 30 years in the future.) In his pamphlet, Some discussed the religious objection that innoculation intervened in divine affairs - a point which had already caused concern among New England dissenters.[65] Some's paper was originally published in 1725 when interest in variolation was high following well-publicised experiments involving Lady Mary Wortley Montague.[66] The practice all but died out in Britain and Europe after 1728 when the dangers and limitations of this method of protection against smallpox became evident. Doddridge arranged for the pamphlet to be reprinted, and to Some's title <u>The case of receiving the smallpox by innoculation impartially considered, and especially in a religious view</u>, Doddridge added the question "I will ask you one Thing Is it lawful ... to save life, or to destroy it?" This theme harks back to the lectures on Ethics, where Doddridge stated that all lawful means are to be used to preserve life: not to preserve it is to destroy. Further, if the action to preserve life brought temporary disorder then the action must still be taken. Innoculation was justified by this means. Doddridge also revealed a passing interest in other diseases or accidents, for example, lockjaw, from which a student (William Worcester) died[67] and antidotes for viper bites on which he submitted a paper to the Royal Society about an experiment conducted by a professional viper catcher, Mr Oliver.[68] Miracle cures were also reported to and by Doddridge in his voluminous correspondence.

Doddridge appears to have enjoyed his membership of the Northampton Literary and Philosophical Society, with which he was involved from its foundation in November 1743. Academy students occasionally accompanied him to the meetings.[69] He read papers to the Society on two occasions: one on the pendulum and another on elastic and inelastic collisions. He later wrote to Henry Baker, the naturalist and poet:

> "... very little is expected from our meetings more than the Amusement & Improvement of those who are learning their first elements in philosophy."[70]

Doddridge was introduced to Baker by William Shipley, (later founder of the Royal Society of Arts in the 1750s) whom he met at the Northampton Society. Doddridge and Baker corresponded regularly on scientific or medical interests between 1747 and 1750, and there are references to exchanges of compliments between Baker and Shipley in the letters.[71] Doddridge also submitted a paper to the Royal Society in London on the Northampton earthquake of 1750[72] and possibly a second about electrical experiments.

Membership of such a society was a hallmark of a cultured gentleman of the period, and like most such gentlemen Doddridge took keen interest in collecting reports of phenomena. His correspondence reveals interest in spontaneous combustion, people with "second sight" and monstrous births. On his journeys he visited any interesting exhibits; in London in 1746 he referred to a "Waxen Lady in Labour" "who concealed nothing from me".[73] On a less sensational level, another letter mentions viewing some "mathematical curiosities" contrived and made by Nathaniel Hickford, the dissenting minister at Chelmsford.

After Doddridge's death, the Academy continued with little change under the direction of Caleb Ashworth,[74] a former student and assistant tutor who was appointed principal in accordance with wishes expressed in Doddridge's will. Shortly afterwards the Academy moved to Daventry where it remained until 1789. Most of the scientific teaching was the responsibility of Samuel Clark,[75] also an ex-student, until his death in 1767. Doddridge's Lectures continued to be read, and Clark's teaching responsibilities included experimental philosophy, thus the work commenced by Doddridge was continued. Indeed the use of demonstrations in the teaching of natural philosophy may have increased, as periodic grants towards equipment were made by the Coward Trust until the end of the 1780s. In 1767, 5 guineas had been voted towards the improvement of the electrical apparatus, and in 1771 £15 was provided for an observatory, the lack of which had caused various inconveniences in the use of astronomical apparatus in the course of the students' work.[76] By 1781 it was reported that the philosophical apparatus was

> "very complete in Mechanics, Hydrostatics, Pneumatics, Electricity and the Airs, but defective in the Astronomical and Optical departments."[77]

Electrical studies were introduced by Ashworth in 1767, at the time of publication of Joseph Priestley's The History and Present State of Electricity. Teaching of the subject continued into the 1780s, when William Broadbent, an ex-student gave a series of lectures, the notes of which have survived. These will be considered in greater detail in Chapter 6; for the time being it is sufficient to note that there was a concentration on the history of electricity, including spectacular experiments, medical uses and descriptions of appropriate equipment. Broadbent also lectured on Chemistry in the same period (1780s), and here the content of his lectures was not dissimilar from those read by Martin Wall at Oxford at a slightly earlier date.

On Ashworth's death in 1775, Thomas Robins[78] was appointed principal but a speech defect forced him to retire in 1781. He was succeeded by Thomas Belsham[79] who had also been a pupil and assistant tutor at the Academy, and was then a minister at Worcester. On being offered the post of Academy Principal by the Coward Trustees who by now played an increasingly important role in the management of the Academy, Belsham immediately sought to have the Academy moved to Worcester but, with an eye to possible distractions, the Trustees "considered it undesirable to have it near the contagion of a fashionable collegiate city and would not hear of it".[80] In the course of his principalship, Belsham was invited to minister at Northampton (1785) and at Warwick (1788), and on both occasions attempted to have the Academy transferred to these locations. These attempts failed, as the Trustees considered a move to be too costly a project.[81]

A shortage of funds became apparent at the Academy in the early 1780s. The Coward Trustees gave financial support to the Hoxton Academy as well as Northampton and the monies available were insufficient to support both institutions. The Hoxton Academy closed in 1785, leaving the Coward Trustees free to consolidate their Funds behind the Northampton/Daventry institution.[82] Belsham resigned his appointment at Daventry in 1789, when he realised that his own religious standpoint (Unitarian) was incompatible with that of his colleagues, and unacceptable to the Coward Trustees. Belsham moved to Hackney College, to take up appointment as principal.

Under John Horsey, the new principal, the Academy returned to Northampton, but from 1789 onwards it was closed to non-ministerial students. According to an early account thought to be based on Miss Horsey's recollections, John Horsey and the Trustees took this decision because of a fear that the continued admission of lay students would force the more "respectable" dissenters to send their sons to the universities or to the "Socinian College"(Hackney Academy, Chapter 8).[83] The Academy thus gave up any claim to be concerned with general, higher level education and became an institution with strictly limited vocational aims. The Academy closed in 1798 after an acrimonious dispute between Horsey and another tutor, Saville, the latter having accused the former of scepticism and unorthodoxy.[84] The students intervened, and later the Trustees became involved. What remained of the Academy was eventually incorporated in the foundation of New College, London.

During its lifetime, between 1729 and 1798, some 466 students were educated at the Northampton/Daventry Academy. Several followed careers which involved some knowledge of scientific or mathematical skills. On completing their course of study, some were to teach natural philosophy at Northampton/Daventry, using Doddridge's own material:

Caleb Ashworth
Thomas Belsham
William Broadbent
Samuel Clark
Timothy Kenrick

Others were to become tutors of natural philosophy or mathematics at other Academies. This group included:

John Aikin, Joseph Priestley and Nicholas Clayton (Warrington)
Samuel Merrivale (Exeter)
Thomas Belsham, Hugh Worthington and Joseph Priestley (Hackney)
Stephen Addington (Mile End)

Doddridge's influence within the Academy movement thus continued to the end of the century.

In addition to those students who became tutors, several more, including at least 14 who received some tuition from Doddridge himself, went on to careers in which scientific knowledge was important (Table 4.4). It is nevertheless difficult to gauge the importance of Academy studies in natural philosophy in these cases; experience of natural philosophy studies at the Academy may have been very significant in some instances and set students on a path towards a lifetime's rewarding study or career. In others interest in scientific matters may have developed later, at a Scottish or Continental university; this is certainly true in the case of John Roebuck. Among the group are a large number of medical men, but there are also present a small number of others who were to become members of local philosophical societies, and were able to develop their scientific interests on a less formal level.

This steady stream of students who pursued careers or interests which required some scientific knowledge indicates that the teaching of the subject at the Academy continued at a competent level almost to the end of the century. Up to Doddridge's death in 1751, it has been shown that science was regarded as an important part of the curriculum, and a conscientious effort made to teach it. The

Students of Northampton/Daventry Academy
who followed scientific or medical careers

Year of Entry	Name	Notes
1732	Joseph Hecline	Medical
1733	Joseph Wilkinson	Trade (possibly related to the family of iron-masters)
1734	Samuel Lucas	?chemical industry
1736	John Firth	Medical
	Samuel Wood	Medical
1737	F. Sylvester Wadsworth	Medical
	John Roebuck	Founder of Carron Ironworks; discovered manufacturing process for sulphuric acid. Also attended Edinbrugh University
1739	Caleb Ashworth	Succeeded Doddridge as principal; lectured on science subjects
1742	John Tylston	Medical
1743	John England	Medical
1745	Samuel Clark	Tutor, scientific subjects, Daventry
1747	William Farr	Medical: may have been connected with Royal Hospital Stafford
1749	Newcome Cappe	Founder of a philosophic club at York
1750	Mathew Rolleston	Medical
	Thomas Robins	Principal, Daventry, later druggist
1751	Joseph Priestley	Academy tutor, minister and natural philosopher
1757	William Cooper	Medical
1758	William Enfield	Tutor, scientific subjects at Warrington

Year of Entry	Name	Notes
1761	Joseph Dawson	Member, Leeds Phil. Society; founder of Low Moor Ironworks; later president of Yorks and Derbys. Ironmasters Assn;author, "The Effects of Air and Moisture on Blast Furnaces", mineralogist
1765	Joseph Turner	Medical
1766	Thomas Belsham	Principal, Hackney Academy, occasionally lectured on scientific subjects
1767	James Johnstone	Medical: published several works including "Dissertatio medica inauguralis de angina maligna"; "An Essay on the use of the Ganglions of the Nerves"
1768	Hugh Worthington	Tutor, Hackney Academy; published treatises on maths.
1769	John Cooke	Medical: graduated Leyden; FRCP
1771	William Highmore	Medical
1773	Edward Johnstone	Medical
1774	William Tattersall	Medical; published Medical Histories, 1795
	Timothy Kenrick	Tutor, scientific subjects, Daventry
1775	Abraham Wilkinson	Medical
	Nathaniel Highmore	Medical; published some specialist papers
1777	William Broadbent	Tutor, scientific subjects, Daventry
1781	Samuel Pett	Medical
1783	John Corrie, FRS	President, Birmingham Phil. Soc., elected FRS 1820, tutor Hackney Academy (not scientific subjects)
1786	Malachi Blake	Medical
1787	Thomas Warwick	Medical; also gave chemistry lectures
1788	John Reid	Medical (also attended Hackney)
	Arthur Aikin	Secretary, Royal Society of Arts

Northampton Academy was modelled on John Jennings's at Kibworth, where Doddridge was educated; both Academies have strong similarity not only in choice of texts but in the structure of the curriculum. Jennings, and later Doddridge, concentrated the teaching of science in the second year of study[85]. It can therefore be stated that all students who completed the Northampton course received at the very least a competent introduction to science subjects. This fact underlines the importance of the Northampton Academy not only because of its size and excellence in ministerial training, but also in regard to its contribution to the teaching of science.

Doddridge taught scientific subjects competently within the philosophical framework of the argument from design, using scientific data to support theological doctrine. He was at his weakest where a detailed understanding of the mathematical underpinning of Newton's theories, or where discussion of the abstract (for example space) were required, but emphasis was clearly placed on the utility of the subject, which reflected his own personal interests and activities outside the Academy. The fact that the Academy retained its general high standing and attained some measure of influence in the teaching of scientific subjects throughout its lifetime was due in no small measure to the work of its founder, Philip Doddridge.

REFERENCES

1. PD to Samuel Clark, 6 Feb 1727/8, Humphreys, J D, ed., The Correspondence and Diary of Philip Doddridge, 1829, n.p. II, p.396. Clark (1684-1750) was minister at St Albans, Herts.

2. PD to Lady Russell, ibid, p.541

3. PD to Samuel Clark, 7 August 1729, op cit, p.487. Three of the initial 7 were ministerial students, Williams, Memoirs of T Belsham, 1833, p.63.

4. PD to David Jennings, 7 December 1732, Humphreys, op cit, III,p.115. The Academy remained open to both types of student until 1789.

5. Gasquinone, T et al., History of Castle Hill Church, Northampton, Northampton, 1896, p.22

6. Williams,J, Memoir of T Belsham, published privatley, 1833, p.64 indicates that the Coward Trustees were consulted over the appointment of tutors in Ashworth's time as principal. The Coward Trust, founded by the will of William Coward (d.1738), a merchant who left property to found a trust to support the training of young men, 15-22 years of age for the dissenting ministry. Most students went to Northampton/Daventry or Hoxton Academies which were thus almost completely maintained from the funds for several years.

7. PD to John Barker, Aug.1733, Humphreys, op cit, III, p.205

   > "As for my terms, they are sixteen pounds a year board, and four pounds teaching. [The £16 board was reduced to £14 for pupils helped by charity.] When pupils enter the Academy they pay a guinea each for a closet, and bring a pair of sheets. They find their own candles, and put out their washing."

   In the same letter, PD remarks that John Barker's gift excused him from further contribution to the Library. See also letter to John Beasley, 10 July 1739: charges had not risen at this later date. The equipment consisted of globes (terrestrial and celestial) donated by Lady Russell and a microscope which PD was advised to mount above a mirror.

8. See Gasquinone, T, op cit, pp63.

9. John Aikin, Job Orton, James Robertson, Samuel Clark, and Thomas Brabant. Orton was to publish a life of Doddridge, and Aikin founded a family which was to have close connections with Warrington and Hackney Academies. Clark was to assist Caleb Ashworth at Daventry, after Doddridge's death, teaching natural philosophy.

10. Orton, J, Memoirs of the Life and Writings of the Rev. Phillip Doddridge, 1766, passim

11. Doddridge, P, A Course of Lectures on the Principal Subjects in Pneumatology, Ethics and Divinity, 1763, Introduction

12. Ibid, quoted Parker, I, Dissenting Academies, p.86

13. Orton, op cit, p.92

14. Humphreys, op cit, IV, p.404, date 1745

15. Quoted in a letter from Thomas Belsham to Samuel Heywood, dated 1781

16. McLachlan, H J, English Education Under the Test Acts, 1931, p.296

17. Doddridge, P, Course of Lectures, first published edition 1763, edited by Samuel Clark; later editions were edited by Kippis and others. Also published in French at Liege and Leipzig, also in Dutch at Rotterdam (see van den Berg and Nuttall, passim)

18. Doddridge, op cit, p.351-2

19. PD uses the Newtonian Cheyne's Philosophical Principles of Reveal'd Religion as one of his sources. Cheyne's text reached 5th edition by 1753, but R E Schofield comments that it was full of gaps and depended heavily on Bentley's Boyle Lectures. (see Schofield, R E, Mechanism and Materialism, Princeton, 1970, passim)

20. Doddridge, Course, p.362-7

21. Ibid, p.364

22. This point was taken up by a later editor of the lectures, Andrew Kippis, whose footnote refers to an "ingenious essay" on the subject by Dr Percival of Warrington, in Manchester Phil.Trans. (1785). This was probably Perceval's "Speculations concerning the Speculative powers of vegetables".

23. Derham, W, Physico-Theology, London, 1713, passim.

24. de la Pluche, Nature Display'd, 1743. This was a most popular text on the continent in the Derham vein. First published in 1732 as Le Spectacle de la Nature, 3rd enlarged edition in English 1743. Structured as conversations between four people, a priest, woman, student and an amateur naturalist.

25. Doddridge, op cit, p.133

26. Ibid, p.446

27. Ibid, p.446

28. Ibid,p.444

29. Ibid, p.400

30. While the others are wellknown, Jackson and Law are less so today. Jackson, probably John Jackson (1686-1763), religious writer, educated Cambridge, anti-deist; Law - probably Edmund Law (1703-1787) educated Cambridge, theological writer.

31. Doddridge, op cit, p.402

32. Colliber, Samuel (fl.1718-1737) writer of theological tracts; profession and other details unknown. The text referred to is An Impartial Enquiry in the Existence and Nature of God (1718)

33. When John Wesley asked Doddridge to provide a list of books suitable for the methodist school at Kingswood, Doddridge responded very fully in a letter dated 18 June 1746. The scientific "titles" recommended were:

"Natural Philosophy
    Rowning
    Nieuwentyt,Religious Philosopher
    Ray, Wisdom of God
    Cotton Mather, Religious Philosopher
    Derham on Boyle's Lectures
Astronomy
    Derham
    Watts
    Jennings Introduction to the Use of Globes

and the Orrery
Wells, _Young Gentlemen's Mathematical Recreation_"

Other titles were recommended in an earlier letter from Doddridge to Daniel Wadsworth, sometime pastor of the First Church of Christ at Hartford, Connecticut in 1740/1:

"Clare's _Fluids_
Keill's _Anatomy_
Gravesande's or Desagulier's _Philosophy_"

No exact titles or dates were supplied. Letter quoted Nuttall,G F, _Calendar of the Correspondence of Philip Doddridge, DD, 1702-1751_, London, 1979, p 130

34. Derham, W _Astro-Theology_,London, 1715, _Physico-Theology_,London,1713; Neiuwentyt, B,_The Religious Philosopher_,1718/19

35. The similarity can be compared: Doddridge's scientific education at Kibworth was as follows:

1st half	Geometry - _Euclid_
2nd half	Algebra
3rd half	Mechanics: lever, screw, wedge, pulley, (Jennings course) Hydrostatics: Abridged lectures of Mr Eames Physics: Le Clerc (except astronomy and anatomy) Harris's _Technicum Lexicon_ Niewentyt's _Religious Philosopher_ Derham's _Physico-_ and _Astro-Theology_ Rohault Varenius &c.. many defects and mistakes in Le Clerc Use of Globes: Jones' course Astronomy & Chronology: Jennings system from his "Miscellanies"
4th half	Physics & Miscellanies: completing 3rd half courses
6th half	Miscellanies: completing 3rd and 4th half courses

Source: PDs letter to Thomas Saunders, Nov.1728, Humphreys,_op cit_, _II_, p463

36. Ray, John, The Wisdom of God Manifested in the Works of Creation,1691, London

37. Ray, op cit, preface, 1st edition.

38. Ibid

39. Doddridge, op cit, p534

40. Ibid, p.535

41. Ray, op cit, p 127-8. Ray also considered a related criticism that the uses of things were not designed by nature, but that man accommodates things to his use. In his view man merely found the required materials and with his own intelligence found ways of using them: the Creator would of course know all the uses to which materials could be put.

42. Watts, Isaac, Knowledge of the Heavens and Earth Made Easy, 1726-8. The text was mostly concerned with detailed explanations in simple language of astronomical and geographical terms (eg peninsula). Some problems were included but readers were referred to other authors for a wider selection.

43. Watts, op cit, p.vi

44. Mather, Cotton The Christian Philosopher: A Collection of the best discoveries in Nature with Religious Improvements,1721. PD refers to this as "Religious Philosopher" but Mather wrote no work with this or similar title.

45. Cheyne,G Philosophical principles of religion natural and revealed, 1705

46. Mather, op cit, p.1

47. Ibid, p.60

48. Ibid,p.17

49. Rowning, John, (1707-71) educated Cambridge,tutor at Magdelen College, Cambridge.

50. Priestley extracted some of the illustrations from it to accompany his own History and Present State of Discoveries relating to Vision, Light and Colours (1772)

51. Thackray,A, Atoms and Powers, Harvard, 1970, p.145, thought of Rowning as an "ancestor" to Roger Boscovich.

52. See Chapter 3 for a brief discussion.

53. See Chapter 7 for further discussion.

54. Clare, M, AM,FRS, The Motion of Fluids; Natural and Artificial in particular that of air and water in a familiar manner proposed and proved by evident and conclusive experiments to which are added many useful remarks done with such plainness and perspicuity as that they may be understood by the unlearned. For whose sake is annexed a short explanation of such uncommon terms which in treating on this subject could not without affectation be avoided with plain draughts or such experiments and machines which by description only might not readily be comprehended. 1738, 2nd edition. Martin Clare was the principal of the Soho Academy, London c.1718/19 to 1751.

55. The Soho Academy was founded by Clare c1717/18 for youths intending to enter commerce.

56. Mayow's "aerial nitre" represented a substance not unlike the later oxygen which was essential for life, and a component of air. It resembled in some ways Lavoisier's oxygen yet fitted well with the theories of Hooke, Lower and Boyle.

57. Topics covered: astronomy, optics, trigonometry, logs, mechanics (including statics), hydrostatics, arithmetic (including algebra) chronology and dialling.

58. Wells, E E Young Gentleman's Mathematical Recreation, London, 1714, preface, vol.I

59. Ibid, p.60

60. Ibid, p.311

61. Bogue and Bennett, History of the Dissenters from the Revolution in 1688 to the Year 1808,4 vols, London 1808-12, III, p.480,484. Quoted Ashley Smith, The Birth of Modern Education,London, 1954, p.141.

62. "Though [Doddridge] seemed formed by nature for cultivating the more polite, rather than the abstruser parts of science, yet he was not a stranger to mathematical and philosophical studies. He thought it inconsistent with his principal business to devote any considerable part of his time to them; yet it appeared from some essays, which he drew up for the use of his pupils that he could easily have pursued these researches to a much greater length."
Orton, op cit, p.92

63. See Deacon, M, Philip Doddridge of Northampton, Northampton, 1980, for information on PD's involvement with the hospital. The published plan for the hospital is document IL2561 of Northants Record Office.

64. Some, David (senior); minister at Market Harborough (d.1737). PD saw the tract in November 1725 when it was first written (letter to Samuel Wright (17/11/25). Some was educated at Rathmell Academy, with Frankland.

65. Mather, Cotton An Account of the Method and Success of Innoculating the Smallpox, 1722

66. Lady Mary Wortley Montague (1689-1762), traveller, and author. Accompanied husband on diplomatic postings to Europe and Far East, where she learned of variolation as a protection against smallpox. Popularised the method on her return to London.

67. Correspondence with Henry Baker FRS (1698-1774) c.1750. Quoted Nuttall, op cit

68. Reported by C Owen in An Essay on the Natural History of the Serpent, London, 1742, p.79. William Oliver, viper catcher of Bath, allowed himself to be bitten, applied his own treatment which included oil of olives; witnessed; reported by Dr Mortimer to Royal Society, date of experiment was 5 June 1735

69. Diary of Thomas A Ward, Sheffield Public Library; quoted Musson, A E & Robinson,E, Science and Technology in the Industrial Revolution, Manchester, 1969, p.149

70. Letter, 3 November 1747, on behalf of the Northampton Society, to Henry Baker, quoted Nuttall, G, op cit, p261

71. See Allan, D., William Shipley, Founder of the Royal Society of Arts: A biography with Documents, first published 1968, reprinted, enlarged 1979, London.

72. Phil Trans., xlxvi (1750) read 25 Oct 1750

73. PD to Mercy Doddridge, 14 August 1746, LCL Reed MS 98, quoted Nuttall, op cit, p.238

74. Ashworth, Caleb (1722-1773) DNB, educated at Northampton and graduated with doctorate from a Scottish university; wrote Treatise on Trigonometry (1768) for use by students of the Academy. Ashworth was already in the district, acting as assistant to a neighbouring minister, James Floyd, when Doddridge died.

75. Clark, Samuel (1729-1769), student, assistant tutor at Northampton Academy; editor of first edition of Doddridge's Lectures.

76. Minutes, Coward Trust, quoted McLachlan, op cit, p.174

77. Quoted McLachlan, op cit, p.174

78. Robins, Thomas: chose the trade of druggist on leaving Daventry, suggesting some interest in medicine and scientific matters. No scientific writings are listed in the BL catalogue, nor is there any reference to his playing an active part in science teaching at Daventry.

79. Belsham, Thomas (1750-1827); DNB, Williams, op cit.

80. Williams, op cit, p.184. The reference to the collegiate city is unclear.

81. Ibid, passim

82. Williams, op cit, passim

83. Horsey Papers, Dr Williams Library, ms 69:7. Possibly reminiscences of Miss Horsey. The "Socinian College" was Hackney. Although not clarified, the universities referred to may have been Scottish.

84. Horsey papers, op cit.

85. See note 35 above for Jennings' curriculum at Kibworth.

CHAPTER 5: CASE STUDY - MOORFIELDS/STEPNEY ACADEMY, JOHN EAMES AND DAVID JENNINGS

This Academy comprised two separate institutions in the East London area, which were linked through members of staff and through the support of the Congregational Fund Board.[1] These were Moorfields (Tenter Alley) Academy (1701-44) and Wellclose Square (Stepney) Academy (1744-62); from 1762 until its closure in 1784, the Academy was based in Hoxton Square, Hoxton.

The Moorfields Academy was founded in 1701 by the Trustees of the Congregational Fund. Throughout the first half of the century these Trustees, and later the Coward Trustees,[2] played an increasingly important role in the Academy's management. Indeed the Academy was known for a time as "Coward College", because of its strong connection with the Coward Trust. Many of the students were funded by these Trusts, and the Charity Trustees were involved in the appointment of staff at the Academy. Isaac Chauncy[3] was appointed the first tutor; aged 68 years at the time of his appointment, for many years Chauncy had been a Congregational minister at Andover, Hants. His own education began in New England, where he studied medicine at Harvard, and was completed at Oxford, where he arrived during the Commonwealth period. Although he was a practising physician as well as a minister, his main interest was divinity. Chauncy's theological standpoint led him to doubt the adequacy of human reason in man's quest for true knowledge. This attitude would not encourage him to foster scientific study with emphasis on observation and experiment and given his interests it is unlikely that scientific subjects were taught at Moorfields during the early years. No information appears to have survived about students from this period.

On Chauncy's death in 1712, Thomas Ridgley[4] was appointed senior tutor at Moorfields. Ridgley had been educated at the Trowbridge Academy and also by a tutor noted for his interest in theology, Thomas Doolittle of Islington 2 Academy. Ridgley's own interests were also concentrated on divinity: for the students' use, he prepared his own teaching text Body of Divinity, which set out the orthodox Calvinist theology. He was also a strong Congregationalist, and held similar views on the role of reason to his predecessor, Isaac Chauncy. Soon after Ridgley's appointment, the Academy appears to have attracted sufficient students to employ a second tutor, John Eames[5] who taught mechanics, statics, hydrostatics, optics, surveyors' trigonometry, pure geometry and anatomy. On Ridgley's death in 1734 Eames became principal tutor and took over responsibility for the teaching of divinity. Soon afterwards, an assistant tutor was appointed, James Densham[6] who was an ex-student of the Academy. Densham's main responsibilities were initially classics, theology and mathematics. In this context "mathematics" is likely to have included instruction on the "globes", navigation and surveying as well as basic arithmetic; in the early 1740s he appears to have taken over some of Eames's teaching duties which included algebra, trigonometry, physics and conic sections.[7] Densham retired from teaching after Eames's death in 1744, and the Academy then passed into the control of David Jennings[8] and Samuel Morton Savage,[9] both of whom were ex-students.

Under Jennings and Savage, the Academy moved to new premises in Wellclose Square, Stepney. At this time the Academy was open to both lay and ministerial students, and the course of study lasted for five years. Jennings had already advised his friend, Philip Doddridge, that Academies could and should assume a wider role in preparing students for other professions than the ministry, which required an increased importance to be given to a wide range of subjects, including the scientific, within the curriculum. In the main Jennings taught theological subjects, leaving the bulk of scientific subjects, mathematics and logic to his colleague Savage, but he also taught the youngest students "the globes" using a text of his own.

The tutors of science at this Academy were:

John Eames	?1713-1744
James Densham	1734-1744
David Jennings	1744-1762
Samuel Morton Savage	1744-?1762
Abraham Rees	1762-1784

This chapter will be chiefly concerned with John Eames and David Jennings, both of whom taught at the Academy between 1700-1750.

John Eames

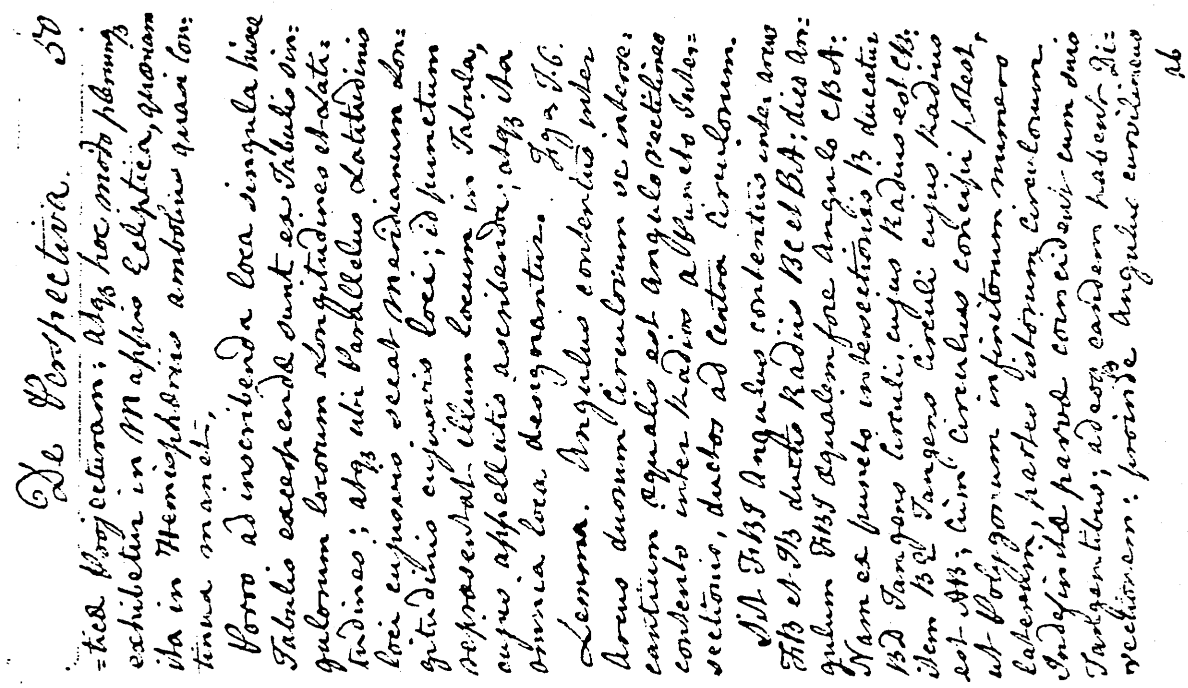
Although trained for the Dissenting ministry, John Eames did not take up this vocation, but instead accepted an appointment as tutor at the Moorfields Academy. Little is known of Eames's life beyond its bare outlines: he is known to have attended Merchant Taylor's School in 1696/7 and to have had a speech defect which almost certainly was an important consideration in his decision to abandon entry to the ministry. Eames may have taken up his tutorship at the Academy as early as 1712, with Thomas Ridgley, but the first clear reference to his presence comes from Thomas Secker (later to conform and become Archbishop of Canterbury) who mentioned attending Eames's lectures at Moorfields in 1716/17.

Eames published no textbooks and no student notes survive which can be clearly dated within his lifetime. However, a set of student notebooks[10] survive from the 1760s, containing notes of lectures originally read by Eames, and which continued in use at the Academy long after his death. This set of three notebooks has been preserved at Dr Williams Library.[11] One notebook is clearly dated 1769, and contains lectures on ethics. The other two, containing lectures on applied mathematics, optics and perspective, are undated and their slightly different page format suggests that they were written by a different student. The title of this notebook clearly mentions John Eames as the original source of the material which followed. The first undated notebook entitled Introductio brevissima ad Perspectivam projectionem qs spherae, orthographicum, stereographicam et gnomonicam is chiefly concerned with perspective. It also covers geometry of the plane and sphere. Various types of projections were illustrated, in the case of Mercator's showing how a human face is distorted when the diagram was produced in one dimension. The notes are well illustrated with diagrams designed to illuminate some of the more complicated points discussed. (See Figure 5.1).

The second undated notebook entitled De Usu Trigonometriae plana in Geodisia has a similar format to the first and is concerned with the use of mathematics in surveying, navigation and astronomy. This set of lectures appears chiefly concerned with practical matters; problems were set and in the solutions,the use of equipment (for example, theodolite, bricklayer's square) was discussed. Navigation received generous attention, and the use of various pieces of mariner's equipment described (quadrant, asimuth compass, Foxe staff,[12] logline). Along with references to standard encyclopaedias such as Harris's Technicum Lexicon or Chambers' Cyclopaedia, the notes mention a work on surveying and navigation, Robert Norton's The Seaman's Practice (1637). The final section of this notebook was concerned with the use of trigonometry for astronomical calculations. The measurement of distances between celestial bodies (for example between earth and moon) was covered, and some less common calculations such as the mathematical method of predicting the phases of the moon were shown. Reference was made in passing to "lunar inhabitants", which probably gave opportunity for some entertaining speculation from the students. Both sets of notes give a clear grounding in the subjects covered, with illustrations in diagrammatic form playing an important part. Most of the notes were written in Latin, with a few passages in shorthand, but the first few pages of

FIGURE 5.1

Pages 49-50 from student notes of Eames' Lectures Introductio brevissima ad Perspectivas, dated 1769 (held at Dr Williams' Library)



De Perspectiva. 50

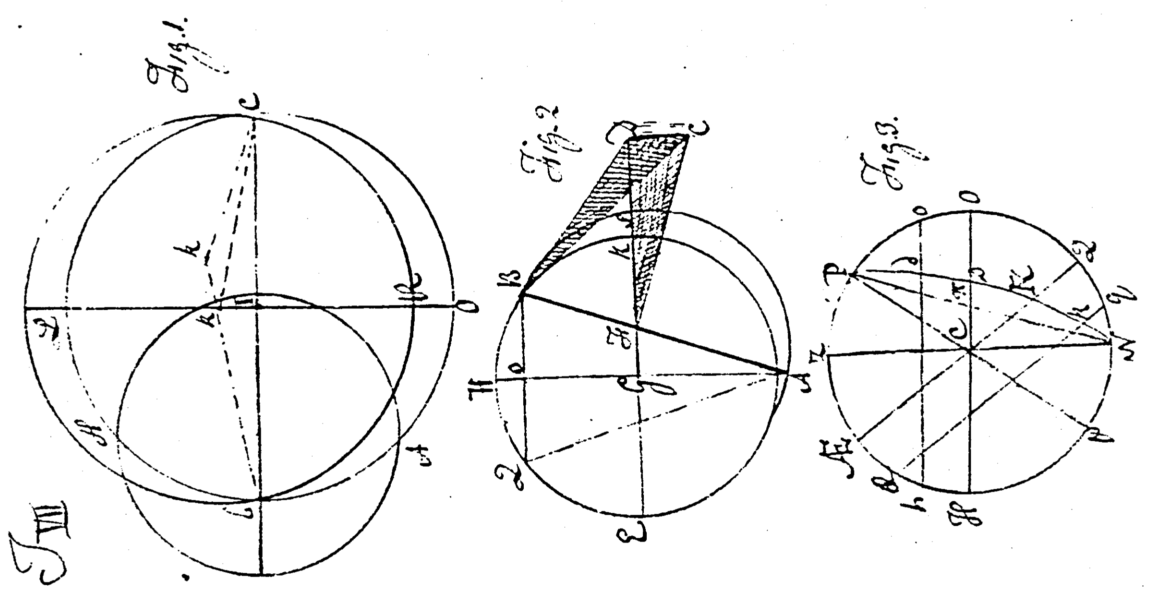
-tica Projecturam; atq; hoc modo plerumq;
exhibetur in Mappis Ecliptica, quoniam
ita in Hemisphæriis ambobus quasi con-
tinua manet.

