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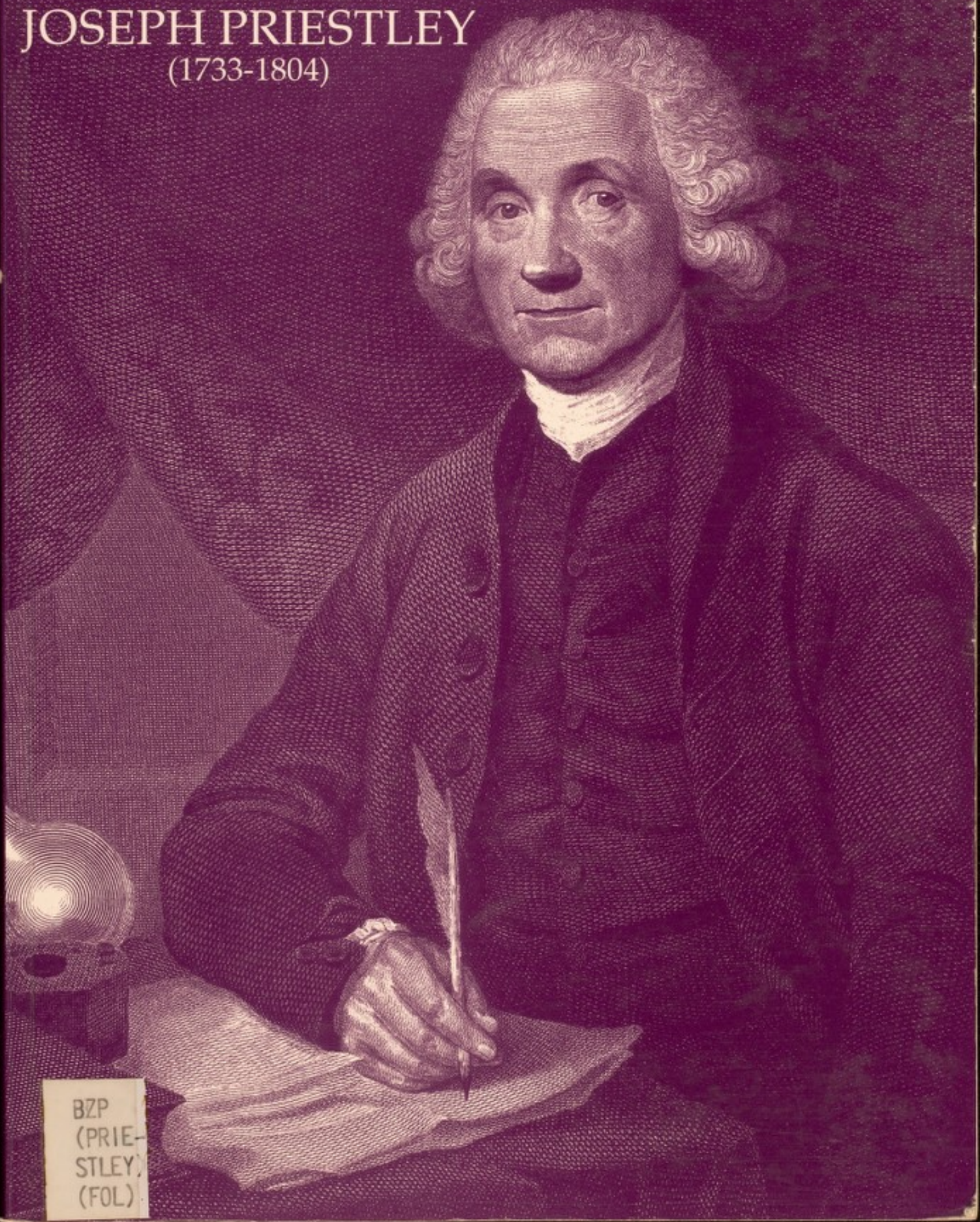
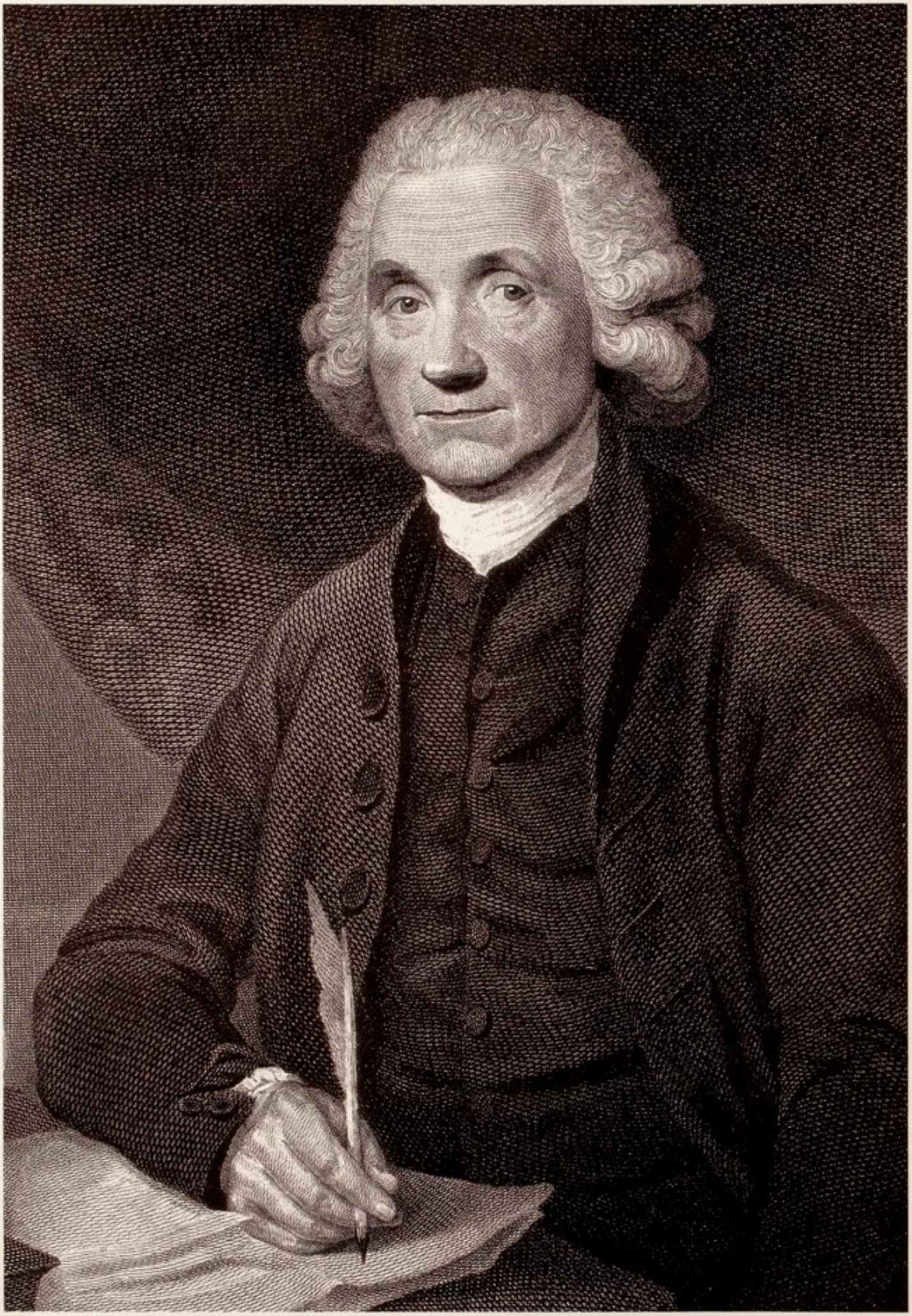
Science, Medicine and Dissent

JOSEPH PRIESTLEY
(1733-1804)





Frontispiece and cover Engraving of Priestley by Thomas Holloway, after the portrait by William Artaud, dated 1794.

Science, Medicine and Dissent: Joseph Priestley (1733-1804)

Papers celebrating the 250th anniversary of the birth of Joseph Priestley together with a catalogue of an exhibition held at the Royal Society and the Wellcome Institute for the History of Medicine.

Edited by R.G.W. Anderson and Christopher Lawrence

Wellcome Trust/Science Museum
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Preface

This volume began when an exhibition of artefacts associated with Joseph Priestley was shown at the two 1983 evening soirees of the Royal Society. The exhibit was mounted by Dr Robert Anderson (then Keeper of Chemistry at the Science Museum) and Dr A.K. Newmark. To allow for wider viewing, the exhibit was transferred to the Wellcome Institute. Here Dr Christopher Lawrence organised a one day symposium on Priestley. The aim of that meeting, in line with current trends in the history of science, was to explore as many aspects as possible of Priestley's remarkable career. The scholarly industry devoted to Priestley is large and of long lineage. Too often, however, his life has been fragmented by historians into different compartments: science, theology, education etc. In organising the symposium the chance was taken to bring together scholars from different areas, some whose work was unknown to each other, in the hope that a more coherent picture of Priestley might emerge. The result was far more pleasing than could have been hoped for, the papers showing a large and illuminating degree of overlap. After deciding to publish, the editors also invited Dr John Brooke, whom they knew had a longstanding interest in Priestley, to write a paper for the volume. The result, we hope, is not simply another disconnected 'conference proceedings' volume, but a coherent account of Priestley's life and work that can be read as one long essay. For those less familiar with Priestley, Lawrence's paper, which comes first, includes an outline biography.

We should like to thank our contributors, those institutions who lent material for the exhibition, the Wellcome Institute for hosting such a successful meeting, Pippa Richardson for her patient editorial assistance and finally, the Wellcome Trustees and the Science Museum for their financial support in making publication possible.

R.G.W. ANDERSON

CHRISTOPHER LAWRENCE

Contents

List of Illustrations

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Figs 1 and 2: Wellcome Institute Library, London
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Priestley in Tahiti:
The Medical Interests of a Dissenting Chemist

CHRISTOPHER LAWRENCE

Joseph Priestley's busy life encompassed such a vast region of political, religious and scientific endeavour that historians of the eighteenth century have taken to falling out with each other over which of these activities should take explanatory precedence over the others.[1] It is curious however that Priestley's medical interests and the medical circles he moved in have never been the subject of a paper let alone a monograph.[2]Although such an investigation would be unlikely to reveal the key which would unlock the complexities of his concerns, the omission remains odd given how many of Priestley's friends were medical men and how much of his work was deliberately devoted to medical ends especially therapeutic and preventative ones. In this paper I shall outline Priestley's biography and point to some areas in it where medicine was of importance.[3] It is hardly surprising that Priestley should have been involved in a great number of medical matters. Although an extraordinary figure in some ways, in others he was a typical Enlightenment Dissenter who displayed a concern for the physical health of the poor and their moral management in medical institutions. It was concern in which were blended the characteristic religious, humanitarian and patriarchal sentiments of the period. Schemes for the relief of the lame and sick, he said, when preaching at the new Leeds Infirmary, "do honour to humanity and to the age in which they are formed."[4] In a century in which health was increasingly sanctioned as an important secular good, and in which natural philosophy was described as providing a means to achieving that end, it is not surprising that the foremost chemist of the day should direct his researches in line with medical concerns. Similarly, at a time when a medical education provided Dissenters with an alternative route to respectable participation in British life, and a practical means of implementing their religious feelings one might expect to find dissenting doctors amongst Priestley's closest associates. Perhaps the most important years for Priestley's involvement in medical matters were the decades of the 1770s and 1780s, for at this time the new gas chemistry, which he was instrumental in creating, was exploited in line with new medical interests, notably the cure and prevention of fever in large populations, especially military ones. In this context the management of scurvy at sea was of central importance.

Joseph Priestley was born at Fieldhead, near Leeds in 1733. His father was a cloth dresser. His mother of whom he could recollect little except her "having children so fast", died when he was six.[5] Shortly after her death he was sent to live with an aunt and did so until 1752. The young Joseph was brought up in the dissenting tradition, his father and aunt being of a strict Calvinist persuasion, although, by the time he was twenty he had rejected some of the sterner elements in his upbringing. By the time he was twenty-two he was a "confirmed Necessarian" harbouring deep doubts about the Trinity and the doctrine of atonement.

The young Priestley was not only nurtured in a religious environment but exposed to science as well. Science and religion had been harnessed together by Dissenters in eighteenth century England. Dissenting thinkers gave to both Unitarian theology and science strong progressive interpretations. Their commitment to science also followed from their concern with practical knowledge that was commercially and industrially useful. At the same time they used science as an alternative to orthodox intellectual culture.[6] Science therefore had a large place in the dissenting educational tradition. At the age of nineteen, and already familiar with, if not exactly competent in, ancient and modern languages, mathematics and natural philosophy, Priestley entered the dissenting academy at Daventry. This school institutionalized the learning, which, for Dissenters, answered the purposes of a "liberal education".[7] Besides training him for the ministry the three years spent at Daventry increased Priestley's familiarity with mathematics, science and philosophy notably that to be found in the works of Newton and Locke. It also introduced him to the works of the great chemist and physician, Hermann Boerhaave. He also encountered a book that was to impress him greatly, David Hartley's *Observations on man, his frame, his duty, and his expectations*, first published in 1749. Hartley was a

Fig 1 'Captain Cook going out on his second voyage', engraving by Lane, no date.

physician whose work welded together Locke's associationism and Newton's aetherial physics into a deterministic physiological psychology. Priestley was rather more taken with the deterministic associationism, than the theory of vibrating brain particles which Hartley had used to explain it. By 1755 then, when he left Daventry, Priestley was almost a picture of a mid-century Dissenter; earnest, progressive, learned, familiar with science and devout. What distinguished him were his idiosyncratic theological opinions.

After Daventry there were a few years of relative setback, pastorally speaking. Ministries in Suffolk and Cheshire were comparative failures, not least because of Priestley's speech impediment. At the second stop though, in Nantwich, he established a school which had some success and, where, besides undertaking the usual round of lectures he demonstrated the secrets of nature with a recently acquired air pump and an electrical machine. At Nantwich the range of his interests began to emerge for he also wrote an English grammar. A crucial year in Priestley's life soon followed, 1761, when he was appointed as a teacher at the Warrington Academy. This insitution was the educational flower of dissenting culture in England. The commitment of its teachers to a broad curriculum prepared its pupils for a practical, busy life in the commercial and incipiently industrializing towns of the North.[8] Many of its alumni went on to study medicine, notably at Edinburgh, where dissenting values were well catered for by a professoriate able to equip students for the demands of large scale medical practice rather than the callings of an elite profession.[9] At Warrington Priestley taught a variety of subjects including anatomy. Whilst there he published works on grammar, and language, and a chart of biography. His experiences in these years formed the basis for many of his later works on education, history and law. It was at Warrington too that his natural philosophical studies started in earnest and he began what later became his famous *History of electricity*, published in 1767. In 1765 Priestley visited London, where he met a number of "electricians" including Benjamin Franklin, John Canton and William Watson. Watson was a former apothecary, but by then a licenciate of the College of Physicians. He was also a friend of Sir John Pringle, and sponsored Priestley's election to the Royal Society in 1766. This was the same year in which Pringle had been made a baronet and was installing himself as the bandmaster of London scientific and medical circles. After their meetings Priestley corresponded with Watson and Canton and Priestley's letters evidence a shared interest in the relations between electricity, air and life:

> I have made a great number of *experiments on animals*, for some of which I refer to a letter I lately wrote to Dr Watson. Since I wrote to him, I discharged 37 Square feet of coated glass through the head and tail of a CAT three or four years old. She was instantly seized with universal convulsions, then lay as dead a few seconds, after that succeeded tremblings in different parts of the body, particularly in the sides; which terminated in a violent convulsive respiration, and that in as quick a breathing, for ¼ of an hour, as can be imagined; after about 20 Minutes she was able to raise her head, and move her fore feet, but not her hind feet in the least, though the shock did not go through these. Thinking she would probably die a lingering death in consequence of the stroke, I gave her a second, about half an hour after the first. She was seized, as before, with universal convulsions, and in the convulsive respiration which succeeded she expired. She was dissected with great care, but nothing particular was observed, except a great redness on the lungs, but no extravasation anywhere. It was impossible to bring her to life by forcing air into her lungs.[10]

It was also at this time that Priestley became a friend of the dissenting physician Thomas Percival, who, in 1764, and while a student in Edinburgh, procured Priestley an LL.D from that University. Percival was also a former Warrington pupil, and later helped effect the removal of the Academy to Manchester. More significantly when he practised as a physician in that city his central concerns were the eradication of dirt, cleanliness, ventilation and the febrile epidemics of urban populations.[11] The Warrington years were also productive of other serious business; Priestley married.