Porro ad inscribenda loca singula hisce
Tabulis excerpenda sunt ex Tabulis sin-
gulorum locorum Longitudines et Lati-
tudines; atq; ubi Parallelus Latitudinis
loci cujusvis secat Meridianum Lon-
gitudinis cujusvis loci; id punctum
repræsentat illum locum in Tabula,
cujus appellatio ascribenda; atq; ita
omnia loca designantur. Fig. 7.6.

Lemma. Angulus contentus inter
Arcus duorum Circulorum se interse-
cantium æqualis est angulo rectilineo
contento inter Radios a Puncto Inter-
sectionis, ductos ad Centra Circulorum.

Sit FBI Angulus contentus inter arcus
FB et IB ductis Radiis BC et BA: dico An-
gulum FBI æqualem fore Angulo CBA:
Nam ex puncto intersectionis B ducatur
BD Tangens Circuli, cujus Radius est CB:
item BE Tangens Circuli cujus Radius
est AB; cum Circulus concipi potest,
ut Polygonum infinitorum numero
laterum, partes istorum Circulorum
Indefinite parvæ coincident cum duo
Tangentibus; adeoq; eandem habent Di-
rectionem: proinde Angulus curvilineus

ab



one notebook contained some basic rules of trignometry which were set out in English. It is probable that Eames himself read the lectures in Latin and that this practice continued into the 1760s.

Eames probably illustrated his lectures by practical demonstrations, for he built up a collection of apparatus (not listed or described), which he bequeathed to the Academy on his death in 1744. In 1745 the equipment was inspected, cleaned and repaired "to make the apparatus complete for a course of experiments", and the Coward Trustees (by then heavily involved in the management of the Academy) agreed that an orrery and an "instrument to show the spheroidal figure of the earth"[13] should be purchased. It is difficult to ascertain what the second item might have been but it is possible that the instrument required was a type of theodolite, a surveying instrument which underwent considerable refinement in the 18th century.

From 1734 Eames undertook full responsibility for the management of the Academy on being appointed principal tutor. He also had to assume new teaching duties, notably responsibility for the subject of divinity. James Densham, an ex-student was appointed from 1734 as his assistant. Densham was known to Philip Doddridge of Northampton, who described him as "a man well furnished for his work, excepting that perhaps he is a little too systematical. His memory is wonderful."[14]

Nothing survives of Densham's work at the Academy, or indeed of any writing whether scientific or not, but as he took over the teaching of algebra, physics, conic sections and trigonometry from Eames, it is likely that his lectures were very closely based on those of his principal. After Eames's death in 1744, Densham appears to have suffered some mental stress[15], and retired from the Academy. He did not, however, give up his interest in science. He was for some time a member of the "Club of Honest Whigs" (so-called by one of its members, Benjamin Franklin), a philosophical club with strong scientific interests. The Club counted among its members at various times, John Canton, FRS, Joseph Priestley, Benjamin Franklin, Thomas Amory (of Taunton Academy) and Richard Price (of Hackney Academy). Samuel Morton Savage, Andrew Kippis and Abraham Rees all later appointments to the Hoxton Academy, were also members,[16] thus it was made possible for Densham to remain on the fringes of the Academy circle for some time after his resignation. [17]

Eames's standing in the scientific world was high. He was a Fellow of the Royal Society, to which he was said to have been introduced by Sir Isaac Newton. No direct evidence of the extent of the connection between Newton and Eames has survived, however. Eames's only published work, undertaken while he was at Moorfields, was an Abridgement of part of the Philosophical Transactions[18] in which he was co-author with John Martyn.[19] Martyn undertook the major portion of the Abridgement, but allotted the first three chapters (on mathematics, including fluxions; optics and astronomy) to Eames. A botanist and medical practitioner, Martyn probably felt inadequately equipped to deal with these subjects, the more "mechanical" side of natural philosophy. For the work, the Philosophical Transactions papers over a period of several years were sorted by subject, and a narrative prepared summarising the contents of the various communications to the Royal Society. The one notable paper incorporated into Eames's chapter on Astronomy was the report from the astronomer James Bradley, dated 1728, in which he described his findings on the aberration of light. Eames contributed two other small items to the Abridgement: the first being a "communication of the late learned Professor Gregory's discourse upon Motion", a document in Latin which reports Gregory's lecture at Edinburgh in 1686, previously unpublished. No information was given as to how this came into Eames's hands. The second contribution was a short paper on printing by Eames himself.

With such limited material, it is difficult to judge Eames's contribution to the teaching at Moorfields. As a natural philosopher, he was highly thought of: his assistance was sought not only within the dissenting world, from Isaac Watts over the preparation of his textbook Knowledge of the Heavens and Earth Made Easy but by the Royal Society (for the preparation of the Abridgement). His teaching was clearly considered authoritative both during and after his lifetime. For at least 25 years after Eames's death his lectures continued to be read at the Academy, in the 1760s Abraham Rees prefacing the lectures with two of his own. Some students attended the Academy just to hear Eames's lectures: Richard Price, the mathematician and dissenting minister (later to teach at the Hackney Academy) may well have been one such student. About 1720, a shortened version of Eames's lectures was read at Kibworth by the tutor John Jennings; this was probably acquired from his brother David, then a student at Moorfields. Philip Doddridge almost certainly heard the Kibworth version, for among his possessions was a notebook containing shorthand notes of Eames's lectures on philosophy.[20]

Eames's reputation may well have been based on ability to understand and to teach clearly the mathematical basis of Newton's theories, an ability not common among Academy tutors at that time. Thus, the presence of John Eames from 1716-17 indicates a strong probability that Moorfields was one of the first Academies where Newtonian theory was regularly and competently taught.

David Jennings

David Jennings[21] was himself a student of the Moorfields Academy in its early years, having been taught by Chauncy, Ridgley and Eames. On his appointment to the Principalship of Moorfields, Jennings revealed concern that he had been absent from the academic world for some years.[22] Nevertheless, by the time of his death some 18 years later, his reputation as a learned man and teacher was very high:

> "there were few branches of science or of arts and manufactures with which he was wholly unacquainted."[23]

and he was assiduous in carrying out his duties:

> "... with what uninterrupted constancy he fill'd up his place in the Academy, never suffering any thing to divert him from his daily attendance .. easy, happy method attended his instructions ... it was his heart's desire and earnest prayer to have his students prove skilful, serious, godly ministers of the glorious gospel of Christ..."[24]

Jennings maintained a lifelong interest in astronomy, occasionally displaying a healthy scepticism:

> "I remember I did hear some time ago that somebody had seen a sixth Satellite of Saturn, perhaps it was a new ring; but indifferent telescopes, assisted by strong fancy, have so often created satellites and comets and other celestial phenomena that I give little heed to such reports, unless I have them from very good authority."[25]

This letter, addressed to Philip Doddridge, also discussed experiments carried out using a microscope.

Jennings published one textbook Introduction to the Use of the Globes and Orrery,[26] which he used as the basis of his weekly lectures to the Academy's junior students. The Preface to the book explains that its purpose was to instruct those persons

> "who tho' they have not the opportunity of attending to the more abstruse parts of Mathematical Science, are desirous of, at least, some general knowledge of these Matters, such who tho' Providence has marked out their Track of Life thro' scenes of Worldly Business, yet have souls large enough to extend themselves now and then, beyond this little Planet, and to take a distant view of other remote Worlds; in the contemplation of which both the philosophic and pious mind may find its Account for entertainment and Profit."[27]

The text (and thus the lectures) were therefore of general interest, and intelligible to an educated reader who had no great knowledge of mathematics. He commented that his ideas were drawn from "many other and bigger Books" though he did not identify them. However, he claimed that his method was "singular": while other writers had treated study of terrestrial and celestial globes as preparatory to the study of geography, he was of the opinion that this method caused confusion, because the student was not allowed sufficient time to familiarise himself with the features of the earth before moving on to the celestial globe and the mechanics of the universe. Jennings took the more familiar terrestrial globe first, and followed it with readings in geography. Twenty problems were set for students to solve, and, in acknowledgement that there might be need for more, another source, Isaac Watts' Knowledge of the Heavens and Earth Made Easy,[28] was recommended.

Jennings's text consisted of straightforward descriptions of the globes, the solar system and the planets. Specialist terminology (meridian, horizon) was explained, and a number of "problems" concerning time or identification of places by measurement were suggested. Realising the need for more exercises than he could supply, Jennings referred students to "Gordon's Geographical Grammar"[29] another basic textbook covering similar ground. More complex mathematical calculations (for example the working out of the dates of future eclipses) were described but considered (rightly) beyond the mathematical skills of the students for whom the text was written. In these cases those interested were referred to Keill and Gregory[30] and to the astronomer Richard Dunthorne's Practical Astronomy of the Moon.[31]

Jennings made some imaginative suggestions to help students grasp ideas in general and to visualise the mechanisms of the universe. He favoured rhyming couplets and mnemonics as a help towards remembering key points: the familiar "30 days hath September, April, June and November ...." was included as well as the less so:

"At Dover Dwells George Brown Esquire
Good Christopher Finch and David Frier"

This couplet enabled students to calculate the day of the week for any date in any year once the Dominical letter was known. Equipment, for example an orrery, was necessary to demonstrate the structure of the solar system. For Jennings's students, this would have posed no problem, for Eames's collection of equipment which had been enhanced by the Trustees, was available. For those without an orrery, Jennings described an imaginative way around the problem: the construction of a model "which may serve tolerably well instead of it". Skilled in the use of tools Jennings

> ".. would often spend a leisure hour with "the turner's wheel and a carpenter's plane"."[32]

But the materials required for the model of the orrery were very basic: 2 balls, a candle, string and hooks to attach string to the balls. A measuring device (to obtain angles of inclination) and additional refinements such as a zodiacal circle, were desirable though not essential. To represent the earth's movement around the sun and its rotation on its own axis the equipment required was a candle (to represent the sun), and a ball, painted half black and half white, suspended from a string (to represent the earth). The ball on the string could be whirled around the candle flame to demonstrate both mechanisms. Further experiments using this basic equipment were designed to illustrate: 1) the changing of the seasons, 2) the phases of the moon, 3) eclipses, and 4) the phenomenon of retrograde motion of the planets.[33] Such equipment could not demonstrate with any degree of precision the movements of the earth and planets. The model could not be built to exact scale, but such makeshift equipment would be enable students to understand the general principles. To help students translate the appearance of the heavens as shown on the celestial globe to actual observation of the night sky, he suggested:

> "But suppose the Globe were made of Glass, then to an Eye placed in the center, the Stars which are drawn upon it would appear in a concave surface just as they do in the natural Heavens."[34]

This description must have been given with the glass orrery sphere in mind, a device which had a solid terrestrial globe in the centre, surrounded by a large glass ball on which the constellations had been stencilled. Such instruments were almost certainly too expensive for the Academy to purchase, and given their fragility, very expensive to maintain. To illustrate a specific point concerning the relative movements of the earth and sun, Jennings suggested an ingenious demonstration requiring a peach to help students understand the relative positions of earth and sun during the twilight period between sunset and absolute dark:

> "Suppose a peach to represent the Earth, the Down on the Peach will fitly enough represent the atmosphere; the height of which is compiled at about fifty miles: for when the Sun is got 18 days below the Horizon, his rays will not reach lower than about 50 miles over our heads, and then we find the Twilight is gone and we can see the smallest stars that are visible to the naked Eye. So that there does not seem to be any Air above that height to reflect the light of the Sun to us."[35]

In common with most natural philosophers of the age, Jennings was in considerable awe of Newton's achievement: in a footnote, he described the planetary system as Pythagorean or Copernican. Dismissing the Ptolemaic and Tychonic systems as antiquated and "justly exploded", he ascribed to Copernicus the honour of reviving the Pythagorean system and to Newton the establishing of it firmly on such a sound mathematical and physically demonstrable basis

> "... as puts its out of all Danger of being ever overthrown by any new contrived system for so long as the Sun and Moon shall endure."[36]

There was no room in the Newtonian universe for astrology and superstition: the former Jennings dismissed, giving the reason that the planets were too distant to effect any influence on men's lives. At the time, comets were particularly noted as omens of disaster but again reference was made to the work of Newton, which showed that these were part of the solar system, fitting within the mechanism of the universe and thus free from any supernatural meaning. The possibility of other habitable worlds was mentioned but here Jennings added nothing new to the debate on the topic.

Throughout the main body of Jennings's text there is little direct reference to religious issues generally, save instances where a scriptural text could usefully be illuminated by the point under discussion. However an appendix was included which covered two common objections to the Biblical account of creation in Genesis. These related to the four "days" taken to form the earth, according to the Genesis account in contrast to the one "day" for the formation of the rest of the universe, and the source of light, before the formation of the sun on the fourth "day". In order to overcome these objections, Jennings made an attempt to marry together scientific hypothesis and biblical text, using a careful examination of the Hebrew words to try to arrive at an explanation acceptable both theologically and scientifically. The use of detailed analysis of the Biblical text in this way was a time-honoured method for the extraction of maximum meaning.

Jennings's work is imaginative, not least because of the ingenious use of everyday materials to create models to clarify ideas difficult for a student to visualise from the text alone. The idea, too, of the need for knowledge beyond what was necessary to earn a living, suggests that he was among those Academy tutors with the broadest intellectual outlook. However, a document (undated and unsigned) is preserved at Dr Williams' Library which corrects a number of mistakes, some arithmetical, some textual which appear in Jennings's book.[37] It is possible that this document, which can be dated approximately 1761 from internal evidence, may be by Jennings himself, as it takes the form of notes of necessary amendments to the

1752 edition ofthe book. Despite the errors of detail, the book remains an imaginative introduction to the globes and into the structure of the universe.

No references have been traced to textbooks studied during the teaching of science at this Academy. This is partly due no doubt to the heavy reliance placed on Eames's lectures which were considered sufficient and which, as already noted, continued in use well into the 1760s.

Jennings's assistant Samuel Morton Savage, occasionally mentioned Doddridge's A Course of Lectures in his writings and these were probably an important source for the philosophy of the science taught. Savage's views may be gauged from an address delivered at an ordination[38] shortly after he became principal of the Academy. He believed that the study of nature

> "...will lead to nature's God; will enlarge and exalt the mind, and prepare it for judging of the evidences and discovering the beauty of the grand scheme of the redemption and recovery of this lost world, which God made."[39]

Here, the philosophy behind the study of science is closely related to the religious ideas of the argument from design, but the language in which Savage couched his remarks has pantheistic overtones, suggesting a God of nature and not necessarily the Christian deity.

The reputation of this Academy for scientific excellence rests chiefly on the work of John Eames. His lectures were clearly regarded as authoritative, as they continued in use for some 20 to 30 years after his death. The prefatory lecture appended by Abraham Rees to Eames's original lectures in the 1760s seems rather cursory by contrast. Although little direct evidence of the quality of Eames's teaching exists, two reasons may be suggested for his high standing. Firstly, his approach to natural philosophy was mathematical, and he evidently displayed a thorough grasp of the intricacies of the mathematical structure of the Newtonian universe. Secondly, it is highly probable that Eames undertook some experimental work, and illustrated his lectures with suitable demonstrations. Both of these attributes were uncommon among Academy tutors in the early 18th century.

Two of Eames's students were to make particular contribution to the teaching of natural philosophy: David Jennings and Samuel Pike. Samuel Pike is the more interesting: although taught by a committed Newtonian philosopher, he rejected this view of the universe and turned to the biblical text for data to enable him to devise his own scheme. Pike published this as Sacra Philosophia, and in the 1750s, founded his own independent Academy in the Hoxton area. His work will be considered in more detail in Chapter 6.

David Jennings brought an imaginative touch to the teaching of the "globes" and the basic mechanics of the structure of the Newtonian universe. He probably made more direct use of the religious framework than Eames, for in his textbook references occur to theological issues. Altogether Jennings's teaching represented a simpler and gentler introduction to natural philosophy than the lectures of Eames.

The Academy trained a small number of men who were to pursue their scientific interests in later life (Table 5.1). Of these, most became tutors at other Academies, but John Jervis, Nathaniel Phillips and William Wood were to pursue their own scientific interests.

TABLE 5.1

Students of Moorfield/Stepney/Hoxton Academy
who followed scientific or medical careers

Name	Approximate date of study	Notes
James Densham (died 1792)	with Eames	Became tutor of natural philosophy during Eames's principalship
David Jennings (1691-1762)	with Eames	Became tutor of natural philosophy at this Academy when it was located at Wellclose Square
John Jervis, FLS (1752-1820)	with Rees	Mineralogist
Thomas Jervis (1748-1833)	with Rees	Tutor of classics, maths, Exeter2, c1770
G C Morgan (1754-1798)	with Rees	Tutor, natural philosophy Hackney
Samuel Pike (1717-73)	with Eames	Devised own anti-Newtonian system. Own Academy at Hoxton Square briefly
Nathaniel Phillips (? -?)	?1753-57	Amateur astronomer
Richard Price (1723-1791)	with Eames	Dissenting minister and mathematician; tutor at Hackney
Abraham Rees (1743-1825)	with Jennings	Editor of Chambers' Encyclopaedia Tutor of maths and some scientific subjects at Hoxton and Hackney
Samuel Morton Savage (1721-85)	with Eames	Became tutor of natural philosophy then principal of this Academy
John Turner (died 1767)	1753-57	Tutor, maths, natural philosophy at Exeter 2
William Wood (1745-1808)	with Rees/ Jennings	Botanist, founder of Linnean Society; contributor to Rees' Cyclopaedia; member, Leeds Lit & Phil. Society

Wood, a botanist was to become a founder member of the Linnean Society, and a member of the Leeds Literary and Philosophic Society. The Academy's tutors, including those of scientific subjects were in informal contact with some of the most influential men of science of the day through the "Club of Honest Whigs". As seen above, this club brought together scientific, philosophical and political interests in a unique blend. Through the Club, Densham and Savage (and later Abraham Rees and Andrew Kippis) were able to have direct contact with other Academy tutors, including those from Warrington (another Academy with a high reputation for science teaching - Chapter 7) and to meet radical thinkers in politics and science.

Another ex-student, Abraham Rees, became an assistant tutor at the Academy during Savage's principalship from 1762. During his tutorship he began to revise Chambers's Cyclopaedia, a work originally published in 1728. In order to complete his revision of the Cyclopaedia, he was assisted by other contributors, including Moorfields ex-student, William Wood. Rees also surveyed a large amount of recent scientific literature, for example the work of Hales, Priestley, Black, Cavendish and Lavoisier are all quoted as references. Rees's edition, published in 1781-6, has been carefully scrutinised[40] and compared with other contemporary encyclopaedias. He generally appears to have relied on Chambers's 1728 entries, updating and including new material where necessary. As a result, some inconsistencies occur; for example on the status of "air" which Rees tried to describe as both an elementary principle

> "...[air] enters into the composition of most, or perhaps all bodies, existing in them under a solid form, deprived of its elasticity and most of its distinguishing properties, and serving as their cement and the universal bond of nature.."

and in a different form as the "vulgar or heterogeneous air" necessary for life. Some outdated material was carried forward and used by Rees in his own New Encyclopaedia (published 1802-20), for example a long article on the philosopher's stone which suggests some residual belief by the author in the existence of such an object.

From 1762, the Academy was located in Hoxton Square in premises originally used by Joshua Oldfield (see chapter 3). At this point the average number of students in the Academy at any one time was approximately 30. Hoxton Square acted as a focus for dissenting interest in the area[41] as it contained the homes of a number of dissenters including Dr Daniel Williams, founder of the present day Dr Williams' Library, now situated in Gordon Square, London, and Edmund Calamy, the compiler of a biographical directory of ejected ministers. Shortly after the move to Hoxton Square, David Jennings died and his assistant, Samuel Morton Savage was appointed in charge. Two new assistant tutors were appointed, Andrew Kippis[42] and Abraham Rees[43] the latter being responsible for teaching scientific subjects. Rees is known to have continued to use Eames's notes for teaching, possibly reading them in the original Latin. As mentioned above, he prefaced Eames's lectures with two of his own covering the history of each of the disciplines and giving some indication of links between disciplines. This introduction led naturally to Eames's material on the use of trigonometry in astronomy and navigation. Rees's lectures appear to have been rather general in nature with few references to works for further reading.[44] Thus, in his teaching he was not particularly innovative. His teaching of the subject should have been enlivened by the introduction of contemporary theories following his research for the revised edition the Chambers's <u>Cyclopaedia</u>: this must remain speculative, as no lectures dating from the 1780s have been discovered.

From the 1770s onwards the Academy began to be affected by disputes over theological doctrine. Savage resigned in 1784, and was succeeded briefly by Rees. Rees and his colleague Kippis became interested in Socinianism. Although not new, the Socinians put forward radical theological doctrines, which denied the doctrine of the Trinity and regarded God the Father only as divine. These beliefs brought a number of philosophical disputes in their wake not only with the established church but with other dissenting sects. Socinianism received an impetus in the mid 1770s when Theophilus Lindsey deserted the established church to found the Unitarian movement which is the form in which Socinianism survives to the present day. Among the followers of this movement was Joseph Priestley whom both Rees and Kippis knew through Academy circles. This shift towards a new theological doctrine on the part of the two Hoxton tutors caused concern among the Coward Trustees, who now provided a high level of financial support for the Academy. The Trustees made plain the fact that they were unwilling to support a foundation where the tutors had discarded Congregationalism; Rees and Kippis resigned in 1784, later becoming involved in the foundation of Hackney (Chapter 8). The Academy was then closed.

Science studies were assured of a place on the curriculum from Eames's arrival as a tutor in the early 1700s. The standards set by Eames were recognised as exceptional and his work continued to be the focus of science teaching for almost all the rest of the Academy's life. Later tutors were generally conscientious in their teaching, and in the case of Jennings, brought some imaginative methods to bear on the subject. Demonstrations almost certainly played a key part in the teaching of the subject by both Eames and Jennings. It can be clearly stated that the teaching took place within the theological framework of the day; the Academy was fortunate in having as its principal tutors men such as Eames, Jennings and Savage, all of whom recognised the value of secular learning, not only for lay students but for intending ministers also.

REFERENCES

1. The Congregational Fund Board was founded in the 1660s. Congregational Churches were independent and autonomous gatherings. As "independents" these were the backbone of Cromwell's support. County Associations, for mutual support, were formed later.

2. Coward Trust, founded by the will of William Coward (d.1738), merchant, who left property to found a trust to support the training of young men (aged 15-22 years) for the dissenting ministry. Most students went to Moorfields/Stepney/Hoxton and Northampton/Daventry Academies which were thus almost maintained from the funds for several years.

3. Chauncy, Isaac (1633-1712/13). Educated at Harvard, New England, and at Oxford on return to England. Congregationalist, practising physician. Many publications but none scientific. DNB.

4. Ridgeley, Thomas (1667?-1734), educated at Trowbridge and Islington (by Doolittle). DNB.

5. Eames, John, FRS (d.1744), educated Merchant Taylors School; trained for dissenting ministry, but did not take up this career. Said to have been an acquaintance of Isaac Newton. DNB.

6. Densham, James, d.1792; educated at Moorfields; was known to Philip Doddridge of Northampton, who had a high opinion of his qualities.

7. TCHS, III, p.272.

8. Jennings, David (1691-1762) educated at Moorfields: a close of friend of Philip Doddridge's. Was awarded DD of St Andrew's University on Doddridge's recommendation in 1747. DNB.

9. Savage, S M (1721-1785). Educated at Moorfields; DD Aberdeen, 1767. Held other posts in addition to his tutorship at the Academy. DNB.

10. A second set of lectures notes (located at the Unitarian College, Manchester) has been described by McLachlan (English Education under the Test Acts, p.293-4); these follow closely the format (Latin text with a large number of diagrams) of those at Dr Williams Libary. The second set is dated c1760-64, and were written by William Wood, a student at the Academy who was later to become a botanist, and founder member of the Linnean Society. The subject matter covered in this set was mechanics, statics, hydrostatics and optics.

11. Northampton Ms., Dr Williams Library, London

12. This is possibly a mishearing on the part of the student for Cross-Staff, an instrument used in early times for measuring the altitude of the sun.

13. Minutes of the Coward Trust, quoted McLachlan, op cit, p.124

14. Philip Doddridge, letter to Samuel Clark, dated 5 April 1743, quoted Nuttall, G F, Calendar of the Correspondence of Philip Doddridge, DD (1703-1751), p 178

15. In a letter from David Jennings to Philip Doddridge, 18 September 1744, Jennings states that Densham's "Head is certainly too far gone" for "a Preachers Place" "in the country" at present. "I most heartily wish his Recovery". Quoted Nuttall, G. op cit., London, 1979, p.205

16. Crane, V W "The Club of Honest Whigs", WMQ, 23 (1966), p.210-233

17. Densham is known to have travelled abroad on business and was a merchant in Oporto in 1769. The date of his death is recorded as 18 July 1792.

18. Eames, J, with John Martyn, Abridgement of the Philosophical Transactions, London, 1735

19. Martyn, John (1699-1768) botanist, physician. Published many works on natural history. Corresponded with Boerhaave and Linneaus.

20. Letter from Philip Doddridge to Mercy Doddridge, 4 July 1735, in which he asks for the notebook. Quoted Nuttall, G F, op cit, p.77

21. See Protestant Dissenters Magazine, 1798, p.87 et seq. "Life of David Jennings, by J.T." (Joshua Toulmin)

22. David Jennings to Philip Doddridge, 14 September 1744, quoted Nuttall, G F op cit, p.205.

23. Savage, S M A Sermon occasioned by the death of the late Revd. David Jennings, DD preached to the church of which he was pastor, 26th September 1762, London 1762

24. Ibid.

25. Letter to Philip Doddridge, quoted Humphreys, IV, p.69-70, and Nuttall, G F, op cit, p.144, dated 12 January 1741/2.

26. Jennings, D Introduction to the Use of the Globes and Orrery with the Application of AStronomy to Chronology. Adapted to the Instruction and Entertainment of such persons as are not previously versed in Mathematical science. With an Appendix Attempting to Explain the First and Fourth Days Work of Creation in the First Chapter of Genesis, 1747

27. Ibid, p.iii

28. Ibid, p iv; see chapter 4 for brief comment on Watts' text.

29. Gordon, G, An Introduction to Geography, AStronomy and Dialling by the descriptions and use of the Terrestrial and Celestial Globes, 1726

30. Keill, Introductio ad Veram Physicam, 1702, and Gregory Astronomiae physicae et geometricae elementa, 1702

31. Dunthorne, R (astronomer 1711-1775) The Practical Astronomy of the Moon, or new tables of the moon;s motions exactly constructed from Sir Isaac Newton's theory and published by Dr Gregory in his astronomy with precepts for computing the place of the moon and eclipses of the luminaries, Cambridge 1739. Dunthorne also published a work on reflection and parallax on the moon's distance from the sun or fixed stars.

32. Protestant Dissenter's Magazine, v, p.86, 1798

33. Ibid, p vi et seq. The book contained several diagrams: these could be modelled by the equipment provided.

34. Jennings, op cit, p.15

35. Ibid, p.43

36. Ibid, p.45. Later (p.120/1) he pointed out that the argument for Copernicus's system against Ptolemy's was based on simplicity.

37. Dr Williams Library ms.38.97. 22. Unsigned, undated but internal evidence (reference to the transit of Venus in 1761) indicates post-1761.

38. Savage, S M, A Sermon preached at the ordination of Mr Samuel Wilton, 18/6/1766, by Phillip Furneaux, with .. a charge delivered by S.M. S., 1766.

39. Savage, S M, Ordination Charge, 1776, p 85-90.

40. Hughes, A, "Science in English Encyclopaedias 1704-1875" Ann.Sci., 1951, 7, pp 340-370, 8, pp 323-367

41. See Morris, A D Hoxton Square and the Hoxton Academies, London, 1957

42. Kippis, Andrew (1725-95) educated Northampton, DNB

43. Rees, Abraham (1743-1825), educated Wellclose Square, DNB.

44. At Dr Williams' Library. Rees, A, Introduction to Mathematics, 1768. Ms notes taken down by Joseph Cornish, student at Hoxton. DWL ms. 69.6

CHAPTER 6: ACADEMIES 1751-1800

In the second half of the 18th century three attempts were made to repeal the Test Acts (1772/3, 1787 and 1790), each meeting with no success in the House of Commons. Despite this failure, some legal and civil rights were restored to Dissenters through the courts during this period. The Test Acts themselves appear to have fallen into desuetude in the latter half of the 18th century: the Acts of Indemnity, commencing in 1729, were doubtless significant in this respect, even though there were some loopholes remaining, through which Dissenters might be prosecuted. Nevertheless, Dissenters were excluded from the mainstream of national and local life, and still felt that prejudice against them remained. In fact from 1790 onwards some hardening of attitudes towards non-Anglican bodies can be detected, notably in the local harrassment of Methodists by Justices of the Peace in an attempt to force them to register as "Protestant Dissenters". Methodism had consolidated its position and its organisation was now fully developed. Between 1767 and 1800, the numbers of Methodists almost quadrupled while the number of Dissenters doubled.[1] In the later years of the century the greatest numbers of converts joined Congregational or Baptist groups, both of which adopted some of the more Methodistic evangelical charactistics in forms of worship.

Between 1751 and 1800, a further 20 new Academies had opened (listed at Appendix 6.1). Evidence exists that scientific subjects were taught in ten of them:

Exeter 2
General Baptist Academy
Gosport
Hackney
Manchester 2
Oswestry
Newport Pagnell
Rotherham (including Idle, Heckmondwyke,Northowram)
Warrington 2
Wymondley

For the following, positive evidence (booklists, contemporary comment) exists enabling the making of a fairly clear assessment of the status of the subject:

Hackney
Manchester 2
Newport Pagnell
Rotherham (including Idle, Heckmondwyke, Northowram)
Warrington 2

Of this group two have been again selected for close study: Warrington 2 (Chapter 7) and Hackney (Chapter 8). Of Academies founded before 1750 the following continued to function in this period:

Bristol Baptist Academy	continued into 19th c.
Findern/Derby	closed 1754
Moorfields/Stepney/Hoxton	1785
Kendal	1751
King's Head/Homerton	continued into 19th c.
Northampton/Daventry	1798

In all of these, science featured strongly in the curriculum. As already noted, at Hoxton David Jennings was succeeded as natural philosophy tutor by Abraham Rees who, while at the Academy, began to revise Chambers's Cyclopaedia (originally 1728) which he published in 1781-6. Rees was to move to Hackney (Chapter 8), with his colleague Kippis, on the closure of Hoxton.

Some natural philosophy was taught at King's Head/Homerton[2] but no information has been traced about the specialist tutor, John Walker, or about the syllabus. The principal tutor, Thomas Gibbons,[3] also had some personal interest in the subject; qualified as a medical practitioner, Gibbons published a small booklet about medical cases he had treated, particularly jaundice and haemorrhage. His methods were thorough: the patient, the examination, symptoms and prescribed treatment were all carefully described[4] and he displayed some psychological subtlety in the way he dealt with his patients.[5] Gibbons' diary[6] shows that he attended a dissection and occasional lectures at the Royal College of Physicians, and also took interest in the broader spectrum of science: for example, he recorded the transits of Venus in 1761 and 1769.

Gibbons' standpoint on science was firmly based within the argument from design, although traces of pantheism are also apparent:

> "The body may be called dust because it was made out of the dust... What are these bones, and sinews, this flesh, this head, these arms, hands and feet, but earth curiously modelled and variously and beautifully shaped and disposed by the God of infinite wisdom and power "by whom we are fearfully and wonderfully made"... and while these bodies are continued in life, do they not derive their supports from the earth and would it not be impossible for us, according to the established laws of God of nature, to continue a week or a day together in strength and vigour unless we received fresh recruits from the animals that are slain for our substance, or from the harvests of the field, and the herbage of the ground, which are but dust appointed to sustain incorporate and mix with dust?" [7]

Taken from a sermon, this passage is a good example of the way in which the minister could put his knowledge of the physical world into an appropriate religious context. In the same sermon, Gibbons also made comment on the impermanence of the human frame, in what may have been a disturbing manner for his listeners:

> "Health and disease make great changes upon us, the first adding to, and the other taking away from these bodies of flesh; and indeed, as is well known to the natural philosopher, our bodies are in a continual variation and particles are as constantly succeeding in their room so that there is no moment of our lives in which we can be said properly to continue in one-state."[8]

Few references to texts used at both old and new Academies are available (Table 6.1): Rowning's work, A Compendious System of Natural Philosophy (1737-43), was read at Northampton/Daventry during Ashworth's principalship[9], at the Bristol Baptist Academy[10] and "with such additions as the modern state of improvement required" at Rotherham Academy.[11] s'Gravesande continued to be read at Northampton/Daventry at least during the early years of this period, together with appropriate sections of Harris's Universal Dictionary (or Technicum Lexicon). At the Bristol Baptist Academy the works of Derham and Ray were read, as they were at the Newport Pagnell Academy.[12] Rotherham, Bristol Baptist and Newport Pagnell Academies all educated students for the ministry only and it is clear that the objectives behind the teaching of science were strongly theological. John Newton, the hymn writer and founder of the Newport Pagnell Academy, stated this clearly in his plans for ministerial training:

> "Natural philosophy is not only a noble science but one which offers the most interesting and profitable relaxations from the weight of severer studies ... the signatures of wisdom, power and goodness, which the wonder-working God has impressed upon every part of the visible creation ....[But ministers] are sent into the world, and into the academy, not to collect shells and fossils and butterflies or to surprise each other with feats of electricity but to win souls for Christ"[13]

TABLE 6.1

Summary of Texts

	Authors listed (with Texts where known) for Science	Comments
Hackney	See Chapter 8 - lectures by tutors Priestley and Morgan	
Manchester 2	Lavoisier's <u>Elements</u> Chaptal, <u>Chemistry</u>	
Newport Pagnell	Derham Ray	
Rotherham	Rowning, <u>Philosophy</u> Walker, <u>Philosophical Lectures</u>	
Warrington 2	See Chapter 7 - wide range of texts in use	
Bristol Baptist Academy	Rowning, <u>Philosophy</u> Derham Ray	
Findern/Derby	Le Clerc sGravesaande	
Moorfields/Hoxton	Eames' lectures Jennings	
Kendal	None known	
Northampton/Daventry	Rowning <u>Philosophy</u> sGravesaande Harris's <u>Technicum Lexicon</u> Boerhaave, <u>Theory of Chemistry</u> Hartley, <u>Observations on Man</u>	Broadbent read own lectures on chemistry and electricity Ashworth also read own lectures on electricity

This placed natural philosophy in the category of a diversion. The influence of Methodism and the evangelical movement is apparent in the phrase "win souls for Christ". William Bull, the Newport Pagnell tutor, read Hutchinson's Moses Principia (1724) in 1800, possibly with a view to introducing it to the students. This work, not new, relied entirely on the scriptures for scientific data regarding the construction of the physical world. Bull found it "difficult" and disliked its divinity, but admired the science within it despite believing that Hutchinson had carried too far the "typical and allegorical interpretations of Moses".[14] Dr E Williams[15] the first principal of the Rotherham Academy, read Descartes and other philosophers with the intention of "purifying" their works from whatever he deemed to be harmful to religious truth. At the Bristol Baptist Academy, open since 1720, John Ryland[16] who was particularly interested in natural history, noted the pleasures of the subject but did not forget its relevance to theology:

> "... our taking pleasure in a survey of the creation around us; a love of the science of astronomy, or geography; or the study of natural history, in any of its branches - zoology, botany, mineralogy &c if these are rendered subservient to our contemplation of the power, wisdom and goodness of the great Creator...."
>
> "... the knowledge of the works of nature tends indeed to enlarge the mind..."[17]

Adam Walker's Philosophical Lectures[18] was selected as a supplementary text for Rotherham Academy. This text was intended as a summary for those who attended Walker's courses of public lectures, and were unfamiliar with the subject matter: the text covered general properties of matter, magnetism, mechanics, chemistry, pneumatics, hydrostatics, electricity, optics, astronomy and the use of the globes. A phlogistic natural philosopher, Walker put forward theories based on this "element" to explain various phenomena, for example the mechanics of respiration. The relationship of phlogiston to fire was carefully explained to avoid confusing both, phlogiston not being fire but one of the "principles of inflammability". This highlights the 18th century convention which distinguished between material elements and the more nebulous idea of "principles". The latter served as a useful term to cover mechanisms which were imperfectly understood. This distinction could lead to confusion, thus Walker's careful explanation in the text. A possible relationship between phlogiston and electricity was also noted. The text is a series of succinct paragraphs which cover the main topics, giving occasional historical notes and definitions of some important terms:

> "Micaceous earths are composed of thin leaves, or lamina, with shining surfaces, and which divide into thinner leaves in the fire, and become brittle." (p.28)

Experiments were suggested, for example in connection with electricity and for "airs". For a satisfactory study of astronomy, an orrery was deemed to be an essential piece of equipment. Walker did not include diagrams and the text was didactic rather than analytical in character. Very few references occurred to theological matters: one of the few relates to the "Almighty" appointing "self-physic" for his works in connection with lightning. But the final sentences express what at first glance may seem a pious sentiment but which on closer examination indicate the underlying religious motive:

> "How inadequate then must be the utmost stretch of human faculties to a conception of that amazing Deity who made and governs the whole! Should not the narrow prejudices, the littleness of human pride soften into humility at this thought?"

Boerhaave's <u>Theory of Chemistry</u>[19] was read at Northampton/Daventry, according to Priestley's memoirs. This text was basically Newtonian but where Boerhaave perceived gaps in Newton's theory he tended to cover these with his own adaptation of Cartesian material[20]. Herman Boerhaave (1668-1738), professor of medicine and later chemistry at Leyden University gained a high reputation as a teacher, and this text was based on lectures read at Leyden. Although phlogiston theory was well established on the continent in the early years of the 18th century, following the work of George Stahl,[21] Boerhaave did not mention it in his work. Heat, light and electricity were classified by him as a form of the "element" fire. Boerhaave's thesis still fitted well with phlogiston theory and with 18th century ideas on electricity, both areas in which Priestley was to become closely involved in the future. It would also have been clear from Boerhaave's text how difficult it was to define a chemical element, a problem which bedevilled 18th century chemists until the time of Antoine Lavoisier. Boerhaave's description has a remarkably modern ring to it: he proposed the existence of ultimate "corpuscles" incapable of change or division but which were far below the threshhold of observation. Boerhaave's second volume dealt with experimental work. The experiments consisted of heating, or mixing substances: the equipment required was described and illustrated in the final pages of volume 1. Some of the items could be made by the experimenter, but others (for example, glassware) may have needed the help of a craftsman. Boerhaave included precise information on construction and tips about the types of material required, particularly where vessels were required to withstand strong heat or acid. The instructions on conducting the experiments were very comprehensive and included some discussion of the results. It is possible that Samuel Clark demonstrated some of these experiments for the Daventry students: the subjects he taught (pneumatics, mechanics and hydrostatics) would be particularly enhanced by the experiments suggested by Boerhaave's text.

There was an interesting choice of chemistry texts at one of the later Academies, Manchester 2:[22] Lavoisier's Traité elementaire de chimie (1789, English translation, 1790) and Chaptal's Elements of Chemistry (1794).[23] This Academy, which opened to lay and ministerial students in 1786, soon after the closure of Warrington 2, accorded a high level of importance to the study of scientific subjects:

> "That another Institution establishd here may furnish opportunities of acquiring both the practical and theoretic knowledge of Chemistry, Anatomy, Physiology and other branches of science to which students of medicine may superadd attendance on the hospital ..."
>
> "...it was unanimously agreed that after due deliberation that an academy should be established in Manchester on a plan affording a full and systematic course of education for divines, and preparatory instructions for other learned professions, as well as for civil and commercial life. This institution will be open to young men of every religious denomination for whom no test, or confession of faith will be required." [24]

The chemistry texts mentioned above were used by John Dalton[25] who was employed by the Trustees to teach mathematics, mechanics, geometry, algebra, natural philosophy and chemistry from 1793 to 1800. (From a reference in the 1798 Minute Book, at a later stage Dalton added the teaching of geography and the use of the globes to the original list.) Dalton's chemistry was thus "modern" and he may even have treated Stahl's phlogiston theory, still current in many institutions, as an outdated hypothesis. Lavoisier's own work was a basic textbook setting out the fundamentals of the new chemistry and incorporating his new nomenclature. A large portion of the work was devoted to a description of apparatus and experimental method. Chaptal's text was a course of chemistry, based on Lavoisier's system and nomenclature. It emphasised the relationship between chemistry and physics, and devoted a large section to descriptions of various substances. There were no religious references, other than one to the "The Supreme Being" which was considered the source of the force of mutual attraction among particles of matter. Dalton's introduction of the "new" chemistry of Lavoisier may be compared to the teaching of the phlogistic system by Priestley at Hackney (Chapter 8).

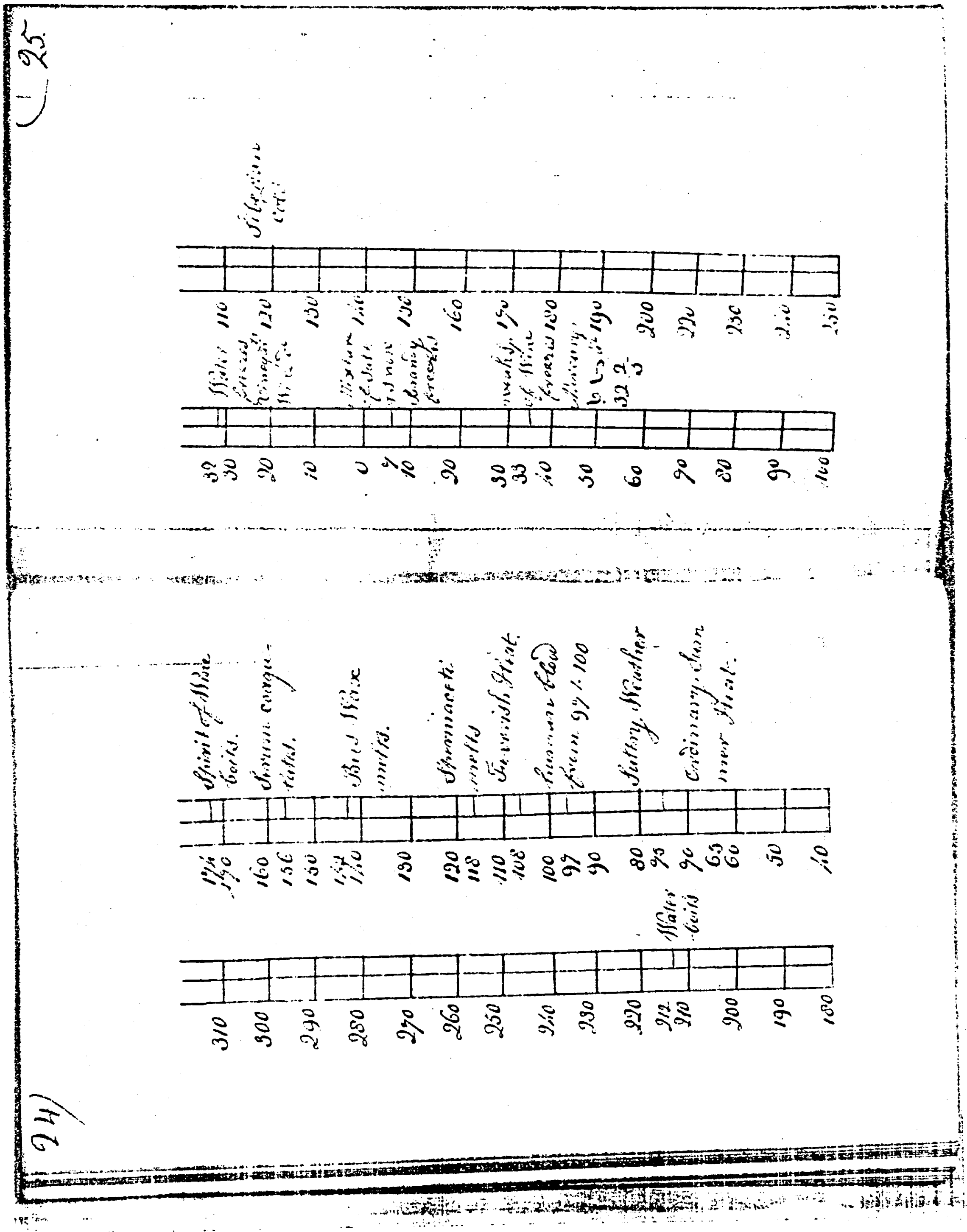
More information on the teaching of chemistry in the Academies can be gleaned from William Broadbent's lectures given at Daventry in 1788.[26] A student, James Scott, took shorthand notes of eleven lectures, the last unfinished. Three themes can be discerned, the first being a brief history of the subject, commencing with the alchemists. References to works by Macquer, Newton and Watson were cited as references for further reading, which would have fleshed out the historical background as well as give an account of some of the underlying philosophy.[27] The second theme concerned the nature of heat. Thermometers received extensive coverage, their history from early dates (Sanctonius), through the "Florentine" (Galileo), to Boyle and Halley was detailed, and a description given of the construction of a thermometer. Wedgewood's ceramic pyrometer[28] was discussed at some length, with a reference to <u>Phil Trans</u> for a report of Wedgewood's presentation of a paper on the subject to the Royal Society. The Reaumur and Fahrenheit scales were compared, and an annotated table showed Fahrenheit's scale extended as far as observations had been confirmed in both extreme heat and cold (Figure 6.1).

References to Cullen and aether suggest that Cullen's experiments on cold produced by evaporation were mentioned. Black's research on latent heat, and Watt's use of this knowledge in the invention of the condensing steam engine were also described. The technique of distillation appears to have been covered. A wide ranging selection of references was given including papers from Phil Trans, Watson's Essays, and to various works by Halley, Desaguliers, Descartes, Rowning and Nieuwentyt. Most of these it will be noted, were not new.

The third theme was concerned with the elements, and reactions between various substances. The effects of acids on metals (eg vitriol on marble, aqua fortis (HNO_3)on silver) were described and discussed, and a brief survey of three types of fermentation (vinous, acetous and putrefactive). The chemical elements were divided into water, phlogiston, earths, acids and alkalis, some time being devoted to a description of the various substances which formed branches of these broad divisions. Bergman's tables of affinity, which attempted to show degrees of reactivity between elements, may have been the basis for the classification, as this chemist was specifically mentioned. Some Aristotelian notions remained: metals were divided into the perfect - gold, silver and platina, and the imperfect - iron, copper, tin and lead. The phlogiston theory was also

FIGURE 6.1

Pages from Notes of William Broadbent's Lectures on Chemistry, read at Northampton/Daventry Academy. The diagrams show the points on the Fahrenheit Scale.



described, and was the basis on which Broadbent's chemical lectures were constructed. There is a reference to "Lavasier", alongside one to "Messuerier"(a misspelling of Meusnier, one of Lavoisier's partners). As phlogiston and phosphorus are mentioned, it is probable that the reference concerns Lavoisier's early work both on phosphorus (c1780) and on the decomposition of water (c1783-4). The lectures break off, without explanation, part way through lecture 11, which related to metals.

These lectures are not markedly different to those given by Martin Wall at the Ashmolean Museum, Oxford in 1782. Wall's lectures covered historical background, heat, cold and thermometers, then moved on to mixtures and other substances. He made reference to chemical apparatus but the practical aspects of chemistry do not appear to have been touched on at all in Broadbent's lectures. An earlier set of chemistry lectures (1780-83), also from Daventry, were given by Timothy Kenrick; [29] the notes taken by the student Benjamin Penn [30] indicate that these too were largely devoted to a description and classification of the elements.

A subject that made its appearance in the Academies from the late 1760s onwards was the study of electricity. In 1767 Ashworth read a set of lectures at Daventry entitled "Brief Hints on the History of Electricity; some observations on Electricity tending to give a general idea of ye discoveries which have been made about it". The notes were divided into 17 sections which discussed the properties and phenomena of static electricity. As these notes date from the year in which Priestley's History of Electricity was published (1767), the lectures depended heavily on that source.

Wiliam Broadbent also lectured on the subject (c1788) and a full set of notes of lectures on electricity to Daventry students exists.[31] These contain several references to Priestley's History, and a drawing of Henley's quadrant electrometer (used to measure the exact strength of charge) almost certainly copied from this source. Benjamin Franklin and John Canton, both keen experimentalists in electricity, and consulted by Priestley in the preparation of the History, were also quoted but less often than Priestley himself. One theme of Broadbent's Lectures was concerned with the history of the subject, a consideration of the various theories[32] and naturally occurring forms of electricity.[33] Another theme concerned the various types of electrical apparatus, including the Leyden jar, of which the Academy had a good selection. Some of these lectures were almost certainly accompanied by demonstrations as a continuance of a pattern established earlier by Doddridge.[34]

A generous portion of Broadbent's lectures appears to have been devoted to accounts of spectacular experiments designed to discover the nature of lightning and its relationship to electricity. Apart from Franklin's well known experiment with the kite, those of Dalibard at Marly in May 1752, Richman's in St Petersburg in 1753 (in which the experimenter lost his life), and John Canton's successful attempt at the same experiment in England in 1752 were all described. The "knobs and points" dispute of the 1770s, about lightning conductor design, was also covered.[35] Reference was also made to Beccaria's 1753 work Dell 'ellettricismo artificialle e naturale libri due with other atmospheric phenomena, suggesting that discussion of attempts to order such phenomena systematically occurred. William Stukeley's work on a possible connection between electricity and earthquakes was also quoted.

Another important theme in Broadbent's lectures on electricity concerned its use in medicine. John Wesley's field trials on people suffering from various ailments were discussed, from which applications were suggested - sciatica, "hemphlega"[hemiplegia] and epilepsies - where such treatment might be effective. The use of electricity in medicine was shunned by the medical profession, and the field was thus left open to "quacks". Academy students with some formal training may have felt competent and indeed encouraged to practise as amateur medical electricians as a result!

From Scott's notes, it is apparent that no attempt was made to quantify or represent relationships between electrical forces mathematically. A heavy reliance was placed on Priestley's History as the main source of information for the lectures. Despite a strong likelihood of lectures being accompanied by demonstration, it is unlikely that an "open-ended" experimental approach was adopted, for the notes suggest a narrative, rather than an analytical approach.

There is one reference to the teaching of zoology, at Daventry Academy, in connection with a second series of shorthand notes taken by the student, Benjamin Penn, dating from 1780-83. These lectures were concerned with a classification of animals for which Linnaeus was the main source. Reference was also made in these lectures to Buffon and Bonnet, both of whom attacked the Linnean system of taxonomy by external characteristics, proposing a heirarchical system with man at the pinnacle. This idea, "The Great Chain of Being", was an idea rooted in Aristotelian philosophy but which had attractions for supporters of the "argument from design" for the prominence it allowed to man in God's creation.[36]

One final Daventry text must be mentioned: Hartley's Observations on Man [37] which made a strong impact on Priestley, during his studies at the Academy. Influenced by Newton's theories of vibrations, described in Opticks and Principia, Hartley used these to replace the mechanism of vital spirits in the nerves with vibratory motion of "small, and as one may say, infinitesimal, medullary particles". The vibrations in the nerves were linked with sensations, either pleasurable or painful, and the result determined man's actions and personality. This text thus explored a means by which Newtonian laws and theories might be used to explain or predict actions in moral terms.

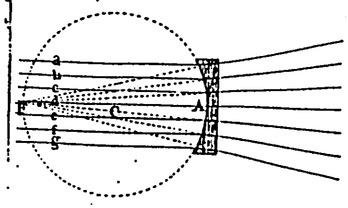
Daventry, Hoxton, Rotherham, Bristol Baptist and Manchester 2 Academies are all known to have acquired several pieces of scientific equipment. Donated through various legacies, the list of equipment for the Bristol Baptist Academy is the most extensive to have survived:

Air pump with all accessories
Prisms
Barometer
Thermometer
Ferguson's optical cards[38]
    (see Figure 6.2)
Small box orrery
Magnet
Electrical machine and accessories
Whirling table
An instrument to show motion of ship in current
    (possibly a "log" or "traverse board")
Square tin vessel for chemical experiments
Instrument to demonstrate resistance of air
    (an early anemometer)
Globes
Reflecting telescope
Mircroscope

FIGURE 6.2

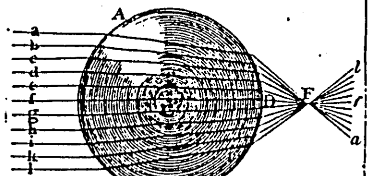
Ferguson's Optical Cards - Sample page

31
Parallel Rays passing through a plano-concave Lens.



These Rays a,b,c,&c. after passing thro' the plano-concave Lens A, will go on in a diverging state; the same as if the Lens were taken away, and the Rays had issued from a Radiant point F in the Virtual Focus of the Lens, which is at double the distance CA or Radius of concavity of the Lens.
See Cards 20 & 22

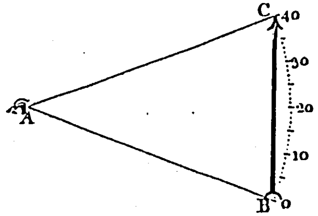
32
Parallel Rays passing thro' a solid Sphere or Globe of Glass.



The Focus of such a Sphere (A) is at F, at the distance DF from its surface, which is half the length of its Radius or Semidiameter CD, and therefore the parallel Rays a,b,c, &c. after passing thro' the Sphere, must unite in its Focus at F, and after intersecting each other there, go on in a diverging and inverted state.

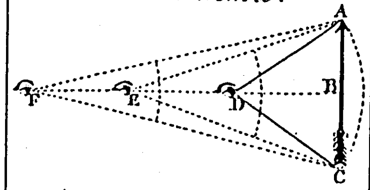
33
The Angle of Vision.

For an Angle see Card 7.



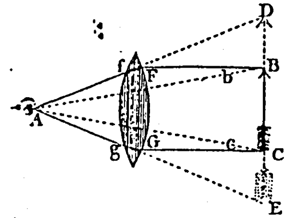
This is the number of Degrees which the Object appears to subtend in a graduated Circle.—Thus the Object B C viewed by the Eye at A appears under the Angle BAC, which contains 40 Degrees.

34
Why an Object appears smaller and smaller as we recede further and further from it.



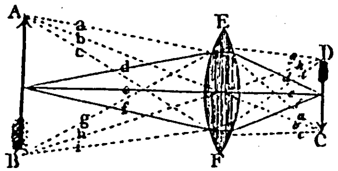
At the distance BD, the Dart ABC appears or is seen by the Eye D under the Angle ADC. At the distance BE, double that of BD, the Dart is seen under the Angle AEC, which is but half the quantity of ADC. And at the distance BF, triple the distance BD, the same Dart is seen under the Angle AFC, which is but a third part of the quantity of the Angle ADC. And therefore the Dart must appear but half as long when seen from E as from D, and but a third part so long when seen from F as from D.

35
A convex Lens magnifies the Angle of Vision, and why.



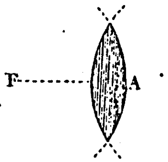
Without a Lens FG, the Eye A would see the Dart B C under the Angle b A c. But the Rays BF and CG from the extremities of the Dart, in passing thro' the Lens are refracted to the Eye in the directions f A & gA, which makes the Dart to be seen under the much larger Angle DAE (the same as the Angle f A g). And therefore the Dart BC will appear so much magnified as to extend in length from D to E.

36
Rays from an Object passing thro' a convex Lens, will make a Picture of the Object in a dark Room.



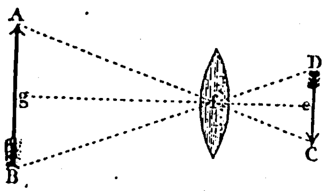
Diverging Pencils of Rays, as abc,def, ghi, issuing from all points of the Object AB on the side next the convex Lens E F) after passing through the Lens, will converge to as many points beyond it: and at those points of convergent meeting they will form an inverted Picture CD of the Object on a white paper.

37
To form the Picture mentioned on Card 36, the Object must be farther from the Lens than the focal distance of the Lens.



This is evident from Card 27, 28, and 29. For, if the Object were at F the Focus of the Lens A, the Rays diverging from the Points of its surface, as from Radiants, would go on parallel after passing through the Lens. If the Object were between the Focus and the Lens, the Rays would continue to diverge after passing through it; and unless they converge and meet in Points, they can form no Picture.

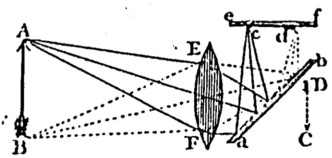
38
To find what proportion the size of the Picture (Card 36) bears to the size of the Object.



As the size of the Object AB is to its distance from the Lens f, so is the size of the Picture CD to its distance from the Lens, that is, As AB is to fg, so is CD to ef.

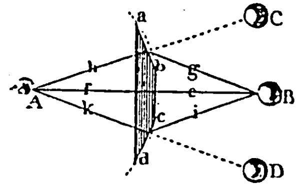
Hence, changing Circumstances, if CD were the Object, AB would be the Picture of it.

39
The Camera Obscura.



It is plain (by Card 36) that the Lens EF would cause an Image of the Object A B to be formed at CD. But the Rays from the Object after passing thro' the Lens, fall here upon the oblique Mirror or Looking Glass ab, which reflects them upward to a rough pane of Glass ef placed horizontal, ... and on this Glass the Rays from AB ... Image cd.

40
The multiplying Glass.



This is a flat plano-convex Lens, ab cd. Rays issuing from the Object B, and falling upon the plane surface bc, come to the Eye A in the direction ef, which shew the Object in its true place at B. But Rays from the same Object also fall upon the flat surfaces ab and cd, and thence coming to the Eye in the directions h and k; make the Object also to be seen at C & D; so that the Object B will be multiplied into as many different Objects as the Lens has flat surfaces ...

Wooden compasses
Round Ruler
(Probably an astrolabe or a ring dial for measuring time)
Round marble slabs to show nature of attraction, maps, charts.

This array of equipment suggests that a large variety of physical phenomena could be demonstrated, and that observations of, for example, natural history specimens as well as basic navigation and surveying exercises were carried out.

Experimental work was also carried out at Rotherham Academy[39] where a galvanic trough, globes, orrery, telescope and quadrant were available. This collection of equipment suggests that the emphasis of the practical science teaching (which included astronomy, mechanics, hydrostatics, pneumatics and electricity) was towards astronomy and possibly surveying. Rotherham students attended specialist lectures in science subjects, for example those offered by the itinerant lecturer John Warltire in 1803.

The natural philosophy equipment held at Manchester 2 was purchased under the guidance of Thomas Percival, a founding trustee and the first president of the Manchester Literary and Philosophical Society, and the tutors Thomas Barnes and Thomas Henry. A telescope and an air pump were donated.[40] Barnes, an apothecary with an interest in chemistry, believed that more might be achieved if more "directed research" took place in chemistry to help industry. With this utilitarian approach, his tutorship would have been noted for the encouragement of practical chemistry. The Trustees allocated a further £100 to be used for the purchase of new "philosophical" equipment in 1792. No record survives of whether Dalton used the equipment available: however Dalton himself certainly carried out research into matters which interested him during his stay at the Academy. In 1794, he prepared and read a paper to the Manchester Literary and Philosophical Society entitled "Extraordinary Facts relating to the Vision of Colours with observations".[41] Dalton's own colourblindness led him to test his students for this disability.[42] His meteorological interests also developed in this period, for in 1799 he read a paper to the Manchester Literary and Philosophical Society, entitled "Experiments and observations to determine whether the quantity of rain and dew is equal to the quantity of water carried off by the rivers and raised by evaporation with an enquiry into the origin of springs". There is a suggestion that Dalton may have discussed his early ideas on atomic structure with Robert Owen, the founder of New Lanark, with whom he became friendly while at the Manchester Academy,[43] and who was also a member of the Manchester Literary and Philosophical Society.

For the following Academies, evidence relating to science teaching is more sketchy:

Exeter 2
Gosport
General Baptist Academy
Oswestry
Wymondley

Doddridge's <u>Course of Lectures</u> was read at the General Baptist Academy[44] certainly well into the 19th century[45]
and William Enfield's Warrington syllabus (see Chapter 7) was believed to have been adopted by Wymondley Academy[46] where scientific subjects, chiefly chemistry and natural philosophy, were taught in the third year of the course.

Mathematics and natural philosophy were considered worthwhile subjects of study by David Bogue, of the Gosport Academy:[47]

> "... improve the mind, and peculiarly to exercise its powers and call forth their energies, the general influence of both may be favourable to his future labours, and the hearers as well as the preacher experience their good effects."[48]

Again, the details of the Gosport curriculum have not survived but a reference exists to the teaching of astronomy at this Academy.[49]

At Exeter 2[50] the scientific subjects were taught first by John Turner, and on his death in 1769 by Thomas Jervis, both ex-students of the Hoxton Academy. Although no details of the curriculum survive, it is possible that science here was influenced by the teachings of Eames and Jennings. At Oswestry, Edward Williams gave a basic course of introduction to science subjects.

References to equipment at Academies are more frequent in this period of time. The range of equipment, too, suggests that a wide selection of demonstrations may have been performed. Electrical studies appear to have been adopted fairly quickly, aided no doubt by the publication of Priestley's <u>History</u>, which was probably widely circulated in the Academies, not the least because of Priestley's connection with Northampton/Daventry and Warrington 2.

Many Academies continued to tie scientific studies closely to theology: Bristol Baptist, Rotherham, Newport Pagnell and probably King's Head/Homerton being particularly notable in this respect. The out-dated texts of Ray and Derham were still read in some of these institutions. A disturbing intervention with implications for the future of scientific work, is revealed at Rotherham, where the Principal, Dr Edward Williams attempted a theological "bowdlerisation" of some texts. However, at Manchester2, the emphasis was upon utility and modernity rather than on religious precepts. In particular, Dalton's adoption of Lavoisier's new oxygen-based chemistry is interesting, and may be the only instance of this development (apart from David Jones's brief interest, described in Chapter 8) in the Academy world in the 1790s.

For the following group of Academies it is unlikely that any science teaching took place:

Axminster/Bridport/Ottery St Mary/Taunton2
Exeter 3
Hoxton Square
Hebden Bridge
Marlborough/Painswick
Mile End/Hoxton 2
Olney
Shrewsbury 2
Trowbridge 2

Little information has survived about the curricula of these institutions: the Axminster group, and the smaller Marlborough group were Academies linked by staff, and which resemble a single institution on the move around the various locations listed. No students known to have followed scientific careers are associated with them, and on balance it appears unlikely that the subject was taught in either of these groups.

At Mile End/Hoxton2 and Shrewsbury 2 the institution's main function was to produce ministers for the circuit as quickly as possible, thus ruling out any opportunity for lengthy courses of study. Robert Gentleman[51] expressed the aims of the Shrewsbury 2 Academy to be:

> "... a short course of studies, sufficient to qualify ... for serving such societies as did not require ministers of profound learning"[52]

At Mile End/Hoxton 2 the tutor Stephen Addington had earlier published school texts, for example arithmetic primers but again given the institution's objective to train ministers, science is unlikely to have been placed on the curriculum.

At Olney, John Sutcliffe (1752-?) ran a Baptist Academy from 1772; Hebden Bridge was also a Baptist Academy, run by John Fawcett (1740-1817) a self-educated Particular Baptist minister. It is unlikely that scientific subjects featured in either Academy. Trowbridge 2 also appears to have had some Baptist connections: it is unlikely that any science was taught as the interest of the tutor Thomas Llewellyn (1743-93) was the production and distribution of the Bible in the Welsh language.

On the other hand, Exeter 3 founded by Joseph Bretland and Timothy Kenrick might be expected to include scientific subjects in the curriculum. But although Kenrick had been a natural philosophy tutor at Daventry, he did not teach the subject at Exeter 3. He taught divinity, returning to the "unpolluted fountain of the scriptures". The "use of the globes" was taught, however, but seems to have been associated more closely with geographical rather than scientific studies.

The most interesting institution in this last group is undoubtedly Hoxton Square (not to be confused with the larger and more stable Hoxton Academy (see Chapter 4) or with Mile End/Hoxton 2). This institution was founded in 1750 by Samuel Pike,[53] the only Dissenting Academy tutor known to have evolved and published his own anti-Newtonian theory of science. It is not known whether science subjects featured in Pike's curriculum, but if so, some time would have been devoted to Pike's own theories, which are worth examining in some detail.

Samuel Pike was taught by the Newtonian, John Eames, at Hoxton, yet he rejected Newton's view of the universe as inadequate. Pike's views on the physical universe were close to those of the Hutchinsonians,[54] who considered that a complete, true natural philosophy could be obtained from study of Old Testament texts in the original Hebrew. Pike's views on the physical universe can be ascertained from his book Philosophia Sacra.[55]

Pike considered Genesis, Chapter 1 to be the most "philosophical" in the Bible:

> "... we cannot but conclude that it is a most regular, orderly and philosophical description of the formation of all things, whether we can understand every part of it clearly or not"

Pike's method, in getting the most out of the text, was to compare other parts of the Bible with Genesis 1, thus avoiding the need for recourse to "systems of present philosophy", and thereby discern the workings and structure of the universe as revealed by God through his word. Hutchinson's method was similar, except that Pike used a "pointed" text, while Hutchinson used an "unpointed" one.[56] The return to the use of the Biblical text was a reassertion of the importance of revealed religion.

An example of Pike's method may be seen in his attempt to ascertain the meaning of the important word "Heavens" from the first verse of Genesis. Pike considered the word to include the weather, and the Heavens to be the instruments by which God "blesses his people with plenty". The quotation Job xxxviii, v.37-8

> "Who can number the clouds in wisdom? or who can stay the bottles of Heaven, When the dust groweth into hardness, and the clods cleave fast together."

confirmed to Pike that the Heavens were the power which causes the cohesion of matter. He described[57] the matter of the Heavens as Celestial Ether "machined" or "formed into a machine by the Creator".[58] This substance was "exceedingly fine and pure, from all gross or defiling mixtures"; evidence from Job suggested that it was in continuous commotion and circulation. This description is very close to the Cartesian plenum, and the idea of circulation suggests an even older source, Artistotelian cosmology. Pike went on to state that "the skies lean aside or incline more one way than another".[59] This important concept was derived from a study of the original Hebrew text of both Genesis and Jeremiah x,v.12, and from it Pike was enabled to give an explanation of the motion of bodies: as the ether pressed on the body more from one side than the other, so the body was propelled forwards. Another important statement concerned gravitation:

> "...heavens have a prevailing pressure towards the body of the sun, from every part or quarter, so that there is a constant universal leaning towards the centre of the system, and this produces the gravitation of heavenly bodies towards the sun. And this gravitation is so nicely adjusted that it is just sufficient to keep the heavenly bodies in their circular orbits, which would otherwise go forward in strait lines and not in circles."[60]

Pike commented that a "philosopher" might say that nature acts through various sources of attraction - gravitation, cohesion, magnetic and electrical. He noted that inherent in such schemes was the belief that the cause of the workings of nature was the _vis inertiae_ and the forces of attraction and repulsion. Although Pike acknowledged that much investigation into these principles had taken place, the philosopher remained at a loss to provide an explanation for them. Pike then offered his account of how nature worked derived from the scriptures.

The method of operation he found to be purely mechanical. To explain the concept he described a machine with interlocking wheels; action was the result of contact (a similar concept to Hutchinson's) not through the influence of remote forces.[61] This again is a clear rejection of Newtonian philosophy, and is reminiscent of Cartesian ideas. Pike described the atoms of matter as God-created, small, solid and indivisible by any created power. Such atoms had of themselves no attractive, repulsive or elastic powers - neither had they the power to move themselves or produce motion in other bodies. The atoms were located in a "very large sphere confined at the extremities" (essential, otherwise Pike's mechanical principle would not work). The "state of stagnation" in primitive darkness described in Genesis i,v2 was equated with the still, solid atoms. By God's hand, the atoms were set in motion. Pike accepted that "all nature tends to equilibrium or equal balance" but until this came about suggested a pattern of forces by which the atoms circulated and spiralled towards the centre of the heavens where the "finest" (in terms of texture) heavens were, and from where the greatest pressure of light emanated. The nature of the Sun itself was considered, particularly whether the influx and efflux were sufficient to maintain movement or whether some other force was required. Here, Pike drew on some of Aristotle's ideas of the universe.