In 1767 Priestley, who had been ordained at Warrington, left the Academy to become minister of Mill-hill Chapel, Leeds. One of his first tasks whilst there was, in 1768, to preach a sermon on behalf of the Leeds Infirmary, one year after its foundation in 1767. The Infirmary was supported by a strong dissenting interest.[12] Priestley's sermon reveals hardly anything, indeed it recounts the typical reasons given in the eighteenth century for founding an infirmary; humanity, Christian duty and the healing of the poor so that they might return to productive labour. If it is at all different from other infirmary sermons it is in its greater emphasis on economic efficiency. It was during his years at Leeds that he became a Socinian, an event which he recorded as one of the most important in his life. It was in Leeds too, that he began his experiments on gases. According to his own later account, this occurred by virtue of living near a brewery, though there is reason to doubt that this is a wholly satisfactory recollection (see below). This work involved him in the design of chemical apparatus, a pursuit in which he excelled. Priestley also remembered that only a local surgeon, William Hey, gave much attention to his experiments. After 1773 his interests were pursued in a rather different atmosphere when he became "resident intellectual" to the Earl of Shelburne, dividing his time between winters in London and summers at Bowood estate at Calne in Wiltshire.[13] During the 1770s and at the height of his powers Priestley matured his deterministic, associationist psychology and his monistic ontology which were expressed in his controversial *Disquisitions relating to matter and spirit* of 1777. These years also saw disputes with the Scottish Common Sense philosophers, especially Thomas Reid, for whom Priestley's work represented a statement of fullblown atheistic materialism.[14]

In an earlier historiographical tradition Priestley's natural philosophical interests were investigated as something quite separate from his religious and

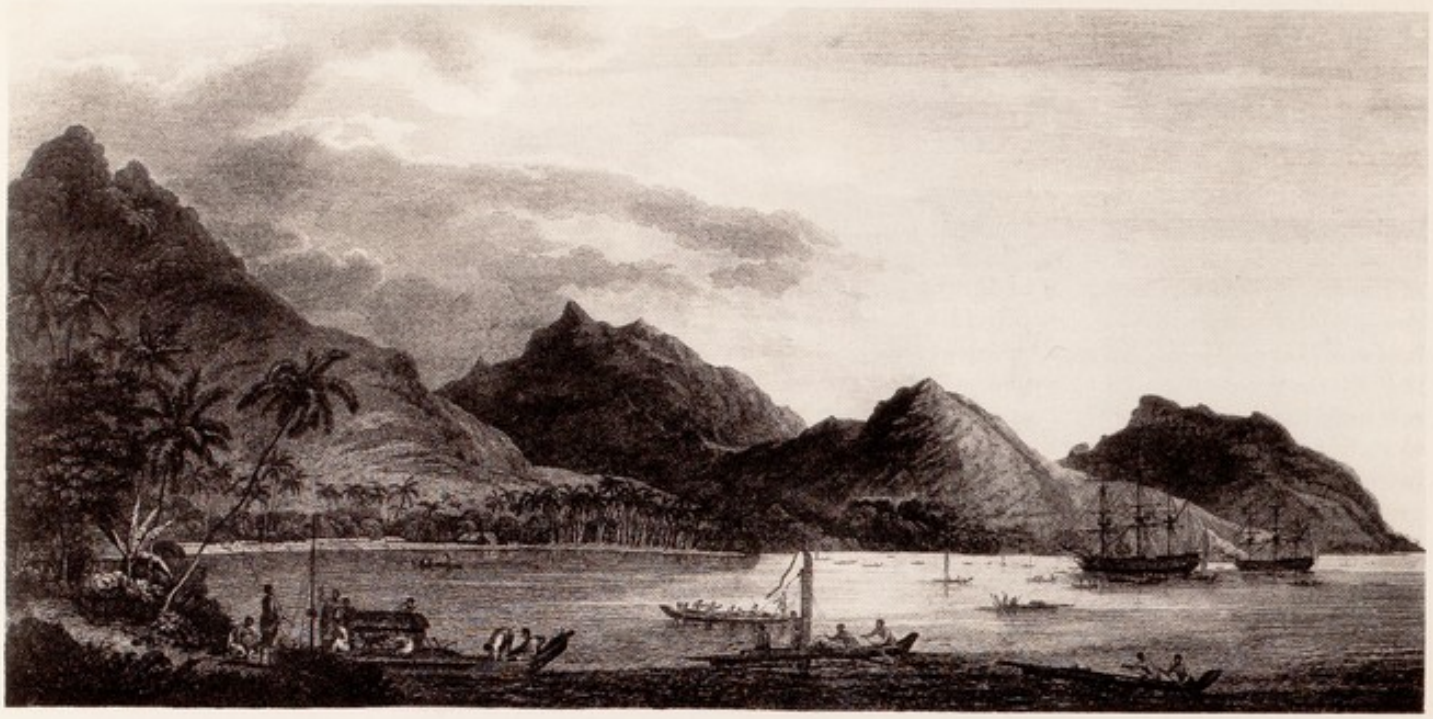

Fig 2 'A view of Huaheine', engraving by W. Byrne after J. Webber, from *Plans and views to Cook's voyages* (1785)

political activities. But it is now becoming clear just how closely related in Priestley's mind these intellectual domains were. It is still the case though, that in the more restricted domain of chemistry, the exact nature of Priestley's interest in gases, and his scientific method for investigating them are a subject of debate amongst historians. The chronology of his work however is at least clear. British pneumatic chemistry is customarily traced back to Stephen Hales' *Vegetable staticks* of 1727 through Joseph Black's description of "fixed air" in 1754 and then to Henry Cavendish's publication, *On factitious airs*, of 1766. In reality however the years between 1740 and 1765 had seen a great deal of chemical interest in air, much of it by physicians, notably William Brownrigg and David MacBride. Priestley's first major publication on gases came in 1772, several years after he had begun work on them. It was a paper which had first been read to the Royal Society and which appeared as *Observations on different kinds of air*. The paper described a pneumatic trough and methods for collecting and manipulating gases. It also contained what Sir John Pringle, in 1773, called the "most brilliant" of Priestley's discoveries, nitrous air, later called nitric oxide, which could be used as a test for "distinguishing good air from bad".[15] Such a test, of course, had important applications for physicians who held bad air to be a major cause of fevers. Priestley's pneumatic experiments continued at a frenetic rate during the 1770s when he prepared several new gases, most famously, at least in retrospect, dephlogisticated air, described 1775, and later designated oxygen when prepared by Lavoisier.

In 1780 Priestley left Shelburne's service after relationships between them cooled slightly. This was not to his immediate financial advantage for it resulted, as he recorded, in the loss of half his income. However his friends came to his rescue and his work over the next few years was, in part, financed by them. Once more doctors were among his benefactors, notably John Fothergill and William Heberden. He left Shelburne for Birmingham, a settlement which he considered "the happiest event in my life".[16] Here he joined in formal association with a number of provincial intellectuals whose meetings comprised the famous Lunar Society. Medical men were prominent in the elite circle; William Withering, Jonathan Stokes, Erasmus Dawin and John Ash.[17] During these years Priestley's energies became less chemically orientated and increasingly devoted to theology, although it was also during this decade that he clashed with Lavoisier over the latter's new oxidation chemistry.

Gradually Priestley's radical theological opinions which had been tolerated in the self-assured days of mid-century became less acceptable, especially to the Established Church which had become increasingly nervous of Dissent in the wake of the French Revolution. In 1791 a 'Church and King' mob destroyed his chapel, his home and his laboratory. He left Birmingham for London and was briefly associated with the dissenting academy at Hackney. Those years however proved difficult "most of the members of the Royal Society shunning me on account of my religious or political opinions".[18] In 1794 therefore he left for America, and settled in Northumberland, Pennsylvania where he continued to write theological and scientific works. In his last years the election of Jefferson to the Presidency meant that, for the first time in his life, he found himself on the side of authority. In 1804 this tranquil man, who caused so much turbulence in those around him, died in Northumberland, where he is buried.

Priestley's life coincided with several major transformations in British medicine and his work was drawn upon and used by the doctors who effected these changes. By the end of the eighteenth century medicine in Britain was increasingly becoming dominated by a new breed of self-assured, practical men. Many of them were Dissenters, no longer orientated to an aristocratic clientele, as were the seventeenth century physicians, but busying themselves with the management of disease in industrial towns and in the army and navy. The most important of these diseases were fever and scurvy.

So called symptomatic fevers, such as accompanied nephritis or pleurisy, were a group of disorders which had long been known to physicians and surgeons.[19] They occurred in random individuals and were associated with a specific, local inflammation. The treatment for these fevers, principally bloodletting to reduce the inflammation, was used by most practitioners throughout the century. Similarly the theory and treatment of intermittent fevers, such as ague, changed little in the eighteenth century. It was with regard to another group of fevers, the continued variety which had no local seat, that major changes in medical theory and practice occurred. This group of diseases began to attract increased attention from about the second quarter of the century. It has been suggested that their identification, and central role in medical debate followed from the fact that they were, indeed, relatively more common than they had formerly been.[20] To contemporaries they certainly seemed to be a corollary of the expanding institutional population, in gaols, hospitals, ships and military camps. Proper management of such institutions therefore meant effective regimes for preventing fevers. Order in society, the doctors implied, meant medical control. By the 1770s there was a fair amount of agreement as to the main features of these apparently new fevers and coherent accounts of their clinical, pathological and epidemiological characteristics had been given by various authorities, notably William Cullen in Edinburgh. Many of the dissenting physicians who tried to apply Priestley's gas chemistry to the cure of fevers had been educated at Edinburgh. The universities at Oxford and Cambridge were of course closed to them as Dissenters.

The new group of fevers was first distinguished clinically as being 'slow' or 'nervous' in character, nervous simply meaning that they were often accompanied by delirium or headache. During the 1720s, 30s and 40s a number of authors, notably Clifford Wintringham, William Hilary, Ebenezer Gilchrist, Browne Langrish, John Barker and John Huxham, described epidemics of 'slow fever'. Some of these authors also designated the fevers as nervous. In 1734, Ebenezer Gilchrist in the *Essays and observations*

published 'An essay on nervous fever', though Gilchrist's theoretical account laid the causal emphasis on a chemical abnormality or lentor of the blood. The disease was a humoral defect which led to nervous system involvement. In many instances the authors who first described the slow fever, for example Hilary and Huxham, had been medical students at Leyden. Here they had learned Hermann Boerhaave's neo-Hippocratism and his respect for the epidemiological methods of Thomas Sydenham. Consequently they investigated the incidence of fevers by a characteristic method; the making of a meteorological record and trying to correlate the weather with the appearance of different fevers.

The fever literature of the second half of the century, although sharing many features with that of the early years, was enlarged and enriched in significant ways. Most notable is the amount of literature produced by military men especially those with experience abroad.[21] A particular feature of this literature was its concentration on the health of well-defined populations, with the monitoring of the well-being of communities rather than individuals. Equally important was an increasing preoccupation with correlating the incidence of the new slow and nervous fevers with the presence of dirt, overcrowding and contagion. Alongside this clinical interest was a new theoretical emphasis on the putrid nature of these disorders. In all these respects the publications of John Pringle in the early 1750s seem to mark a watershed. Pringle's *Observations on the nature and cure of hospital and jayl-fevers* appeared in 1750. In this work Pringle stigmatised gaols as the "...sources of slow and malignant fevers, which generally prevail in large and crowded cities".[22] The cause he identified as the air, vitiated by filth, perspiration, and excrement. The disease was highly contagious. His second publication appeared in 1752, and was entitled *Observations on the diseases of the army in camp and garrison*. This work iterated his earlier account of gaol fever, and contained accounts of other fevers, such as dysentery which was also more common in overcrowded conditions. The book was also a vehement attack on uncleanliness, and stressed the dangers of overcrowding, poor sanitation, bad ventilation, infrequent washing and the malignancy of stagnant air. Pringle also tackled another question crucial to fever theory: the nature of putrefaction. Pringle rejected earlier mechanistic accounts of putridity and conjectured that cause of the malignant fever was a "*miasma* or septic ferment" received into the blood.[23] He also appended to his texts, "experiments and observations performed upon septic and antiseptic substances" which was an account of contributions he had made to the Royal Society in the years 1750-52. Pringle tested various substances, such as decoctions of bark, or wormwood, for their "antiseptic" properties in order to determine how long they would preserve the yolks of eggs. He hoped that these substances would prove useful in the control of putrid or septic fevers. Pringle's account of the pathology of fever was, therefore, vitalistic and he was at the forefront of the theorists who rejected mechanism in physiology, especially in the form of the very popular Boerhaavian, hydraulic model of the body. The words 'septic' and 'ferment' were used by him and others to describe vital pathological phenomena that could not be explained in simple mechanical or chemical terms. The use of such a terminology characterises the writings of all the physicians concerned with the new fevers.

By the second half of the eighteenth century therefore the Hippocratic epidemiology and meteorology of the earlier period had been elaborated into a more complex philosophy of the aerial system that directed attention to stagnation, overcrowding, and dirt. These changes in epidemiological thought which took shape around mid-century have been related by several writers to wider issues. The most important of these are Cameralism and the origins of medical police. It has been suggested that British physicians during the eighteenth century increasingly looked to meteorology, pneumatics and the powers of the atmosphere to demonstrate the whole system of nature and in turn explain health and disease. This medical understanding of the circulation in the atmospheric economy created a role for physicians in the policing of health and managing of sickness in society at large. Hygiene and health were coupled with descriptions of how the whole system naturally operated harmoniously. The explanation of disease, on the other hand, directed epidemiological concern to the sources of putrefaction, corruption, and decay, where pathology resulted from a stagnation of the vital circulation.[24]

Another concern related to these was the pursuit of cleanliness. Owsei Temkin has suggested that, before the eighteenth century, dirt was deprecated mainly for aesthetic reasons. He has also pointed out that, increasingly during the Enlightenment, dirt was stigmatised as having a harmful physiological action. In addition he noted that this new concept, the pathological action of dirt, was coupled with stress on the *moral* qualities of cleanliness.[25] In other words, disease was increasingly being designated as the physical sign and moral stigma of matter out of place. Dirt, Mary Douglas has conjectured, "is the by-product of systematic ordering and classification of matter".[26] In the eighteenth century ordering of things, physical cleanliness and social and moral order were conflated. Pringle makes this quite clear:

> Cleanliness is conducive to health but is it not obvious that it also tends to good order and other virtues?[27]

Such a judgement of course implied an important role for physicians as guardians of the physical and moral health of the populace.