Having created a system which could continue under its own momentum, Pike was anxious to find a continuing role for God. God's presence was necessary, he argued, almost as a celestial mechanic upholding "the whole in existence continually", to maintaining its mechanical powers, and keeping it altogether in a machine. God also intervened specifically to speed or retard the motions of the universe "at his sovereign pleasure".

Like Hutchinson, Pike did not attack the mathematical aspects of other systems: he pointed to the failure of other philosophers to assign the true causes of the "laws" of nature. Pike commented on the difference between investigation of the laws and assigning a cause: in his view the latter was reserved for revelation. His own scheme made no use of mathematics, but he commended it to other philosophers.

Pike's descriptions of observed forces exhibit the Hutchinsonian anxiety to separate the spiritual from the material. Newton's laws of motion ascribe a force of resistance to all bodies: Pike challenged this view because matter was inert, or as he put it "dead". If matter were dead, he reasoned, it could not produce, continue or resist motion. Nevertheless two atoms cannot exist in one space. He compared the resistance of matter in mercury, water and air, and his observations led him to conclude that the resistance was due to the condition of the fluid in which the matter existed: its grossness or its fineness. The ether theory fitted well such a conclusion.

Pike used the ether theory to good effect to explain two other important phenomena: the continued motion of a body once it is set moving, and the force of cohesion. He also used it in his explanations of magnetism and electricity, possibly influenced by the works of Benjamin Wilson (1721-88) who was one of the first to adapt ether to his theory of electricty.

In the case of motion, Pike suggested that where bodies were pushed together with great force, and where the bodies are without "pores" (channels permitting the passage through of ether) they would adhere together. Larger bodies of matter contained such pores, but here the coarse grains of ether, attempting to flow where finer grains only can pass, compressed the parts together. Pike again firmly rejected any suggestion that inert matter possessed any inherent power of attraction: his own theory derived from study of the scriptural text, likening the inert material to the primitive darkness described in Genesis i,v2, before God's power set them in motion. Elasticity, he considered, was closely connected to the force of cohesion, and occurred where some slight accident resulted in matter being driven apart, but not so far that the cohesion was completely destroyed.

The working of the lodestone was judged to prevent the free flow of ether in north and south directions. Like Bishop Horne[62] Pike saw electricity as an important proof of the whole theory. An electrical machine could demonstrate, in microcosm, the whole system:

> "The globe by turning swiftly round and rubbing against a hand or piece of leather, and the like, imitates the <u>function</u> of the Sun, for it grinds the masses of <u>spirit</u> into <u>light</u> and so there is a continual flow of light from it and of <u>spirit</u> to it.
>
> Does this influx to and efflux from the electric globe, cause small bodies to accede towards it? So, the <u>influx</u> and <u>efflux</u> to and from the Sun, causes the heavenly bodies to incline that way: so that we have a specimen of the <u>cause</u> and manner of Gravitation. Farther, since the electric light is conveyed at any distances, through a medium proper to receive it, does not this prove, that nature is full, so that there is no absolute vacuum in it?"[63]

Electrical attraction and repulsion were explained as a non-electric body touching an electric one, and being filled with light, receding: when the body lost its charge it was driven again by the spirit flowing towards the electrified body.

Thus Pike made clear the point that while philosophers can "very judiciously explain upon mathematical principles", the philosophical principles of revelation offered a mechanical account of the *vis inertiae* and gravitation. If the properties of matter and laws of motion arose from the "expansion of the Heavens" as Pike attempted to show, then he claimed that the various effects and appearances following from that should not be ascribed to a *vis inertiae* or to any attractive or elastic powers but to the agency of the Heavens.

One chapter dealt with the creation of the Earth. Not unnaturally, Pike's main source was Genesis, with reference to other Biblical books where it was necessary to elaborate or clarify particular points. He was aware of other accounts of the formation of the Earth, for example the theory based on the Noachian Flood and expounded by Burnet and Woodward to explain certain geological phenomena; this he described as being "invented and proposed to the world". He made no specific comment about the timescale of creation, other than to comment that ".... we cannot imagine that the earth (for instance) should have continued its revolution for more than 5000 years without some assistance".[64]

Pike had confidence in his system: he was sure that it was reasonable to the ordinary reader, in that it did not rely on powers ascribed to matter. Schemes devised by man had the imperfection of a philosopher imagining unknown and inexplicable properties in matter. Pike's system on the other hand was soundly based on revelation and also on experiment based on observation, and he believed that unlike other schemes which depended heavily on one agent (eg fire, or light) his scheme explained the nature of each of the various agents and how they interacted.

Pike's heavy reliance on revelation and the squeezing of the scriptural text for scientific meaning sometimes presented him with difficult problems of interpretation, which he nevertheless managed to confront successfully, or to obviate.[65] Overall, he felt his work offered the reader information concerning the operations of Nature and gave "additional confirmation of the truth and excellency of divine Revelation". Some of his ideas though were strongly influenced by other sources, particularly Descartes and Aristotle. As far as is known Pike's work influenced no one connected with science teaching in the Academies. He was, however, highly regarded by John Wesley. Pike was later to become a Sandemanian, a member of a small sect founded by John Glas in the early 18th century and later led by Robert Sandeman. Sandemanianism was based on small communities organised like those of the Congregationalists but which later adopted some unusual practices (for example, the ritual washing of feet and strict dietary observance). Glas was later to reject Hutchinson's ideas (similar to those of Pike) that the Bible could provide a complete system of physical science. On joining the Sandemanians, Pike followed John Glas's lead and repudiated his own work, <u>Philosophia Sacra</u>.

The second half of the 18th century produced great diversity in the range of Academies. Olney and Rotherham were both dedicated to the training of ministers, teaching science strictly within the "argument from design", and basing their studies on the old texts of Ray and Derham. At the Rotherham Academy, the principal Edward Williams went so far as to attempt to censor those scientific works which put forward theologically unacceptable ideas, and which appeared to threaten God's role in the universe. By contrast at Warrington 2 and Manchester 2, a wide variety of scientific subjects was taught, without invoking profound theological questions. This was achieved by concentrating on narrative, classification and practical aspects as can readily be seen from the lectures of Enfield at Warrington, Broadbent at Daventry and Priestley at Hackney. In the lectures which have survived from these institutions, discussion of the philosophical foundations of science study appears to have been kept to the minimum.

At Olney and Rotherham, and similar Academies the prime purpose was to educate ministers quickly. This need arose in response to the challenge of Methodism which continued to attract converts at a rate double that of the new, evangelical dissent. Both Methodists and the new dissenters (new Congregationalists, Particular and General Baptists) sought converts from artisans and labourers, particularly in the new manufacturing districts of the north and the midlands. By the second half of the 18th century, Methodism had consolidated its position: its organisation reached maturity and two institutions[66] offering formal education according to Methodist precepts had been founded by Wesley. But the vast majority of Methodists, it should be noted, were to be educated informally by itinerant preachers, who sold digests of important books printed on cheap paper as they travelled their circuits. Some of these tracts were concerned with scientific or medical matters, Wesley's own Primitive Physic (1747), The Desideratum (1760), on the use of electricity in medicine and The Compendium (1763) which gave a digest of current knowledge in all branches of science, being the best known examples. Wesley's yardstick for a scientific text was its theological content, and thus he favoured those scientific writers who forcefully supported the "argument from design". The pressure was thus on some Academies to concentrate on a quick through-put of students to compete as ministers and teachers alongside the Methodists.

Samuel Pike's attempt to derive a new scientific model for the structure of the universe, based on revelation through biblical texts represents an extreme attempt to shore up orthodox Christian theology. Although his theories were incoherent when looked at scientifically, they were sound and very persuasive from a religious point of view. Pike's main strength was as a biblical scholar, and he was able to use whatever scientific knowledge he had acquired from study of the Cartesian universe or the Greek philosophers to supplement information teased from the biblical text and provide a complete, alternative model for the universe to that proposed by the Newtonian philosophers. Despite this strong trend towards "revealed religion", a few Academies were receptive to change in scientific ideas. There is the example of Dalton at Manchester 2, who taught Lavoisier's new chemistry. Electrical studies were taken up in a number of Academies, but at what appears to be a rather shallow level. This period also saw an increase in the amount of equipment available for demonstrations: particularly noteworthy in this respect were Warrington 2 and the Bristol Baptist Academy.

It is particularly interesting to note that of the Academies which survived into the 19th century, almost all were concerned with the training of ministers. This is an issue which will be considered further in Chapter 9.

REFERENCES

1. Gilbert, A D, Religion and Society in Industrial England, London, 1976 passim

2. King's Head/Homerton, founded 1730, moved to Homerton in 1769, where it remained until its amalgamation with others to form New College, London

3. Gibbons, Thomas, MD (1720-85), ed. at Deptford, then Moorfield under Eames.

4. Gibbons, Thomas, Medical Cases, 1799. He found calomel effective in the treatment of jaundice, and nitre for haemorrhage.

5. "I have ever seen that patients in general expect more from a medicine the composition of which they are ignorant of, than from one they are acquainted with" (p78)
"...other patients many of the clergy for instance ... who have attended anatomical and chemical lectures, and perhaps acquired a knowledge of the theory of Physick. These are not to be put off with an ipse dixit. They have a right to know the physician's opinion of their disorder - the intention of cure, and by what means it is to be brought about."(p80)
Gibbons, Medical Cases

6. TCHS, I & II, contains extracts

7. Gibbons, Thomas, Sermon, 16 November 1760, p.36-37

8. Ibid, p.37

9. Priestley is the main source of information about texts in use at the Academy during Ashworth's tenure. Having read s'Gravesande's Elements of Natural Philosophy before entry, Priestley was permitted to enter the second year of study at the Academy. This suggests that s'Gravesande remained a study text during the early years of Ashworth's tenure at least. Priestley, Memoirs, ed. Lindsay, Bath, 1970, p.72

10. Bristol Baptist Academy was founded under the will of Edward Terrill (d.1679) who left a bequest for the provision of training of ministers informally. The College was inaugurated in 1720, with the arrival of Bernard Foskett. Reconstituted in 1770. At this

period the teaching was dominated by classics and divinity. Bristol Baptist College - 250 years 1679-1929, Bristol, n.d.

11. Rotherham Academy founded in the 1790s appears to have incorporated three very small institutions from the same neighbourhood: Idle, Northowram and Heckmondwyke. Northowram had inherited books and scientific apparatus from Heckmondwyke which was tutored by James Scott (1710-1783), who attended Edinburgh 1728/9. On this slender evidence it seems possible that some science was included in the curricula of both Heckmondwyke and Northowram. Ultimately this institution joined others to become Yorkshire United Academy.

12. The Newport Pagnell Academy was founded c1785 by an Anglican John Newton (1725-1807) who employed William Bull (1738-1814) educated at Daventry, as the first tutor. In early correspondence between Bull and Newton, there are references to a "Utopian" college, as what was planned was an institution which was to try to bridge the gap between Dissenters and Methodists (who at that time were still part of the established Church). The Academy was reasonably well-based financially, initially supported by wealthy benefactors but later by public subscription. Some 100 students passed through the Academy, initially there were disciplinary problems but although these led Bull to predict a short life for the institution, it continued for several years. See Newton, J, Works,v, London, 1808,"Plan of Academical Preparation for the Ministry", p.61-96

13. Newton, J Works, v London, 1808, p.69

14. Bull, J, Memoirs of William Bull, 1864, p.322

15. Williams, Dr E (1750-1813). See Memoir of the Life of E Williams for details. He was well read in the physical sciences and chemistry.

16. Ryland, John (1753-1825), DNB, had kept a school in Northampton, before joining the Academy.

17. Ryland, J Pastoral Mem. II, p.285; quoted Ashley Smith, op cit, p.216 and ibid Ryland, p.94

18. Walker, A, Philosophical Lectures, 7th edition, London, 1795

19. Boerhaave, H, Elements of Chemistry, (Dallowe's edition),1735

20. See Thackray, A, Atoms and Powers, Harvard, 1970, p.112

21. G E Stahl (1660-1734). German chemist and medical theorist. Extended original phlogiston theory in Specimen Beccherianum, (1703)

22. Manchester 2 opened in 1786. Among the early tutors were Thomas Barnes (1746/7-1810) and Ralph Harrison (1748-1800) both ministers at the Cross Street Church Manchester. Barnes had read a paper before the Manchester Literary and Philosophical Society in which he pleaded for a college in which the "arts" of liberal science and commercial industry might be combined by learning in natural philosophy, mathematics and a broad selection of other subjects ("A Plan for the Improvement and Extension of Liberal Education in Manchester" read April 1783) This college was inaugurated in June 1783 but closed in 1786, as the Academy opened. Barnes and Harrison joined the staff of the new Academy, and it is believed that a colleague from the first college, Thomas Henry, an apothecary, may have given lectures on chemistry until the arrival of John Dalton. John White gave lectures to intending medical students, of whom 10 were enrolled 1786-98. The Academy catered for three types of student; those intending for the Ministry, for whom a five year course(including the sciences) was available, those intended for learned professions for whom a three year course was offered, again including sciences, and those destined for commercial life whose course was similar to those entering professions. Shortly after 1800 the Academy moved to York, and became an antecedent to the present day Manchester College, Oxford. It should be noted that the Academy faced severe financial difficulties during its early life, as it was competing with Hackney Academy from the same limited pool of resource. (See Wykes, D L "Sons and Subscribers: Lay support for the College" from Smith, Truth, Liberty and Religion, Oxford, 1986.

23. Lavoisier, A, Traite elementaire de chimie first published 1789, English edition by Kerr published 1790. Chaptal, J, Elements of Chemistry, translated Nicolson, 1795.

24. Manchester Academy Minute Book A, Manchester College Oxford.

25. Dalton appears to have carried out his teaching to the satisfaction of the Trustees, for a note to this effect is recorded in both minutes and annual report for 1797, and his resignation in 1800 was accepted with regret by the Trustees at the March 1800 meeting.

26. James Scott appears to have retained the notebooks for sometime after he left Daventry. The last page of one contains notes dated 1803 entitled "Explanation of some of the Principal Forms lately introduced into chemistry". These later notes are half page in length, and the terms mentioned are "caloric", "carbon", "chemistry" and "oxygen", and seem to relate to an attempt to come to terms with post-phlogistic chemistry.

27. Macquer, P J, (1718-84) Elêmens de Chymie, 3 vols, 1749-51. Favourable to Newtonian and Stahlian ideas. Assumed no prior knowledge of the subject and gave systematic account of chemical ideas, including doctrine of affinities. Last great French phlogistic chemist. Watson's Essays were the published version of Bishop Watson's chemical lectures read at Cambridge 1766-8. Newtonian text mentioned was Opticks, no page references but Query 31 was mentioned elsewhere.

28. Wedgewood's ceramic pyrometer: an instrument devised by Wedgewood for the measurement of high temperatures, particularly during the firing of pottery in the kiln.

29. Kenrick, Timothy (1759-1804), DNB, moved to Exeter c.1785, where he participated in an attempt to revive the Exeter Academy.

30. At Manchester College, Oxford.

31. James Scott's notes: Dr Williams Library, MS 28 107-9.

32. Dufay, Nollet, Aepinus were included in the survey.

33. Tourmaline, amber, were discussed

34. The student referred to Priestley's History Part 1; period x,6, which contained a reference to Symmer's electrical stockings, an experiment which was no doubt copied.

35. See Heilbron, J, Electricity in the seventeenth and eighteenth centuries, California, 1979, passim for descriptions of these experiments.

36. Lovejoy, A, The Great Chain of Being, 1936, reprinted 1964, for the history of this idea.

37. Hartley, D, Observations on Man, 1749. Priestley issued his own edition of this work in 1775 but removed all references to the theory of vibrations. See Oldfield and Oldfield, Ann.Sci, 8, p.371-81.

38. These were originally prepared by John Collett Ryland (1723-93), the father of John Ryland, but modified by James Ferguson, FRS.

39. See Williams, Memoir of the life of E Williams, p535

40. Minute book A, Manchester College, Oxford

41. Read on 31 October, 1794. Dalton was encouraged to join the Society by Robert Owen (1771-1858) who was already a member.

42. Greenway, F, John Dalton and the Atom,London, 1976, p101

43. Brocklebank, E, John Dalton, Manchester, 1944, p16

44. Founded in 1794, in London. First tutor, Stephen Freeman, resigned after one year and was replaced by John Evans (1767-1827) ex Bristol Baptist Academy, Edinburgh University, DNB. Evans kept a school, and some classes were common to both school and Academy.

45. Reported by Christian Reformer,n.s.xvii,1817m p.316

46. Wymondley was founded in 1799 and the tutor of scientific subjects was William Parry (1754-1819). Maths was taught in the first year.

47. Gosport Academy was founded in 1789 by David Bogue (1750-1825); ed. at Edinburgh University, later DD from Yale, co-author of 4-volume History of the Dissenters. Academy was open to theological students only, course lasting 3 years.

48. Bogue,D and Bennett, J, History of the Dissenters from the Revolution of 1788 until the year 1808, III, p.270

49. McLachlan, English Education under the Test Acts, Manchester, 1931, p 8

50. Exeter 2, founded by Towgood in 1760. Open to both lay and theological students. Academy closed in 1772.

51. Gentleman, Robert (1746-95) educated Daventry, under Ashworth; later transferred to Carmarthen Academy.

52. Wilson, Walter, Dissenting Churches, i, p.192

53. Pike, Samuel (1712-73) DNB, settled in London in 1747; was for a time lecturer at Pinners Hall, London, but was expelled as his congregation believed he had become a Glassite or Sandemanian. He was described as a man of character and ability with considerable

biblical scholarship.

54. Founded by William Hutchinson whose book Moses Principia (1724), enjoyed revived popularity in mid-18th century, with discussion on the nature of electricity which at that time seemed to require an ethereal explanation.

55. Philosophia Sacra, 1755, many editions. Text seen was the 1815 edition with an introduction by S Kittle. Kittle notes that Pike was generally considered to have been an Hutchinsonian.

56. Pointed texts showed vowel markings in the Hebrew, unpointed ones did not.

57. Pike, op cit, p.15

58. These remarks are very similar to Hutchinson's who also argued that there existed an ethereal medium in this case composed of fire, light and air.

59. Pike, op cit,p.17. Later Pike returns to this idea, to explain the force of gravity. The ether is the agent.

60. Ibid, p18

61. A comparison with Newton's Opticks (1717) shows that a difficult problem for Newton was "how matter might act where it is not". The introduction of ether was intended to help solve this problem by referring the observed multitude of forces to the unity of one "certain most subtile spirit".

62. Horne, Bishop George (1730-1792) anti-Newtonian; supported Hutchinson's theory.

63. Pike, op cit, p.56

64. Ibid, p.73

65. Pike managed to slide around the difficulty presented by the reference to "wings of the earth" (Job, 37, v.3; Job,38, v.12-14) by explaining that these were a mechanism derived from heat which produced sufficient momentum to spin the globe.

66. Kingswood School, Bristol, and Trevecca, Talgarth, Brecknock.

CHAPTER 7 - CASE STUDY, WARRINGTON ACADEMY (1757-1786)

The Warrington Academy opened in 1757[1] with three members of staff: John Taylor, DD, the first Principal and divinity tutor; John Aikin (senior), DD, classics tutor; and John Holt, natural philosophy and mathematics tutor. The Academy was open to lay as well as ministerial students, and its curriculum enabled all students to take courses which met specialist needs, after sharing a common "first year". Although specialist selections of courses had been possible in a small way at Northampton, where Doddridge permitted lay students to forego some of the theological studies, the scale of specialisation practised at Warrington was much greater. Students could select from three broad groups of courses: in addition to the theological course there was a group of subjects with a modern/commercial bias including languages, geography, history, bookkeeping and surveying, and a third group with a scientific/medical bias, natural philosophy, anatomy, chemistry and mathematics. For some subjects (bookkeeping, surveying, chemistry and anatomy) specialist tutors were appointed. The study of the English language was highlighted and instruction was also offered in French, fine arts and the classics. The theological course was the longest, taking five years to complete, while the "modern/commercial" and scientific courses were of three years' duration.

Some 393 students[2] were to be educated at the Warrington Academy between 1757 and 1786. The precise number of students present at any one time is uncertain, but over the 29 years of the Academy's existence the annual intake of new students averaged at 13 to 14. The minimum age of entry was 13 years. It is likely that the population of new and continuing students at any one time was between 45 to 60, in size approximating to a medium-sized English university college.

Of the 393 students, the later careers of about half are known: of these by far the largest proportion entered commerce, the next largest group became ministers, followed by an equal number split between medicine/science and the law. This rough breakdown suggests that at any one time at least half, and possibly two-thirds, of the student population were lay students following the "modern/commercial" or the medical/scientific group of courses. Thirty-four students can be firmly identified as entering occupations or following leisure interests which involved some practical use of scientific knowledge. These are listed in Table 7.1, and will be discussed later in the chapter.

The Academy was founded by a group of Dissenters from the Liverpool/Warrington area. The Management of the Academy was organised through a group of Trustees, some of whom had actively participated in the foundation of the institution. The Trustees held regular meetings at which issues concerning the day to day management of the Academy were discussed. The founders included men who were interested in scientific matters: John Seddon, Matthew Turner and

Thomas Bentley. Seddon[3] was an acquaintance of John Canton FRS; Canton included among his associates Benjamin Franklin, and was the focus of a London scientific circle[4], in which Joseph Priestley was to become involved, (through Seddon's good offices), while tutor at Warrington. Turner[5] was a Liverpool surgeon, who was also interested in the commercial uses of chemistry, and for a few years he taught short specialist courses in the subject at Warrington. Bentley[6] was a china manufacturer, and among his acquaintances numbered Benjamin Franklin, Joseph Banks and Joseph Priestley. It is not surprising therefore that the practical aspects of science were stressed, particularly the importance of understanding chemical processes for the improvement of manufactures. In stressing the need for scientific equipment, the Trustees of the Academy made plain in the Annual Report of 1760 the importance they accorded the study of science:

> "This is a Branch of Science which deserves very great Attention: The Improvement of NATURAL KNOWLEDGE upon the foundation of EXPERIMENT seems to be an Object which engages the Notice of the learned in all Parts of World and if [to] the Common Experiments in Philosophy could be added some of the more important processes in CHEMISTRY, expecially that Part of it which has a Connection with our Manufactures and Commerce, it would probably have the best effect."[7]

This suggests some sensitivity on the part of the Trustees towards the importance of experimental science for the development of manufacture and trade. How far this was developed in the Academy will be considered in the course of this chapter.

The first students were admitted in 1757, while planning was still in process. From August 1757, plans for the purchase of books and scientific equipment were under discussion, and the collection of funds for this purpose was hastened.[8] Tutors were asked to submit lists of the books and philosophical instruments required.[9] In their responses, the tutors were cautious over the purchase of large numbers of books, as they indicated that their own personal libraries would be at the service of the Academy. The tutors' offer probably arose from a desire to husband the Academy's limited financial resources. (The Academy had no systematic means of obtaining funds for its upkeep and special needs, but was dependent on ad hoc subscriptions throughout its existence.) The only books recommended for purchase at this time were those required for the planning of the initial lecture programme.

At the same meeting, the provision of instruments for experimental philosophy was considered. The tutors believed:

> "that it will not be immediately necessary to purchase many, as a course of Philosophy cannot be entered upon before the previous studies have been gone thro', but if the Gentlemen choose to purchase a set of Optical instruments, Mechanical, Electrical, or other that they shall be employ'd as much as possible, for ye Improvement & Entertainment of the Students..."[10]

The use of the word "entertainment" implies a pleasant mode of instruction, rather than the modern sense of amusement. John Holt, the first natural philosophy tutor, purchased for the Academy equipment which had belonged firstly to the Morpeth schoolmaster, John Horsley, and secondly to Caleb Rotheram of Kendal. The stock of equipment was increased by purchase or gift over the years; later, in the 1780s, the divinity tutor, Nicholas Clayton[11] was sufficiently skilled to manufacture some of the required items, and even to have invented some to help his colleague, William Enfield, teach mechanics.[12]

The tutors of science at the Warrington Academy were

John Holt	1757-72(?)	Natural philosophy Mathematics
J R Forster	1767-70	Natural history
William Enfield	1770-83	Natural philosophy

These three tutors made the most substantial contributions to the teaching of scientific subjects at the Academy, and will be subject to the most detailed consideration. In order to pursue its policy of specialisation in scientific and medical subjects the Academy Trustees engaged local medical practitioners to teach short courses on chemistry and anatomy. These were:

Matthew Turner	c1762	Chemistry
John Aikin (jnr)	c1777	Anatomy, Chemistry

John Holt

John Holt,[13] a mathematician from Walton near Liverpool, was invited to take up his appointment at the Warrington Academy in the following terms:

> ".... your abilities, your very amiable character, yourhaving been so long employ'd in this [service ?] & the Honourable and Affectionate manner in wch your Pupils have ever mentioned your name first directed our Thoughts this way ....." [14]

An experienced tutor from outside the Academy world was thus chosen. It may be assumed that John Holt made the recommendations for the purchase of the first texts in natural philosophy and mathematics, listed as:

"Smith's Opticks"

"Dr Desagulier's Experimental Philosophy"

"McLaurin's Fluxions"

"Wallis's Mathematical Works"

"Simpson's Conick Sections"

Robert Smith's Compleat System of Opticks in four books, published in 1738, provided a comprehensive survey of the phenomena of light. As a text its strengths lay in the demonstration of the laws of reflection (catoptrics) and refraction (dioptrics), which included worked examples with geometrical proofs. The text was particularly noted for its mathematical treatment of the design of lens systems. Smith touched on theory only briefly, and then in a popular manner. Smith's text was also used at Cambridge (where Smith was a tutor at Trinity College) until 1774. As a companion text, Holt chose Desaguliers' A Course of Experimental Philosophy[15], published 1743-4. (Desaguliers gave optics only the briefest treatment in his work, as he considered Smith's text covered the subject very adequately.) Desaguliers' Course was an elementary text in natural philosophy which, in addition to Newtonian mechanics, covered simple machines (including pulleys, levers) and inventions such as the windmill and early steam engine. It was practical in nature, with a limited amount of theory and very little mathematical calculation. Desaguliers was fully aware of the work of other English and continental Newtonian philosophers and a formidable critic of some of their work. He carried out original work which he published in a series of papers in Philosophical Transactions of the Royal Society, and these in turn were incorporated into the Course. He was particularly impressed by Stephen Hales' Vegetable Staticks (1727), which inspired him to undertake further experiment. Hales's experiments on the properties of gases (which he did not differentiate but referred to as "airs") led to a model in which "airs" could be attractive or repulsive. This supported a theory of the elasticity of solids which Desaguliers had adopted from s'Gravesande which supposed that particles could simultaneously attract (the cause of cohesion) and repel (the cause of elasticity) one another. Particles of matter were pictured at the centres of alternating spheres of attractive and repulsive force: matter therefore remained homogeneous, and whether particles approached or receded from one another was an accident of distance.Study of Desaguliers' text would have made clear to Warrington students that far from being a clearly defined mechanism, the Newtonian universe contained inconsistencies and unanswered questions. The use of such a work suggests that Holt was a tutor of some subtlety and did not intend the students to receive a simple, digested version of Newtonian philosophy but rather to stretch their understanding to its limits.

Of the mathematical texts, Wallis' Mathematical Works was the earliest, dating from 1693-8 and based on Wallis's mid-17th century work. This text was in use at the English universities around 1730. The works of Simpson[16] and McLaurin[17] were Newtonian in outlook and date from c1740. These complemented Holt's choice of natural philosophy texts, matching Newtonian scientific theory with the appropriate mathematical techniques.

Occasionally the Trustees commented on Holt's teaching: in 1762 he was requested to:

> "...go over a course of experimental Philosophy in a familar manner for the benefit of students at large"[18]

In 1764 further instructions were issued in which Holt was asked to:

".....fit up the Experiment Room and the other apartment that is intended to be the Repository of the Instruments, in the manner which he shall think the most commodious."[19]

Three years later, the Trustees were more critical, and made detailed suggestions about the teaching of natural philosophy:

"In order that the study of Mathematics, Geometry and Natural Philosophy may be carried on in a more pleasing popular and useful manner; and be more likely to engage the attention of young gentlemen in general the trustees agree in earnestly recommending the following particulars, to the consideration of Mr. Holt, as an improvement in his classes especially with regard to those who are not intended to be regular scholars and cannot be supposed to go thro' a full and compleat course of those studies

1) That Arithmetic be taught by a book of rules to which the students may have recourse when they have forgotten anything; and that they be obliged to keep a Register of all their Questions & Operations

2) That those who are not designed for any of the Learned Professions be taught a compendious and practical system of Geometry like that of Dr. Wells intended for the use of a Young Gentleman. It is thought that this method would be much preferable to the other of going regularly thro' all the books of Euclid.

3) That this class of students have their attention directed less to the abstract and mathematical and more to the Experimental part of Natural Philosophy.It is thought that by conducting the business in this manner, not less than two courses of Experimental Philosophy might be gone thro' in the session. And if some of the Young Gentlemen were encouraged to perform some of the Experiments themselves it might have good effect.

4) It is recommended that Every Branch of Mathematics be applied to practice in ye actual Mensuration of height, distances,[superficies ?], solids & etc and in Surveying and Mapping of Land that by this means the Young Gentlemen might acquire a better idea, and some facility in the use of the Instrument, and be allowed to turn this attention more to this Branch of Literature.

5) And lastly it is desired that Geography and the use of the Globes be made a part of the business of every week during the whole session that this very useful and popular branch of knowledge be made as familiar to the student as possible."[20]

These Minutes all confirm the Trustees continued, keen interest in the teaching of this subject. The importance of practical work was clearly recognised by the Trustees, and the last minute suggests that Holt's teaching tended to be biassed towards the theoretical. This minute also indicates a perceived need to distinguish between groups of students, primarily on vocational grounds, as the needs of those intended for entry to the professions were different to those of students seeking a career in commerce or manufacture. As the Trustees saw it, the latter group of students required greater practical experience. Implicit in the Trustees' statement is the view that such students were less able: the reference to "Dr Wells" indicates that a need for a primer which assumed little previous knowledge of mathematics existed. The Young Gentlemen's Course of Mathematics (1714) was already in use in other Academies, for example Northampton. The minute also confirms the Trustees' continued interest in the practical aspects of science. This reflects earlier remarks on the value of the subject in manufacture. A novel suggestion is made - that students should perform experimental work themselves. Here the influence and example of Matthew Turner, a visiting tutor and founder (see below) can be discerned. It is clear that up until this time the students in Holt's classes did not participate in experimental work; it is more likely that the experiments suggested in the texts of Smith and Desaguliers were demonstrated by the tutor.

John Holt left no publications, and no lecture notes survive. He chose reliable texts for his students, and in his choice showed himself unafraid to underline the fact that areas of uncertainty remained in man's understanding of the physical universe, despite the work of Newton. Evidence from an early historian of the Academy, William Turner, indicates that Holt was assiduous in his duties as natural philosophy tutor and readily approachable to his students.[21] If the Trustees' advice was taken, then Holt's classes with the modern/commercial group of students would have been exceptional in that experimental work, however basic in nature would have formed a regular part of the syllabus.

Johann Reinhold Forster

From 1767 to 1769 Warrington Academy secured the services of Johann Reinhold Forster.[22] Forster's arrival at the Academy brought a new dimension: a noted scholar from the Continent, well thought of by his contemporaries.[23] A traveller and naturalist, Forster was initially appointed to teach modern languages. Arriving in England for the first time in 1766 in the company of his eldest son, Forster made contact with fellow natural scientists (including Daniel Solander), with Lord Shelburne (for whom Priestley was to work from 1773 to 1780) and with a Mr Vaughan, whose two sons were then students at Warrington Academy. Forster also came into contact with Benjamin Franklin in his early days in London, and his later writings indicate that he held radical and reforming views on such subjects as American independence and slavery. Initially Forster made a living in London by selling various curiosities (coins, fossils, manuscripts) gathered on his travels in Russia. Very soon, Forster's name was put forward to John Seddon, Trustee and the then principal, as a suitable modern languages tutor who could fill the vacancy caused by Priestley's resignation. (Priestley taught languages and history at the Academy from 1761 to 1767.)

Shortly after his arrival at the Academy in 1767 Forster began to deliver lectures on Natural Philosophy. (He was to prove a tutor of many talents: in 1768 he was able to offer a course on "fortifications, gunning and tactics". This innovation resulted from a request made by one student who was destined for an Army career.) His first series of lectures has been described[24] as an attempt to demonstrate how utility, and metaphysical and divine purpose may be discerned in studies of natural history. A review of world progress in various branches followed culminating in the Linnean system, of which Forster was at once critical (citing the drawbacks of the method) and appreciative (of the desire to bring order to the study of nature).[25] Forster told the Warrington students that although Linnaeus himself appeared at times to be unsure of his ideas, the Linnean system of classification was the best devised so far for the living world:

> "Therefore [a] great many other very sensible writers opposed Linnaeus in regard to his classes, as Klein Siegesbeck, Buffon and others. We look upon this with Impartiality, see the Faults and Imperfections of Linnaeus's system but they are not so much faults peculiar to his Book but Imperfections which are general to the whole science. Let us study Nature and improve these Imperfections: but certainly let us look upon Linnaeus's system as the most perfect of them all upon the whole, and therefore, we propose as much as possible to follow this great Man in the Animal & Vegetable Kingdoms, in the Mineral we have partly made use of Wallenius, Woltersdorf, Cronstedt, Lehmann & some others who are undoubtedly preferable to Linnaeus's performance."

Forster's lectures contained a survey of museums: he had visited the museums of St Petersburg, London (The Royal Society, and the recently opened (1759) British Museum), and the Ashmolean at Oxford, which he condemned as "a poor, dirty and ill-arranged collection"[26]. He had also seen the private collections of John Forthergill, Emanual da Costa and Margaret Cavendish, the Duchess of Portland. The importance of the work of scientific travellers, and the foundation of specialist societies for the advancement of science was also stressed. Forster's approach to the subject took the student beyond the immediate confines of the Academy, and suggested some avenues through which interested students could continue their studies in later life.

Forster's Introduction to Mineralogy, (1768)[27] includes material from lectures on this branch of natural philosophy given at Warrington, and was written to meet a need for a reliable English student text on the subject.[28] From this text it is possible to gain some insight into Forster's philosophy and his teaching at Warrington.

Forster's view of the natural world was firmly rooted in the argument from design, with Man at the pinnacle. A duty was thus placed upon Man to study the natural world, to confirm belief in the Creator, and to ensure that the best use is made of His gifts:

> "A System of Natural History is a scientific enumeration of the natural bodies which compose the surface of the globe.
>
> God is the supreme Lord and Creator of the universe, that is of the spiritual and of the visible world.
>
> The visible world is the compass of all actual things; it comprehends the heavenly bodies, the various elements, and this globe which we inhabit and these together make up the vast Empire of Nature. The

> knowledge of the heavenly bodies and their motions is astronomy.
> ... the great utility of natural history appears at first sight; it confirms us in the belief of the Existence, enlarges our ideas of the wisdom and power, goodness and providence of the Supreme Being, and when seriously attended to, will leave the deepest and most lasting impressions of religion and piety on our hearts.
>
> The benevolent Creator of the world having subjected everything here below to the dominion, and designed them to be employed in the service of mankind, it becomes us to be acquainted with the general properties of everything around us, and several important purposes to which they are capable of being applied. But this can only be done by careful observation, and accurate study of nature: it is from this force we are to derive that knowledge of the powers of natural bodies, which can alone enable us to apply them in procuring the necessaries, or in adding to the comforts and ornaments of human life."[29]

This extract indicates how strongly Forster believed that scientific study would enhance and support religious belief. It also makes clear that he saw that the utility of the subject went hand in hand with the concept of God in the argument from design.

The main body of the text was devoted to a classification and description of minerals, their nature and origin. Forster's basic elements were Aristotelian:

> "The Elements are the materials, of which the bodies of the visible world and particularly our globe, are composed, and are generally said to be four viz. Earth, Water, Air, Fire; the qualities, relations and proportions of these in the composition and decomposition of bodies are the objects of Chemistry."[30]

He used the Scholastic "two principles" to explain further the structure of matter, these being the absolute substance:

> "From the chemical experiment it appears that the integrant parts of mineral bodies may be reduced to a few homogeneous principles, which cannot be reduced any further by human art.
>
> These principles are according to the most celebrated and skilful mineralogists are <u>earthy</u>, an <u>inflammable</u>, and a <u>mercurial</u> principle.

> The combination of these principles forms the different mineral bodies. The different qualities and relations of these principles ... are the causes of the varieties which are observed in mineral bodies."[31]

Each material was described by colour, texture and shape:

> "crystalline sulphur (sulphur virgineum) is a transparent sulphur of a fine lemon-colour and like yellow amber"[32]

Behaviour on heating, smell and taste were reported when significant:

> "Salts also, in respect to mineralogy are mineral bodies, soluble in water, fusible in fire, attended with smoak [sic] during the operation, congealing again in little masses, of a regular figure and affecting the tongue with a sharp sensation."[33]

Locations were given for some of the minerals, particularly where they might be found in Russia and the area covered by modern Germany, reflecting Forster's own travels.

Some time was devoted to an explanation of the origins of minerals and metals. Fossils and bones found in rock showed that minerals were generated by aggregation. Forster explained the generation of fossils, minerals and metals by "combination" of which there were three main forms: solution (action of air and water); extraction (action of air and fire); and fusion (action of fire alone). An important phenomenon was the action of mephitic air which was considered significant in the cohesion of bodies, for example metals. Mephitic air contained

> "...swimming as it were in itself, the finer parts of fluids, acids, inflammables and metallic substances, when they are detached and risen like vapours in subterraneous inclosed clefts and to carry them through such fossils and other bodies, as are lax and porous enough to let them pass." [34]

The danger of mephitic air to miners was noted. Forster distinguished the action of common air as congealing and hardening wet, soft mixtures underground; it precipitated the matter swimming in mephitic air into hard masses, dissolving fossils, minerals to form other mixtures (for example, limestone). The action of water dissolved salts, fossils, etc, in the process becoming a good solvent for other bodies, especially the metallic. Dissolved particles were precipitated into and gradually filled rock clefts, a useful point which explained the vertical insertions of material into other rocks which had been observed.

The action of subterranean fire, which brought about fusion, was described as a form of fermentation. Different from "culinary" or hearth fire, Forster suggested that an analogy might exist in the action of steel filings mixed with sulphur and air[35]. Fires which occurred in coal pits were cited as evidence of this phenomenon at work. Heat, he also noted, could act as a carrier of fluid, acid, inflammable air and metallic principles, again depositing these in rock clefts to form new materials.[36]

These general descriptions were followed by a series of chapters in which the different actions forming particular groups of substances were explained. Stones, for example, were formed from masses of soft, dissolved earth, but indurated by elective attraction, crystallisation or evaporation. Salts were derived from many operations: solution, evaporation, elective attraction and crystallisation. The different characteristics of individual salts Forster explained by slight differences in the way each was formed.

According to Forster, all inflammables contained vitriolic acid: in the case of naptha, "ambergrease" [sic], and yellow amber, the acid was "intimately united" with fat or oily particles from which it could not easily be separated. This is reminiscent of J J Becher's[37] early formulation of the phlogiston theory where an "oily earth" was thought to be present in combustible material, a "principle" of fire, which was released on combustion. Forster did not discuss phlogiston specifically, and appeared to be able to explain most reactions between substances without it. The rest of the inflammables contained "phlegm", the vitriolic acid and oil or inflammable matter, and some earthy particles. The different proportions of the mixture, and the varying means of their coming together explained observable differences. Most substances could be explained in this way except arsenic and saltpetre which remained mysterious. A longer chapter on the generation of metals followed, which was based on the sulphur-mercury theory of metals, and was not new.[38]

The history of the earth was touched upon with reference to "original or primogenial mountains" and "latter[sic] or secondary mountains". At the time of writing the Introduction to Mineralogy, Forster believed that the Noachic flood was the chief cause of the "latter or secondary mountains" but volcanoes, earthquakes and oceanic movement had also contributed. Petrefactions were most commonly found in "secondary" mountains but only under rare circumstances in the "original" mountains.[39] Later (1798) Forster was to return to this subject, by which time he had become convinced of the importance of the effects of volcanoes in shaping the Earth's surface. He tried to unite, unsuccessfully, both theories, to be later known as Vulcanist and Neptunist.[40]

At the end of the book some material (not all of it closely linked with the main subject) was included which Forster evidently considered useful to students: Lehmann's Tables (Halotechnia)[41], a table of specific gravities compiled by Forster, and a summary of Priestley's findings on mineral substances as conductors of electricity, reported in his History of Electricity (1767).

Forster's approach to mineralogy was very practical in nature. In 1771, after leaving Warrington, he published a booklet[42] outlining a series of experiments which an amateur could perform on samples collected. A small apparatus, Mr. Engstroem's Pocket Laboratory, which might be used for such experimental work was described - and its defects pointed out. Additional equipment (hammer, magnet, acids) was recommended and a series of tests suggested. Some of these ideas may well have been introduced to the Warrington students during their course.

Towards the end of his stay at the Academy Forster completed a series of lectures on Entomology; these were divided into topics: parts of insects and their descriptions; the generation and metamorphosis of insects, and the division and characters of insects. A glossary of technical terms, and a listing of "Names of Authors corresponding to Linnaeus" completed the coverage. Forster considered publishing an Entomology but found himself hampered by lack of works of reference at Warrington. He had however collected

> "4 drawers full and more than 300 species and more than 1000 specimens."[43]

After publication of Introduction to Mineralogy, Forster planned to publish a Natural History, the basis of which was to be the lectures given at the Academy. By October 1768 the sections on Insects and Mineralogy were complete, and work begun on the botanical sections. In correspondence with the English traveller and naturalist, Thomas Pennant (1726-1798), Forster complained of a want of books and "subsidia" at Warrington:

> "I could do nothing for want of books: I wanted chiefly English Names of Animals which I hoped to collect from the books I wrote for. It is for me a very troublesome work to write in a language which I know by since two year. It is impossible to be acquainted with every expression, especially in Natural History, a study of so immense an Extent."[44]

And shortly after:

> "[Natural History] is not a study which one might write ex cerebro, so as a spider makes from her own stores Cobweb; one is obliged to see what people have sayd before us & to compare their accounts & to make from all this, one totum."[45]

Forster clearly felt that despite his contact with Pennant and the local intelligentsia, he was in isolation. He felt deprived of the scholar's essential tool: access to a comprehensive library in his field of interest.[46] It is known that the Academy Library[47] contained not only Woodward's Natural History of the Earth (1695), but early works by Grew and Ray[48] on botany and on animal life, books by Albin and Thorley,[49] but these clearly were insufficient to meet Forster's needs.

During his stay at the Academy, Forster participated fully in the cultural life of Warrington town:[50] he was elected to the Committee of the Circulating Library in 1768, on which he remained with one break until November 1770. Travel books were well represented, reflecting Forster's interest and experience. He also became acquainted with the amateur naturalist Anna Blackburne and her family at Orford Hall, north of Warrington. He became a regular guest at the Blackburne's dinner parties,[51] and several of his Warrington lectures were read to Anna Blackburne. Through the family, Forster appears to have first met Thomas Pennant and introduced him to the Academy: certainly both corresponded about visits and joint plans to translate travel books.[52] (In this latter venture, Forster received some help from a fellow tutor, John Aikin (senior).)

Problems relating to the maintenance of discipline in classes began to disturb Forster, who believed that the students were deliberately baiting him because of his accent and unfamiliar ways. (Disciplinary problems were endemic at the Academy, as is evident from regular references in the Minute Book.) Moreover, financial problems beset Forster, making it necessary for him to take up additional teaching outside the Academy. His debts accumulated, and doubtless some unpleasant scenes with local tradesmen occurred in the town, given his irascible nature. The final straw seems to have been an attempt to administer corporal punishment to one of the Academy students. For this he was formally censured by the Principal, John Seddon. Forster was dismissed and left the Academy at the end of the academic year, June 1769.[53]

After leaving the Academy, Forster published a Catalogue of British Insects, (1770) and a Novae Species Insectorum, (1771) which was described as "very indifferent" by fellow Prussian naturalist Peter Pallas. Forster's subsequent career included a professorial chair at Halle University, and an appointment on the second voyage of discovery of Captain Cook. In the 1780s, Forster was to renew contact with Priestley, prompted by a need to learn more of the latter's work on the composition of the air. Forster's own research at the time concerned the treatment and origins of scurvy; he believed he had identified a connection between respiration and phlogiston in the blood. Later, helped by the Irish chemist Richard Kirwan, he translated Scheele's Chemical Observations and Experiments on Fire and Air. Thus his contacts with the English and Irish natural philosophers never entirely faded away.

Forster's reputation among modern writers has not been high: for example, Professor Roy Porter in The Making of Geology wrongly describes Forster as a person "who made a living on the commercial margins of science"[54]. In the light of Forster's work at Warrington, this is an inadequate assessment. Pejorative judgments of Forster originate with a work by William Wales, a fellow traveller on the Cook voyage to which Forster was appointed.[55] Wales' attack on Forster derived from bad relations on the voyage, possibly rooted in professional jealousy and exacerbated by Forster's temperament. Vitriolic exchanges of correspondence occurred between Wales and Forster's family and friends which, in England, resulted in the tarnishing of Forster's reputation for years to come.

Wales' remarks relate to one specific episode in Forster's career and ignored his period of work in England at the Warrington Academy. The Academy community was enriched by the presence of a continental scholar, who brought first-hand experience of fieldwork in distant lands and for which he had earned the respect of his contemporaries. Forster was clearly a competent tutor: if his lectures suffered somewhat from his unfamiliarity with English his text reveals command of his subject and of written English. Forster's text on mineralogy, specially prepared for the Academy students, represents a sound attempt to set out a comprehensive classification of mineral substances, with origins and structure of matter explained succinctly within the terms of current knowledge. He was able to discuss the theological aspects of natural philosophy as well as the more practical and utilitarian. It is very likely that Forster extended further the experimental work in natural philosophy by encouraging students to collect and examine samples as he himself was accustomed to doing. The sheer intellectual energy of the man is also apparent in his ability to teach not only languages as appointed, but a diversity of additional subjects in natural philosophy which supplemented the work of his colleague John Holt, and the unique course on fortifications. He was also able to plan and commence an extensive work on natural history, but unfortunately he was never to complete this. For his versatility and intellectual powers Forster must rank as one of the most stimulating members of staff to be appointed to any Dissenting Academy.

William Enfield

William Enfield, educated at Daventry and an honorary graduate of Edinburgh University (1774), took over the teaching of mathematics and natural philosophy in 1774. After Holt's death in 1772, George Walker, FRS[56] had taught mathematics for a brief period. Walker was later to publish two mathematical works, on the sphere and on conic sections. Enfield was appointed to Warrington Academy in 1770 as Rector and divinity tutor, and to these duties he added the teaching of "belles lettres" in 1772, and mathematics and natural philosophy in 1774. Despite what must have been a not inconsiderable workload, he participated in the activities of the town's literary society and was to prepare a collation of extracts from works of English literature (The Speaker, published 1827) for his students' use.

William Enfield compiled the Institutes of Natural Philosophy[57] (published in 1785 as he was about to leave the Academy) because he considered it difficult to find a text which was not too complex mathematically for what he termed "elementary" instruction. This phrase was not explained but it appears that the problem of the different requirements of various groups of students at the Academy and identified by the Trustees in Holt's time, was still present. In his work, Enfield sought to bring together the mechanics and mathematics of the Newtonian universe in one compendium. As sources he listed Newton, Keill, Whiston, s'Gravesande, Cotes, Smith, Helsham, Rowning and Rutherforth,[58] (but few references are given in the course of the text). The Institutes offers a good guide to the manner in which he covered the teaching of scientific subjects at the Academy.

The Institutes of Natural Philosophy followed a common pattern of the time: definition, scholia, corollary, proposition. It is presented in a readily memorised note form, and divided into "books": I Matter, II Motion and Mechanics, III Hydrostatics and Pneumatics, IV Optics, V Astronomy, VI Magnetism and VII Electricity.
The boundaries for discussion of natural philosophy were clearly set out:

> "Natural philosophy being employed in investigating the laws of nature by experiment and observation, and in explaining the phenomena of nature by these laws, has no concern with metaphysical speculations...." [59]

Thus discussion of the subject was detached from religious argument, a standpoint which would have been unacceptable to Doddridge some forty years earlier, or indeed to Forster.

In the first book (Matter), a primary definition of the subject was set out:

> "Matter is an extended, solid, inactive and movable substance."

The scholium which related to this definition indicated that it was not necessary at that point to enquire "if solidity necessarily supposes impenetrability". A number of propositions about matter were then considered which could be tested experimentally and mathematically. Occasionally an idea which harked back to Cartesian theory was introduced, as in the first proposition which stated that "matter is infinitely divisible, or is capable of being divided beyond any supposed division". Elementary divisions were described first, using geometrical figures which showed that any given line was infinitely divisible.[60] The point was further illustrated by a natural example of minute division, gold leaf spread from a grain of gold. Cohesion was discussed at length and was described as

> "that force by which parts of the same body or of different bodies on their contact or near approach, are united to, or tend towards each other ...."[61]

Here, Enfield suggested some experiments which the student could perform to verify the different powers of cohesion in different solids: none required sophisticated equipment - threads of different kinds and wooden weights, for example. Suggestions for experiment are well represented in the Institutes: many of these students could perform for themselves. Clayton, a fellow tutor of Enfield's, devised some equipment for his colleague, thus demonstrations were almost certainly a feature of Enfield's teaching. The third, fourth and fifth propositions were concerned with the strength of the cohesive force between fluids and solids. Again various simple experiments were suggested, though some required small quantities of mercury.[62] Some experiments related to capillarity, for example:

> "The fluid will rise between parallel plates, and in capillary tubes in vacuo. Hence it appears that the ascent of fluids in capillary tubes is not owing to pressure of air"

a possible reason was then suggested:

> "the suspension of the fluid in capillary tubes is owing to the attraction of the ring of glass contiguous to the upper surface of the fluid"[63]

followed by a geometrical proof which allowed the student to demonstrate the veracity of this proposition without practical work, if so desired.

Enfield described the phenomenon of repulsion:

> "Some bodies appear to possess a power the reverse of the attraction of cohesion, called repulsion."[64]

and suggested experiments with water, mercury, tinfoil etc For example a piece of iron placed over mercury would create a depression in the surface of the mercury near the iron. Gravity explained the falling of a stone, but where smoke and vapours were concerned Enfield suggested that these were supported by air, or were acted upon by forces greater than gravitation. In this section some interesting experiments were suggested including placing boiling liquid on the scales in order to show that a substance falls out of balance through evaporation.

The second book, on Mechanics and Motion, was based on Newtonian theory, and covered the general laws of motion, speed, simple and compound forces, of motion communicated by percussion in non-elastic and elastic bodies and the laws of gravitation (i.e. speed of fall). Simple machines, such as pendulums, levers, pulleys, screws, wedges, and centrifugal and centripetal forces were also covered. Enfield generally appeared more confident in this section, one reason being perhaps the wealth of material upon which he could draw. Hydrostatics were covered in Book III which also included pneumatics, and the treatment of air, including sound, which he related to the elasticity of air. Meteorology was also examined in this section.

Books IV and V covered Optics and Astronomy. The laws of light and vision were examined in Book IV. Enfield, in common with most natural philosophers of the day, favoured a particulate nature for light, the individual particles being "exceedingly small". Experiments, using lenses, which demonstrated the laws of refraction were suggested. In the section on colours, Newton's famous experiment using the prisms was described. The rainbow, as the product of numbers of raindrops acting as prisms, was explained by this means. The function of the eye was described and explained: here students were recommended to undertake the dissection of an ox's eye. Instructions were also provided for making of mechanical models which clarified the working of the eye were also provided. Finally Enfield gave descriptions of various optical instruments: telescopes, magic lantern and camera obscura. In Book V, the treatment of Astronomy included a number of problems or puzzles which the student could solve by using the orrery or the globes. The movements of celestial bodies were linked back to the laws of motion described in Book II.

Book VI on Magnetism was very brief, merely outlining current knowledge about the subject: its connection with iron, and the phenomena of polarity, attraction and repulsion. Few experiments were suggested.[65] Book VII, on Electricity, followed a similar pattern, giving a general outline of the nature of the phenomenon. The final paragraphs suggested that atmospherical phenomena, such as the Aurora Borealis might be caused by "electrical fluid".

The sections of the Institutes in which Enfield felt most confident were those on Mechanics, Hydrostatics and Optics, all of which were supported by extensive sources - the Academy Library was particularly well stocked with texts in these branches of natural philosophy. On the whole, he gave a very competent survey of the physical world in the Institutes. Some traces of the Cartesian universe remained embedded in his thought but Enfield generally appears to have held orthodox views. He adopted a strictly mechanical approach, and did not engage in philosophic speculation about the "first cause" or about the relevance of natural philosophy to theology.

Students could supplement the more practical course which Enfield taught, by drawing on the library stock for a wide selection of books which could develop their understanding of theory. The Academy library appears to have been particularly rich in science texts, both English and continental. A few have already been mentioned in connection with Forster's teaching, but far more were relevant to astronomy and areas covered by physics and mechanics. For astronomy and optics, the library contained books which might be termed "classics": Galileo's Siderius Nuncius, Kepler's Dioptrics, and Huygens' Cosmotheoros. Later texts include Gassendi's Institutio Astronomica, and a selection of Newtonian authors: Keill (Introductio ad veram Astronomia), Gregory (Astronomiae physicae et geometricae elementa), Whiston (Astronomical Principles), Cheselden (Astronomy), Harris (Astronomical Dialogues), Ferguson (Astronomy) and the basic Watts (Introduction to Astronomy and Geography). For optics, Newton's own text (Opticks), Hooke's Micrographia, and the earlier Mydorgi's Catoptric Dioptric were available. Of a simpler and more practical nature was Baker's The Microscope Made Easy, which testifies to an interest in the collection and examination of specimens.

More generally the library held a stock of books on the main "modern" philosophies and on the "argument from design". Descartes principal works were included together with Gabriel Daniel's Voyage to the World of Cartesius (English edition, 1694). Clarke's Rohault was also listed. Not unnaturally, there were many more Newtonian texts, including Newton's Principia, and the less mathematical System of the World. Early popular Newtonian texts by Cheyne (Philosophical Principles of Religion: Natural and Reveal'd), Keill (Introductio ad Veram Physicam) and Pemberton (On Newton's Philosophy) and by later authors Rowning (A Compendious System of Philosophy), Rutherforth (A System of Natural Philosophy) and a teaching text by Desaguliers (A Course of Experimental Philosophy) were included. Continental works on Newtonian philosophy were represented by Boerhaave's Elements of Chemistry and s'Gravesande's Mathematical Elements of Natural Philosophy. The theological view of the universe, as represented by the argument from design was represented by Ray's The Wisdom of God, Derham's less rigorous Physico- and Astro-Theology, de la Pluche's Nature Display'd and several works by Boyle.

Specialist Tutors: Matthew Turner and John Aikin (junior)

From time to time the Trustees appointed additional tutors to give short specialist courses suited to students intending to enter the professions, or commerce. Commercial subjects were taught by a local mathematical tutor, Mr Bright. Matthew Turner, one of the founders and a Liverpool surgeon, taught chemistry in the 1760s and in the late 1770s it was taught by an ex-student and local physician, John Aikin (junior) who also lectured on anatomy to Warrington's intending medical students.

The Academy Reports for the years 1762 and 1763 describe specialist lectures in practical and commercial chemistry given by Matthew Turner. Little is known about Turner, but he was highly regarded by his contemporaries; one of whom described him as "a gentleman deservedly esteemed for his skill as a chemist".[66] He is known to have held radical views (he was a republican, and supported the American cause) and to have challenged Priestley's religious beliefs by means of an anonymous pamphlet.[67] Founder of the Liverpool Academy of Arts (1769) he gave lectures on anatomy and the theory of forms at that institution. Turner's chemistry lectures were illustrated by demonstrations. On one occasion Joseph Priestley reported:

> "I was one who assisted in the making of a quantity of spirit of nitre [HNO_3] in a manner not so expeditious, indeed as that which I suppose is now generally used but in which I am pretty confident there was no opportunity for any air to get into the composition of."[68]

Some participation in the experimental/practical side of the lectures was thus required on the part of the audience. This example may well have been in the minds of the Trustees when they suggested similar student participation in John Holt's lectures. Turner's course is thought[69] to have been based on William Lewis's Commercium Philosophico-Technicum, or the Philosophical Commerce of Arts (1763-5), a text especially directed towards research in applied chemistry and physics. Turner had personal experience of commercial chemistry; he was possibly the first to prepare in volume for commercial purposes and to use in his medical practice, the anaesthetic, sulphuric aether. His knowledge of industrial chemical processes was valued and he was consulted by manufacturers Matthew Boulton and Josiah Wedgewood. Thus it seems that the Trustees' idea, expressed in the Annual Report of 1760, of encouraging the study of chemistry for practical commercial purposes had begun to be put into practice. Indeed, this idea is probably due in part to Turner, who thus made an important contribution to the direction which the Academy was to take. How long Turner's connection with the Warrington Academy lasted is unknown. The specialist courses he taught were offered only when student demand was sufficient: the last date when such courses were advertised was 1766.[70]

John Aikin (junior) (1747-1822) taught chemistry and anatomy at Warrington from the late 1770s. Aikin prepared his own texts for both courses: for chemistry, Heads of Chemistry, and for anatomy Sketch of Animal Economy. No copy of Aikin's Heads of Chemistry has been traced. In a biography of her father, John Aikin, DD, Lucy Aikin mentioned that during his teaching at Warrington her brother John performed several experiments "in conjunction with one of the elder students";[71] unfortunately she gave no further details of the nature of these experiments. Aikin's interest in the scientific world extended beyond his medical work and the lectures; he translated Baumé's Manual of Chemistry in 1778, and was to edit the first edition of Gilbert White's The Natural History of Selborne(1802): Aikin also published A Naturalist's Calendar (1795) which contained extracts from White's diaries.

Aikin's chemistry course (30 lectures) was presented alternately with the anatomy course (15-20 lectures). The courses were intended

> "... to introduce into these studies those young gentlemen whose profession would require a further attention to them, and to give such a general knowledge of them to others as belongs to a course of liberal education."[72]

Thus these courses were intended to meet two different objectives: the intending professional, and the more general student.

Aikin's Sketch of Animal Economy[73] is a short booklet (35 pages) giving no more than a very basic guide to animal physiology. The language is not technical, and no diagrams are included. Aikin introduced his subject by making an initial distinction between the mineral, animal and vegetable kingdoms; there then follows a brief chapter on each of the parts and functions of the body, ending with a rather cursory description of reproduction, birth, growth and death.

Aikin's text was largely narrative; for instance, in his brief description of the heart, arterial and vascular systems he remarked that on its passage through the lungs, blood appeared both to receive something salutary, and to part with something noxious by its near approach to the air in the lungs. Respiration was related to "animal heat", a theory current in the earlier 18th century which related body temperature to friction in the blood vessels.[74] However no suggestion was offered about how such a mechanism might work.

The role of the lymphatic system was described as being the means of ridding the body cavities of fluid which is continually effused into them from the arterial system. Several different types of body secretion are listed and described: for example, sweat, urine, saliva, fat, bile. These were not classified or grouped in any way.

Some old ideas were repeated: the brain was described as a gland:

> "for the secretion of the animal spirits and that the nerves are the ducts by which these spirits are conveyed to the several parts of the body. It is conjectured that these spirits are a very subtle fluid; but no such has ever been discovered by the senses, either in the brain or the nerves."[75]

This idea originated with Descartes and was reinforced in the work of Herman Boerhaave: it was still current in Aikin's time. The senses were described briefly: the effect of "feeling" was said to arise from the nervous protuberances or papillae of the skin as they are applied in succession to the object examined.

There is nothing new or original in Aikin's text. The booklet was better suited to the general student who might wish to gain some idea of how the body works than to an intending medical student. It offers a very slight description of human physiology and, given the absence of technical terms or diagrams would <u>of itself</u> have been quite inadequate as a serious preparation for medical studies. Aikin is known to have given some private tuition, "preparatory to physic" to intending medical students, which was probably more detailed in nature than this text.[76] (It is interesting to note that the text was put to another use: Aikin translated the text into "elegant Latin" to lead intending medical students to pay more attention to securing a correct Latin style.[77])

Those who wished to discover more about anatomy and physic could remedy the deficiencies in Aikin's text by consulting works held in the Academy Library. The Library held general anatomical treatises (Keill and Gibson, already in use in other Academies), medical dictionaries (Quincey's), and some works on specific illnesses ("Mead on the Smallpox and Measles", and "Lob on the Stone and Gout"). These latter works were probably chosen to give the intending medical student some background in those problems most commonly encountered by an 18th century doctor. Quincey's Dispensatory (Pharmocopaeia Officinalis et extemporanea or a compleat English Dispensatory, 1718, 1st edition, revised by W Lewis in 1753) was a pharmocopaeia which would provide an introduction to the prescription of medicines. The history and philosophy of medicine were represented by Le Clerc's Histoire de la médicine and Hearn's Ductor Hippocrates. These medical works were not particularly up-to-date but would have provided more information than Aikin's slight text.

Much has been written about Warrington Academy which attests to the quality of the teaching, and its general contribution to education.[78] A small but steady stream of students emerged from the Academy to follow medical careers or to become connected in some other way with science or technology; these are listed in Table 7.1. Over half those listed entered medicine, many achieving high standing within the profession - Percival, Aikin, Martineau, Parry and

TABLE 7.1

Students of Warrington Academy
who followed scientific or medical careers

Year of Entry	Name	Notes
1757	Thos. Percival	Medical, author of several works including Medical Ethics interested in mortality figures; founder of Manchester Lit & Phil Society; involved in Manchester Board of Health & Manchester Infirmary. DNB
1758	John Aikin	Medical; taught at Warrington; translator and editor of many works, including edition of Gilbert White's works.
	Samuel Farr	Medical; graduated at Leyden, published Translation of the Epidemics of Hipparchus.
	William Acklom [Acklam]	Medical
	Robert Denison	Stocking manufacturer, Nottingham. Introduced machines to manufacture.
1759	John Taylor	Medical
1760	Timothy Bentley	Medical
1761	Edward Rigby	Medical; published Essay on the Uterine Haemorrhage which precedes delivery of the full-grown Foetus
	William Wilkinson	Ironmaster, brother of John Wilkinson
1763	John Bostock (snr)	Medical; known to have assisted Priestley in some experiments
	Snowden White	Medical
1764	Robert Dukinfield	Medical, army surgeon
	Thos. Barnes	Co-founder of Manchester 2, and its first principal
1765	Philip Meadow Martineau	Medical; published paper on dropsy in Phil Trans, 1784
	John Wadsworth	Medical

Year of Entry	Name	Notes
1768	George Forster	Scientist, traveller, DNB. (son of J R Forster)
	Samuel Galton	Member of Lunar Society; Collector of scientific instruments
1770	Caleb Hiller Parry	Medical; published treatises on angina, pulse, hydrophobia, tetanus; also on wool
1771	Freeman Strickland	"Improver of agriculture"
1772	John Norman	Amateur chemist, traveller
	John Vize Medical	
1773	? Moorhouse	Medical; died while a student at Edinburgh
1775	George Daniell	Medical
1775	Richard Markham (Salisbury)	Botanist, member of Linnean Society
1776	Thomas Crompton	Medical; died while a student at Edinburgh
1777	William Turner	Founder of Newcastle Lit & Phil Society
	Phillip Holland	Medical; DNB
	Richard Codrington	Medical
	Edward Chorley	Medical; trained at Edinburgh, Leyden
1778	John Goodricke	Astronomer; received Copley Medal, 1784
1781	Peter Crompton	Medical
Date of entry unknown	John Turner	Medical
	? Watson	Instrument maker
	William Hassall	Engaged in coalmining and canals

Holland. Of these, the most noteworthy is Thomas Percival who also developed an interest in public health in the Manchester/Liverpool area, where he was involved with the Manchester Board of Health and in the management of the Manchester Infirmary. One student achieved national eminence as an astronomer, John Goodricke, who received the Royal Society's Copley Medal for his research into the fluctuations of light emitted from Algol, a star in the constellation Medusa. Some were involved in manufacture: the best known being the ironmaster William Wilkinson. Others helped in the development of local literary and philosophical societies, which provided a local forum for the discussion of scientific ideas; Thomas Percival was co-founder with another ex-student, Thomas Barnes, of the Manchester Literary and Philosophical Society. Another, William Turner, was a founder of a similar society in Newcastle. Barnes was also to become involved in the founding of the second Manchester Academy, which opened in 1786. Thus for a relatively small institution, the list of student achievements in science and medicine is noteworthy. It represents a high degree of success and ensured a wide sphere of influence.

The teaching of science at Warrington reached a degree of excellence, not matched in any other Academy. Its excellence arises from a number of factors: the interest of and enlightened attitude of the Trustees towards the teaching of science; the contribution of the tutors, the facilities available in terms of a well-stocked library (from the point of view of science texts) and a reasonable supply of equipment; and with Priestley, some understanding of the practice of original research. All of these elements helped to create an intellectual atmosphere, particularly during the 1760s, in which the study of science per se might be fostered.

The most important contribution was by the staff, whose achievements and interests, as discussed above, enhanced the academic milieu. In particular, the arrival of Forster enriched the community by bringing continental scholarship and experience of fieldwork in distant lands. Of considerable importance also was the work of Joseph Priestley who, although not appointed to teach scientific subjects, undertook most of the experimental work leading to the publication of The History and Present State of Electricity, with original experiments (1767) while at the Academy. When established as a tutor, and all his lectures on belles lettres had been prepared, Priestley felt free to turn his attention to natural philosophy, and more particularly to research into the history of electricity.[79] At his request, the Principal John Seddon arranged for Priestley's introduction into the scientific circle which surrounded John Canton FRS.[80] Through Canton, Priestley made contact with Benjamin Franklin[81] for whom he later undertook some experiments. Priestley's original idea of writing an historical survey of the electrical phenomena was quickly extended into an attempt to resolve issues about electricity currently in dispute.[82] Letters surviving between Priestley, Canton and Franklin[83] describe some of the experiments (eg on conductive powers of various substances, on the nature of electrical attraction and repulsion, and on animals) many of which were original, but some simply repeated work reported by others.

Priestley probably used some of the Academy's electrical equipment: on one occasion his attention was directed away from his work on the History into an attempt to improve the design of the electrical machine he was using. Some experiments, though, called for special equipment: for one he required a kite to be placed upon the roof of the Academy to collect atmospheric electricity in imitation of Frankin's famous experiment. The History itself contained a selection of suitable experiments for young electricians; some of these may have been developed with the Warrington students. One student, John Bostock,[84] did help with some practical work, and a fellow tutor, John Holt, was called in by Priestley to witness significant experiments, due reference being made to this in the Preface to the History.

Priestley's and Seddon's involvement with John Canton's circle in London brought contact with radical politics, and the acquaintance of tutors from the London Dissenting Academies. Nearer to Warrington, Priestley and an ex-student Samuel Galton brought links with the Lunar Society in Birmingham, which involved some of the foremost local manufacturers and amateur scientists.

Under the Trustees' guidance, the Academy made a strong and consistent effort to offer courses in scientific subjects which were suitable as a grounding for further professional training (chiefly for medicine) but also introduced students to the idea of applied chemistry for use in commercial ventures. The Trustees recognised that the level of teaching must be matched with the specific academic and vocational needs of groups of students. Practical work in science studies was built into the curriculum from early days and continued (as is evident from the number of experiments using simple equipment included in Enfield's Institutes) until its closure. The Academy, through its Trustees, staff and students, had a wide variety of contacts; on the academic side, the presence of Forster and Priestley ensured some involvement with new ideas and noted scientists. Local manufacturers also had some involvement, initially through the founders Turner and Bentley, later to be extended through the membership of Priestley of the Lunar Society. These contacts were maintained through the Aikin family, after Priestley's departure.

Nevertheless, some pressures clearly existed to pull the Academy back to more conventional lines: this is implied in a statement in the Annual Report for 1766:

> "The only learned profession which this institution is calculated fully to prepare gentlemen for is the CHRISTIAN MINISTRY" [85]

These remarks appear to reflect the concern of some Trustees that the Academy should give greater prominence to the more limited role of a theological training college for dissenting ministers, rather than continue to pursue the much wider path it had embarked upon.

The Academy closed in 1786, but as early as 1760 tensions were becoming apparent. The Minute Book indicates that there was a serious dispute between John Taylor and the Trustees over interference by the latter in the internal management of the Academy. The meanness of the Trustees over the purchase of books generally was criticised, although given the limited funds it is difficult to see how more generous spending could have been permitted. The curriculum for students intended for the ministry was also criticised. Further issues discussed were the appointment of tutors in Taylor's absence (and presumably without reference to him), and general disunity within the Academy. Following the death of John Taylor in 1761, John Seddon, held the appointment from 1761 until 1770, when William Enfield was appointed principal. Lack of discipline may have been a factor in the decision leading to the Academy's closure; but references to this matter occur regularly from the early days. Gilbert Wakefield[86] (a Cambridge graduate and somewhat disaffected witness), compared the disciplinary system of the Academy unfavourably with that of a university.[87] In a letter to the Trustees of 7 January 1785[88] the last principal, William Enfield also referred to the bad behaviour of the students, despite the tightening up of rules over the years. According to Enfield's account, matters were so bad that local tradesmen refused to supply goods because of the Academy's reputation (this also points to financial problems), and none of the Trustees were willing to send their sons to the Academy. At this point, the roll was down to 17 students. Enfield suggested a "domestic plan of education which would enable the benefits of private superintendence" (namely that students should be boarded with tutors) to be enjoyed. Whether this was taken up or not is unclear.