Most striking is the way that these medical concerns repeatedly surface in Priestley's publications of the 1770s. His classic papers on gases have long been examined through the eyes of historians of chemistry yet they are replete with references to the putrid fevers, fixed air as an antiseptic, the management of scurvy and the nature of respiration. The thrust of Priestley's work was in line with Pringle's theories of fever. In 1773 he published a paper refuting the views of William Alexander, an Edinburgh graduate, who asserted that the exhalations from putrid marshes were innocuous. Such a doctrine ran counter to the new aerial pathology. Alexander's claim was based on

experiments in which pieces of beef were hung over both pure water and slime from the notorious Edinburgh North Loch. The beef hung over pure water turned putrid far more quickly than the other. Indeed Alexander's experiments showed that the effluvia from a 'necessary house' had antiseptic properties.[28] These experiments were completely at variance with the views of Pringle, whose *Diseases of the army* had expressly pointed to the great mischief of marsh effluvia. Priestley came to Pringle's defence, not however by repudiating Alexander's experimental technique but by suggesting that air "loaded with putrid effluvias is exceeding noxious when taken into the lungs" even though it might not putrify pieces of meat.[29] This fact he said was proven by the nitrous air test which shown the unrespirability of the air collected from marsh water.

Priestley's much cited *Experiments and observations on different kinds of air* of 1774 was filled with material of medical relevance. This time the medical uses of gases were reported in the appendix by the Leeds surgeon, William Hey, in an account of the treatment of putrid fever by the anal injection of fixed air. Also in the appendix was an essay 'Observations on the medicinal uses of fixed air' by Thomas Percival which was an expanded version of an earlier work. Percival reported having administered fixed air to patients with phthisis and he also reported that William Withering had successfully treated a case in the same manner. He also pointed to its use in ulcerous sore throats and the success Charles White had had in this regard. Percival also recommended the use of fixed air in scurvy. William Falconer on the other hand reported that he had "tried fixed air as an antiseptic taken in by respiration but with no great success."[30]

The second volume of *Experiments* published in 1775 also contained medical testimony to the virtues of fixed air, notably from Matthew Dobson who reported four cases of putrid fever treated by the gas. Similarly from Taunton another physician, John Warren, wrote "I have latterly employed it in almost every putrid case that offered".[31] The appendices to his *Experiments and observations relating to various branches of natural philosophy* (1779-1786) contained similar reports. There is plenty of evidence that during the 1770s and 1780s leading physicians such as John Coakley Lettsom, who was a major authority on the putrid fevers, saw Priestley's work as having elucidated some of the key features of these diseases.[32] Another matter related to all these problems was of course the more general question of the nature of respiration, the use of the blood, and the role of plants in maintaining the atmospheric oeconomy. Priestley published work which touched on all these questions.[33]

Important though slow fevers were to physicians it seems probable that the most sustained discussions in the 1770s and 80s on the role of air in the production of disease and use of fixed air as a therapy centred on scurvy, a disorder which seemed to have many features that resembled those of the fevers. Scurvy amongst seamen was perhaps the greatest problem an expanding power had to face. The horrifying effects of this disease were familiar to eighteenth century observers who had seen the results of the disastrous circumnavigation by Anson in 1740-44 when, because of disease, only 130 of 510 men returned home. Modern accounts of scurvy as a deficiency disease are of no help in rediscovering eighteenth century conceptions. At that time scurvy was not considered as a disorder which was quite different from fevers but, pathologically speaking, it was the representative instance of them. It was what Lloyd Stevenson has called an exemplary disease.[34] That is, it was investigated as the paradigm case of the putrid and slow fevers. If the cause and cure of scurvy could be discovered, the reasoning ran, so could those of all the related fevers. By this time the putrid pathology of scurvy and the fevers was held to be analogous to the decay seen in butchers' meat. The causes were anything which promoted this state, especially stagnant air, certain foods, notably salty provisions and last, but not least, dirt. As such the closest analogues of scurvy were gaol fever and hospital fever, the diseases of institutionalized populations. Scurvy and these other fevers were considered preventable by any suitable substance which stopped putrefaction, any antiseptic agent such as vinegar, lemon juice, oil of vitriol, tobacco smoke and the substance which, in the 1770s, was accepted as the best antiseptic of all: fixed air. As David MacBride said "the cure of putrid diseases in general and that of the *scurvy* in particular depends greatly on the quantity of *new [ie. fixed] air* thrown into the blood".[35]

It seems possible that Sir John Pringle brought the greatest influence to bear in the scurvy debates of the 1760s and 1770s.[36] In 1772 he had become President of the Royal Society, was author of the most cited works on the putrid fevers and wielded great power. It was almost certainly through Pringle's influence that David MacBride's infamous 'wort', or malt preparation, because of the fixed air it contained, was adopted as the standard naval remedy for scurvy during this period. Priestley's work was used by Pringle to endorse this remedy.

It is quite possible that Priestley's first experiments on fixed air, begun in 1767, were prompted not as he said by his proximity to a brewery, but by correspondence with an apothecary, William Bewley. Shortly after Priestley had begun his fixed air experiments Bewley wrote a review of Priestley's *History of electricity* in which he hoped that fixed air could be "applied to the relief of putrid disorders and particularly the sea scurvy". It is known that Priestley had been in correspondence with Bewley earlier in the same year.[37]

The following year, 1768, was of great significance in the history of scurvy therapy as it was then that James Cook set sail in the *Endeavour* on his first voyage. When MacBride had first described wort in 1764 it had been enthusiastically approved by Pringle, then Surgeon-in-Chief of the Army, and John Hunter. On Admiralty orders, wort was the staple antiscorbutic which Cook took with him. Its cheapness compared to other remedies, such as citrus fruits, also told in its favour.[38] The remedy seemed to work reasonably well in Cook's well-victualled and well-run ships. Although there were cases of scurvy on *Endeavour* there were no deaths.[39] On the return of the vessel the surgeon's report approved the virtues of wort.

It is not clear why Priestley returned to chemical studies and the use of fixed air in the early 1770s. But his attempts to make artificial spa waters with a high fixed air content, which were demonstrated to the College of Physicians and published in 1772, were definitely pursued with a scurvy cure in mind. He wrote in his memoirs:

> My first publication on the subject of air was in 1772. It was a small pamphlet, on the method of impregnating water with fixed air; which being immediately translated into French, excited a great degree of attention to the subject, and this was much increased by the publication of my first paper of experiments, in a large article of the 'Philosophical Transactions', the year following, for which I received the gold medal of the Society. My method of impregnating water with fixed air, was considered at a meeting of the College of Physicians, before whome I made the experiments, and by them it was recommended to the lords of the Admiralty, (by whom they had been summoned for the purpose) as likely to be of use in the sea scurvy.[40]

In April 1772 Priestley wrote:

> Yesterday I sent my papers and drawings to the Lords of the Admiralty, have been requested to make the communication to the commanders and surgeons of the Resolution and Adventure, in which Messrs. banks &c., are to make their voyage.[41]

The papers were passed on to Cook, about to start his second voyage.[42] Later the same year Benjamin Franklin wrote to John Winthrop about Priestley's work. Expectations of the therapeutic possibilities of water impregnated with fixed air were obviously high, for Winthrop replied; "If it should prove an effectual remedy for the sea-scurvy it would be indeed a most important discovery".[43]

In 1773 Priestley was awarded the Copley medal of the Royal Society. The medal was presented by Pringle who drew attention to Priestley's work in this regard. Describing Priestley researches he said:

> For having learned from Dr. Black that this fixed or mephitic air could in great abundance be procured from chalk, by means of diluted spirit of vitriol; from Dr. MacBride, that this fluid was of a considerable antiseptic nature; from Mr. Cavendish, that it could in a large quantity be absorbed by water; and from Dr. Brownrigg, that it was this very air which gave the briskness and chief virtues to the Spa and Pyrmont waters: Dr. Priestley, I say so well instructed, conceived that common water impregnated with this fluid alone might be useful in medicine, particularly for Sailors on long voyages, for curing or preventing the Sea-scurvy. This, we know, is a putrid distemper requiring all the antiseptic quality of those mineral waters, without the chalybeate principle, which might injure by over-heating the blood too much disposed to inflammation.[44]

Priestley's award of the medal was also for his discovery of nitrous air. Pringle reported that Priestley thought this to be "one of the strongest antiseptics", of "superior efficiency" even to fixed air.[45] Superiority notwithstanding it does not seem to have been employed in the scurvy. Pringle also reported in this address that Priestley had described how plants restored the goodness of air vitiated by animal respiration or combustion. Priestley concluded that the oceans absorb what is putrid for the purification of the atmosphere. From all this Pringle drew the appropriate natural theological conclusion that nothing grows in vain.

So successful, from the point of view of health, was Cook's second voyage that the Admiralty used the returning surgeon's endorsement of malt as the authority for victualling its ships over the next twenty years.[46] In November 1776 Cook, now at sea, was awarded the Copley medal in a speech by Pringle. Cook's award was for a paper on the health of seamen which he delivered to the Society in March 1776. Malt he had found "one of the best antiscorbutic sea medicines" though he was unsure of its value in an advanced state of scurvy at sea. Central to Cook's account was the importance of cleanliness to prevent a "putrid offensive smell below".[47] In a well ventilated, clean ship, he insisted, scurvy rarely occurred. As he was leaving in July 1776 for his third voyage Cook wrote to Pringle:

> I entirely agree with you that the dearness of the Rob of lemon and oranges will hinder them from being furnished in large quantities. But I do not think this so necessary; for though they may assist other things, I have no great opinion of them alone.[48]

Thus in 1776 the most eminent mariner of the age presented a paper to Britain's most august scientific body and seemingly conclusively proved that scurvy was a putrid disorder preventable by cleanliness, caused by stagnant air and cured by fixed air. Not surprisingly Pringle's speech, later published, celebrated these conclusions, and although Priestley was not mentioned by name the work of the foremost chemist supported Pringle's text like an invisible backbone.[49] There is a final irony in all this. In 1771 Banks had invited Priestley to join the scientific crew on Cook's second voyage and later he withdrew the offer on the grounds that the university professoriate would veto a unitarian. Had Priestley gone to sea he might have been obliged to taste some of his own medicine.[50]

Notes and References

I am indebted to Roy Porter who read and commented on this paper in draft form.

1 See the papers by J. McEvoy, 'Joseph Priestley, 'Aerial philosopher': metaphysics and methodology in Priestley's chemical thought from 1762 to 1781', I. *Ambix*, 1978, *25*: 1-55; II. Ibid., 93-116; III. Ibid.; 153-75; IV. Ibid., 1979, *26*: 16-38. See the critique of McEvoy in J.R.R. Christie and J.V. Golinski, 'The spreading of the word: new directions in the historiography of chemistry 1600-1800', *Hist. Sci.*, 1982, *20*: 236-266. See also Simon Schaffer, 'Priestley's questions: a historiographic survey', *Hist. Sci.*, 1984 *22*: 151-183.

2 One of the few authors to point strongly to Priestley's medical connections is Schaffer above, and in this volume, and I am indebted to his papers in this regard.

3 An outline of Priestley's life and a guide to the secondary sources can be found in the article by Robert E. Schofield in Charles C. Gillispie (ed.), *Dictionary of scientific biography*, New York, Charles Schribner's Sons, 1975, Vol. 2, pp. 139-149. Schofield's interpretation of Priestley's scientific work has been the object of some criticism, notably by McEvoy, op.cit., note 1 above.

4 Joseph Priestley, *A sermon preached on behalf of the Leeds Infirmary (1768)*, Leeds, Richard Jackson, 1910, p.8.

5 Joseph Priestley, *Memoirs*, originally published in Northumberland, Pennsylvania in 1805 and reprinted as *Autobiography of Joseph Priestley*, Bath, Adams and Dart, 1970, p.69.

6 There are many studies on Dissenters and their use of science. See Arnold Thackray, 'Natural knowledge in cultural context, the Manchester model', *Amer. Hist. Rev.*, 1974, *79*: 672-709.

7 Rev. Mr. Hargrove, *The Inquirer*, Jan. 16, 1904 cited in T.E. Thorpe *Joseph Priestley*, London, J.M. Dent and Co., 1906, p.18. Thorpe cites from Priestley's journal on the range of his Daventry Studies, pp. 18-19.

8 John F. Fulton, 'The Warrington Academy (1757-1786) and its influence upon medicine and science', *Bull. Hist. Med.*, 1933, *1*: 50-80.

9 Christopher Lawrence, 'Ornate physicians and learned artisans: Edinburgh medical men 1726-1776', in W.F. Bynum and Roy Porter (eds.), *William Hunter*, Cambridge University Press, 1985.

10 Priestley, to John Canton, Warrington June 1766. Cited in Robert E. Schofield, *A scientific autobiography of Joseph Priestley (1733-1804)*, Camb. Mass., M.I.T. Press, 1966, p.35.

11 See J.V. Pickstone and S.V.F. Butler 'The politics of medicine in Manchester, 1788-1792: hospital reform and public health services in the early industrial city', *Med. Hist.*, 1984, *28*, 227-249.

12 Priestley, op.cit., note 4 above. See S.T. Anning, *The General Infirmary at Leeds*, Edinburgh, E & S Livingstone Ltd., 1963, vol. 1., p.85, on the Quaker support for the Infirmary.

13 Schofield, op.cit., note 3 above, p.140.

14 See Barfoot this volume.

15 Douglas McKie, 'Joseph Priestley and the Copley Medal', *Ambix*, 1961, *9*: 8-9.

16 *Autobiography*, op.cit., note 5 above, p.120.

17 Robert E. Schofield, *The Lunar Society of Birmingham*, Oxford, Clarendon Press, 1963; idem., 'Membership of the Lunar Society of Birmingham' *Ann. Sci.*, 1956, *12*: 118-136.

18 *Autobiography*, op.cit., note 5, above, p.130.

19 Much of the following relies on the chapter on William Cullen in my PhD thesis, 'Medicine as Culture: Edinburgh and the Scottish Enlightenment', University of London 1984. See also Dale C. Smith, 'Medical science, medical practice and the emerging concept of typhus in mid-eighteenth century Britain' and W.F. Bynum, 'Cullen and the study of fevers in Britain 1760-1820', in W.F. Bynum and Vivian Nutton, (eds.), *Theories of fever from Antiquity to the Enlightenment*, London, Wellcome Institute for the History of Medicine, 1981.

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21 Peter Mathias, 'Swords and ploughshares: the armed forces, medicine and public health in the late eighteenth century', in J.M. Winter (ed.), *War and economic development*, Cambridge, University Press, 1975. Ulrich Tröhler, 'Quantification in British medicine and surgery, 1750-1830, with special reference to its introduction into therapeutics', Ph.D thesis, University of London, 1978.

22 John Pringle, *Observations on the nature and cure of hospital and jayl-fevers*, London, A. Millar and D. Wilson, 1750, p.2.

23 John Pringle, *Observations on the diseases of the army*, London, A. Millar and D. Wilson, 1752, p.356.

24 L.J. Jordanova, 'Earth science and environmental medicine: the synthesis of the late Enlightenment', in L.J. Jordanova and Roy Porter (eds.), *Images of the earth*, Chalfont St. Giles, BSHS Monographs 1. 1978; pp 119-146. Simon Schaffer, 'Natural philosophy and public spectacle in the eighteenth century', *Hist. Sci.*, 1983, *21*: 1-43.