Financial instability also appears to have been an important factor. The Academy seems to have been dependent on raising subscriptions in an ad hoc manner to meet its costs. Yet shortly before its closure there were plans to embark on expansion, without first placing the finances on a sound basis. This was clearly a recipe for disaster. Gilbert Wakefield commented that lack of funds, and the enormous expense inherent in the upkeep of buildings, were very significant factors in events leading to the closure of the Academy. Wakefield also considered that the attitude of some of the Trustees towards the Academy was now no more than lukewarm.[89] It is probable that a combination of factors - financial, internal management (including student discipline) and uncertainty about the direction in which the Academy was moving - brought about its closure. These issues will be considered further in connection with Warrington in Chapter 9.

REFERENCES

1. Kendrick's Warrington Worthies, Warrington, 1853, has a small drawing on its cover of the Academy building (probably its second premises) which has three floors and may have been "L-shaped". The first building was at Bridge Foot, Warrington, where the Academy remained until 1762, then transferring to buildings in Academy Place.

2. Information about student numbers taken from Turner, W, "Warrington Academy", reprinted 1957, from Monthly Repository, 1813-1815.

3. Seddon, John (d.1770) former student of Caleb Rotheram of Kendal Academy, and graduate of Glasgow University.

4. Others involved with Canton were electricians, John Ellicott and William Watson. Canton invented a method for making artificial magnets, which brought about a charge of plagiarism from another electrician, John Michell.

5. Little is known of Matthew Turner's life. He was associated with Josiah Wedgewood as his physician, and also provided some chemicals for use in the china factory. He was a freethinker. Died c.1788. DNB.

6. Bentley, Thomas (1731-1780), DNB; porcelain manufacturer, for a time in partnership with Wedgewood. Associated with Priestley, Franklin, Joseph Banks of the Royal Society and Matthew Turner.

7. Warrington Academy Report, 10 July 1760, Manchester College, Oxford.

8. Warrington Minute Book 1, Manchester College, Oxford.

9. Ibid, 5 January 1758.

10. Ibid, 5 January 1758

11. Clayton, Nicholas (1733-97) educated at Daventry and at Glasgow University, appointed divinity tutor at Warrington, 1780-83.

12. Among the equipment made by Clayton were the following:

> "an apparatus for demonstrating the laws of composition and resolution of forces; another for the phenomena of the collision of elastic and non-elastic bodies, and a pair of whirling tables, the comparative velocities of which might be accurately adjusted according to a variety of rates." (Monthly Repository, viii, p.629, 1813)

The first of these pieces of equipment is likely to have been a machine on the lines of those constructed by the instrument maker and Cambridge mathematics tutor, George Atwood (1746-1807), and the second a type of "parallelogram of forces board", and the "whirling tables" a centrifugal machine.

13. Holt, John (1704-1772), mathematician. At the Academy from 1757 to 1772. His son, John Holt (jnr), ran a mathematical and mercantile school in the Manchester area in the 1780s, and some confusion between the two has arisen.

14. Warrington Minute Book 1, p.32

15. Desaguliers, J T (1683-1744), educated at Oxford, lecturer in natural philosophy, at Hart Hall Oxford; curator of experiments for the Royal Society; experimental assistant to Isaac Newton from 1713 to 1744.

16. Simpson, T (1710-61), professor of Mathematics at Woolwich Academy 1743 (not a Dissenting Academy), FRS 1749, noted for his application of fluxions to problems in physics and astronomy.

17. McLaurin, C (1698-1746), educated Glasgow University, Profesor of Mathematics at Aberdeen University.

18. Warrington Minute Book 1, AGM, 1 July 1762.

19. Ibid,AGM, 28th June 1764

20. Ibid, AGM, 25 June 1767

21. "In his experiments in natural history he is said to have been accurate and successful, clear in his illustration of the principles to be deduced from them, and ready to answer questions that were proposed, and to solve difficulties that were started."

    Turner, W, "Warrington Academy", reprinted, 1957 from Monthly Repository, 1813-1815, p.8

22. The main source for biographical detail is M E Hoare's The Tactless Philosopher, Melbourne, 1975. Briefly Forster, of English ancestry, was educated at Halle University and ordained in 1753. He took up pastoral duties at Hoch-Nassenbuhen in the same year, and was married in 1754. Children followed rapidly of whom seven survived into adulthood and Forster's life began to be plagued by the financial problems which pressed him for the rest of his life. Natural history became his main interest and occupation, forcing his pastoral duties into second place. Before arriving in England in 1766, he had surveyed the River Volga for Catherin the Great of Russia but this commission ended under a cloud, as the promised payments were not forthcoming, his report unacceptable to the authorities but no reason given to Forster himself. Many episodes in Forster's life were doomed to end in this manner: whilst he was honest, painstaking and uncompromising in his work, by nature he was irascible and somewhat intolerant, usually leading to clashes between himself and his current employer.

23. Forster's work was used by Thomas Pennant (the English naturalist) Linnaeus, and K J P Sprengel (1750-1816) a botanist from Halle University. He was commended by J D Michaelis (1717-1791), a philologist from Gottingen and B Kennicott (1718-1783) a philologist from Oxford.

24. Ms germ.octav.22a; 60 Staatsbibliothek der Stiftung Preussischer Kulturbesitz, Berlin, quoted Hoare, op cit p.55

25. Forster was the first to apply Linnean classification to the wildlife he had seen on his journey down the Volga.

26. Hoare, M E, op cit, p. 56, quoting from Forster's manuscript lectures held at Staatsbibliothek der Stiftung Preussischer Kulturbesitz, Berlin

27. Forster, J R An Introduction to Mineralogy or an accurate classification of fossils and minerals, London, 1768

28. Forster dismissed John Webster's Metallographia(1671) as too early and written on "too confined a plan to answer the purpose". There was a similar objection to Dr Woodward's Essay Towards a Natural History of the Earth (1695) as the author "could not be supposed acquainted with the modern improvements in this branch [mineralogy]". This book however was present in the Academy Library. Dr. John Hill's book, History of Fossils, (1748) was too voluminous and abounded in unintelligible terms, as made it "very improper to put

into the hands of students who are designed for a commercial life, and to whom this very important branch of knowledge should be made as easy and accessible as possible". Mr Emanuel da Costa's book was "not yet perfected", he noted.

29. Forster, J R, op cit, Introduction

30. Ibid, Introduction

31. Ibid, p57

32. Ibid, p.35

33. Ibid, p.25

34. Ibid, p61

35. The reaction Forster meant was that of sulphur and iron filings, which when heated produced a vigorous reaction. The terms "steel" and "iron" were used rather loosely, and sometimes, as here, interchangeably.

36. Ibid, p62

37. Becher, J J, (1635-82), first formulated the theory of combustion which was to be developed into phlogiston theory by Georg Stahl (1660-1732).

38. "As metals are composed of earthy parts of the greatest subtility which therefore are capable of the strongest cohesion, it is very natural that they should considerably exceed the fossils and minerals in weight and solidity: and as the inflammable principle which penetrates the metals if the finest and most fixed their ductility and toughness will likewise be the greater; and as the subtle, volatile and penetrating parts of the mercurial principle are enabled to pervade the whole mass, after that the acid of the inflammables has enlarged the earthy parts for their reception; it is evident from the nature of this whole mixture the greater weight, density, opacity, splendor, cohesion, fusibility and perfection of metals in general must arise. The finer and more subtle the parts of the three principles are the better and more perfect is the compound." Forster, op cit. p.67

39. Quotes an example of a cavern filled with a "dripping stone".

40. Forster, J R, Observations and Truths, 1798

41. Appended to Introduction to Mineralogy. Lehmann, J G (1719-67) geologist and mineralogist was appointed to take responsibility for overseeing scientific expeditions in Russia. Forster describes Lehmann as "in some measure my Tutor in Mineralogy" (Letter to J Nourse, London publisher, from Warrington, 8/10/1768, file no.91800 Wellcome Institute)

42. Forster,J R, An Easy Method of Assaying and Classifying Minerals, Warrington, 1771

43. Forster to Pennant, 4 June 1769, PM Salem, quoted Hoare, op cit, p 64

44. Forster to Pennant, 17 October 1768, PM Salem, quoted Hoare, op cit,, p 59

45. Forster to Pennant, 30 October 1768, PM Salem quoted Hoare, op cit., p 59.

46. Priestley also commented that there was little opportunity to form acquaintances outside the Academy, and his main "local" friendship appears to have been with Thomas Bentley, and through him, with Wedgewood. His other main circle of friends were those based in London, around John Canton.

47. Ms copy of the catalogue of the Library survives at Manchester College, Oxford

48. Grew, N, Anatomy of Plants, (1681) and Ray, J History of Plants (1686).

49. Albin, E A Natural History of Spiders and Other Curious Insects, 1730; Thorley,J, Female Monarchy, or the History of Bees, 1744

50. Carter, G A Warrington Hundred, 1947, Pt1, p.44, estimates that the "Academy circle" consisted of about 100 people.

51. Wystrach, V P, Anna Blackburne, J.Soc.Bibl.Nat.Hist. (1977), 8(2), p.148-168. Miss Blackburne was known to have corresponded with Linnaeus, Pallas and Pennant.

52. Hoare, op cit, passim

53. Forster's account of the row between himself and Seddon is given in an undated holograph letter from Forster to Seddon, bound in with the ms. of James Kendrick's book; ms 269, Warrington Municipal Library.

54. Porter, R, The Making of Geology, p.100

55. William Wales (1734-98) was present with Forster on Resolution, where he looked after the chronometers. Published Remarks on Mr Forster's Account of Captain Cook's last voyage round the world,1778, in which he lampooned Forster personally, and descried him as a scientist.

56. Walker, George (1734(?)-1807), educated at Kendal Academy, and at Edinburgh and Glasgow Universities. Later to become theological tutor at Manchester 2.

57. Enfield, W, Institutes of Natural Philosophy, first edition,London, 1785, later extended American edition, 1799

58. Rutherforth, T (1712-1771), wrote a system of natural philosophy in mid 18th centry. Helsham published a popular text Course of Lectures in Natural Philosophy at about the same time. R Smith(1689-1768) published A Compleat System of Opticks, Cambridge, 1738, a text used by John Holt in early Warrington days. Texts by Rutherforth and Smith were available in the Academy Library.

59. Enfield, op cit, p.1

60. The 1799 American edition introduces Keill's Theorems from the 5th lecture here. Enfield also stated that "... in the present state of knowledge it is impossible to determine how far the division of matter can actually be carried, or whether there be any indivisible atoms ...' (p2, 1799 edition)

61. Enfield, op cit, p.2

62. Although the discussion on cohesion was limited in the first edition, it was considerably extended for the 1799 American edition, where the force was explained as necessary for keeping parts of bodies together. Together with the different shapes of particles, it explained the hardness, softness and fluidity of some bodies. Elasticity arose "from the particles of a body when disturbed not being drawn out of each other's attraction; as soon, therefore, as the force upon it ceases to act, they restore themselves to their former position" (p.5). Solids were believed to dissolve in menstruums from the particles of the solid being more attracted to the fluid than to themselves (p.6)

63. Enfield, op cit, p.5

64. Ibid, p.8

65. The later American edition (1799) contained a much enlarged section including speculation about the earth's magnetic powers.

66. Warrington Academy Annual Report 1762, Manchester College, Oxford.

67. An Answer to Dr Priestley's Letters to a Philosophical Unbeliever, 1782. This attacked Priestley's exposition of the argument from design.

68. Priestley, J Philosophical Empiricism, p.45

69. Reported in the DNB.

70. Warrington Academy Annual Report, 1766, Manchester College, Oxford.

> "A very useful Apparatus for Experimental Philosophy consisting of most of the capital intruments, is already purchased and additions will be made to it from time to time. Some progress hath likewise been made in forming an apparatus for some of the most useful processes in Chemistry this hath been principally done by favour of a gentleman, who is himself a considerable artist in this way; and whose love of natural knowledge hath induced him to offer to go through a course of chemistry in the Academy, as often as a sufficient number of students may call for his attendance."

71. Aikin, L Memoir of John Aikin, DD, 1823, vol.1

72. Turner, W, op cit, 1813-15, p.42-3

73. Aikin, J, Sketch of Animal Economy, published at Warrington, 1781

74. Both A Pitcairne and R Douglas wrote on this theory in the mid-1740s. A late 1770s modification involved the transfer of phlogiston between air and blood. See Mendelsohn, E, Heat and Life, Harvard, 1964, for further details of these theories.

75. Aikin, Animal Economy, p.23

76. Warrington Academy Prospectus, 1777, Manchester College, Oxford

77. Turner, op cit, p 42

78. For example, Turner, W, The Warrington Academy, reprinted, 1957; Fulton, J F The Warrington Academy (1757-86) and its influence upon Medicine and Science,

1933; McLachlan, H J, Warrington Academy, 1943.

79. Priestley, J, Autobiography, ed. J. Lindsay, 1970, Bath, p.50

80. Canton, John (1712-72) FRS; originally London schoolmaster but became interested in electricity. He copied Franklin's experiments successfully for first time in England. Copley medal winner.

81. Letter John Seddon to John Canton, 18th December 1765, quoted Schofield, RE, A Scientific Autobiography of Joseph Priestley, 1733-1804,

82. For example the claim by a Glasgow academic that frozen water is a non-conductor. Priestley proved otherwise.

83. Quoted in Schofield, R E, op cit, passim

84. Bostock, John (1740-1774), graduate of Edinburgh, 1769. Only published work concerned gout.
Son, J Bostock (1773-1846) also Edinburgh graduate, better known medical writer and chemist, was familiar with the work of Priestley, Lavoisier. Was chemistry tutor at Guys Hospital, London. No known Academy connections.

85. Warrington Academy Report 1766, Manchester College, Oxford

86. Wakefield, Gilbert (1756-1801) classics tutor, 1774-83, educated at Cambridge. Had planned to open school at Liverpool but received no encouragement; continued to try to find a way out of the Anglican ministry. See Memoirs, London 1792.

87. Quoted in McLachlan, H, Warrington Academy, Manchester, 1943, p.98

88. Odgers Papers, Dr Williams Library, London.

89. Wakefield, G, Memoirs of the Life of Gilbert Wakefield, London, 1792, p.190. Also similar points made in a biography of Thomas Perceval, MD, Percival, E, Memoirs of the Life and Writings of Thomas Percival, 1807, pxii.

CHAPTER 8 - CASE STUDY: HACKNEY ACADEMY (1786-1796)

Late in 1785, a group of Dissenters began to plan the new Hackney Academy. Among this group of men were several who had already been involved in the Academy world: Andrew Kippis, Abraham Rees, Matthew Towgood and Hugh Worthington. Kippis, Rees and Worthington were all shortly to be appointed to the teaching staff of the new Academy. Matthew Towgood was a member of a west country family from which two Academy tutors had already come. Richard Price (1723-1791), a leading Dissenter and political philosopher, was also a member of the group of founders and his interest in mathematics was to ensure him a place for a short period on the teaching staff of the Academy.[1] In March 1786, Henry Beaufoy, MP[2] joined the group: Beaufoy was an important political ally of the Dissenters who had already played a leading role in the unsuccessful petition of 1770/71 to Parliament against subscription to the 39 Articles.

The aims of the Academy were well publicised: a circular drafted by some of the first tutors, including Kippis, Price and Rees, set out the reasons why a "liberal" plan of education at a London Dissenting College was so important. There was ready access to libraries, and tutors in "every branch of literature and science" were available in the city.[3] In April 1786 Andrew Kippis preached a sermon in which he announced the two-fold purpose of the Academy: firstly to train young men for the Christian ministry "among that part of the Protestant Dissenters with which we are more immediately connected".[4] Both Kippis and Rees had been forced to leave the Hoxton Academy because of their unitarian outlook; Thomas Belsham was to join them from Northampton/Daventry after his difference of opinion with the Coward Trustees. Thus the Hackney tutors were likely to promote a more radical theological doctrine from the outset. The second objective was to provide an education for young men who were intended for a "civil" life, that is a career in commerce or the professions. Science studies were not given quite the same degree of prominence in the early literature about Hackney as they had been at Warrington. At the new Academy the emphasis was to be on the education of "good" men, as a draft circular dated March 1786 had already proposed:

> "... [the Academy would] contribute towards supplying the community with enlightened and well principled Citizens .. as well as our Congregations with able and faithfull Ministers"[5]

In a sermon dated 1788, tutor and founder Abraham Rees listed the personal and intellectual qualities a lay student might expect to gain from the Hackney course:

> habits of diligence
> knowledge to enable him to establish his reputation in life
> sufficient knowledge to indulge in intellectual leisure activities
> foundation for good friendship
> qualities which encouraged temperance and refinement of manner
> ability to be useful in the community
> interests and hobbies for future life, including old age
> religious knowledge[6]

Rees thus underlined the earlier statements of the founders that the Academy should not only be concerned with intellectual excellence, or the training of ministers, but to prepare students to become good citizens.

By May 1787 the founders of the Academy had made a formal decision that the Academy was to be open to all denominations, and to offer a comprehensive and liberal education[7]. The curriculum was to include a wide range of subjects:

> "The course of education will be comprehensive and liberal, and adapted to youth in general, whether they are intended for civil or commercial life, or for any of the learned professions. This course will include the Latin, Greek, and Hebrew Languages, Greek and Roman Antiquities, Ancient and Modern Geography, Universal Grammar, Rhetoric and Composition, Chronology, History, Civil and Ecclesiastical, the Principles of Law and Government, the several Branches of Mathematics, Astronomy, Natural and Experimental Physics and Chemistry, Logic, Metaphysics and Ethics, the Evidences of Religion, Natural and Revealed, Theology, Jewish Antiquities, and Critical Lectures on the Scriptures, ... and Elocution ...; French, other Modern Languages, Drawing, &c. at a separate expence."[8]

The use of the word "liberal" is significant and important since it implies an enlightened attitude towards education. The list from which students were able to choose groups of courses to meet their vocational needs was an impressive one. For lay students, the course extended over 3 years, and for the theological, 5 years. No lay student was to be admitted under the age of 15 years and for theological students entry between the ages of 16 and 18 only was permitted.

The curriculum, outlined above, offered a wide choice of "modern" subjects alongside the classical and theological. From time to time tutors supplemented this list with courses on their own particular academic interest: Richard Price lectured on the Doctrine of Chances and Life Annuities, a subject in which he had spent many years of personal research. Students were able to choose, apparently quite freely, which groups of courses they would take. William Hazlitt, the essayist, who attended Hackney from 1793-96, chose _inter alia_ modern history (with Priestley), mathematics, classical studies, modern geography, shorthand and logic.[9] In Hazlitt's case, the fact that his tutors were prepared to encourage him to write, in essay form, on subjects which interested him[10] is a further indication that tutors were concerned to develop each student's potential to its limits. From Hazlitt's testimony it appears that, perhaps for the first time at a Dissenting Academy, a significant number of the students may have taken a study programme which did not include any theological courses.

The Academy opened in 1786 with 5 students; by 1787 the number had increased to 18, with a further 16 admitted in 1788. The figures available suggest that at its peak around 1790/1, the average number of students attending the Academy at any one time was approximately 45 to 50, roughly equivalent to a medium-sized university college, and also to Warrington Academy. The Annual Reports for 1789,1790 and 1791 indicate that well over half this number would have been lay students.

The founders of Hackney considered that their new Academy was the "descendant" of a long line of Academies which included Taunton, Bridgewater, Findern and Kendal from earlier times, and more recently Warrington 2, Exeter 2 and Hoxton. They were thus able to draw on a fund of goodwill, generated by ex-students, Trustees and staff of these institutions. Links with the Hoxton Academy were particularly strong: the tutors Andrew Kippis and Abraham Rees both transferred from Hoxton to Hackney, and the Coward Trust was to be involved in the funding of students at both. The involvement of the Coward Trust brought a link with the Northampton/Daventry Academy, which also received financial support from this source.

The founders of Hackney seem to have examined carefully the histories of some of these earlier Academies, and made efforts to avoid the more serious problems which had beset them. From the start, Hackney had a more complex system of government than had been the practice elsewhere. A system of Sub Committees was set up to deal with various aspects of its business: a Committee of Treasury dealt with financial matters, the Superintending Committee concerned itself with the discipline of tutors and students,[11] and yet another, consisting chiefly of the tutors, was delegated on 18 March 1787 to plan the "terms of education". (This, it should be noted, was after the admission of the first students.)

The planners were very aware of the importance of a permanent fund for financial support of the Academy and tried to ensure that regular income would be available. A system was proposed whereby each Governor of the Academy was required to subscribe towards the funds; in exchange, each had the right to elect representatives to the management committee of the Academy. The Governors appear to have been drawn largely from the more wealthy dissenters, and to have occupied a position similar to the modern investor in a private company. By October 1786 £6944 had been received[12] and plans were afoot for a new purpose-built building on vacant land between Hackney and Dalston, to the east of the city of London. An early eighteenth century mansion, Homerton Hall, and 18 acres of land were purchased. The sense of lineage which connected them with the earlier Academies enabled Hackney to press for support from the Trustees of Warrington 2 in the form of scientific apparatus, books and funds. Attention was drawn by the Hackney founders to common aims, and the overlap of personnel with interest in both institutions, in particular the Aikin family of Warrington. The persistent lobbying in early 1786 proved fruitful; by July of that year the Warrington Trustees had agreed to pass on the Academy's philosophical apparatus to Hackney, together with one half of the funds raised from the sale of the Warrington buildings. The Warrington Academy Library, however, passed to Manchester 2, and the Hackney founders immediately sought and obtained on loan the library of the then defunct Exeter 2 Academy.

The tutors of scientific subjects at the Academy were as follows:

Abraham Rees, FRS	1786-1796	Globes, Astronomy
George Cadogan Morgan	1786-1792	Natural Philosophy
David Jones	c1791	Chemistry
Thomas Belsham	1789-1796	Natural Philosophy?
Joseph Priestley	1792-1794	Natural Philosophy

The work of George Cadogan Morgan and Joseph Priestley will be considered in detail in this chapter. The three other members of staff, Abraham Rees, David Jones, and Thomas Belsham, made a lesser contribution, which will be covered more briefly.

George Cadogan Morgan

George Cadogan Morgan received an invitation to become minister at the Gravel Pit Meeting House, Hackney, in 1786; the invitation followed the illness of his uncle, Richard Price's colleague. At the time, Price was heavily involved in plans for the new Academy, where he was shortly to be appointed tutor. On arrival, Morgan was drawn into the Academy circle, and was soon appointed classics tutor with the additional duty of assisting his uncle with the teaching of mathematics.[13]

Richard Price used the following texts in teaching mathematics:

Newton's Principia

Jebbs' Excerpta

Thomas Simpson's Treatise on Fluxions

Simpson's text has already been mentioned in connection with John Holt at Warrington; Jebb's work, Excerpta quaedam e Newtoni Principiis Philosophiae Naturalis, (1765), was an abridged version of Newton's work, which became a standard teaching text at Cambridge. Price appears to have been the only Academy tutor who used one of Newton's own works for teaching purposes. An account by a student, Thomas Broadhurst, described the tutorials:

> "The good Doctor had only three pupils to attend upon him, these being the only students then in the college sufficiently advanced to attend [his] lectures ... [He] gave but very few lectures at all ... both tutor and pupils being better pleased to fill up the lecture hour in agreeable conversation on philosophy or on politics, rather than employ it in difficult and abstruse calculations."[14]

Broadhurst's report suggests that the intellectual calibre of most of the early Hackney students was not particularly high. The students' keen interest in the political and philosophical questions of the day is also evident. When Price gave up his connection with the Academy in 1787, Morgan was chosen as the natural philosophy tutor; although he did not entirely welcome it,[15] he accepted the appointment. He retained the position until 1792 when pressure of work and the need to devote more care to his own private pupils forced him to resign his Academy tutorship.

Both Morgan and Richard Price held somewhat idealistic views of what education might accomplish. Morgan believed, somewhat naively, that an improved system of education in conjunction with a more enlightened system of government than currently existing, could lead to such improvements in the human mind as might enable it in time to know intuitively what was at present acquired by great labour and a long series of deductions. Price had even greater hopes: increasing scientific knowledge might in the future lead the way to immortality, but Morgan did not subscribe to this hypothesis.

Morgan's [16] interest in science was well developed before his arrival at Hackney. In 1785, he contributed a paper to Philosophical Transactions on "Observations and Experiments on the Light of Bodies in a State of Combustion".[17] In this paper he proposed that light was a substance subject to gravity but heterogeneous, the same attractive power operating differently on its different parts. Light, he suggested, was present in combustible material combined with other substances and was expelled on heating. These ideas fitted with 18th century ideas of "subtle fluids" and with phlogistic chemistry, a system to which Morgan remained attached for the rest of his life. Despite increasing interest in Lavoisier's new chemistry, Morgan considered writing a major work on phlogiston; he thought he could demonstrate its presence in matter "at least as satisfactorily as the existence of heat or light has hitherto been demonstrated".[18] However this projected work did not progress beyond the planning stage before Morgan's death in 1798. Nevertheless, Hackney students did receive some information about Lavoisier's work before 1792 as David Jones, an ex-student who taught some chemistry before Priestley's arrival, had apparently heard of the new chemistry and appeared to favour it over phlogistic theory (see below).

Morgan's published Lectures on Electricity,[19] were based on those given to both his Academy and his private students. The Lectures give an insight into Morgan's views on teaching method, and on the importance of natural philosophy. He believed that the repetition of facts, strengthened by visual impression was the best means of teaching. He strongly recommended his students to write notes from memory after lectures, and to attend the same lecture a second time to "fix" and add to the impressions received from the first hearing. The importance of experimental work to the serious natural philosopher was noted, and thus a need existed for equipment. Although it could be purchased, Morgan recommended that the students should make some equipment for themselves, thereby gaining further expertise in manual skills and in the use of tools of all kinds.

The study of electricity, Morgan commented, was still in its infancy: an adequate descriptive vocabulary was lacking, and it had rarely been the subject of serious study, generally being considered suitable for frightening the ignorant or for amusement. Philosophers recognised it as a curiosity with confused and peculiar properties, but noted that some discoveries of importance connected with it had been made.[20] Morgan considered that the electrical "fluid" was a means of explaining various atmospheric phenomena, including the Northern Lights, thunder, earthquakes and meteors. All of these natural phenomena were discussed with reference to contemporary works and pamphlets by Blagden, Beccaria, Reed and Stukeley.[21] A proportion of the text was concerned with lightning, and the efficacy of lightning conductors. Morgan had his own views in the "knobs and points" controversy over the shape of lightning conductors; he contested Franklin's views on the importance of the shape of the conductor, believing that the safety of a building depended on the connections between lightning rods, not the number of conductors or their shape. Again, contrary to Franklin, Morgan thought that conductors drew down lightning by means of a stroke and not as electrical fluid without a lightning stroke.

Electricity also appeared to have important links with other branches of science, but here Morgan noted initial hopes had not always proved justified.[22] He pointed to a failure to explore possible relationships between electricity and mechanics, and speculated upon the possibility that Berthollet's "new gunpowder" might one day be fired at a safe distance using electrical fluid.[23] The "new gunpowder" was partially composed of potassium chlorate, making it a more volatile substance than the older form which used saltpetre. Thus some new form of detonation was necessary in order to ensure safe handling of the substance. The relationship of electricity to medicine and to chemistry (where it had broken down substances into their component parts), was explained and the relevant work of Ingenhousz, Duvernier, Carnoy and the Abbé d'Orsay described. The need to improve the apparatus available was also discussed as current equipment was both complex and troublesome; this was suggested as a line which students might wish to pursue further. Galvani's work on the nervous system was used as an example of the presence and importance of electricity in animal life. Naturally occurring electric species, the torpedo and the gymnotus, were also discussed. The question whether electricity had any effect on the growth and nourishment of vegetables was introduced in the context of its effects on the living; results of contemporary experiments were ambiguous, but Morgan believed the effects to be beneficial. An effective and cheap method of keeping a constant current of "electrical fluid" passing through plants had yet to be found, however.

In sum, Morgan commended the science of electricity as it was

> "... well formed for strengthening the memory, for invigorating its powers of association, and for habituating us to such deliberate and multiplied pains as are necessary to complete the images or mental impressions, which, with equal pains we have previously estimated and selected."[24]

In the introductory lecture there is mention of "the same wise Omnipotence" as the source of the "electrical fluid" and the power of gravity, otherwise Morgan did not discuss any theological approaches to science. He appears to have placed stronger emphasis on the powers of human reason than on faith:

> "Let me however hope that your resolutions are already determined to seek no pleasure from philosophy, but those of the mind; to obey no motive but that which is rational, and to indulge no views but those of enlightening the world by the improvement of your own faculties."[25]

and

> "There is but one consideration that bears sway in the soul of a philosopher. That truth stands alone which interests his

> desires and stimulates his active principles. He is convinced that to follow nature is to follow the sure road to boundless attainments: for its treasures fill the universe..."[26]

These concepts were current in France at the time, and Morgan may have absorbed some of the philosophical ideas fermenting in Paris during his visit there in 1789/90. The exemplar placed before the students was Isaac Newton, whom he held in great reverence:

> "How many years must you toil before you have traced out the steps already impressed by the great Newton? How little probability of flushing up in the field he has ranged through, one object which escaped his penetration?"[27]

Morgan's lectures were excellent in the way the experimental demonstrations were knitted together with the theoretical. Morgan was not afraid to put forward his own ideas where appropriate; he gave careful descriptions of what were then considered different types of electricity, devoted much attention to equipment, and ended the course with a description of electrical apparatus including the electrometer, battery, lightning conductor and electroscope. He stressed the need for the experimentalist to become adept at apparatus design and mechanical tasks.

The course was carefully structured by Morgan so that the more complex ideas were built on to simpler ones. The relationship between electricity and other branches of scientific knowledge was also considered. Given such preoccupations, the more showy aspects of the subject received limited attention.

<u>Joseph Priestley</u>

Following the attack by rioters at his Birmingham home on 14 July 1791, the anniversary of Bastille Day, Priestley received and accepted an invitation to minister to the late Richard Price's congregation at Hackney. Priestley's books and papers were severely damaged, and his laboratory was completely destroyed by the rioters. Priestley moved to Hackney[28] in September, 1791 but some time passed before he could make good the loss of apparatus and samples, and recommence experimental work.[29] With help from his friends, his laboratory was re-established at his new home, and in 1792 he became chemistry tutor at the Academy. In a letter to a friend, James Keir, (a chemical manufacturer of Tipton, West Bromwich, and member of the Lunar Society) Priestley stated that having agreed to undertake the chemistry lectures, he was now obliged

> "... to attend to the whole course of chemistry with several branches of which I was but little acquainted."[30]

Priestley remained at the Academy until 1794, when he left London to join his sons in New England, where he remained until his death in 1804.

Priestley published as Heads of Lectures on a Course of Experimental Philosophy, particularly including Chemistry[31] a summary of the lectures read to his Hackney students. The text, dedicated to the students, was intended to save them the trouble of transcribing their notes and, most importantly, to be a source for information on the most significant scientific discoveries to date. In an earlier work for young people, Institutes of Natural and Revealed Religion, (1772/3), Priestley had already laid the philosophical groundwork, and sought to reconcile religious belief, reason and science in philosophical terms, but for the specialist course at Hackney, a detailed text more narrowly concerned with chemistry was required. The Heads of Lectures are in the form of easily memorised and succinct notes. No written account was given of the many experiments which Priestley demonstrated in the course of his weekly lectures to students, but it appears that these were a regular feature, and if time was short, he merely showed the materials necessary, and the result.[32]

In the introduction, Priestley set out the reasons why he believed experimental philosophy to be important: its object was

> "... the knowledge of nature in general, or more strictly, that of the properties of natural substances and of the changes of those properties in different circumstances."[33]

Such knowledge, he said, could only be gained by experiment and observation. Science had a utilitarian value: for example the invention of the steam engine followed from man's knowledge of the properties of water as steam:

> "The ease with which water is converted into vapour by heat has given a great power to mechanicians, either by employing the natural pressure of the atmosphere, when steam is condensed under a movable pistern, [sic] in an iron cylinder, which was the principle of the old fire-engine, or by employing the elastic power of steam to produce the same effect, which is the principle of Mr Watt's "steam engine"."[34]

Before moving on to specific substances, Priestley set out the various rules governing scientific enquiry and the classification of substances. The uniformity present in nature led to the discovery of general principles or laws, from which results could be predicted. The relationship between "cause" and "effect" was explained: everything observable had a cause and the principle rule was that no more causes are allowed than were necessary to account for effects. To illustrate the point he showed how Descartes' vortex theory could be rejected on the grounds that the force of gravity alone was sufficient to explain the retention of the planets in their orbits. In cases where the cause was unknown, for example, the "cause" of gravity, the convention was to name this as the "principle of gravity". (Here he drew a comparison with the algebraic use of "x" and "y" as useful ways of describing unknown mathematical quantities.)

Rules more specifically related to chemistry followed: the importance Priestley accorded to phlogiston is demonstrated by one:

> "all metals consist of a peculiar earth and phlogiston, ... "[35]

Phlogiston was the key principle: its presence or absence accounted for the differences between many substances, for example:

> "All these substances have been termed "phlogistic" because the effect is not produced but by substances supposed to contain phlogiston in a volatile state, and by the affinity between phlogiston and the dephlogisticated part of air the one separated from the other."[36]

Two forms of chemical affinity were distinguished, the simple, where parts of compounds can be precipitated by the addition of a substance, and double, where two compounds separate and reform into two new substances. Here he warned that it was not possible to predict with certainty the properties of a compound from those of its constituent parts. Three current methods of classification of substances were noted:

1) animal, vegetable and mineral
2) by elements, from composition (favoured by Macquer, Bergman)
3) by form, in which the substances were usually found - aerial, fluid or solid.

Priestley favoured the last model and based his classification upon it.

The more general properties of matter were also covered, for example infinite divisibility, about which Priestley drew on

Cartesian ideas:

> "...[this] is a necessary property of all extended substances and from this circumstance it will follow that the smallest quantity of solid matter may be made to fill the largest space, and yet none of the pores shall exceed the smallest given magnitude; and consequently that for anything we know to the contrary, all the bodies in the universe may be comprised in the smallest space."[37]

On the impenetrability of matter, Priestley stated that the only proof was resistance to putting one substance in place occupied by another. Demonstrations were described which showed the resistance to relate to a power of repulsion "acting at a real distance from these surfaces". This was a difficult issue as a "more positive argument for the <u>penetrability</u> of matter is that the particles of light after entering the densest transparent substance do not appear to meet with any obstruction to their progress till they come to the opposite side."[38]

Noting that all solids may become fluids then vapours by heating, Priestley explained the principle of crystallisation as the moment when the subject passed from a fluid to a solid, at which time the component parts assumed a particular mode of arrangement. The forces of attraction and repulsion were common to all forms of matter; gravitation was classified as a form of attraction, but acting at a great distance. Chemical attraction and cohesion were, in contrast, short distance forces. The causes of the various forms of attraction were unknown. Priestley did not suggest that there were different types of matter, but that substances or matter possessed certain properties in various degrees, which led to their observable differences. As noted, the role of phlogiston was particularly significant.

Having set out the "universal" rules of chemistry, Priestley could then turn to the classification and properties of various known substances. As already noted Priestley preferred classification by form, that is whether the substance was gaseous, fluid or solid. Not unnaturally, given his particular interests, Priestley devoted a large part of his course to gases, "aerial substances", on which he continued to work (particularly the "inflammables") during his stay at Hackney.

Priestley identified a number of different gaseous substances, which he seems to have grouped as acidic, alkaline, "phlogisticated", or "dephlogisticated". He regarded them all as modifications of "air". "Dephlogisticated air" [O_2] was recognised as an important constituent part of atmospheric air, and essential for respiration; it was also a plant product from light.[39] This, Priestley suggested, seemed to be the chief means adopted by nature to preserve the purity of the atmosphere. He did not give further details of the relationship between "dephlogisticated air" and green plants (photosynthesis) in the Heads of Lectures but probably described some of his earlier work on this to any students who were particularly interested. "Dephlogisticated air" could also be extracted from substances containing it by heat, and was particularly common as a compound of nitrous and vitriolic substances. "Phlogisticated air" [N_2] was then briefly described. "Inflammable air" which could be obtained by the action of acid on metal, or by "sparking" oils or spirit of wine [alcohol], seems to have been the source of considerable confusion in Priestley's mind, as he did not distinguish what are now known to be different gases (H_2, CO and CH_4). The purest and lightest form of the substance [H_2] was formed by passing steam across metal (usually iron or zinc) giving a substance ten times lighter than atmospheric air. Priestley made the comment that the "animal product" [CH_4] was the heavier form. Priestley's confusion over the substance "inflammable air" had continued from 1772 when he first began work on gas chemistry. Some of these difficulties may have been caused by contaminated samples which led to varying results.

The presence or absence of phlogiston accounted for the difference between nitrous air [NO] and dephlogisticated nitrous air [N_2O]. A common substance, fixed air [CO_2] had a medical use: when administered to the intestines, it gave relief in some cases of "putrid disease". (Another reference to medical use of a substance is given later, where the properties of aether - probably diethyl ether - as a painkiller are briefly mentioned.)

Several acid gases were described; hepatic air [H_2S], which produced a similar effect to Harrogate waters when dissolved in water; "phosphoric air" [PH_3] generated by a solution of phosphorus in caustic fixed alkali, which became very flammable if mixed with mercury. Four further substances were identified: "dephlogisticated marine acid air" [Cl_2] and phlogisticated marine acid air [HCl]: the former he thought contained some dephlogisticated air, and noted its use as a bleaching agent. The last two, vitriolic acid air [SO_2] and fluor acid air [silicon fluoride] were mentioned briefly. One "alkaline air" [NH_3] was also briefly described.

Having considered the various "airs", Priestley then turned to liquids; he commenced with the most common, water which was described in its various forms - liquid, ice, steam and vapour. Mention was made of Canton's experiment demonstrating the effects of atmospheric pressure on water.

The next part of the Heads of Lectures dealt with groups of acids and alkalis. In passing, Priestley suggested tests for distinguishing between the two; he included taste, and the very different effects of both on vegetable juices. Among the acids was sulphurous acid [H_2SO_3] which he described correctly as the solution of vitriolic acid air in water, and recognised as a substance distinct from vitriol [H_2SO_4]. The power of aqua regia [$HCl + HNO_3$] to dissolve gold and platina, which neither acid can do separately, was noted. The list of vegetable acids and "others of a less perfect nature" included acetous (product of fermentation), tartaric acid, wood acid (from smoke), acid of sugar (oxalic - vegetable matter distilled in HNO_3), acid of galls (tannic - from oak bark) and an acidic substance formed by heating amber in a closed vessel (succinic acid). Of the lesser mineral acids, borax (boracic acid) [H_3BO_3] was best known but Priestley pointed out that other minerals (arsenic, molybdenum, and tungsten) had also been shown to yield "peculiar acids". Of the animal acids, phosphoric acid was considered the most important but here Priestley's classification of acids (based on mineral, vegetable and animal) seems to have come under some strain, as he noted that this substance had also been identified in mineral substances. Other animal acids listed included milk (lactic acid), fatty acid, and distilled animal calculus, which yielded a substance believed to be related to phosphoric acid.

Alkalis were divided between fixed and volatile; the fixed being of vegetable (potash) or mineral (soda) origin, whilst the volatile were distinguished by pungent smell (ammonia). Alkalis were followed by a group of inflammable substances, which included oils and alcohol.

Priestley briefly touched upon earth history in the lecture on oils, in discussion of bituminous (fossil) oil:

> "But all fossil oil is probably of vegetable or animal origin from masses of vegetables or animals long buried in the earth. Their differences from resins and other oily matters are probably owing to time; the combinations of mineral acids and oils so nearly resembling bitumens, the principal differences being their insolubility in spirit of wine ... and pit coal has been often found with both the internal texture and external appearance of wood; so that strata of pit-coal have probably been beds of peat, in some former state of the earth."[40]

As this course was primarily concerned with chemistry, Priestley did not need to discuss the implications of this for the age of the earth. Had he been drawn into discussion during the lectures, he would probably have adopted a Woodwardian or Wernerist standpoint as this would have accorded with his religious principles but also have offered an acceptable explanation for the existence of rock strata.[41]

Solid substances were roughly divided into the metallizable (ores) or the non-metallizable (earths). of the ores, the "perfect" were those united to phlogiston - gold, silver and the recently discovered "platina"; the imperfect consisted of mercury, lead, copper, iron and tin, all of which Priestley believed to dissipate the phlogiston on heating. The non-metallizable earths included calcareous, silaceous, argillaceous, terra ponderosa [$BaSO_4$] and manganese.

Other lectures in the course covered heat, light, magnetism and electricity. Priestley described heat as an "affectation of bodies" produced by friction or compression and not as a separate substance. Latent heat was considered a "wise provision"[42]; various means of measuring heat, notably Reaumur and Fahrenheit scales and thermometers, and Cavendish's modified mercury thermometer[43] were discussed. Animal heat and control of body temperature were introduced: Priestley favoured Dr Crawford's[44] theory, which he described in detail. Some of the appeal of this theory no doubt arose from the fact that it required the presence of phlogiston to maintain temperature at an even level. This theory had been heavily criticised by William Morgan but Priestley appears not to have mentioned these adverse reactions to his students.

Students were introduced to the dispute about the nature of light, whether wave or corpuscular in form. In common with most scientists of the age, Priestley favoured the particle theory as the most probable, citing the emission of light as a result of heating as evidence of its material nature.[45] The importance of light in photosynthesis was restated and the effect of light on the colour, taste and smell of vegetables was noted. Priestley also put forward the idea that the colour of man was affected through the action of light particles on a fluid immediately beneath the skin.

The main properties of the magnet[46] were listed and it was noted that the earth itself was a magnetic body. Priestley suggested that the reason for this was the amount of iron ore present in the planet. Halley's theory (relating to differences between external and internal shell movements within the earth) was put foward as an explanation of variations in compass readings which had been observed. Halley's work also appears to have been the source of Priestley's suggestion that the aurora borealis was of magnetic origin.[47]

In the Heads of Lectures, Priestley gave no more than an outline of the phenomena of electricity. No doubt those students who were particularly interested in the subject were referred to Priestley's own History and Present State of Electricity. The recent work which had established electrical connections between brain and muscle, for example the work of Galvani (not named in the text) and William Cruickshank (named) made a deep impression on Priestley, who described these findings as

> ".... one of the last and most important of all philosophical discoveries."[48]

In the Heads of Lectures, students were introduced to the arguments for and against the existence of phlogiston. Priestley had indicated to the botanist and fellow Lunar Society member, William Withering, that he proposed to include a section in the published version of his lectures on the "new theory" (Lavoisier's). In the same letter he made clear his continued allegiance to phlogiston, at the same time revealing an inability to grasp the nature of the arguments against:

> "... some things I have done tend to confirm the doctrine of phlogiston. I cannot yet learn what the French philosophers object to in my last paper, and I have repeatedly applied to them for the purpose, so that I think with you, their Charbon or hydrogene will prove to be nothing more than another name for phlogiston."[49]

The section of the Lectures devoted to phlogiston commenced with a summary of the work of Stahl which led to the development of the phlogistic theory of combustion. Lavoisier's opposition and the "new theory" were then assessed briefly:

> "The principal fact adduced by them [Lavoisier and followers] to prove that metals do not lose anything when they become calces, but only gain something is that mercury becomes a calx, called precipitate per se; by imbibing pure air, and that it becomes running mercury again by parting with it."[50]

However, in this instance Lavoisier's new system was acknowledged to hold some truth, but even so Priestley managed to allow for the continued existence of phlogiston:

> "This is acknowledged, but it is almost the only case of any calx being revived without the help of some known phlogistic substance; and in this particular case it is not absurd to suppose that the mercury in becoming precipitate per se may retain all its phlogiston as well as imbibe pure air and therefore be revived by simply parting with that air."[51]

Anti-phlogistians, he noted, had claimed that the burning of phosphorus which caused a dimunition of atmospheric air, supported their cause. Priestley stated that this was wrong:

> "... there is the same proof of phosphorus containing phlogiston that there is of dry flesh containing it: since the produce of the solution of it in nitrous acid and its effects upon the acid are the same, viz, the production of phlogisticated air and the phlogistication of the acid."[52]

An important element of this debate was the interpretation of results of experiments on the decomposition of water. Lavoisier had made this a key point in his demolition of the phlogiston theory. Priestley however offered a different interpretation which allowed him to retain the concept of phlogiston, and thought it probable that:

> "... water united to the principle of heat constitutes atmospherical air and if so, it must consist of the elements of both dephlogisticated and phlogisticated air, which is a supposition very different from that of the French chemists."[53]

Professor Schofield has suggested[54] that the acceptance of

Lavoisier's system, which involved several distinct elements, would have required Priestley to abandon his view of matter as an homogeneous, particulate substance. Priestley's view was that matter was ultimately derived from the Creator and thus an essential part of the evidence for the "argument from design". The acceptance of Lavoisier's system would have involved him in a denial of an important theological concept and, given Priestley's view of the interdependent relationship between theology and science, this was impossible. This concept would explain Priestley's tenacity in defence of phlogiston which is evident in Heads of Lectures and lay behind the only overt statement on theological issues which appears in the text. Priestley considered that the fundamental reason for the study of the subject was to pursue

> "... an investigation of the wisdom of God in the works and the laws of nature, so that it is one of the greatest objects to the mind of man, and opens a field of inquiry which has no bounds; every advance we make suggesting new doubts, and subjects of further enquiry."[55]

The significance of the "argument from design" for science is made very clear, there being no aspect of scientific discovery for which it would not have relevance. From this text, Priestley appears as a philosopher tied to a system of thought which, in science, required not only that observation be accurate but fit both current scientific theory and the theological argument from design. He was thus unable to consider an alternative hypothesis (such as Lavoisier's) if it challenged in some detail the theological basis on which his scientific ideas were built. Priestley's dilemma perhaps encapsulates the difficulties which faced the Academies as a whole in the teaching of science.

Priestley's Hackney lectures contained nothing original but gave a summary in simple terms of his view of the scientific "map" of the early 1790s. Perhaps the most important feature implicit in the text is the stress upon experience of practical work. A disproportionate amount of time appears to have been spent on gases but this was one of Priestley's main scientific interests from the 1770s onwards and his achievements in preparing and describing a number of different gaseous substances are important. Nevertheless, study of the Heads of Lectures, leaves the reader with a sense of some confusion. Priestley's experiments seem unsatisfactory; in the section on airs it is often unclear precisely to which gas he is making reference as the information cited is relevant to more than one substance, or different substances are confused as one. His choice of experiment (although this is much more evident from the History of Electricity) seems to have been dictated by availability of samples or equipment.

It is not possible to endorse Dr Hill's view of Priestley as the most important chemist since the Restoration on the basis of what is revealed in Heads of Lectures. Priestley's contribution was of a much more general nature: it resided in the emphasis he placed on the value of scientific knowledge as part of a liberal education. Priestley's philosophy of education was both idealistic and enthusiastic. He championed many ideas which are at the foundation of modern educational practice: the education of boys and girls alike, the teaching of modern subjects (languages, including English, history) and in techniques, (visual aids (demonstrations, models, charts), encouragement of student participation). Priestley gave the key role in any scheme of liberal education to science and not to the humanities. He believed the study of nature in all its aspects to be "sublime", and through such study the wellbeing of man could be ensured and promoted. Science was an important key by which man's understanding could enable the highest achievements:

> ".. grasping at the noblest objects, and increasing its own powers, by acquiring to itself the powers of nature, and directing them to the accomplishment of its own views, whereby the security and happiness of mankind are daily improved."[56]

In 1791 Priestley urged the Hackney students to work towards

> "..the flourishing state of science, arts, manufactures and commerce.."[57]

He expressed his belief in the view that development of arts and sciences were closely interlinked and interdependent. As he put it

> "..the arts in return, promote society and humanity, which are so favourable to the progress of science in all its branches."[58]

However, he saw that the arts may have some limitations, but he did not believe this to be true for science:

> "that even excellence in arts that have perceivable limits, contracts the faculties and cherishes the meaner and baser passions of our minds; but that true science, being unbounded in its nature and objects, doth, as it were enlarge the soul, extend the faculties and give scope to the most generous affections."[59]

These statements, innovative for their time, place an exceptionally important emphasis on the part science might play in the curriculum of an Academy, and indeed in education generally.

<u>David Jones, Abraham Rees and Thomas Belsham</u>

Of these three tutors, the least information is available about David Jones (1765-1816).[60] Nothing of his work at Hackney has survived, nor is he known to have written any scientific works. He was a student who transferred from Homerton Academy to Hackney on becoming a Unitarian. He preceded Joseph Priestley as assistant tutor with responsibility for chemistry, leaving Hackney to travel in France. Priestley provided him with a letter of introduction to Antoine Lavoisier:

> "I take the liberty to introduce you to Mr. Jones, who was lecturer in chemistry at the New College in Hackney, in which employment I now succeed him ... You will find him to be equally modest and sensible, and, as a philosopher, more inclined I believe to your system than to mine; but open as we ought all to be, to conviction as new facts present themselves to us."[61]

A later letter of Priestley's[62] indicates that Jones may have been unable to contact Lavoisier. Priestley's tantalizing reference indicates Jones's interest in the work of Lavoisier. He may well have introduced the new system of chemistry to Hackney students in the course of his teaching, and in doing so, have encountered opposition from his colleague, George Cadogan Morgan, a committed phlogistic philosopher.

There is no evidence to suggest that Abraham Rees contributed much to the teaching of science at the Academy. Whilst at Hoxton, his revised version of Chambers' Cyclopaedia was published (1781-86). Whilst at Hackney, Rees almost certainly began preparation for his own New Encyclopaedia; this was to be published in instalments from 1802 onwards and the preparatory work would have absorbed much of his intellectual energy.

According to the advertisement published in 1788 Rees taught elementary mathematics, the use of the globes, and introductory astronomy with the help of another tutor, George Cadogan Morgan. For mathematics, he used two texts: Bonnycastle's Introduction to Algebra (1782) and Simpson's Elements of Geometry.[63] Although no texts are cited for the "Globes" or astronomy, because of Rees's connection with the author through Hoxton Academy, it is probable that use was made of Jennings' text Introduction to the Globes and the Orrery. Although by then some forty years old, this would still have served well as an introductory text. Rees may also have drawn on Watts' Knowledge of the Heavens and Earth Made Easy which provided additional problems on which the students could work.

No lecture notes from Rees's period at Hackney appear to have survived, and he did not himself publish any scientific or mathematical texts for students. He seems to have been popular with his students:

> "I like Dr Rees' lectures very much - I passed the Ass's bridge very safely and very solitarily on Friday" [64]

This student, William Hazlitt, left an account of his studies during 1793, when he appears to have spent at least 3 hours each week on mathematics.[65]

Whether Thomas Belsham taught electrical studies at the Academy is uncertain. A set of lecture notes, in Belsham's own hand is preserved at Dr Williams' Library.[66] These have been dated from Belsham's Northampton days but internal evidence (a page reference to Priestley's Heads of Lectures) indicates that they are later than 1794. After the Academy's closure, Belsham took private student boarders and it may have been these young men to whom these lectures were read.

Belsham's lectures were merely an introduction to the subject, listing all important experiments and discoveries. Priestley's History of Electricity was quoted as a reference from time to time. Indeed, Belsham regarded the publication of the History as a "landmark", for one section of his notes was concerned with new discoveries after its publication. While the main part of the lectures was devoted to the history of the subject, appendices deal with atmospheric phenomena, animal electricity, and the various theories of the nature of electricity. The lectures amount to no more than a popular digest. The dangers involved in experimentation were mentioned but there is no indication that the lectures were illustrated by experimental demonstration.

The majority who attended Hackney Academy were lay students, and thus intended for the professions, including medicine, or for commerce. It is all the more surprising to find that it is difficult to name any who were to make their mark in the field of science. One such was Arthur Aikin, of the Aikin family of Warrington, who became a freelance lecturer on chemistry and chemical manufactures, and also chemistry lecturer at Guy's Hospital Medical School. Aikin was also to become a valued member of the Askesian Society of London.[67] Another has already been noted: David Jones, who briefly taught chemistry at the Academy but who was not to follow up his scientific interests afterwards.

There was a significant difference between the teaching of science at Hackney and at Warrington: in the case of the latter, the appointment of specialist tutors in some subjects allowed a greater emphasis to be placed on vocational training for medical or commercial careers. At Hackney, science was an important part of the curriculum and, in the case of both Morgan and Priestley, the practical aspects of the subject were given serious attention. The keenly vocational aspect concerning medicine or commerce which was present at Manchester 2, and at Warrington was less prominent. In important respects, the science taught at Hackney was disappointing in content; although competent tutors, both Priestley and Morgan stood for the retention of older systems, notably the phlogistic theory of chemistry. What information survives of Rees's work suggests a fairly basic level of teaching in the subject. But, as shown above, Priestley's importance for the teaching of science in Academies transcends the rather disappointing Heads of Lectures.

Priestley epitomised the radicalism for which Hackney gained a lasting reputation and was aware of the effect of his presence in the Academy.[68] He warned his students that they would encounter prejudiced attitudes:

> "Many persons entertain a prejudice against this College on account of the republican and, as they choose to call them the licentious, principles of government, which are supposed to be taught here. Show, then, by your general conversation and conduct, that you are the friends of peace and good order ..."[69]

The radicalism took many forms: a majority of the tutors embraced the Unitarian doctrine, which, as noted earlier, could lead to clashes among Dissenters as well as with the established Church. The students themselves were immersed in the radical politics of the day, taking keen interest in any political controversy and attending such events as the trial of Warren Hastings at Westminster in 1788/9 and the debates on the repeal of the Test Acts. There was also support for the revolutionaries in France, and the tutor, G C Morgan, visited Paris at the time of the storming of the Bastille, sending eye-witness reports to his uncle, Richard Price. Tom Paine was the guest of honour at a dinner given at the Academy in 1792. One member of the Academy management committee, William Stone, was tried but later acquitted on a charge of conspiracy to incite rebellion and to destroy the King.

The questioning of established authority, whether disciplinary or intellectual, which is associated with radicalism, fostered an independent and unsubmissive attitude on the part of the students. The Academy founders tried to restrain student behaviour by an attempt to require students to formally agree to the rules of the Academy before being admitted. The members of the Superintending Committee were responsible for the maintenance of discipline, thus removing this aspect of management from the responsibility of the principal tutor, a structure upon which Thomas Belsham commented adversely on his arrival as Principal in 1789. One view of the situation was summed up by the classical tutor, Gilbert Wakefield in 1791:

> "The College here holds up tolerably this year, but its best friends regard the case[?] as desperate"[70]

and again in 1792:

> "As for the College here, I look upon it myself as ipso facto done up; nor is Education so conducted there as to make it any Benefit to Society."[71]

Wakefield's stay at Hackney was brief, and probably rather unhappy. With his university and established church background Wakefield was somewhat conservative in outlook, and would have found himself out of step with the radicalism of his Hackney surroundings. But his judgment was shared by some of his contemporaries, including "respectable" Dissenters who viewed the Academy with hostility believing its radical political and educational atmosphere lured the young student into atheism and revolution. By 1793 the student body appears to have become more subdued, for Belsham was able to write to a friend in Exeter:

> "You will perhaps like to know something of the state of our College, and I can inform you with great satisfaction that its internal state is better than I have ever yet known it. I speak the truth when I say, that I never yet knew so much order and good behaviour in any public family since I have been connected with colleges... I think I may honestly say, that we have not one irregular member, and that it gives me great satisfaction to see that my labour to promote order and discipline have been attended with such good effect..."[72]

Despite the founders' attempts to secure the financial future of the Academy, hints appear in the minute book about financial worries as early as 1788, when arrears in subscriptions began to be noted. (At this point a novel suggestion was made: that tutors' salaries might rise and fall with the number of students in the college! In fact, student numbers gave no immediate cause for concern, rising steadily until 1791.) An initial reference to a "large debt" was made in the minute book in 1790[73] which was later mentioned by Belsham in a letter to a friend:

> "The Managers of the College unfortunately set out upon a plan in which it was impossible to continue. They thought the liberality of the public was inexhaustible, and went on purchasing and building till they ran themselves aground in a most enormous debt to pay the interest of which there is no provision. The consequence is, that it is intended to sell the premises at the end of this session, and the institution must be removed to some other place."[74]

Given the past examples of Warrington, where serious financial problems also arose, some degree of recklessness on the part of the Hackney management committee is indicated here.

Crises beset the Academy in its decline from 1793 to 1796. William Hazlitt, who was a student in this period, lost his vocation for the ministry, and received a somewhat sketchy education but, in his own words, the Academy had started him on his first "perilous and staggering searches after truth". This indicates that the idealism of the founders and the tutors, at least in one case, was realised. On the Academy's closure in midsummer 1796, the principal Thomas Belsham, embittered by his experience, wrote its epitaph:

> "The Spirit of the times was against it; It fell - and the birds of night, ignorance, envy, bigotry and rancour screamed their ungenerous triumph over the ruins of this stately edifice; whilst virtue, truth and learning mourned in secret over the disappointment of their fond hopes and of their too highly elevated expectation."[75]

REFERENCES

1. For information on Richard Price see Holland, J D, "An 18th Century Pioneer: Richard Price DD, FRS, 1723-91", Notes and Records, 23, 1968, p.43-61.

2. Beaufoy, Henry, d.1795. Whig politician from 1783. Attended Hoxton and Warrington Academies, and was interested in science. Tried to achieve repeal of Test Acts in 1787 and 1789 but was unsuccessful, also supported Charles James Fox's attempt in 1790. In late 1786 Beaufoy was willing to raise in parliament a question on which the Hackney Trustees had already been lobbying the more "friendly" MPs - the exemption of Dissenting Academy students from service in the militia. If achieved, Dissenting Academy students would have been on a par with University students.

3. Copy of circular appended to the Hackney Minute Book, Dr Williams Library, London.

4. Kippis, A, Sermon, dated 26th April 1786, p.33

5. Hackney Minute Book,Dr Williams Library,London, 28 March 1786

6. Rees, Sermon, 30 April 1788, p.15-28

7. An advertisement for the College, dated 2 May 1787. A similar advert with pro forma for donation of money, was issued on 24 June 1788.

8. Price, Sermon, 25.4.1787. Annual Report appended to the Sermon, pp 1-3.

9. Quoted Ashley Smith, J W, The Birth of Modern Education, London, 1951, page 176-7

10. Baker, H, William Hazlitt, Cambridge (Mass), 1962, page 27.

11. Minutes of the Meeting of Friends of the New Academical Institution, 10 March 1786

12. Hackney Minute Book,28 March 1786, Dr Williams Library, London

13. Monthly Magazine, 1798: Price stated that he must have the assistance of a competent mathematician to share the work.

14. Broadhurst, Thomas in Christian Reformer, n.s., xiv, p.624, published 1858

15. Monthly Mag.,ibid

16. Morgan, George Cadogan (1754-98); biographical details, given in Monthly Magazine, 1798, and appended to Morgan, G C, The Use of a Scientific Table,1826. The nephew of Richard Price, educated at Oxford, but did not complete studies; continued education at Hoxton Academy where interests widened from classical studies to embrace natural philosophy and mathematics. In 1776 settled as dissenting minister at Norwich. Transferred to Hackney in 1786. Failed to take Richard Price's place with the Hackney congregation in 1791, as formal lobbying was necessary which GCM failed to undertake. He continued to teach privately after leaving Hackney Academy (1792), and started to work on a biography of his uncle, and a massive work on science but died (1798) before either project developed beyond an early stage.

17. Morgan, G C, Phil Trans, vol 75, 1785

18. Morgan, G C, biographical notes appended to The Use of a Scientific Table, p.xix.

19. Morgan, G C, Lectures on Electricity, 2 vols, 1794

20. Morgan's main sources for his lectures were Priestley's History, and Franklin's Lectures on Electricity. Cavallo's Treatise was also suggested as suitable reference material for students, and also Volta's Scelte d'Opuscule. (Morgan noted in passing that "foreigners" seemed generally more interested in chemistry than electricity.)

21. Reed,J, Summary View of the Spontaneous Electricity of the Earth and Atmosphere,1793; Stukeley, W, The Philosophy of Earthquakes, 1756 (probably the text, though not named); Blagden, Sir C "An Account of some late Fiery Meteors", Phil Trans, 1784, and Beccaria G B, A Treatise on Artificial Electricity, London 1776, or Elletrisismo Atmosferico Lettere, 1758

22. For example, in navigation where there had been an unsuccessful search for a magnet which would turn to the Pole without variation, Morgan, op cit, p.xvi

23. Ibid, p.xvi

24. Ibid, p.xvii

25. Ibid, p.ix

26. _Ibid_, p.xi

27. _Ibid_, p.viii

28. Priestley's address in Hackney was 46 Lower Clapton Road, now demolished.

29. Priestley to Sir Joseph Banks (10/1/1792). Banks offered black lead, various sands, earth of borax, tobasher; Galton and Withering sent financial help; the Wedgewoods money and apparatus; Watt, apparatus, including a digester; Keir, some chemicals. See Schofield, R E _The Lunar Society_, Oxford, 1963, p.362

30. Priestley to Capt. James Keir, 12/1/1792. Kier (1735-1820) owned a chemical factory at West Bromwich, and published a treatise on gases, and part of a chemical dictionary. See Bolton,L J, _Scientific Correspondence of Priestley_.

31. Priestley, J _Heads of Lectures on a Course of Experimental Philosophy particularly including Chemistry_, 1794.

32. Priestley, _op cit_, p.v

33. _Ibid_, p.1

34. _Ibid_, p.43

35. _Ibid_, p.4

36. _Ibid_, p.15

37. _Ibid_, p.10. Priestley used the phrase "nutshell" elsewhere. This relates to Keill's _Introductio ad veram Physicam_, (1702) rather than Newton, who allowed his disciples to develop the idea. Some brief exposition did occur in the 1704 _Opticks_.

38. _Ibid_, p.11

39. Priestley first noticed the action of plants in changing CO_2 to O_2 in 1771; but only in 1779 hinted at the necessity for light in the reaction, definitely confirming this point in 1781 (after Ingenhousz, who described the main facts of photosynthesis in 1779). Priestley explained the reaction in phlogistic terms, but no full account was given in this text.

40. Priestley, _op cit_, p.75

41. See Priestley, _Experiments and Observations_, 1786

42. Priestley, _op cit_, p. 142

43. Cavendish's modification was a restricted return flow of mercury. Priestley also mentioned an innovation by "Mr Six" (1782) the invention of a min/max thermometer using iron markers.

44. Crawford, A (1748/9-1795), FRS, physician. Published Experiments and Observations on Animal Heat, and the Inflammation of Combustible Bodies, Being an attempt to resolve these phenomena into a general law of nature, 1779. Crawford's theories were strongly criticised by William Morgan in 1781 (An Examination of Dr Crawford's Theory of Heat and Combustion) but this was not mentioned by Priestley. Crawford's theory was that the exchange of phlogiston in the lungs changed the heat capacity of the blood and thus released heat into animal tissues. See Mendelssohn, E Heat and Life, for a full discussion of the place of Crawford's theory in respiration and blood circulation. Crawford was a friend of Priestley's, and used some of Priestley's work on gases in the development of his theory of respiration.

45. He did note that phosphorous and putrescent matter could give out light without being heated.

46. Dipole nature; declination; that it can act through any medium without losing power; its relationship with iron; methods of arming a magnet to increase its power.

47. This seems to have been first suggested in 1792 in an obscure journal. Dalton mentions it in his 1793 paper Meterological Observations and Essays

48. Priestley, op cit, p.165

49. Priestley to William Withering, 15 April 1793, quoted Schofield, An Autobiography of Joseph Priestley, p.266

50. Priestley, op cit, p.129

51. Ibid, p.129

52. Ibid, p.130

53. Ibid, p.134

54. Schofield, R E "Joseph Priestley: Theology, Physics and Metaphysics", Enlightenment and Dissent, 2, 1983 p.69-81

55. Ibid, p 2

56. Priestley, Works, XXV, p.345.

57. Priestley, Works, XV, p.434

58. Priestley, Works, XXIV, p.311

59. Priestley, Works, XXIII, p.491

60. Jones, David (1765-1816). Educated at Homerton and Hackney Academies. Taught chemistry briefly at Hackney. On his return from France in October 1792, he succeeded Priestley at the New Meeting Congregation in Birmingham, but was later to leave the ministry for the legal profession. In the years 1794-5, he taught some courses on "the philosophy of the human mind as connected with education", the theory of morals and history. See DNB.

61. Priestley to Lavoisier, 2 June 1792, quoted Schofield, R E, A Scientific Autobiography of Joseph Priestley, 1733-1804,.

62. Priestley to William Withering, 2 Oct, 1792, quoted Schofield, op cit.

63. Smith, J W A, The Birth of Modern Education, London, 1951, p 176

64. Quoted McLachlan, English Education Under the Test Acts, Manchester, 1931 p.250. The "Ass's Bridge" indicates that the subject was geometry and the isosceles triangle theorem in particular which denoted the limit of the study of geometry in the medieval university.

65. Hazlitt, W, The Hazlitts: An Account of their Origin and Descent, 1911, p.399-401

66. Dr Williams Library, London, Congregational Library MS I b 16.

67. Inkster, I, "Science and Society in the Metropolis: a Preliminary Examination fo the Social and Institutional Context of the Askesian Society of London, 1796-1807", Ann.Sci., 34, (1977), p.1-32

68. Priestley was certainly aware that his presence was not necessarily beneficial; he declined an invitation from Belsham to attend the Daventry Academy in August 1782 as it might have been "extremely obnoxious" to Belsham's neighbours and friends of the Academy. He also tried to obtain a secure place elsewhere for his friend Belsham. Priestley to ? 10 June, 1793, Dr Williams Library, London, ms 12-45

69. Priestley, op cit, p.xix

70. Wakefield, G to ? 18 November 1791, Dr Williams Library, London, ms 12-45

71. Wakefield, G to ? 12 February 1792, Dr Williams Library, London, ms12-45

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CHAPTER 9

At any one time during the period between 1662 and 1800 approximately half the Dissenting Academies were teaching scientific subjects. In the first half of the 18th century, the percentage was slightly higher: approximately two-thirds of the Academies active in this period are known to have taught some science. From 1751 to 1800, the level returned to approximately half, with 10 of the 20 new Academies of this period teaching science.

Of the 30 Academies founded before 1700, 14 are known to have included the teaching of science in their curriculum. In the main, study of scientific subjects focussed on theoretical and philosophical issues but was not in general separated into narrow specialist topics. Knowledge, and therefore the study of the physical world was recognised as part of the cultured man's intellectual furniture and as a framework complementary to divinity, classical studies, the fine arts and other subjects. Most of the scientific study took place as "natural philosophy", a name inherited from Scholasticism, while the more mathematical aspects, for example mechanics and optics, were sometimes covered under mathematics. The only area which might be considered specialist was anatomy, a course offered as a preliminary to medical training at a Scottish or continental university as well as for general study, but even this subject was taught by the general tutor or tutors at an Academy, and not by a specialist.

In Chapter 2, it has been shown that a variety of philosophies were taught in the Academies up to 1700. Most were Cartesian in essence, representing the many different interpretations of Descartes' universe; others were attempts to combine Cartesian and Scholastic ideas; unmodified Scholastic philosophy was also studied in a very few institutions. (Newtonian philosophy was not common in the Academies before approximately 1720.) In addition the Biblical text was considered a source of scientific data about the physical world, and was closely studied in Academies as it was central to the training of Dissenting ministers.

In a typical Academy the student might well encounter one selection of Cartesian and Scholastic works in natural philosophy. Another, different selection of texts may have been studied in logic or general philosophy, and in divinity study of the Biblical text dominated (see table 2.1 of Chapter 2 for some examples.) Without a clear view of the physical world, it was difficult to develop a coherent approach to natural philosophy; the variety of philosophies placed before students a bewildering array of ideas, many conflicting. Tutors attempted to help students pick their way through by the staging of debates where, for example, one tutor might take the Scholastic standpoint, the other the Cartesian. In a few Academies "free discussion", without prejudice towards any particular philosophy, was encouraged among tutors and students. While these methods were helpful in opening minds to new ideas, they are also an indication that tutors themselves were confused and unable to give a clear lead. In a few instances (for example Thomas Rowe and Thomas Gale of Newington Green 1) tutors devised and taught their own philosophy. Although intended to clarify existing confusion, these efforts probably only added to it: few such schemes survived their creators, and rarely survived as written text. One, by Charles Morton of Newington Green 2, which sets out his scheme of natural philosophy, is the earliest surviving original text specifically prepared for science studies in an Academy. As shown in Chapter 2, this text contained ideas culled from a number of sources including Aristotelian, Cartesian and alchemical theories of chemical combination. It was not particularly up to date at the time of preparation (1680s), and it helped to perpetuate some ideas already outdated. However, in most Academies the tutors of science subjects relied on widely available textbooks: these texts are listed in table 2.1 for the period before 1700, and again reflect the wide range of philosophies current at the time. They have been the subject of a more detailed discussion in Chapter 2.