25 Owsei Temkin, 'An historical analysis of the concept of infection', in his *Studies in intellectual history*, Baltimore, The Johns Hopkins Press, 1953, pp. 123-147.

26 Mary Douglas, *Purity and danger*, Harmondsworth, Penguin, 1970, p.48.

27 Cited in Temkin, op.cit., note 25, p.143. A work which discusses these issues is Norbert Elias, *The civilizing process*, New York, Urizen Books, 1978.

28 William Alexander, *An experimental enquiry concerning the causes which have generally been said to produce putrid diseases*, London, T. Beckett, 1771. Alexander thought it more likely that the cause of putrid disease lay in the "follies and irregularities of our lives" (p.3).

29 Joseph Priestley, 'On the noxious quality of the effluvia of putrid marshes', *Phil. Trans. Roy. Soc.*, 1773-4, *64*: 91.

30 Joseph Priestley, *Experiments and observations on different kinds of air*, London, J. Johnson, 2nd ed., 1775, Vol.1, pp. 288-324. Charles White had reported "In putrid fevers and in the putrid sore throat I have frequently advised patients to breath the fixed air arising from effervescent mixtures" *A treatise on the management of pregnant and lying-in women*, London, Edward and Charles Dilly, 1773, p.179.

31 Joseph Priestley, *Experiments and observations on different kinds of air*, London, J. Johnson, 1775, Vol. 2, p.376.

32 [J.C. Lettsom], *Reflections on the general treatment and cure of fevers*, London, The author, 1772. Fixed air, Lettsom noted, is "a powerful remedy in fevers with a putrid tendency" (p.8) to which he footnoted Priestley's *Essay* on making artificial Pyrmont water (see below).

33 See especially 'Observations on respiration and the use of the blood', *Phil. Trans. Roy. Soc.*, 1776, *66*: 226-248. One of the few papers to deal more generally with Priestley's views on life is Harold J. Abrahams, 'Priestley answers the proponents of abiogenesis', *Ambix*, 1964, *12*: 44-71.

34 Lloyd G. Stevenson, 'Exemplary disease: the typhoid pattern', *J. Hist. Med.*, 1982, *37*: 159-181.

35 David MacBride, *Experimental essays* London, A. Millar, 1764, pp.175-6 and p.190.

36 For an excellent account of the extent of the medical circles around Pringle see Dorothea Waley Singer, 'Sir John Pringle and his circle', *Ambix*, 1948-50,6: 127-80; 229-261.

37 [William Bewley], 'Account of Dr. Priestley's History of Electricity' *Monthly Review*, 1767, *37*: 453. Cited in Schofield op.cit., note 10 above, p.131. Schofield is also the source of the evidence on Bewley's correspondence.

38 Christopher Lloyd and Jack L.S. Coulter, *Medicine and the navy*, Edinburgh, E.S. Livingstone, 1961, vol.3, 293-328. David MacBride's account of wort appeared as *An historical account of a new method of treating the scurvy at sea*, Dublin, W.G. Jones, 1767. This had first appeared as a pamphlet in 1764. See Lloyd p.308.

39 Joseph Banks, who was also on the voyage, recorded in his private journal how wort had had no effect on his scorbutic symptoms but that, when he "flew to the lemon juice", he was cured within a week. See Lloyd, op.cit. note 38 above, p.311.

40 *Autobiography*, op.cit., note 5 above, p.95.

41 Cited in Schofield, op.cit., note 10 above, p.131.

42 J.C. Beaglehole, *The Life of Captain James Cook*, London, Adam and Charles Black, 1974, p.283. He also advised James Lind on the process. See catalogue (this volume) item 24.

43 John Winthrop to Benjamin Franklin, Cambridge, New England, 1773. Cited in Schofield, op.cit., note 10 above, p.114.

44 MacKie op.cit., note 15 above, p.7.

45 Ibid., p.9. It is interesting that MacKie's article was published to refute Thorpe's "nonsense", that Priestley was awarded the medal for making "soda water". Pringle's address however, suggests that he had a higher opinion of "soda water" than MacKie thought likely.

46 Christopher Lloyd, 'The introduction of lemon juice as a cure for scurvy', *Bull. Hist. Med.*, 1961, *35:* 123-132.

47 James Cook 'The method taken for preserving the health of the crew of Her Majesty's ship *Resolution*, during her late voyage round the world' in John Pringle, *A discourse upon some later improvements of the means for preserving the health of mariners*, London, Royal Society, 1776, p.40.

48 Ibid. 'Extract, of a letter from Captain Cook to Sir John Pringle Bart. dated, Plymouth Sound, July 7, 1776, p.44.

49 Pringle, op.cit. note 47 above.

50 Beaglehole, op.cit., note 42 above, p.192.

Joseph Priestley (1733-1804) and William Whewell (1794-1866): Apologists and Historians of Science. A Tale of Two Stereotypes.

JOHN HEDLEY BROOKE

With reference to the celebrated thesis of R.K. Merton, the question is still asked whether we know any more today about the relations between Puritanism and science than in 1938 when Merton first published. A possible answer, to judge from a recent analysis by Gary Abraham, is that we know less. For "the diverse parties among the historians have *all* failed to appreciate [Merton's] central line of argument" and "most historians seem never to have understood Merton's original intentions".[1] My object in this paper is not to discuss Merton's thesis *per se*, but to expose a few problems that seem to arise in applying and testing the stereotypes that have been derived from it. This may be to flog an old war-horse, but hardly a dead one if there is truth in Abraham's judgement.

Two of the most common stereotypes would certainly be deducible from the thesis which Merton re-affirmed in 1970: "the autonomous case for pure science evolved out of the derivative case for applied science".[2] That derivative case, according to the original thesis, had been legitimised by a set of religious values associated with ascetic Protestantism. Merton made it perfectly clear that Puritan values were not *necessary* for science, but he emphasised a correlation that has been erected into a type:

> The Puritan complex of a scarcely disguised utilitarianism; of intramundane interests; methodical, unremitting action; thoroughgoing empiricism; of the right and even the duty of *libre examen*; of anti-traditionalism - all this was congenial to the same values in science.[3]

Leaving aside, for the moment, the multiple layers of ambiguity associated with the words 'Puritan' and 'utilitarianism', the reference to anti-traditionalism in Merton's formulation shows how the type can be hypostatized; that is by contrast with a second type which embraces the values of traditionalism.

The resulting dichotomy was probably at its sharpest in Christopher Hill's *Intellectual origins of the English Revolution:*

> One the one hand, Puritanism, the new science, optimistic belief in progress, and Parliamentarianism; on the other, neo-popery, traditional medieval theology, sceptical pessimism and royalism.[4]

The type erected on that *other* hand has commonly been reinforced by references to Oxbridge, its neglect of science when it had little and its neglect of useful science when it eventually had some. Thus Merton himself drew an unflattering comparison between the English universities and dissenting academies as far as the encouragement of science was concerned.[5] In rather more depth Donald Cardwell emphasised the role of dissenting clergy, and dissenters generally, in promoting popular scientific education - the contrast with aristocratic and Anglican values being epitomised by the courage of one Anglican gentleman who lectured the mechanics on the folly of their institutes.[6] The contrast between an Oxbridge and a dissenting ethos, in its relevance to science, goes back, of course, a long way before Merton. One recalls that much quoted passage in Halevy:

> It is in Non-conformist England, the England excluded from the national universities, in industrial England with its new centres of population and civilisation, that we must seek the institutions which gave birth to the utilitarian and scientific culture of the new era.[7]

Despite the refinement and revision of intervening years, the types continue to be applied, and in refreshing new ways. Two recent examples occur in the contributions of Derek Orange[8] and Michael Neve[9] to a comparative study of *Metropolis and province*. Orange has investigated William Turner's commitment to the Newcastle Literary and Philosophical Society, arguing that the springs of his intellectual mission are to be found in the values of Rational Dissent. Accordingly, "the visible symbol of the marriage between liberal politics, liberal religion and useful knowledge was Turner's chapel in Hanover Square".[10] Turner himself had argued for the "absolute dependence of...

Fig 3 Wedgwood medallion depicting Priestley, attributed to William Hackwood, c. 1779.
Catalogue 2 (see page 98)

commerce upon science, and the necessary connection between the extension of the one and the enlightened application of the other".[11] If Protestant values were conducive to an expanding capitalism, Rational Dissent, in Orange's interpretation, "added ... a social dimension, a process theology which seemed to make sense of material change". The industrial revolution was to take place "not, as it were, behind God's back but at his express command".[12]

By contrast, the sponsorship of science in a less industrial city, Bristol in the early nineteenth century, was of a different hue. Neve's analysis of the scientific culture of that city is refreshing because it cuts across any facile identification of science with radicalism. Nevertheless, in describing the culture of the Bristol elite as imitative of Oxbridge, the appeal to a 'type' is still an essential part of the argument. In Neve's characterisation of the Bristol Institution, alert Toryism and conservative science become key words, in conjunction with a theology of creationism and a natural theology of the Oxbridge style. The apparent failure of the Institution to deliver any *practical* goods[13] (either for its port or its manufacturers) seems only to underline the dichotomy between the established types.

In this paper my principle object is not to criticize the types but to emphasise a series of ulterior problems in their testing. The paper had its origin in the realisation that I had been studying Whewell and Priestley, with different objects in view, and largely disregarding the stereotypes to which they have often been assimilated. It occurred to me that, despite the obvious problem of chronology, a comparison between their respective apologias for science might be instructive, if it could be related to some of the dichotomies we have just been considering.

The introduction of individuals into the case is beset with certain preliminary difficulties, two of which are obvious and one rather less so. The first obvious snag is that even if an individual turned to conform to type, it would hardly add up to much by way of corroboration. The second is that any individual worth his salt is going to be idiosyncratic in some way or other, or one would presumably not be talking about him in the first place. The less obvious difficulty is that in certain constructions placed on theses of the Merton kind, the actors, the promotors of science, are simply irrelevant to the thesis. Thus Abraham insists that Merton's thesis, properly understood, relates to the audience for science and its receptivity, rather than to religious motivations or sanctions among scientific publicists. In other words, Puritan values did not stimulate any form of scientific activity; they simply served to elevate the status of useful science in an audience prepared to listen. Since Priestley and Whewell emphatically fall into the category of the preachers rather than the converted, they might both be considered irrelevant to the case. Merton felt from the first, writes Abraham, that "the various forms in which he couched his argument would make plain that he was talking about the increasing public and publicistic interest in science".[14]

Can this veto be allowed to stick? Merton in fact assumed that the religious beliefs of scientific practitioners *were* relevant to his case. With reference to the pre-history of the Royal Society, he noted that among the leading spirits were Wilkins, Wallis, Jonathan Goddard, and later Boyle and Petty "upon all of whom", he wrote, "religious forces seem to have had a singularly strong influence".[15] There is value in the veto in that it calls into question a large and suspect literature on head-counting, but even in Abraham's reconstruction it does not entirely stick. His paraphrase includes the assertion that "Puritan sources for the new belief that science would be as worthy a personal vocation ... as any other - this (Merton argues) affected both ... *scientists themselves* and their publics".[16] If it did, then actors as well as audience can be brought into play.

The point of bringing Priestley and Whewell on to the field is that they would seem to be perfect candidates for testing the types, the one epitomising the ultimate in Protestant dissent, the other a powerful architect of Cambridge science. Priestley was educated, and taught for a while, at a dissenting academy; Whewell was educated and taught at Cambridge. Each was a reverend and stout religious apologist. If religious values had a bearing on their science, it ought to be as visible in their case as in any. Merton himself took advantage of Priestley's religious commitment when complaining about Feuer's ascription of the scientific ethos to a libertarian-hedonist ethic.[17] Each was an apologist for science as well as for religion; and each (bless them!) wrote volumes on the history of science. Comparisons are therefore possible.

In the case of each there is already an extensive literature, identifying connections between their respective religious belief and the slant of their science.[18] At a fairly rudimentary level, one could point to the antipathy of each towards theories of spontaneous generation and organic transformation, the one a critic of Erasmus Darwin,[19] the other of the anonymous author of *Vestiges of the natural history of creation*.[20] Priestley was quite explicit in saying that his efforts had been designed to bring science and religion closer together.[21] Whewell, too, in his wrangle with Brewster over a plurality of worlds came close to admitting that religious beliefs were the primary determinant of his position. In a manuscript draft, replying to an irate review in the *Edinburgh*, he asked "But why does not the Reviewer consider the question *whether* there *are* religious grounds for believing the unique position of man?"[22] For all the Scottish grumble, Whewell evidently believed there were. Given the priority both Priestley and Whewell were prepared to give to theological issues, a comparison between them may well prove illuminating.

The assimilation of Priestley and Whewell to their respective types turns out to be so smooth - at least to a first approximation - that one can quite see how they have come to be archetypal. An an aperitif, it is interesting to note that Priestley had tasted for himself the illiberal norms of Oxbridge. There was the messy business of a proposal from Joseph Banks that Priestley should accompany him, on his second voyage, as an astronomer. The proposal was subsequently withdrawn. "You now tell me", Priestley rejoined,

that, as the different Professors of Oxford and Cambridge will have the naming of the person, and they are all clergymen, they may possibly have some scruples on the head of religion; and that on this account you do not think you could get me nominated ... I thought that this had been a business of philosophy, and not of divinity ... I am surprised that the persons who have the chief influence in this expedition, having minds so despicably illiberal, should give any countenance to so noble an undertaking.[23]

I shall begin the comparison with their respective histories since, for Priestley, the history of science was a way *into* science.[24] For Whewell, it was a way out.[25] One of the objects of Priestley's history of electricity, as McEvoy has shown, was to make the practice of science egalitarian.[26] Even the amateur could play his part in uncovering nature's secrets. In Whewell's historical writing, by contrast, there are remarks which smack of intellectual elitism. Whereas Priestley presented an image of scientific progress as the discovery of facts, Whewell was more concerned with the contribution of the mind. Priestley's vision of the history of science was one in which genius was expendable, even Newton's. His description of scientific experiments had an over-riding object: "the directions I have given are sufficient to enable any person to do everything after me".[27] Everything of value in science could be made perfectly intelligible even to those bereft of mathematics.[28] In Whewell's history the emphasis falls on theoretical insight, on the "peculiar sagacity", even the "genius" of the discoverer.[29] Challenging facile accounts of the inductive method, Whewell even found in Priestley an obliging historical example. The initially strong resistance in Britain to Lavoisier's oxygen-centred chemistry - which Priestley illustrated par excellence - showed that there was more to scientific perception and innovation than straightforward inferences from matters of fact. Some English writers had been expressing the opinion that there was little that was original in Lavoisier's doctrines. But if they were so obvious, Whewell replied, "what are we to say of eminent chemists, as Black and Cavendish, who hesitated when they were presented, or Kirwan and Priestley, who rejected them?" No; it required "some peculiar insight to see the evidence of these truths".[30]

In keeping with his projection of a non-elitist science, Priestley stressed the role of chance in scientific discovery. In his own experience, a theoretical anticipation of scientific results was almost always thwarted. Discoveries were often accidental in the sense that one found something out that one had not expected to find. It was not Whewell's intention to suggest that the mind could infallibly anticipate nature, but his emphasis on fundamental ideas at the base of each branch of science gained in plausibility if he could show that the solution to scientific problems had been anticipated in outline, if not in detail. A favourite example was the identity of magnetic and electrical forces which had been divined before it had been discovered.[31] Regulating the most impressive work in electrochemistry, Faraday's in particular, had been the fundamental idea of polarity. If Priestley had made room for the amateur there was a sense in which Whewell wished to see him squeezed. When eligibility for membership of the incipient British Association for the Advancement of Science was under discussion, Whewell enquired of Vernon Harcourt "whether it might not be better to make your Association consist of all persons who have *written papers* in the memoirs of any learned society".[32] A long list of lay members was undesirable and would replicate one of the worst features of the Royal Society. Finally, in comparing their respective histories, there is a clear contrast between their avowed intentions. It was a principal object of Priestley's histories that they would collate such information as was necessary for the advancement of *science*. There was a defect to be remedied:

> At present, philosophical knowledge is so dispersed in various books and languages, that it is in the power of few persons to make themselves acquainted with everything that they would wish to know ... and on this account, the progress of this valuable kind of knowledge is much retarded.[33]

By contrast, the explicit object of Whewell's history was to advance, not science itself, but the philosophy of science.

Their respective histories indicate other divergences which seem to conform to the common types. In Priestley there was an emphasis on nature as epistemologically open and expansive - in the sense that there had been progress in all directions. To extrapolate the past history of science conjured up a winning and glorious vista:

> If the progress continues the same in another period, of equal length, what a glorious science shall we see unfold, what a fund of entertainment is there in store for us, and what important benefits must derive to mankind.[34]

In Whewell's history, science also had the distinction of converging on the truth about nature. There was a most decided progress to record. But the idealist elements in his philosophy produced an image of the unfolding of knowledge, as each generalisation about the natural world was progressively subsumed under those of still higher generality. One historian has even characterised Whewell's position in these terms: Fresh knowledge corroborated old knowledge. Nothing fundamentally new would result from research.[35] Whewell, in common, it is alleged, with Sedgwick, Pusey and Newman, was "worried about the implications of novelty".[36]

In no way could this be said of Priestley for whom the history of science even served the heuristic function of promoting novelty:

> The history of science cannot but animate us in our attempts to advance still further, and suggest methods and experiments to assist us in our future progress.[37]

The history of science had a heuristic function for Whewell too. But it was a more donnish purpose he had in mind. The primary, educational function of the history of science was to supply examples of proper

inductive reasoning.[38] It could create an awareness of scientific principles, perhaps even suggest methods, but hardly experiments.

Priestley's conception of progress, which his history of science underscored, implied a process of emancipation from superstition and Christian orthodoxies. It was a kind of progress which would be:

> the means under God of extirpating all error and prejudice, and of putting an end to all undue and usurped authority in the business of religion as well as of science.[39]

Whatever the breadth of Whewell's churchmanship, he could never have condoned such snide attacks on the Anglican establishment. From his angle, the attainment of true knowledge through scientific progress highlighted the God-given mind, without which there were, in the last analysis, no epistemological guarantees.[40] This theologically grounded idealism was an aspect of, not a threat to, Whewell's Anglicanism. The inductive method, properly understood, was part of Anglican culture, not subversive of it.

The next comparison involves the quintessential correlation between Protestant dissent and socially useful forms of applied science. Once again, Priestley and Whewell can be made to appear archetypal, the former a champion of utility, the latter regarding the sciences as a source of polite information and sound reasoning. True to type, Priestley applied himself to the application of science. His solution of 'fixed air' in water he was quick to launch as a preventive remedy for scurvy.[41] Nor did commercial promise elude him. To one correspondent he boasted that "I can make better [mineral water] than you import, and what cost you five shillings will not cost me a penny".[42] His most celebrated product, oxygen, was promised as a luxury at an affordable price.[43] And so it was with most of his 'airs'. Each surely had its use? "Yesterday", he informed Alessandro Volta, "we ate a pigeon which I had kept in nitrous air near six weeks. It was perfectly sweet and good", though "the water in which it had stood was very putrid".[44] French balloonists would acknowledge their debt to Priestley[45] who, in conversation with fellow members of the Lunar Society, would doubtless have approved a more mundane use for the air-borne vehicle: to carry manure uphill.[46] The successful application of science was, for Priestley, a touchstone of progressive civilisation, part of a Providentially ordained process leading to human perfectibility.

By contrast, Whewell, in his controversy with Brewster over the objectives of the British Association, was to emerge as a champion of pure science. The thought of advising government on fisheries perished him, as did Brewster's conception of government finance for scientific research.[47] It was Brewster's complaint against Whewell's history not only that there was a conspicuous absence of Scotsmen, but also of railways and steam-guns.[48] Even to say that Whewell saw science as part of polite *culture* is going a bit far. Science was appropriate information for cultured people - which is not the same thing. The sciences, he once wrote, "do not constitute the *culture* [but] they belong to the information of the well-educated man".[49] When he addressed himself to the principles of English university education, he was perfectly explicit on what he understood by utility. The physical sciences were "useful, not only as belonging to the information of the educated man, but also as supplying him with examples of inductive reasoning".[50] It is not difficult to see why such an apparently restrictive vision, from the very architect of the natural sciences tripos, should be presented as an archetypal image of what Oxbridge science had to offer. One historian has even suggested that it would probably never have crossed Whewell's mind that science might be beneficial to industry.[51]

On the assumption that specialised knowledge in a defined area is a prerequisite of scientific advance, there is another sense in which Priestley might be shown to have the forward-looking mentality. To say that he displayed a keener sense of what scientific specialisation required may appear paradoxical in the light of the earlier contrast between Priestley's allowance for the amateur and Whewell's concern for rigour. Whewell, after all, proposed that the British Association should encourage specialised reports on the progress of individual sciences.[52] And as far as the study of chemistry is concerned Priestley can always be shown to have been less 'professional', less quantitatively rigorous, less systematic than Lavoisier.[53] Nevertheless Priestley's self-effacing remarks about his own inadequacies as a chemist betray an impressive awareness of a large and specialised branch of knowledge, which, however diffuse, was well enough delineated to create in Priestley himself the feeling that he was but cultivating the margins.[54] It should also be noted that Priestley's histories of science were histories - separate histories - of separate sciences: electricity, optics, the study of airs etc.

There is, by contrast, a certain omnivorous quality about Whewell's involvement with the sciences. In a well-known quip it was said that though science was his forte, omniscience was his foible. It was an affliction he had suffered from his youth. As a young student, just ensconced in Cambridge, he wrote home to his Lancaster friend, George Morland, alluding to:

> certain yearnings after the whole circle of the sciences, certain ecstatic aspirations after universal knowledge, certain indefinite desires to approximate to something like omniscience.[55]

To be fair, he was having second thoughts: to rest content with the amplitude of general views was to be seduced, so he wrote, by the "magnificence of extensive vacuity". Not much good, he predicted, "would be likely to come to me if I were to remain in such an all-reading, all-learning mood for ever".[56] The irony is that he was wrong. A prize-winner in poetry, a devotee of the classics, respected natural theologian, critic of utilitarian ethics, champion of mechanics, recipient of a Royal Medal for his researches on the tides, his first professorship was in mineralogy. He was to tread the whole circle of the sciences with almost embarrassing success. Despite his doubts about the British

Association for the Advancement of Science, he soon found himself its President. Despite his being no more than a commentator on current geological debates, he found himself President of the Geological Society. In Trinity he was able to make himself indispensable as a Fellowship examiner in the three 'M's': morals, metaphysics and mathematics. His promotion to his highest Presidency shows that it was possible for a jack-of-all trades to become Master of Trinity. The history of science, for Whewell, was arguably not a history of separate specialisms. It embraced all the sciences, each having its own fundamental principles to be sure, but each contributing to an over-arching epistemological unity. The comparison may be insensitive, but it is more likely to be said of Whewell than Priestley that he preferred to know about all the sciences than to cultivate one.

A consideration of their respective theologies becomes a pressing matter since the point of constructing the 'types' has often been to correlate attitudes towards science with religious variables. One is certainly tempted to say that Priestley's egalitarianism in the practice of science was matched by his egalitarianism in matters theological. It was, he believed, one of the strengths of his simple theology of repentance that it could be understood by the common ploughman.[57] By contrast, the metaphysics underlying the doctrine of the Trinity and Atonement was so abstruse - so Priestley suggested - that they passed the common, if not all, understanding. And his theology was egalitarian in the more technical sense of eschewing Calvinist doctrines of election which implied the existence of a spiritual elite, and its unpalatable corollary, a mass of mankind predestined to eternal misery.[58] The seductive notion that God simply wanted the happiness of His creatures would almost certainly have appeared simplistic to Whewell who, far from being an enemy of metaphysical theology, was such a fluent exponent that large sections of his *Essay* on the *Plurality of worlds* had to be ditched before publication, for the very reason that it would have left his audience, let alone a common ploughman, far behind.[59] Like matter itself, Priestley's radical theology could be put in a nutshell: the rational Christian considers the Divine Being as having produced all creatures with a view to making them happy, bearing a "most intense, and absolutely impartial affection to all his offspring ... inflexibly punishing all wilful obstinate transgressors, but freely pardoning all offences that are sincerely repented of, and receiving into his love and mercy all who use their best endeavours to discharge the duty incumbent upon them".[60]

With such a vision Priestley could ground his ethics in a theology which sanctioned utilitarianism. The premise that God desired man's happiness, not his misery or annihilation, was far more likely to promote works of charity, so Priestley reasoned, than any 'orthodox' theology.[61] Bentham may have secularised the creed, but, for Priestley, the maximum happiness for the maximum number was an essentially religious goal. But it was a goal too facile for Whewell whose ethics were to be grounded in a God-given and enlightened conscience and whose moral philosophy was directed against the utilitarianism of Bentham and Paley.[62]

An antithesis between the radicalism of Priestley and the conservatism of Whewell might be advanced by observing that although Priestley's theology of nature allowed room for some of the biblical miracles, the main thrust of his theologising was against divine intervention, even in the workings of the mind.[63] Such biblical miracles as could be reasonably affirmed had been executed to authenticate a gospel which rendered further miracles superfluous, and claims for them suspect.[64] Whewell, it could be argued, took a more tolerant view. In his commentaries on the fossil record, the progressive creationism which he shared with Sedgwick and Buckland indicated a superintending Providence and the inability of natural causes to give a complete account of the origin of species.[65] In Sedgwick's case there was an explicit renunciation of the kind of closed, deteministic system of nature which Priestley had arguably sponsored. For an Anglican geologist in Cambridge, the great beauty of his science was that it pointed, through a long succession of material changes,

> towards a beginning of things, when there was not one material quality fitted to act on senses like our own; and thus [it takes] from nature that aspect of unchangeableness and stern necessity which has driven some men to downright atheism.[66]

In his philosophy of nature Priestley was just such a stern necessitarian, though emphatically not an atheist. He may be presented as one who reacted against a voluntarist theology of creation, preferring to ground the uniformity of nature not in the immediate activity of the Divine Will but in an inner nexus of determinate relations which bound effects to their causes.[67] Whewell, however, deliberately aligned himself with a voluntarist tradition which, in the *Bridgewater treatise*, he traced back to such virtuosi of the late seventeenth century as Boyle and Newton.[68] Whewell was to be adamant that a physical law presupposed an Agent "conscious of the relations on which the law depends, producing the effects which the law prescribes".[69]

Again, apparently true to type, there was a millenarian streak in Priestley's theology, but invisible in Whewell.[70] There is the striking contrast too between Priestley's rejection of a matter/spirit duality and its retention in Whewell. "I have never expressed any doubt of the existence of other orders of spiritual beings" - so Whewell informed Sedgwick.[71] Whereas Priestley saw in Platonism an evil which had corrupted Christianity, Whewell was arguably a Platonist of a kind, especially in his epistemology. It is difficult to resist the remark that the very name of the College, of which Whewell was to be Master, epitomised for Priestley all that was wrong with Christian theology.

Priestley's critique of a corrupted Christianity, together with the historical analysis by which it was endorsed, had obvious political connotations however much be wished to play them down. He could advise his fellow dissenters to display the Christian virtues of patience and longsuffering in bearing the indignity of discrimination. But such advice was not intended to inhibit an active pen.[72] In a well-known passage he

even invested science with an overt radicalism, suggesting that the English hierarchy had reason to tremble before air pumps and electrical machines.[73] In the years surrounding the French Revolution there was clearly a limit to the number of times one could use the gunpowder metaphor before it backfired.[74]

Whewell, true to type, was a Tory, appointed to his Mastership by Sir Robert Peel. His recommendations on the principles of university education had connotations which were manifestly anti-revolutionary. It was one of his complainst against the teaching of philosophy in German universities that revolutions in thought, by which Hegel had superseded Schelling had superseded Fichte had superseded Kant, had led to a "dire shedding of ink", and to consequences even more dire:

> In Germany and France, we are told that there prevails among the young men of the universities a vehement and general hostility to the existing institutions of their country ... Such a consequence may naturally flow from an education which invokes the critical spirit, and invites it to employ itself on the comparison between the realities of society and the dreams of system makers.[75]

If ever there had been a system maker with a dream it was surely Priestley, who had cherished a vision of the future in which peace would triumph over war, toleration over discrimination, rational Christianity over other, less rational, religions; until a day would come when all men might be united by the very beliefs he held. It was that very convergence towards unanimity which required that Christianity be unitarian.[76] How else could Jews and Mahometans begin to take it seriously?[77] The political contrast between the two men might be symbolised by the fate of their respective houses. Priestley's was burned by a mob in the Birmingham riots. Whewell's - once its incumbent had eliminated all possible rivals from outer space - was secured as the most prestigious lodge in the universe.

It is remarkable how well Priestley and Whewell seem to conform to type. The comparison, by virtue of its anachronism, may be considered even more pointed. Priestley was stressing the practical utility of scientific knowledge some sixty years or more before Whewell proposed that gentlemen ought to know a bit about it. But conformity to type does not itself establish the kind of links between the different sets of correlates which would allow one to conclude that a thesis of the Merton type was sound. In particular, if the heart of the correlation is supposedly between religious values and useful *applied* science, there is still the problem of how one gets from the one to the other, and the ulterior problem of how one knows when one has got there. It is at this point that I should like to identify the problems that arise when putting the 'correspondence rules' to the test. Do the connections between the respective correlates really connect?