Very little information on Academy timetables has survived from this early period, but the numbers of study texts quoted at Shrewsbury, Rathmell and particularly Sherrifhales (table 2.1) suggest that a generous amount of time was devoted to the science; in these cases it was clearly not a "fringe" subject. In a contemporary account of the Highgate/Bethnal Green Academy, natural philosophy was taught during the final year, a position in the curriculum which accords approximately with its place in the degree courses of English universities, where the subject was studied after the award of the BA and before the MA was conferred.

In the period 1700 to 1750, there appears generally to have been an upsurge of interest in natural philosophy. This arose from the growing importance of Newtonian philosophy, and its subsequent dominance over the myriad of systems based on Cartesian or Scholastic philosophies. Cartesian philosophy did away with the notion of a final cause, thus denying a need for God and creating immense difficulties for Christian theologians. This central problem doubtless accounted for the popularity in Academies of the Cartesian interpreter Le Clerc, and of the alternative philosophy of Gassendi, in each case the author sought to retain a role for God. Newton personally did not deny the necessity of final causes, or a role for God, but his work was open to two extreme interpretations. The Newtonian universe could function without God after creation was completed, an interpretation put forward by French philosophers, for example in the works of Baron d'Holbach. In another view, which Newton himself preferred,[1] the universe required God's everlasting watchfulness and even possible intervention. This latter interpretation fitted easily with studies in divinity, which were at the centre of the Academies' curriculum. As shown in Chapter 3, Newtonian science was not commonly taught in Academies before the mid-1720s. The earliest dates when Newtonian philosophy might have been taught are c.1707 by Joshua Oldfield and c1716/17 onwards by John Eames, both tutors at London Academies. Evidence concerning Oldfield is very nebulous, but in 1707 he was sufficiently aware of Newton's work (as shown in Chapter 3) to mention it briefly in his book An Essay Towards the Improvement of the Human Mind. It is probable that Eames taught Newtonian philosophy from the date of his appointment to Moorfields/Hoxton, c1716/17[2]. He is believed to have been acquainted with Newton through the Royal Society of which he became a Fellow, and through his work on the astronomical and mechanical topics in the Abridgement of the Royal Society's Transactions. Preparation of this work required familiarity with Newtonian philosophy, and some facility in dealing with mathematical ideas, a skill which Eames certainly possessed. From c1719/20 onwards, a number of textbooks in English were published which popularised and interpreted Newton's mathematical theories for the layman: from the appearance of such works, thorough dissemination of Newton's ideas was assured. As noted earlier (Chapter 3), Newton's own works were not used as study texts in the Academies, except in one instance (Hackney), in contrast with the universities where tutors recommended them for study. After the mid-1720s, the basis for discussion of the physical universe in the Academies was Newtonian with one probable exception in the 1750s: at Hoxton Square, Samuel Pike devised an alternative philosophy based on scientific data gleaned from the Biblical text. Pike's work is assessed in Chapter 6: his philosophy attracted few followers, and his text was not adopted for study in any other Academy.

In some Academies, primarily Kibworth and Northampton, science and theology appear in a particularly close relationship, which found expression in the form of a revival of the Scholastic "argument from design". This was an important development and owes much to the work of Philip Doddridge of Northampton (Chapter 4), who was perhaps the most articulate and persuasive advocate of this particular philosophy in the Academies. In published form, his Course of Lectures reached a wide audience, and his influence was also extensive through the number of ex-students of the Northampton Academy who went on to teach and carry his philosophy to many other Academies. In Chapter 4 Philip Doddridge's own version of this philosophy, with its limitations is discussed.

From the curricula which survive for Academies active in the first half of the 18th century, for example Northampton (table 4.1 of Chapter 4) and Kibworth (Chapter 3), it seems evident that a large proportion of study time continued to be concentrated on mathematical and scientific matters. Alongside the theoretical studies there are an increasing number of references to experimental work. Before 1700, there were two instances where experimental work almost certainly took place: at the Sherriffhales and Newington Green 2 Academies where the work seems to have consisted of surveying, measuring, the making of sundials and possibly dissection of small animals. After 1700, references to apparatus become more frequent in Academy records, and by mid-century at least four Academies (Moorfields, Northampton, Kibworth and Kendal) had built up a fairly extensive stock of equipment. The most commonly found large items were connected with astronomy (orrery and telescope) or optics (microscope) but other pieces such as air pumps, thermometers and surveying equipment also feature. John Eames of Hoxton and Caleb Rotheram of Kendal both acquired many items of equipment for their personal use; in Rotheram's case, these were used in the presentation of public lectures with demonstrations across the North of England.

It is evident that some other Academy tutors did not rely on purchased equipment, or more likely, could not afford it. David Jennings of Moorfields suggested ways in which, for example, a home-made orrery could be constructed using everyday items such as balls, candles and string. While such home-made apparatus could not be used satisfactorily for accurate measurements, it nevertheless provided a means whereby the structure of the planetary system could be visualised. G C Morgan, a tutor at Hackney, actively encouraged his students to construct their own equipment in order to enhance their practical skills.

Between 1700 and 1750 there was very little movement towards specialisation in scientific subjects. Tutors with an aptitude for the subject but with no specialist training were appointed to teach scientific subjects at the Academies (for example Samuel Clark at Northampton, or James Densham at Moorfields). Most such tutors were ex-students of the Academies, who were appointed as assistant tutors for a few years shortly after completing their own education.

After 1750 approximately half the new Academies (10 out of 20) were to include some science teaching on the curriculum, and as 1800 approached, the pattern of science study became more "modern". For example a form of chemistry recognisable to the modern scientist was introduced at a few academies; in Warrington (Chapter 7) and Manchester 2 (Chapter 6), specialist groups of courses were offered in preparation for careers other than the ministry: (medicine and commerce) and a few specialist tutors were appointed to teach chemistry, medical and commercial subjects (for example Matthew Turner and John Aikin at Warrington, and John White at Manchester 2).

In some Academies, a much stronger emphasis on practical work in science is also apparent; for example, the Trustees of the Warrington Academy offered specific advice on more than one occasion to the natural philosophy tutor, John Holt, on ways in which the practical element of his tutorials might be increased. More significantly, both the Warrington and Manchester 2 Academies also indicate evidence of an early trend towards a technical institute, and recognition of the importance of scientific research to the progress of industry. The Trustees of both Manchester 2 and Warrington made public their belief in the value of "directed research" to manufacture, in the case of Warrington as early as 1760, an idea which was to be reiterated by James Yates in 1827, in the discussions leading to the founding of University College, London[3]. However this interest was unique in the Academy world to these two institutions. Only one other instance has been found when Professor Farish of Magdalene College, Cambridge began a series of lectures entitled "The Application of Chemistry to the arts and Manufactures". Farish's lectures described various processes involved in the manufacture of chemicals, and in mining and smelting, and explained the principles of industrial machines of the day.[4]

There appears an emphasis on the practical rather than on the philosophical in teaching texts dating from the later part of this period. In their textbooks (discussed in Chapters 7 and 8) Morgan, Priestley and Enfield do not rehearse the details of the philosophical framework on which their scientific work rested. The argument from design remained the underlying philosophy of these tutors' works, but was not treated centrally or extensively in science texts, the authors being content with the occasional reference to this principle. Forster's Introduction to Mineralogy of a slightly earlier date contained a Preface which clearly stated the theological background, but the main text contained few references of a theological nature.

This thesis makes clear that the claim that science was not neglected in any Academy cannot be supported. In roughly one third to one half there is no evidence to suggest that the subject featured on the curriculum. Evidence of precisely what the curriculum covered is not available for all known Academies, particularly the smaller ones and it has been necesary therefore to consult diaries, correspondence, or other works to ascertain whether the principal tutor had any partical interest in scientific matters. Some tutors mentioned in Chapters 2, 3 and 6 had specialist interests in other subjects, which they were more likely to have pursued with their students. Others, for example Philip Henry, make no reference to scientific matters in a voluminous diary and correspondence. In such a case it may be concluded that the tutor had little knowledge of and lacked interest in science. In the last half of the 18th Century some Academies (see Chapter 6) stripped the curriculum of subjects not directly related to the education of ministers and in these cases science was dropped. This drastic step was taken in order to meet the need to train ministers quickly to compete with the rapidly expanding Methodist organisation. In all such instances it is very unlikely that scientific subjects were formally taught.

Throughout the 140 years of the Academies' existence, some tutors publicly distanced themselves from natural philosophy, ostensibly on the grounds that they were sceptical of its value. For example, even though he taught some "philosophy" involving the structure and matter of the universe, Thomas Cole of Nettlebed felt the value of science was limited as it did not lead to greater understanding of theological matters. John Flavell of Dartmouth considered study of the subject a useless occupation: although (as shown in Chapter 2), his store of knowledge about the natural world was vast it is unlikely, given his general opinion of the subject, that he taught science formally. Flavell's writings, which are occasionally found in other Academy libraries, used scientific knowledge in drawing very clear parallels between the husbandry of God and man. This was probably the chief use to which many Academy students put their practical scientific knowledge, incorporating it into homely sermons for their congregations. Most later Academy tutors were not so outspoken in their criticism, or dismissal of the subject but the crude, anti-intellectual statements of Flavell found an echo in John Newton of Newport Pagnell in the 1770s and later Edward Williams of Rotheram, both of whom judged that the teaching of the subject was not the most important business of an Academy.

A most important and complex question relating to science in the Academies is why scientific studies were included in the curriculum at all. In Chapter 1 reference is made to a perceived antithesis among Dissenters about the purpose of Dissenting Academies: whether they were institutions to educate the "good men" described by Joshua Toulmin and Joseph Priestley[5] through a broad general curriculum, or whether their objectives were more limited, namely the vocational training of ministers. In the 1660s, the first view is well represented by Edward Reyner of the Lincoln Academy, who believed that ministers should receive a broad education, including scientific matters, which would fit them for their future role within the community, a view which was to find support later from Joseph Priestley, David Bogue of Gosport and Samuel Morton Savage of Hoxton. Savage stated that "learning cannot of itself make a good minister .. [but].. no man can be thoroughly furnished for the ministry without it". He saw positive advantage in some aspects of secular learning: some subjects helped to form "good taste", style in speech and writing, and some enriched the imagination. That the study of science was a pleasurable activity was also remarked by Reyner and others.

Most importantly, science was seen as <u>useful</u>, both in a practical way and in philosophical/theological argument. The utilitarian purpose, which was rooted in the Baconian and Puritan view of science, came to the fore towards the end of the 18th Century at both Warrington and Manchester 2 where the idea of directed research for commercial ends was mooted. The value of knowledge about simple mechanics (inclined planes, pulleys and levers) seems to have been clear in earlier Academies, for such studies featured regularly on the curriculum. In a few of the texts chosen for study, (for example Clare's <u>The Motion of Fluids</u>) the value of such information in the construction of machines was made explicit. The Warrington and Manchester 2 Academies both had connections with manufacturers and commerce either through common membership of local philosophic clubs (Priestley, Watt and the Wedgewoods via the Lunar Society) or through generations of students such as the Wilkinsons at Kendal and Northampton. These connections brought a practical element into the Academies, and helped direct attention to the usefulness of teaching science.

Quite apart from such broad issues it was expected that individual Dissenting ministers, unlike their counterparts in the established church, would need to supplement their meagre stipend by practising another trade or profession. There was no security of tenure or the provision of a house as was normally the case for ministers of the established church. The draconian legal measures of the latter half of the 17th century encouraged wealthy supporters to drift away from Dissent and with support concentrated thereafter on local merchants, tradesmen and skilled artisans in the main, the funds for payment of dissenting ministers were limited. The promotion of "useful" subjects such as the scientific or medical at Academies could be valuable in preparing ministers to enter medical practice or teaching as a way of supplementing income. Ebenezer Hill of Findern Academy and Isaac Chauncy of Moorfields Academy are good examples where ministers combined medicine with the ministry, and Joseph Priestley, the ministry with teaching.

But the most valuable way in which scientific learning could be used by students of the Academies related to theology. An important reason for undertaking scientific studies was that of "pleasing God" by increasing man's knowledge of the natural world. Through such study, man could be taught to appreciate more fully God's bounty to mankind. In the 1660s William Petty set out an agenda which natural philosophers might investigate (Chapter 1), as did Edward Reyner in his Treatise. Scientific knowledge could also be used in a number of ways to support theology: in a simple way as by Flavell, to draw clear analogies for congregations between God's and man's husbandry, or at a more sophisticated level to support and confirm the central theological issue of the final cause. In the Academies, this was most successfully accomplished in the works of Philip Doddridge of Northampton.

Some comments on the quality of the science taught in the Dissenting Academies have already been made in previous chapters. Overall, the most significant and striking point is the variety in the quality of the teaching of science across the 140 years, which ranges from the exceptional to the merely perfunctory. Quite clearly the most outstanding of the Academies was Warrington. As seen in Chapter 7, this excellence arises from a number of factors: the interest of the Trustees in practical work, and their early recognition of the value of applied science, the facilities available in the form of a reasonable supply of equipment, the library with its good selection of science texts old and new, and most importantly, the contribution of the tutors. The lesser known tutors, John Holt, William Enfield and Matthew Turner provided good coverage of the subject, but there was an outstanding member of staff for a short while: J Reinhold Forster, an internationally known natural philosopher who brought a taste of continental scholarship to Warrington. Although employed initially to teach modern languages, Forster taught courses in specialist areas of natural philosophy (for example mineralogy) which complemented Holt's main course. While at the Academy, Joseph Priestley carried out original research into the phenomena of electricity. Thus both Priestley and Forster helped create an intellectual climate at Warrington in the late 1760s in which scientific learning could be fostered. Other Academies had some but not all of the features of Warrington, and also achieved a degree of quality in their approach. At Manchester 2 for example, the Trustees recognised the importance of "directed research" to assist manufacture. Mancester 2 also gained the services of John Dalton who, whilst at the Academy, commenced some research on meteorology and on colour-blindness, and may also have begun to formulate his atomic theory. As far as can be ascertained Dalton was the only Academy tutor before 1800 to have introduced the teaching of Lavoisier's new chemistry. The phlogistic system of chemistry remained dominant in other Academies and was strongly supported by both Joseph Priestley and George Cadogan Morgan at Hackney in the 1790s, despite increasing interest in Lavoisier's new system at the time (see Chapter 8). No other references to the teaching from texts based on the new system exist.

At Northampton, serious attempts were also made to teach scientific subjects, with an introduction to practical work. In this Academy, pre-1750, the teaching of science in support of the argument from design, can be seen at its most persuasive, and the particularly supportive relationship which could exist between theology and science was strongly demonstrated. Doddridge's Lectures are an eloquent statement of this philosophy, but also reveal some of its weaknesses: notably a failure to deal adequately with disasters, the existence of poisonous plants or animals dangerous to man. In

Doddridge's case, this was coupled with some impatience with the study of the more abstruse areas of the subject, such as the nature of time and space, an approach which might encourage a rather shallow attitude towards the study and the intrinsic value of science. Nevertheless, the Northampton students were made aware of the practical and social benefits of science through Doddridge's own work in connection with the founding of Northampton Hospital and the local philosophical society. At Hoxton, the tutors, Eames and Jennings (Chapter 5) displayed two very different but important qualities for the encouragement of scientific interest. Eames showed an exceptional ability to deal clearly with the mathematical formulation of Newton's universe and his qualities as a teacher of natural philosophy drew students from other Academies to Hoxton. His lectures were considered rather special events![6] Although David Jennings might be faulted on detail, he brought another equally valuable quality to teaching - an imaginative approach which enabled him to suggest ways in which the universe could be modelled and thus visualised without need for very expensive equipment. The work of both of these tutors was well known outside the Hoxton Academy although neither was as widely influential in the Academy world as Doddridge.

Other Academies where science teaching was important are Sherrifhales, Rathmell, Newington Green 2, Hackney, and Kendal. All of these Academies (with others discussed in Chapters 2, 3 and 6) attempted to develop an environment in which the study of science could be fostered. For many of them, tutor notes or texts, or student notes survive. (It is recognised that student notes might have been subjected to a filter in the form of a student's understanding but in two significant instances[7] comparison between sets of student notes, and of student notes with the tutor's printed text suggests that the tutors' practice was probably to dictate standard notes, thus deviations are considered likely to be minimal.)

Study of texts by Doddridge, Forster, Morton and Priestley reveals that whatever the prevailing philosophy - Cartesian or Newtonian - the tutor's work always contained elements of earlier ideas. For instance, even though based in Newtonian philosophy, Philip Doddridge's Lectures contain threads from Scholasticism and Cartesianism (see Chapter 4). Morton's system, as seen in Chapter 2, was firmly rooted in Aristotelianism, even though ideas from Descartes were adopted where they appeared to fit. Priestley tenaciously defended phlogiston in the 1790s, when it was already under attack. Forster's lectures on mineralogy contained some elements which dated back to the very early theories of chemistry, for example the sulphur-mercury theory of the constitution of metals (Chapter 7). This feature was not unique to Academy tutors: it was also common in the published texts they (and often University tutors) chose to base their teaching. In this respect the Academies were neither more nor less advanced than other institutions. It reveals perhaps a general tendency to hold on to the old, tried ideas rather than risk embracing the new.

However, not all Academies taught science equally well. Generalisations must not be made on the strength of the excellence of individual academies, particularly Warrington, or individual tutors such as Forster, Dalton or Priestley. Nettlebed gave some rather grudging attention to a subject which it seemed did little to assist students' understanding of theology. In other instances, for example Bristol Baptist, Newport Pagnell and Rotherham Academies, science was subordinated to theology. In Rotherham Academy, the most disturbing distortion of scientific study occured, where the principal, Edward Williams, attempted a "bowdlerisation" of some scientific texts which in his view did not meet theological requirements.

The educational contribution of the Academies to the study of science lay in the regular teaching of scientific subjects, and in their attempts to come to terms with a subject which was difficult to accommodate philosophically and practically. The significant difference between the Dissenting Academies and the Universities is that while few students of the Universities proceeded to the MA course and thus received some introduction to the sciences, <u>all</u> students who completed their course at Academies where natural philosophy was taught received some tuition in science. This varied widely, however, ranging from a competent introduction with practical work to the less competent where the subject was taught largely from superseded texts or from home-made philosophies.

The Academies educated a steady stream of students who went on to make a contribution to the medical or scientific world. Warrington produced the greatest number of ex-students who made contributions to the scientific, industrial or medical worlds (Table 7.1). Other Academies educated early industrialists, among them the ironmaster John Wilkinson, the Nicholson brothers who founded the Hunslet Copperas works, and John Roebuck, founder of the Carron

Ironworks (although according to one account, Roebuck's experience at the Northampton Academy may not have contributed greatly to his future career in industry.) Other ex-students (and tutors) pursued their scientific interests through membership of philosophical clubs in their own locality for informal exchange of information and ideas. Students were involved in the Manchester, Newcastle, Leicester, Birmingham and Leeds Philosophical societies, in the Royal Society, the Linnean Society and in the Lunar Society. (Individuals are listed in tables within Chapters 2-7.) On these students, part of the reputation of the Academies as centres of scientific learning has been built. They represent a sizeable contribution on the part of the Academies to the local community in science, medicine or teaching; few ex-students, however, achieved such distinction as to become nationally known.

The Academies have in conventional historical assessment been compared to the English universities. For example, Dr Christopher Hill has claimed that the Academies offered "better" teaching than the universities. From the evidence of this thesis, such a general assertion, unfortunately, cannot be substantiated in respect of scientific studies. As has been shown, the standards of teaching at the Academies were very variable. The facilities offered to university students, such as equipment, museums, libraries, were simply not available in the small, shortlived Dissenting Academies, a point made by contemporary eyewitnesses. At university, too, interest was encouraged and nurtured by those tutors who undertook scientific research; an early example are the groups which surrounded John Lydall and John Wilkins at Oxford in the 1650s,[8] and later the group which centred on Newton at Trinity, Cambridge. While many Dissenting Academy tutors followed a lifelong interest in science, it was of a more passive nature, taking the form of cataloguing of natural history specimens, society membership or occasional attendance at lectures, dissections or exhibitions. As far as can be ascertained, only two tutors, Joseph Priestley and John Dalton actively pursued original scientific research while teaching at a Dissenting Academy. Thus an important intellectual dimension was lost to Academy students.

The tendency in Academies was to copy some elements of English university life: for example, the use of Latin, or the wearing of gowns, both of which lingered on into the 1720s. Reading lists of English universities and Dissenting Academies for science were very similar before 1700, as has been noted in Chapter 2. This is not surprising, as the majority of tutors of the first academies had themselves been educated at one of the two English universities. In the significant issue of the introduction of Newtonian philosophy, the Academies tended to follow the English universities rather than to lead. But as noted above, those Academies which taught science led the Universities in one respect: the placing of scientific subjects firmly on the curriculum, so that all who completed their course had at least an introduction to the ideas of, and often the practice of science.

Another group of institutions did exist in the 18th century which might also justifiably be compared with Dissenting Academies. In his work New Trends in Education in the 18th Century, Nicholas

Hans has listed a number of technical and military academies which were active at that time, some of which offered very similar courses, but without concentration on theology, to those available at Dissenting Academies. The science syllabus devised by Worster and Watts of the Little Tower Academy in the 1720s covered mechanics, laws of motion, hydrostatics, pneumatics and optics, and was a course of lectures illustrated by demonstrations. The work of Newton was specifically mentioned in this syllabus which resembles that of its contemporary Dissenting Academy, Northampton. Martin Clare of the Soho Academy also offered a course on science subjects, and published a textbook based on his lectures, The Motion of Fluids, which was in use at Northampton. Clare's text had a strong "how things work" theme, which probably closely reflected the flavour of the Soho course. In terms of student age and level of preparation, there were similarities between the commercial and military academies and the Dissenting Academies, the social backgrounds of both sets (merchants, artisans, tradesmen) were also similar. It is thus reasonable to compare Dissenting Academies to these institutions, particularly with regard to science teaching; this is therefore a question which deserves further attention.

During the 140 years of their existence the Dissenting Academies met and overcame many challenges: legal and political opposition, the onslaught of Deism, the growth of Methodism. The Academies evolved as a response to the need for an educated dissenting leadership and ministry in a hostile climate. Initially, they also encapsulated the radicalism, political, theological and intellectual, of the Commonwealth period.

Two main reasons for the general decline of the Academies at the end of the 18th century have been implied in the works of McLachlan and Smith: lack of funds and/or disciplinary problems. However both of these problems were not new (see chapters 2-8 passim) and had been present in varying degrees from early days. Thus a more subtle reason for the decline must be sought.

In Chapter 1 and above, reference has been made to a possible conflict of aims in Academies: on the one hand the provision of a broad, intellectual education, and on the other a relatively narrow vocational requirement to train ministers. As seen in Chapter 6, some Academies in the later 18th century were pressured into becoming vocational institutions by the need to produce ministers for the circuit in response to the challenges of Methodism. Others, which continued to offer a general education, exhibited some signs of internal tension. At Hoxton, Northampton and Hackney, the last years were marked by sectarian and narrow disputes about theological dogma. A heavy emphasis on student indiscipline is also apparent, in particular at Hackney where interest in such radical matters as the French Revolution caused dismay among the more conservative dissenters. The vocational function of the Academies which necessarily put theology to the fore, may have impeded free inquiry to a greater degree than adhesion to the Thirty-Nine Articles did at the English universities.

The evidence here presented is by definition restricted to the study and teaching of science but it raises a much broader question concerning the intellectual tensions which developed between the aim of providing a broad general education and the narrower vocational aim. In this period of time, the relationship between theology and science in the Academies was closely intertwined, and found its most eloquent expression in the argument from design. However the criticism of the argument from David Hume and from continental philosophers, such as Voltaire and Maupertius, became stronger during the 18th century. There were growing contradictions between observed evidence and the need to fit observations into the theological framework: for example, the increasing interest in fossils and rock formations indicated an approaching conflict with the Biblically based earth chronology which set the date of creation at 4004 BC. These issues required open discussion and examination in any institution which claimed to offer a broad intellectual education, yet to question the validity of the argument from design was unthinkable in the Academies. Indeed, if taken to its logical conclusion criticism of the argument from design led to the questioning of the very basis for the Academy's existence. As seen in Chapter 8, Joseph Priestley's stand against Lavoisier's new chemistry was rooted in conflict between the requirements of the argument from design, and those of a new scientific hypothesis. Certain avenues of intellectual exploration were therefore blocked in Academies.

Although bound to the established church, the English universities represented a more stable environment, with no single vocational aim among their objectives; thus a more tolerant atmosphere may have existed where there was a questioning of established philosophy. Some Academies turned away from the intellectual challenge in respect of the argument from design and confined themselves to their vocational role. In the case of the last great general academies, Warrington, Hoxton, and Hackney, their intellectual energies were dissipated in sectarian disputes. Those Academies which survived into the 19th century offered a purely vocational training; some science continued to be taught at these institutions but generally followed the orthodox argument from design.

Strong sectarian disputes were still apparent among the members of the group of Dissenters which joined with Henry Brougham, George Birkbeck and others in the founding of the new University College, London in the late 1820s.[9] It was claimed that the Baptists appeared too dominant among the group, and the interests of Independents, Presbyterians and Methodists had been neglected. It is not without significance that Thomas Campbell, the driving force behind the attempt to found a new university in London, was firmly opposed to a theological association with dissent, and was greatly relieved when the new University College was designated as secular.

The question of the conflict between the vocational function and the wider and deeper educational aspirations in the Academies is interesting and deserves a more detailed appraisal. <u>Prima facie</u>, it offers a more convincing reason for the decline of the Academies than has hitherto been put forward.

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1. The text of Richard Bentley's Boyle Lectures of 1693 expresses Newton's view, derived from the correspondence betwen Bentley and Newton of 1692-93.

2. The date of Eames's introduction to Newtonian science is unknown. Having attended the Merchant Taylors School in 1697/98, it is possible he moved to the London Academy of Oldfield to prepare for the ministry. Oldfield clearly knew of Newton's work before 1707.

3. Yates, James Thoughts on the Advancement of Academical Education in England, London, 1827

4. Professor Farish's lectures are fully described in Wordsworth, C Scholae Academicae, p.190-2

5. For Joshua Toulmin's description, see Chapter 1. Priestley considered that liberal education should combine literary and scientific excellence with moral qualities, to add "unspeakably to the value of a character"; ingenuity and modesty, great genius and benevolence, and true piety constituted the perfect human character. Heads of Lectures, page xvii.

6. Nuttall, G F, Correspondence of Philip Doddridge, p.21

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List of Appendices

APPENDIX 2.1

Academies 1662-1700

Name	Active	Science Taught or not	Science Tutor (if known)	Students contributing to science or medicine	Comments
Attercliffe	?1690-1714	Unlikely	?Timothy Jollie	N Saunderson (Professor of of Mathematics, D Some (medicine)	
Bedworth	c1690-1714	Unlikely			
Bethnal Green/ Highgate	1680-c1700	Yes	John Ker	John Ward, FRS (Prof. of Rhetoric at Gresham College)	See Table 2.1 for texts used
Bridgewater	c1680-1748	Yes	John Moore, snr John Moore, jnr	Thomas Morgan, MD Samuel Chandler, FRS	
Broad Oak	1690-1706	Unlikely			
Colyton/Lyme Regis	c1680-1716	Unlikely			
Coventry	1663-1699	Unlikely			See Ch 3 for Academy after its removal to London
Dartmouth	1668-1691	Unlikely			

Name	Active	Science Taught or not	Science Tutor (if known)	Students contributing to science or medicine	Comments
Exeter1	1690-1722	Unlikely		Medical practitioners: ?Eveleigh W Hallett J Huxham FRS J Porter R Remmett T Sanden J Smith J Westcott	
Hungerford	c1696-1700	Unlikely		Thomas Powell ? (medicine)	
Ipswich	c1698-1703	Unlikely			
Islington 1	c1672-1702	Unlikely			
Islington 2	1672-1680	Unlikely			
Lincoln	1663(?)	Unlikely	?Edward Reyner		
Nettlebed	1666-1672	Yes	Thomas Cole		
Newington Green 1	1665-1705	Yes	Thomas Rowe Thomas Gale	Isaac Watts, author of elementary treatise on the globes	See table 2.1 for texts used
Newington Green 2	c1667-c1706	Yes	Charles Morton		See table 2.1 for texts used
Nottingham	1680-1714	Yes	?E Reynolds		

Name	Active	Science Taught or not	Science Tutor (if known)	Students contributing to science or medicine	Comments
Penrith	1696-1700	Unlikely			
Rathmell	1665-1698	Yes	Richard Frankland	Medical practitioners: J Bowes T Buckley(Buckly) J Cay(Key) J Clegg M Drinkall J Eaton(Eyton) G Henshaw J Heslopp(Heslop) W Higginbottom A Holland T Manlove N Ogle J Sharp D Some (also at (Attercliffe)	See Table 2.1 for texts used
Saffron Walden	c1680-1690	Unlikely		Theophilus Lobb (also at Pinner Academy)	
Sherifhales	1663-1697	Yes	John Woodhouse		See Table 2.1 for texts used
Shrewsbury/ Oswestry	c1676-1715	Yes	James Owen	Richard Biscoe (Boyle lecturer)	See Table 2.1 for texts used

Name	Active	Science Taught or not	Science Tutor (if known)	Students contributing to science or medicine	Comments
Stourbridge/ Bromsgrove	1665-1675	Yes	Henry Hickman	John Ball, MD	
Sulby	1680-88	Unlikely			
Taunton 1 Robert Darch	1665-17?	Yes	Thomas Amory	George Brett (natural philosopher)	Texts by Derodon, Burgersdyck and Morton used
Tubney	1668-1679	Yes	Henry Langley		
Wapping	1670-??	Unlikely			
Whitchurch	1668-??	Unlikely			
Wickhambrook	c1670-1696	Yes	Samuel Cradock		Tutor devised own free philosophy

APPENDIX 3.1

Academies 1701-1750

Name	Active	Science Taught or not	Science Tutor (if known)	Students contributing to science or medicine	Comments
Alcester	c1700-1721	Unlikely			
Bridgenorth	1726-c1749	Unlikely			
Bristol Baptist Academy	1720-	Yes	John Rylands		Texts used: Gordon, Watts Martin; later Ray, Derham, Rowning
Findern/Derby	1700-1754	Yes	Thomas Hill Ebenezer Latham	? Ray (medicine) ? Davison (medicine)	See Table 3.1 for texts used
Kendal	1735-1751	Yes	Caleb Rotheram	Medical: Thos Dawson John Kennion John Manning John Rotheram Manufacture: Saml Nicholson James Nicholson Robert Nicholson (partners, Copperas works, Hunslet) John Wilkinson (ironmaster)	See Table 3.1 for texts used

Name	Active	Science Taught or not	Science Tutor (if known)	Students contributing to science or medicine	Comments
Kendal cont'd				John Banks (itinerant lecturer) Benjamin Piele (naturalist) John Widdington (Pres. Newcastle Lit. & Phil. Society) George Walker (mathematician, tutor at Warrington; Pres. Manchester Lit. & Phil)	
Hoxton/ Moorfields/ Stepney	See Chapter 4				
Hoxton Square	c1693-1727	Unlikely	Joshua Oldfield		
Kibworth/ Hinkley	1715-1723	Yes	John Jennings	John Coltman (founder, Leicester Lit. & Phil.)	See Table 3.1 for texts
King's Head/ Mile End/ Homerton[1]	c1730-	Yes	Thomas Gibbons John Walker	Thomas Gibbons (medicine)	
Manchester/	1698-1713	Yes	John Chorlton		
Northampton/ Daventry	See Chapter 5				
Mixenden	1701-1730	Unlikely			

Name	Active	Science Taught or not	Science Tutor (if known)	Students contributing to science or medicine	Comments
Pinner	c1699-1716	Unlikely			
Stratford upon Avon	c1715-1735	Unlikely			
Tewkesbury/	c1690-1725	Yes	?Samuel Jones		Texts used: Le Clerc, notes of Gronovius Leyden lectures
Tiverton	c1700-1729	Unlikely		? Glass, graduated at Leyden	
Trowbridge	? - 1743	Unlikely			
Warrington 1	c1700-1746	Unlikely			
Whitehaven/	1708-1729	Yes	?Thos Dixon	Caleb Rotheram	See Table 3.1 for texts used

1 Includes Deptford, Clerkenwell, Stepney 2 Academies, all of which were open for brief periods only.

Academies 1751-1800

Name	Active	Science Taught or not	Science Tutor (if known)	Students contributing to science or medicine	Comments
Axminster/ Bridport/ Ottery St Mary	c1754-	Unlikely			
Exeter 2	1760-1771	Yes	John Jervis John Turner		
Exeter 3	1796-	Unlikely			
General Baptist Academy	1794-	Yes			Doddridge's <u>Course of Lectures</u> used
Gosport	c1780-	Yes	David Bogue		
Hebden Bridge		Unlikely			
Hackney	1786-1796	——	See Chapter 8	——	
Hoxton2/Mile End	1791-	Unlikely			
Hoxton Square	c1750	Unlikely	?Samuel Pike		
Marlborough/ Painswick	1783-	Unlikely			

Name	Active	Science Taught or not	Science Tutor (if known)	Students contributing to science or medicine	Comments
Manchester 2	1786-	Yes	John Dalton	Medicine: John Thompson Edward Holme Other: John Moore, Pres., Manchester Natural History Society William Henry, chemist Samuel Hibbert-Ware geologist	See Table 6.1
Newport Pagnell	c1782-	Yes	William Bull		See Table 6.1
Olney	1772-	Unlikely			
Oswestry	1782-91	Yes	Edward Williams		
Rotherham/ Heckmondwyke/ Idle/Northowram	c1794-	Yes	Edward Williams		See Table 6.1
Shrewsbury 2	1770-	Unlikely			
Taunton 2	1780-	Unlikely			
Trowbridge 2	? -1793	Unlikely			
Warrington 2	1757-1784	——	See Chapter 7	——	
Wymondley	1799-	Yes	William Parry		Enfield's *Institutes* used

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