If, as Merton argued, the values of ascetic Protestantism were not *necessary* for scientific development, but merely catalytic within a particular social structure, there is the immediate problem of the weight to be attached to those values when one happens to find them in a different context - as one does, for example, in Priestley's case.[78] Any limitation on the scope of the type might seem to call in question the ascription of primacy to the religious values even when they are conspicuous. There is nothing new in this point. Over twenty-five years ago, in a somewhat non-committal account of Merton's thesis, Cardwell emphasised its limited application. Many scientific academies and institutions in different European societies had clearly arisen without the aid of Calvin - and especially in England where it was possible for Cardwell to stress the "marked individualism" of English life, as revealed in the diversity of religious belief and the freedom of political institutions:

> We are not surprised ... when we find that English scientists have subscribed to all religions, or to none, that they have come from all walks of life - from pitmen to peers, that their political allegiances have ranged from High Tory to radical revolutionary and that their vocations - when amateurs - have been almost as many as their numbers.[79]

The more one uncovers the diversity of values that have sustained an interest in applied science, the more precarious it would seem to seize on one set as uniquely propitious. And, if this is a problem, it arises not just in the case of Merton's thesis. It can as easily arise in critiques of that thesis if there is any attempt to replace one stereotype with another. A case in point would be the Jacobs' critique of Merton, in which liberal Anglicanism supplants ascetic Puritanism as the type.[80] Their assertion that modern science found its presuppositions in liberal Anglicanism would seem to be doubly parochial, in its restriction to Anglicanism and, more importantly, in its reference to Anglican *origins*. There was no suggestion in Merton that science had Puritan *origins*. It is surely a deficiency in the Jacobs' account that it lacks the breadth of a European focus which would allow one to say that the mechanical philosophy had first been christianised, albeit controversially, in Catholic France.[81]

The problem of what weight to give to religious beliefs which may have informed attitudes towards science is not easily solved, even in particular cases. It is tempting to say that if connections between scientific and religious beliefs are explicit in primary sources, they must be given the weight which the author himself gives them. But this has always been a potentially, if not always actually, a naive answer. It may gloss over distinctions between substance and rhetoric. It may also gloss over social pressures which might have encouraged particular forms of religious language. And there is the additional complication that the author's own connections may be affirmed with a degree of exclusivity which makes it difficult to take them quite seriously. It may, for example, tell us a lot about Priestley that he could foresee irrationally constituted governments quaking before an electrical machine, but, as Roy Porter has so succinctly put it, he was wrong - judged that is against Humphry Davy's skill at the Royal Institution in putting airs and pumps before heirs and graces.[82]

It does not, of course, follow that because a plethora of value systems may have sustained interest in applied science a particular set was not important in an individual case, but it must make it more difficult to *test* the alleged correlation. The difficulty if further compounded if one is bent on talking about motivation and not merely sanction. It is interesting that Merton could claim that his thesis did not require any discussion of motivation;[83] yet at the same time he would freely use the word twice in one sentence:

> Expressing his motives, anticipating possible objections, facing actual censure, the scientist found motive, sanction and authority alike in the Puritan teachings.[84]

Where such a conern with motivation is retained, a second set of problems must be taken into account.

Given a set of correlates within a type, additional problems surely arise as soon as one tries to establish either temporal or logical priority of one over another. This particular hazard was recognized by Merton who insisted that his thesis was not about historical factors but about historical interdependence. And to locate the arrow of dependence was virtually impossible. In 1970 he raised the difficulty in this form:

> To what extent did the old Puritans turn their attention to science (and, for that matter to commercial and industrial activity) because this interest was generated by their ethos, and to what extent was it rather the other way, with those having entered upon a career in science ... subsequently finding the values of Puritanism congenial to them?[85]

His answer in 1970 was that both processes were at work to an unknown extent. This was perhaps a little more agnostic than in 1938 when he had written:

> The values implicit in these doctrines which struck the deepest roots in English life were those congenial to tendencies developing *independently* in other compartments of culture, and, in this way, Puritanism was integrated with many cultural trends which were in their incipiency.[86]

Hence the problem: the notion of independence has crept into a thesis ostensibly about interdependence. How then may an alleged interdependence be tested?

This difficulty with the testing of Merton's thesis has been exposed by Arnold Thackray in his discussion of the Manchester Literary and Philosophical Society. One senses that Thackray was inclined to accept stereotypes that could be derived from Merton. Thus the Unitarian chapel in Cross Street, Manchester, is described as the cathedral of arriviste manufacturers, merchants and medical men who took up science as a form of cultural expression.[87] It is emphasised that the three prime activists in the early years of the Society were Unitarians (though it might be added that each was also called Thomas).[88] It is also emphasised that six Unitarian families were particularly prominent in the history of the Society. Nevertheless, is it not possible that the religious values of Rational Dissent and an interest in science, instead of being interdependent variables, were separate variables, each dependent upon ulterior forces? This is, of course, the line that Thackray took, offering it as a criticism of the Merton model.[89] The ulterior forces were subsumed under the various heads of population growth, increase in wealth, social and geographical isolation, a zest for political reform, and increase in the seamier side of an expanding city which, in turn, would elicit moral imperatives.

Since Thackray was able to list no less than seven motivations or justifications for an interest in science, of which only one was theological edification (and that common to pretty well all theological traditions), the effect was to denude correlation of the Merton type of any doctrinal substance. This might be seen as an extension of a tradition of criticism in which even those sympathetic to Merton's cause have sometimes placed themselves. It is striking, for example, that in his high estimate of the Protestant Reformation in the promotion of modern science, R. Hooykaas was prepared to say that the doctrine of the priesthood of all believers was probably the only specifically Protestant *doctrine* to have a bearing on the issue.[90]

The problem, then, is that any connections made between the correlates within the type may be epiphenomenal. If they are not, how can one show that they are not? Priestley's entry into science illustrates the problem rather well. There is no doubt that he saw congruence between values appropriate both to science and to Rational Dissent. Religion and science, in their different ways, were antidotes against those vices which Boyle had captured with his reference to "bags, bottles and mistresses", and Thomas Henry to the gaming table, the tavern and the brothel. But how did one get from one to the other - from the religion to the science, that is? In Priestley's case the religion came first, temporally, but did it push him into scientific enquiry? Might it not be nearer to the mark to suggest, as Crosland has, that Priestley's principal object was to boost his income by writing on science - histories of science in the first instance, but with an increasing reference to his own experiments?[91] His entry into the gaseous state would then be explained by the relative cheapness of the apparatus required. And if one asks whence he derived his Baconian interest in applied science, the problem becomes even more acute. Here one can make the case that the ethos of the dissenting academies predisposed him to look favourably on a marriage between science and industry. The trustees of the Warrington Academy, where Priestley began his teaching, had recently defined the object of science teaching so as to emphasise "the more important processes in chemistry, especially that part of it which has a connection with our manufactures and commerce .."[92] Did something of this rub on to the young tutor in languages and *belles lettres*?

The difficulty, according to one historian of the dissenting academies, is that although there was plenty in Priestley's educational background to dispose him towards an interest in science, there was little or nothing to point him in the direction his scientific interests actually took.[93] As a student at the Daventry

DISQUISITIONS

RELATING TO

MATTER AND SPIRIT.

TO WHICH IS ADDED,

The History of the Philosophical Doctrine concerning the Origin of the Soul, and the Nature of Matter; with its Influence on Christianity, especially with Respect to the Doctrine of the Pre-existence of Christ.

By JOSEPH PRIESTLEY, LL.D.F.R.S.

Si quelqu'un demontreroit jamais, qu *l'áme eſt materielle*, loin de s'en alarmer, il faudroit admirer la puiſſance, qui auroit donné a la matiere la capacité de penſer. .

BONNETT. *Palingeneſie.* Vol. I, p. 50.

LONDON:

PRINTED FOR J. JOHNSON, No. 72, ST. PAUL'S CHURCH-YARD. 1777.

Fig 4 Priestley's *Disquisitions Relating to Matter and Spirit* (1777).

Academy he would have encountered the association between science and natural theology but the utility of applied science would have been a less prominent motif. If Priestly's induction into practical chemistry was via the lectures and demonstrations of Matthew Turner, who lectured at Warrington between 1763 and 1765, there is a certain irony.[94] Turner made connections between chemistry and commerce, but he appears to have been notable as an atheist.[95] As for other origins of Priestley's interest in utilitarian science, there is a case for saying that it was through salt that he came to Bacon. Whilst at Nantwich he appears to have taken an interest in the local manufacture of Cheshire salt and, according to one biographer, probably came across William Brownrigg's *The art of making common salt* (1748) - a book with a Baconian preface, extolling a knowledge of the mechanic arts for the relief of man's estate.[96] One point is abundantly clear. It would be difficult to see in ascetic Calvinism the spur to Priestley's science when he had already been dismantling the doctrinal edifice of Calvanism brick by brick.[97] The general difficulty is perhaps best symbolised by a remark made, later in life, when he was addressing Edmund Burke. Priestley's "social millennium" was going to be brought about by "the influence of the commercial spirit *aided* by Christianity and true philsophy"[98] - not, it should be noted, by Christianity and true philosophy aided by the commercial spirit.

The difficulty in establishing correspondence rules for linking correlates within the type does not disqualify the attempt to trace the connections which Priestley made to confer consistency on his metaphysics. The considerations above are not intended as a critique of the style of analysis offered by John McEvoy, whose reconstruction of Priestley's philosophical writings shows how, in matters of ontology and epistemology, it would be extremely difficult to disentangle the religious from other threads of argument. McEvoy has, in any case, renounced the claim that the problems, concepts and techniques that concerned Priestley as natural philosopher were derived from his metaphysics.[99] The difficulty nevertheless remains. In extending Merton's conception of motivation to embrace Priestley's scientific activity the problem of proof is writ large.

There is the further and predictable problem: to what extent can one allow divergence from the type before conceding that it has failed in a particular case? The assimilation of Priestley and Whewell to their respective types was accomplished with relative ease. But it has to be confessed that it was altogether too slick. In the first place there were marked similarities between them which a preoccupation with the types would probably obscure. There is first the question of whether their ideas on the application of science were so very different. In Thackray's account of Mancunian science, Priestley is taken as the symbol of a particular attitude towards experimental philosophy and progressive culture. Nevertheless, the science of the Literary and Philosophical Society is still presented with the accent on cultural expression rather than on utility in a narrow technological sense. Thackray accordingly complains that "the interaction between science and technology within the Society's walls has assumed for historian commentators a degree and kind of importance it never possessed for contemporaries whether manufacturers or men of science".[100] In the case of Priestley himself there is surely irony in that his very own application of science (his carbonated water) was based on virtually no science - as he freely and somewhat embarrassingly confessed - whilst as a preventive remedy for scurvy it was an abject failure.[101] The episode serves as a reminder that what Priestley's contemporary Thomas Barnes called the "happy art of connecting together liberal science and commercial industry" has been one of the great *elusives*, so diverse in its manifestations that it can scarcely be codified into a type.

And what of Whewell? Was the archetypal Oxbridge philosopher so blind to the practical application of theoretical science? Almost certainly not. It was just that Cambridge was not the place for the dissemination of such information. His point was that "practical knowledge", such as civil engineering, arts and trades, "must be learned, as in fact they are learned, among professional men and practical applications".[102] For Whewell, knowledge of the practical application of science was on a par with, not inferior to, a knowledge of the higher physical sciences: "if they are wished for as information, they stand on the same ground as the higher physical sciences".[103] Nor should it be forgotten that Whewell's campaigning to relate professorial lectures more closely to undergraduate examinations helped to pave the way for Robert Willis to lecture on "Mechanics and Mechanism and their application to manufacturing processes, the steam engine etc."[104] It was, moreover, one of the hallmarks of Whewell's instruction in mechanics that the principles were to be mastered by reference to down-to-earth applications.[105] He was neither blind nor averse to the practical application of science. It was simply that such knowledge could not constitute a liberal education. And if he underplayed the association between pure and applied science, he may well have had diplomatic reasons for so doing. As Eric Ashby pointed out, the too ready association of science with utility created an obstacle for those, like Whewell, who sought to bring science into the curriculum:

> One unhappy consequence of [a] narrowly pragmatic attitude to science was that scientific education tended to be regarded as more suitable for artisans and the lower middle classes than for the governing classes.[106]

To have dwelled on pragmatism rather than edification would have been to lose the case. We should not have an image of Whewell as a boffin unconcerned with the measurement of the real world. He was not above devising a piece of apparatus even if it was only a self-registering anemometer.[107] Still "threshing away at the tides" in April 1838, he expected to show "how each year's observations may ... add something to the accuracy of the existing tide tables of the place where they are made".[108] That being so, it appeared to him that government did, after all, have a responsibility in the matter. It was the "business of all civilized.

governments to maintain tide observatories and tide calculators, just as much as observatories and calculators whose work appears in any other page of the *Nautical Almanac*".[109] Useful science required the highest patronage.

When assimilating Priestley and Whewell to their respective types, it was easy to contrast Whewell's philosophical idealism with the factoidal mentality of Priestley. But it was never that simple. As both McEvoy and Schofield have said, there are pronounced idealist elements in Priestley's epistemology.[110] In fact, Priestley's reason for preferring histories of science to civil and political histories was that they revealed the integrated relationship between the human mind and a knowable natural world.[111] In Priestley, as in Whewell, it was the constructive interaction between the mind and the natural world which provided compelling evidence of a predetermined design. Similarly, as Butts has shown, there were strong realist elements in Whewell's philosophy of science.[112] Experiment was just as vital for Whewell as for Priestley - not least because he was deliberately distancing himself from the *a priorism* of German Naturphilosophie which, in its sillier manifestations, stood as a warning against ambitious claims for the anticipation of nature.[113] Whilst it is true that Whewell, more than Priestley, developed the notion that scientific reasoning was regulated by ideas that were not themselves derivable from experience, he showed the same concern as Priestley for the discovery of truth. In the unfolding and refining of ideas experimental enquiry was crucial. Whewell's concern for a convergence towards the truth about nature is nicely illustrated by his tacit distinction between *real* history of science and *mere* history of science. Real history of science documented the experimental articulation and refinement of hypotheses which converged on the truth. Mere history of science was the category into which one put erroneous speculations, such as those of the Greek atomists.[114] The notion that Whewell's idealism betrays a fear of novelty will not stand up to serious examination. Much of his *History* is a paeon to scientific originality. It was other English writers, Whewell complained, who were denuding innovations of their novelty. That was precisely his reason for bringing Priestley into play. If Lavoisier's ideas had been so obvious why had Priestley rejected them?[115] To the objection that Newton's discoveries were not original because they were contained in those of Kepler, Whewell had an immediate reply: "They were so, but they needed a Newton to find them .."[116]

Whewell's rejection of both Greek and Daltonian atoms draws attention to a further similarity which a preoccupation with types might obscure. In the sphere of ontology Whewell's arguments against indivisible and impenetrable atoms were essentially those of Priestley.[117] Despite the obvious contrast between dualism and monism, Whewell's theory of matter stands in the dynamic tradition which one can trace, with variation, though Boscovich, Priestley, Davy and Faraday - the last being Whewell's mentor on the subject.[118] Whewell believed that the idea of polarity was more fundamental than the idea of atoms. Priestley would have agreed.

Appearances notwithstanding, their respective theologies of nature were a good deal closer than a simple contrast between voluntarism and determinism would imply. Admittedly, part of Priestley's rebellion against Calvinism consisted in a rejection of an arbitrary will unleashed on the world. But his discussion of causality still presupposed a divine will acting through predetermined mechanisms. McEvoy is correct to reveal Priestley's God as "subject to a moral necessity and to the Perfection of his Nature".[119] But at the same time he reveals a Priestley who could claim that "no powers of nature can take place" and "no creature whatever can exist, without the Divine agency; so that we can no more *continue*, than we could *begin* to exist without the Divine will".[120] In that remark, and in Priestley's assumption that God could change or suspend His laws there is at the very least an overlap with the voluntarism of a Boyle or a Whewell. Indeed, it was one of Priestley's objects to show that God was more in control of everything on *his* system than on a crude interventionist model which implied that God was not in control when He was not interfering.[121] As far as divine control was concerned there was very little difference between Whewell's voluntarism and Priestley's monotheistic determinism. In their approach to natural theology there is also a striking resemblance. As Simon Schaffer has indicated, it was a distinctive move on Priestley's part to ground the arguments for God's power and wisdom in a system of relationships *between* the powers and forces of nature, rather than in the spectacular effects of individual forces.[122] Whewell may have operated at a higher level of abstraction, but, in a letter to Babbage, the same emphasis on the system and its interconnections may be discerned:

> The strongest arguments borrowed from the sciences in support of religion, appear to me to be, not those borrowed from any specific analogies of numerical or other mathematical laws, but those founded on considering how various are the *kinds* of law, and yet how *connected* these kinds all are ;- and how physical connexions graduate into physiological; and these into moral relations :- to that the existence of a purpose in man's moral faculties, is as certain as in his bodily organs, and final causes part of the same scheme as physical causes.[123]

Doubtless other similarities could be found which cut across the types, but, before leaving the issue of conformity, there is the more substantial problem arising from deviancy. To typecast Whewell as an Oxbridge conservative violates his perception of himself as a reformer, even a reformer for the people. When he wrote of his review of Herschel's philosophy of science that it was "as good an attempt as I could make to get the people into a right way of thinking about induction" it was "*the people*" he underlined.[124] As a reformer of Cambridge mathematics and as campaigner for the natural sciences he cannot be presented as typically conservative. The gist of the problem then becomes obvious: how can the archetypes cope with conservative reform?

I shall return to this point, but it should be noted that deviation from type, in Whewell's case, extends also to

the question of class. It has been tempting to correlate idealist philosophies of nature with aristocratic Oxbridge science; and it is true, of course, that Whewell spiralled upwards through his Cambridge career. But to be born in a back street of Lancaster to a master-carpenter is hardly an aristocratic beginning. And much the same applies to Whewell's schoolboy contemporary and biological idealist, Richard Owen, who also hailed from Lancaster.[125] There was poignancy in the occasion when Whewell married into the flax-spinning Marshall family, which had once been associated with Priestley's unitarian chapel in Leeds.[126] He was too embarrassed by his own family to have them to the wedding. He found himself writing the kind of invitation which implied that they were welcome to come as long as they didn't show up.[127]

It has been tempting for historians to follow the generation after Whewell in dismissing him as one who had doubtless read the *preface* to a good many books. He has symbolised the superficiality of Oxbridge science. But his omniscience was not all foible, his eclecticism not entirely parasitic. In his writings on chemistry, for example, he saw the need for more interaction between chemistry and crystallography for insight into chemical structure.[128] This programme eventually prospered in France, culminating with the work of Pasteur.[129] Such inter-disciplinary insights have often been denied to the narrow specialist. There was nothing superficial in Whewell's attempt to relate his methodology to the practice of science. In its critical aspect it informed his searching comments on Lyell's uniformitarianism[130] In its constructive aspect it could provide procedural guidelines for the elevation of a rudimentary science, such as geological dynamics, onto a more rigorous level. As Crosbie Smith has recently suggested, Whewell's insistence on a phenomenological geology as a prerequisite of geological dynamics, and the latter as a prerequisite of historical causal reconstruction, was actually reflected in the physical geology of William Hopkins who sought to bring mathematical models to bear on the elevation of the Earth's crust.[131]

What emerges in the case of both Whewell and Priestley is a good deal of idiosyncrasy. Whewell was explicit in saying that his philosophy was taking him where he expected no-one to follow.[132] To reduce him to type is to caricature him. His attack on a plurality of worlds was generally perceived as eccentric. Contemporaries saw a quixotic don turned cosmic Don Quixote.[133] Priestley, too, had in many respects been a law unto himself, departing from friends as close as Richard Price in his monism and his quasi-chemical account of the resurrection.[134] In his theology Priestley did not conform to non-conformity - whether one looks at his historical critique of Christian creeds or his unpopular defence of toleration for Roman Catholics. [135] It was a charge levelled against him from early in his career that he had been too severe, and insensitively so, on his fellow Dissenters.[136]

Where idiosyncrasy rules, one begins to wonder whether the archetypes have any value at all, or whether one should not look to some meta-level thesis concerning a correlation between interest in science and deviancy - a deviancy from the religious tradition in which the scientific apologist had been nurtured. That would be a weak thesis, but it may be better to be weak and right than strong and wrong. It is not without interest that in his attempt to retrieve Merton's thesis from the historians, Abraham has rekindled it as a meta-thesis in which the spirit of intramundane asceticism is distilled out of a range of Protestant positions, which Merton had found it unnecessary to delineate. On this view what the historians have objected to in Merton - an excessively blunt use of the term 'puritan' - turns out to be the very respect in which the thesis allegedly has strength. Merton's main claim, according to Abraham, was that "Protestant asceticism was a style of behaviour that transcended Protestant orthodoxy and that it became an effective force for the institutionalization of 'science as a value' only when the ideal of ascetic manner became generalized beyond particularistic religious roots".[137]

To switch to such a meta-thesis does not really resolve the problems of testability because meta-theses, in their very nature, are more difficult to falsify than lower-level correlations. It may be appropriate here to return to the problem of the conservative reformer which is writ large in Whewell's case. Here the testability problem is exposed in its most glaring form. Where one has an exemplar of a 'mixed' type, as it were, do the conservative elements vindicate the type irrespective of the radical elements? Or do the radical elements vitiate the type despite the conservative hue? It is an old point but terms like 'progressive', 'radical', 'conservative', 'reactionary' and their many correlates look too rigid even to accommodate such archetypal figures as Priestley and Whewell. Schaffer has made it plain that Priestley could be read in different ways in the late eighteenth century, his writings on science providing a resource for radicals such as Erasmus Darwin and Thomas Beddoes, but also, via their natural theology, a resource for more conventional objectives.[138] The over rigidity of the types is nicely exposed by such inter-textual analysis, although still in the interpretation of the results of such analysis, the tendency remains to lay out the various responses along a radical/conservative axis.

Three of Whewell's campaigns help to illuminate the problem: his efforts in the direction of a natural sciences tripos; his reforms in the teaching of mathematics; and - on a more metaphysical plane - his reform of the cosmos. Whewell's advocacy of the natural sciences usually marks him out as a reformer in the Cambridge of the 1840s. On closer examination, a certain ambivalence comes to the surface. He could recommend that the sciences were only to be taught at the later stage of a university career. In fact, during the first ten years or so of its existence, the natural sciences tripos could only be taken by students who already had a degree.[139] A more interesting ambivalence may be seen in Whewell's recommendations concerning the mode of science teaching. Having insisted on a distinction between the practical and speculative modes of teaching - the former requiring the active participation of the student, the latter referring to the passive assimilation of the lecturer's opinions - Whewell promptly placed the teaching of science where he should not expect to find it: in the speculative, not the

practical mode. His reasoning was that a science such as geology was still too immature a discipline to be learned in any other way. Even with the physical sciences, there was "no room for acquiring habits of interpretation which could be tested by the teacher".[140] In Whewell's reforms one sees the qualifications as clearly as the innovations. Sometimes this could generate tension between different lines of arguments. To emphasise the primacy of mathematics in a liberal education, he resorted to the historical thesis that the progress of the sciences, seen as a touchstone of civilization, had been dependent on a recognition of the value of mathematics.[141] In the absence of such recognition, the sciences had invariably ground to a halt. And yet, what he wrote of the sciences themselves seemed to disqualify them from being a touchstone of civilization. After all they conveyed information more than culture.

As for the reform of Cambridge mathematics, it is again impossible to slot Whewell's achievement into a neatly labelled compartment. His introduction of continental mechanics has traditionally and rightly been seen as a contribution to the 'analytic revolution'. Yet, as Becher has shown, there was an important respect in which he was a counter-revolutionary:

> In the 1830s he urged the continued expansion of applied mathematics in the curriculum, but he became convinced that the concomitant expansion of analysis, especially pure analysis, threatened to destroy the foundations of a liberal education.[142]

In Becher's evaluation, Whewell was a limited reformer who attempted a 'compromise' by grafting analytic mathematics onto specific physical problems rooted in the intuitive. If the French mathematicians had shown what Whewell described as a "disrelish for the more physical", he insisted that the student should be grounded in the real world of pulleys, machines and forces. It was part of Whewell's programme, Becher concludes, "to prevent the establishment of the study of abstract analysis as a discipline independent of, and as prestigious as, mixed mathematics".[143] It appears that, in the last analysis, the only form of pure mathematics he found truly satisfying was Euclidean geometry. In his own work on the tides he used the equilibrium theory of the eighteenth century rather than the dynamic theory of Laplace. Nor was his counter-revolution without success. A Grace of 1846 eventually helped to remedy what Whewell had seen as an unwarranted neglect of Newton. In short Whewell was both reformer and conservative. The failure of the archetypes is nowhere more sharply thrown into relief than by his insistence on *applications* which, in a scientific context, might mark him as a 'radical' (judged by Cambridge standards), but which in a mathematical context is the very posture which marks him a 'conservative'. Those historians of Cambridge who have structured their discussion of University reform around the twin poles of progressivism and anachronism have still to learn, as Becher himself observes, that Whewell doesn't fit.[144]

The rigidity of the types is also exposed by Whewell's reform of the cosmos. His extermination of other worlds had both reforming and conservative aspects. It was radical in at least three respects. To deny a plurality of worlds was to challenge a popular dogma which had enjoyed the sanction of natural theology. What, after all, was the point of other suns if they did not shine on other worlds? In the second place, in his efforts to make planets uninhabitable, he had them made out of nebular material in a manner which, to some critics, smacked of a dangerous commitment to the nebular hypothesis of Laplace. Thirdly, he was obliged to develop the disconcerting thesis that the existence of waste in nature was not incompatible with design. And yet, underlying the radical thrust, was a deep concern to protect an incarnational theology and the uniqueness of the human intellect. Whewell's debate with Brewster bears investigation precisely because it defies categorisation according to type. Superficially at least, Whewell the *liberal* Anglican took the more conservative doctrinal stand than Brewster the Scottish evangelical. In an amusing breakdown of communication each could accuse the other of supporting the (truly radical?) thesis of *Vestiges* when it was an unmistakable object of both to unhinge it.[145]

If the fundamental defect of the types is that they tend to be too rigid to provide a grip on historical change, the above examples also underline the central problem of testability. Do the convervative elements corroborate the type? Or does the sheer complexity not destroy its value altogether? With these questions still in mind there is one last difficulty worth exploring. There is a further problem of testing which arises from a series of pressure that tend, over a period of time, to conceal or smother what may have been (or may not) a real impulse derived from religious values. A *locus classicus* for this particular problem would be Charles Webster's review of the origins of the Royal Society.[146] On Webster's interpretation, Margery Purver had been misled by Sprat's latitudinarian façade for the Society - misled into discounting a Puritan impulse in the period prior to the Restoration. Sprat was under new social and political pressures to play down the Puritan element in what had been the active nucleus of the proto-Society. It is the latitudinarian façade which creates the problem - whether, for example, it is merely a façade or whether it is possible to erect an alternative typology in which religious *moderation* correlates with an interest in science. Developing the latter possibility, Barbara Shapiro has insisted that there are sound epistemological reasons why a scientific mentality would be congruous with a certain distancing of oneself from contentious religious doctrines.[147] But this does little to remove the problem of testing the correlation since, by the standards of the many religious extremists diversifying during the interregnum, almost any intellectual involved with science is bound to appear a moderate.

At least three pressures seem to have recurred in this smothering process. There are the cognitive pressures towards the establishment of value-free knowledge, which can be tested independently of the motivation of those who undertook the enquiry in the first place - a process which usually, if not immediately, leads to the elimination of any quirkiness in the content of the science. There are also pressures of action and reaction within the dynamics of political history - a fact of which Priestley was acutely aware, both in his reconstruction

of history and in his political comment. The more grasping the Anglican clergy became in their extraction of tithes, the more certainly were they digging their own grave.[148] When the action involved the execution of a king (whether English or French) the reaction could dramatically change perceptions.[149] The effect of this process on English science in the seventeenth century has been discussed by Rattansi[150] and the Jacobs[151]. The argument is that a 'mechanical philosophy' gained ground among scientific and religious apologists partly at least because it could be used as a stick to beat religious extremists who acknowledge no authority but private illumination. Similarly, in the reaction to the French Revolution in an England which Priestley found increasingly inhospitable, there were new pressures to dissociate science from any radical religious impulse it may have had. The third kind of pressure stems from a different pragmatism. When new scientific institutions have come into being, the necessity that the 'church scientific' should be a broad church has often encouraged the projection of an image in which the broad church ceases to be a metaphor. Recent work on the early British Association has stressed the same need for an eclectic façade and the value of natural theology as a mediating agent between science and its public, and between different religious traditions.[152] Rhetorical claims for a unique 'scientific method' could also be a response to the same pressures for a unified image,[153] with the interesting result that Whewell's fine distinctions between the methodological requirements of different sciences could themselves be smothered.[154]

The problem is simply this: how can one test a correlation of the Merton style when the grounds on which the correlation is affirmed are, through normal historical processes, shifting or being overlaid by the pressures for value-neutrality? And does convergence towards value-neutrality allow the erection of an alternative type whereby science becomes an analgesic against the pain of religious disputation? This last question has a certain topicality in the context of Priestley scholarship since Crosland appears to have applied the alternative type to a study of the origins of Priestley's interest in science. On Crosland's interpretation, Priestley found in science a haven, a retreat from the anguish of religious polemics.[155] The smothering process had, as it were, begun with Priestley himself. For Crosland there is no positive correlation between Priestley's science and his religious beliefs. Or, if there is, it operates by default. Given that Priestley was casting around for subjects to teach, options other than science were debarred because of his religious radicalism.[156] Even on this interpretation, however, the problem of testability remains. Crosland makes a point of saying that "my thesis about Priestley using the supposed neutrality of science is not invalidated at all by the fact that, after only a short interval, he launched himself back into the fray more vigorously than ever".[157] One cannot refrain from asking how short the interval would have to be to invalidate the thesis? I should also like to raise the question whether the following considerations would count against it. Priestley gives us little evidence that he wished to avoid theological disputation and that he therefore looked to science for solace. "On no former occasion",he wrote in the 1780s, "have I declined, but on the contrary I have rather courted, and provoked opposition, because I am sensible it is the only method of discovering truth .."[158] Moreover, one rarely gets the impression that Priestley lacked the theological resources to cope with his opposition - partly, of course, because he could always explain why his orthodox opponents took the corrupt line they did. Crosland's analysis suggests a difference in kind between scientific and religious reasoning; but it is not clear that for Priestley they were so dissimilar. In science, as in religion, one sought to persuade by argument rather than silence by power.[159] Nor did he pretend that scientific and religious discourse were disconnected. It comes from late in his life, it is true, but there is a telling letter to Theophilus Lindsey where he writes:

> The view of the creation and the connection of its parts must convince any attentive person of the folly of Arianism. No Being but he that planned and executed the whole could execute or superintend any part of the system.[160]

In the contemplation of nature, as decoded by science, there was an argument for the superiority of Socinianism over Arianism. From such a perspective, science was a way into theological controversy not an exit. In the early 1770s, as he had been completing his history of discoveries relating to vision, light and colours, he had written to Lindsey:

> I am fully convinced that, if I would make anything of my *philosophical work*, I must make the word believe what is by no means true, that I mind nothing else. But there are many ways of imposing upon the world, as well of being imposed upon by it.[161]

It may perhaps be inferred that Priestley might have deluded us into thinking that his excursion into science and its history was more important to him, or more independent, than it was. To see it even as a haven may be to exaggerate its significance. In the critical year of 1771, he had no compunction in saying that his favourite employment was as a minister.[162] One wonders too whether he could have been as naive as to suppose that science would constitute a haven. He seems to have shared with James Keir the view that "the more we discover of nature, the further we are removed from the conceit of our being able to understand her operations" - a view which left plenty of room for controversy.[163] If Crosland is correct there is heavy irony in that Priestley's excursion into science and metaphysics brought him little relief, as his altercation with the Catholic Boscovich shows.[164] Even heavier is the irony that he was eventually forced to conclude.

> Bigotry is not confined to theology. It seems to be as conspicuous among philosophers, who disclaim every thing of the kind.[165]

Disclaimers notwithstanding, if science were a haven it was one that had proved a delusion.

There is an exasperating anachronism about this paper, but in one respect the smothering process spanned the years that separated Priestley's histories from Whewell's. At the first meeting of the British Association, in 1831, Whewell was absent - but not so

Priestley! On the Wednesday morning of the York meeting, Priestley made his phantom appearance.

An essay by William Henry was read, having as its title "An estimate of the philosophical character of Dr. Priestley". It was an estimate that rehabilitated him, that took the sting out of his radical reputation. Expatiating on Priestley's discoveries, Henry surmised that their author "must have been furnished by nature with intellectual endowments, far surpassing the common average of human endowments"[166] - an estimate perfectly out of key with Priestley's egalitarian inductivism. The rehabilitation was not without its critical observations or without a critical reception. Luke Howard protested that one should not so readily whitewash Priestley's political and religious intentions.[167] Nevertheless, in Henry's account, Priestley emerged as a comfortable hero:

> Even in these few examples, his errors may be traced to causes connected with the actual condition of science at the time .. but never to carelessness of inquiry or negligence of truth.[168]

In Priestley's life, Henry proclaimed, the purest morals had been connected with the highest philosophy. The rehabilitation was then nicely sealed with the stamp of natural theology: "He has enforced, with warm and impressive eloquence, the considerations that flow from the contemplation of those arrangements ... which are not only perfect in themselves but are essential parts of one grand and harmonious design".[169] Whewell and this new, anodyne Priestley were contemporaries after all.

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102 Whewell, op. cit., note 49 above, pp. 45-46.

103 Ibid., p.46.

104 T.J.N. Hilken, *Engineering at Cambridge University 1783-1965*, Cambridge, Cambridge University Press, 1967, p.54.

105 Harvey W. Becher, 'William Whewell and Cambridge mathematics', *Historical Studies in the Physical Sciences*, 1980, *11*: 1-48, p.15 and passim.

106 Eric Ashby, *Technology and the academics*, London, Macmillan, 1959, p.31.

107 Walter F. Cannon, 'Whewell's contributions to science and learning', *Notes and Records of the Royal Society*, 1964, *19*: 176-191, pp.179-183.

108 Whewell to J.D. Forbes, 2 April 1838, in Todhunter, op. cit., note 25 above, vol. 2, p.269.

109 Ibid.

110 McEvoy, op. cit., note 26 above, p.5.; Robert E. Schofield, 'The professional work of an amateur chemist' in Proceedings, op. cit., note 18 above, pp.410-431. Schofield writes that Priestley's philosophy of science "more nearly approaches the idealist philosophy of Immanuel Kant than any other Briton was to achieve during the eighteenth century."(p.324).

111 McEvoy, ibid., p.5.

112 Butts, op. cit., note 18 above, p.179.

113 Whewell, note 49 above, p.25. Thus he would insist that the forces which really exist in nature could not be deduced from a bare idea of polarity and from convictions respecting the connection of polarities. Hegel and Schelling were frequently accused of vagueness, ambiguity, and a failure to recognise the need for precision experiments. There was a fear among some of his Cambridge colleagues that the metaphysical cast of his mind might make him an easy victim of the German metaphysicians. But writing from Nuremberg to his old friend Richard

Jones, he reported that such a fear was groundless: "I believe I go among them pretty well secured by a previous resolution not to adopt any of their fancies ... I separate more and more from them as I go along". Whewell to Rev. R. Jones, 14 July 1839, in Todhunter, op. cit., note 25 above, vol.2, pp.280-281.

114 Whewell, op. cit., note 31 above, vol. 1, p.427.

115 Whewell, op. cit., note 30 above, p.119.

116 Ibid.

117 Joseph Priestley, *Disquisitions relating to matter and spirit*, London, 1777, Section 1, chs. 1 and 2; Whewell, op. cit., note 31 above, vol.1, pp. 432-433.

118 Whewell was particularly impressed by the manner in which Faraday, by appealing to axes of power, was able to dispense with particles altogether; Whewell, op. cit., note 31 above, vol.1, pp.354-355.
There was reciprocal interaction between Whewell and Faraday, the latter consulting the former not only on matters of terminology but also for mathematical advice. Their correspondence is accessible in L. Pearce Williams, *The selected correspondence of Michael Faraday*, Cambridge, Cambridge University Press, 2 vols., 1971.

119 McEvoy, this volume.

120 Ibid.

121 For Priestley, the exclusion of miraculous interposition was not inconsistent with belief in particular providence. He saw it as one of the advantages of his necessitarianism that it permitted the integration of general and particular providence: "whether those coincidences, which are ascribed to a particular providence, be brought about just at the time of the respective events, or were originally provided for in the general plan, the design is the very same". Priestley, op. cit., note 63 above, p.vi. Similarly he could argue that his philosophical monism was *less* materialistic than the common doctrines of dualism. God's power "is the very life and soul of everything that exists; and strictly speaking, without him, we are, as well as can do nothing. But exclude the idea of Deity on the common hypothesis, and the idea of solid matter is no more excluded than that of space". See McEvoy and McGuire, op.cit., note 18 above. p.336.

122 Schaffer, this volume.

123 Whewell to Babbage, 30 May 1837, Whewell papers, Trinity College Cambridge, 266 c 80 149 16.

124 Whewell to Rev. R. Jones, February 1831, in Todhunter, op. cit., note 25 above, vol. 2, p. 115.

125 John H. Brooke, 'Middle positions', *London Review of Books*, 1983, *5* no. 13: 11-12.

126 Thackray, op. cit., note 7 above. p.705.

127 W.G. Rimmer, *Marshalls of Leeds, Flax-spinners 1788-1886*, Cambridge, Cambridge University Press, 1960, p.223.

128 Whewell, op. cit., note 31 above, vol.1, p.459.

129 Seymour H. Mauskopf, 'Crystals and compounds: molecular structure and compositon in 19th-century French science', *Trans. Am. Phil. Soc.*, 1976, *66* part 3: 1-82, pp.6-7 and passim.

130 William Whewell, Review of vol.1 of Charles Lyell's *Principles of geology*, *British Critic*, 1831, *17*: 180-206.

131 Crosbie Smith, 'Geologists and mathematicians: the rise of physical geology', in Peter M. Harman (ed.) *Wranglers and Physicists*, Manchester, Manchester University Press, 1985.

132 Whewell to Archdeacon Hare, 7 January 1838, in Todhunter, op. cit., note 25 above, vol. 2, p.267.

133 Samuel Warren, 'Speculators among the stars', *Blackwood's Magazine*, 1854, *76*: 288-300 and 371-403, p.380.

134 Joseph Priestley and Richard Price, *A free discussion of the doctrines of materialism and philosophical necessity in a correspondence between Dr. Price and Dr. Priestley*, London, 1778, pp.19,20,23,36, 30-40, 73.

135 Martin Fitzpatrick, 'Joseph Priestley and the cause of universal toleration', *The Price-Priestley Newsletter*, 1977, *1*: 3-21.

136 J. MacGowan, *Familiar epistles to the Rev. Dr. Priestley*, London, 1771, p.12.

137 Abraham, op. cit., note 1 above, p.383.

138 Schaffer, this volume.

139 Whewell, op. cit., note 49 above, pp.42-44; Gerrylynn K. Roberts, 'The liberally-educated chemist: chemistry in the Cambridge natural sciences tripos, 1851-1914' *Hist. Stud. Phys. Sci.*, 1980, *11*: 157-183, p.159.

140 Whewell, ibid., pp.5-7, 9.

141 Ibid., pp.20-25.

142 Becher, op. cit., note 105 above, p.3.

143 Ibid., p.19.

144 Ibid., pp.47-48.

145 For further elaboration of points in this paragraph, see Brooke, op. cit., note 18 above (1977).

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147 Barbara J. Shapiro, 'Latitudinarianism and science in 17th-century England', *Past and Present*, 1968, *40*: 16-41.

148 Priestley, op. cit., note 72 above, p.xiv.

149 Porter, op. cit., note 82 above p.372.

150 P.M. Rattansi, 'The social interpretation of seventeenth century science', in Peter Mathias (ed.), *Science and Society 1600-1900*, Cambridge, Cambridge University Press, 1972, 1-32, pp.21-24.

151 Jacob and Jacob, op. cit., note 80 above.

152 Jack Morrell and Arnold Thackray, *Gentlement of Science*, Oxford, Clarendon Press, 1981, pp.224-245. John H. Brooke, 'The natural theology of the geologists: some theological strata', in Ludmilla Jordanova and Roy Porter (eds.), *Images of the Earth*, Chalfont St. Giles, British Society for the History of Science, 1979, 39-64

153 Yeo, op. cit., note 38 above, pp.15-20.

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155 Crosland, op. cit., note 24 above, pp.227-230.

156 Ibid., p.226.

157 Ibid., p.230.

158 Quoted by Gibbs, op. cit., note 41 above, p.174. For a similar rejection of this aspect of Crosland's interpretation, see Simon Schaffer, 'Priestley's questions', *Hist. Sci.*, 1984, *22*: 151-183, p.158.

159 See the letter from Priestley to the French chemists, 15 June 1796, in Schofield, op. cit., note 21 above. p.289.

160 Priestley to Theophilus Lindsey, 2 October 1801, in ibid., p.311.

161 Priestley to Theophilus Lindsey, 23 December 1770, in ibid., p.82.

162 Priestley to Richard Price, 5 December 1771, in ibid., p.96.

163 James Keir to Priestley, undated, in ibid., p.252. Priestley himself conceded that in scientific activity "we cannot solve one doubt without creating several new ones". See McEvoy and McGuire, op. cit., note 18 above, p. 347.

164 Schofield, op. cit., note 21 above, pp. 166-171.

165 Priestley to William Morgan, 23 October 1802, in ibid., p.316.

166 William Henry, 'An estimate of the philosophical character of Dr. Priestley', First Report of the British Association for the Advancement of Science, London 1831-2, 60-69, p.63.

167 Morrell and Thackray, op. cit., note 152 above, p.229.

168 Henry, op. cit., note 166 above, p.67.

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ATTIC MISCELLANY.

Political Portraiture N.º 4.

DOCTER PHLOGISTON,
The PRIESTLEY politcian or the
Political Priest.

Fig 5 'Doctor Phlogiston, the Priestley politician or the Political Priest', 1791.
(BM Catalogue 7887)

Joseph Priestley and the Millennium

MARTIN FITZPATRICK

Seventy years ago, Albert Schweitzer remarked, "We must accept the fact that the oldest records about Jesus are mingled with much that is miraculous, unclear, foreign to our ideas", and suggested that "the real Jesus may prove to be so conditioned by his age in his whole world of ideas that our relation to him becomes a problem".[1] He warned that the solution could not be found by extracting an ethical core from Christianity and forgetting the rest: the ethics of Jesus could not be separated from the eschatology or apocalyptic.[2]

In a secular age, the problem to which Schweizer drew attention is formidable indeed. In a recent study, *The English churches in a secular society*, Jeffrey Cox noted that when the Reverend Fuller Gooch of the Prophecy Investigation Society preached on prophecy the subsequent newspaper account turned out to be "unintelligible gibberish", for the transcriber of the sermons was too unfamiliar with revelation to be able to follow his argument.[3] That transcriber's situation is surely the situation of the vast majority of us today. We have come to regard the apocalyptic dimension of Christianity as incomprehensible or eccentric, something with which no enlightened person should be concerned. This had been Voltaire's view: he passed over the preoccupation with revelation of his hero, Newton, remarking, "Sir Isaac Newton wrote his comment upon the Revelation, to console mankind for the great superiority that he had over them in other respects."[4] Voltaire's view of Newton and also his attitude to revelation in general, prevailed.[5]

It is perhaps not surprising that theologians, who so often are sensitive to the forces of intellectual change, eased the transition to a more secular age by ignoring the apocalyptic writings or explaining them away, nor that Unitarians, who prided themselves on their progressive views, should have been in the van. James Martineau believed that "the whole mind of the Palestinian Jews had become saturated with the high colouring of a rude apocalyptic literature" and that it was necessary to distinguish between such popular ideas and the original message of Jesus. For him, the "identification ... of Jesus with the Messianic figure" was "the first act of Christian mythology". He attributed the perpetuation of Messianic ideas to the Roman Catholic Church, which had incongruously blended "spiritual truth and apocalyptic imaginations in an authoritative *regula fidei*".[6] Yet the same Dr. Martineau also believed that Joseph Priestley's *History of early opinions concerning Jesus Christ* (1786) should be reserved for the "choicest shelves of every theological library", in spite of Priestley's preoccupation with "rude apocalyptic".[7] Another notable nineteenth-century Unitarian scholar, Alexander Gordon, referred to Martineau's opinion in his excellent discussion of Priestley in his *Heads of English Unitarian history*, but he did not note the paradox for he totally ignored Priestley's millenarianism. Gordon was quite happy to admit that in his scientific work Priestley was like "alchemists of old", but he made no similar admission for his outdatedness in theology.[8] On the other hand when Gordon wrote the biography of Richard Brothers for the *Dictionary of national biography*, Gordon showed that he could be a sympathetic interpreter of millenariansim. It may be that he wanted to distance Priestley from popular millenarianism, although Priestley himself had repudiated the popular, not to say mad, millenarianism of Brothers. It is more likely that Gordon was unable to reconcile the progressive theological views of Priestley with his millenarianism, which was thus an embarrassment best ignored.[9]

For a long time, interpreters of Priestley followed Gordon and ignored his interest in apocalyptic thought, which seemed irreconcilable with his progressive ideas in other respects. The situation changed only when scholars began to reappraise the significance of millenarian ideas in western thought. Ernest Lee Tuveson drew attention to the crucial role which millenarian ideas played in the development of utopian ideas, a role totally ignored by J.B. Bury in his classic work on the history of the idea of progress.[10] Detailed scholarly work on Newton has shown that his millenarian speculations can no longer be dismissed as dotty and irrelevant to his other ideas.[11] Margaret Jacob has done much to rescue more generally the scholarly

millenarian tradition in post-Restoration England.[12] The apocalyptic dimension of western political thought has been demonstrated, using what would once have been regarded as unlikely and implausible sources, most notably by J.G.A. Pocock in his magisterial work, *The Machiavellian moment*.[13] To complete the process in which the academic world has been turned upside down, Norman Hampson, one of the shrewdest commentators on the Enlightenment, has recently drawn attention in the pre-1789 period to the "millenarian streak in French radical thinking ... already more developed, and widespread, than elsewhere in Europe".[14]

The recovery and reappraisal of the millenarian tradition in western thought has not generally been accompanied by a renewed concern with the meaning of the apocalyptic message today.[15] This, no doubt, has enabled the process to occur smoothly and without a hitch, but it does mean that the exercise is fraught with danger. We are no longer steeped in biblical knowledge; in interpreting Priestley we encounter at least some of the problems noted by Schweitzer in the interpretation of Jesus. My own relative ignorance of revelation theology may have led me to miss not only subtleties and nuances, but even fairly obvious things in my attempt to understand its meaning for Joseph Priestley. The problem is compounded in his case by the vast corpus of his work. The views I shall put forward, however assertive they may appear, are therefore ultimately tentative.

I cannot claim to be a pioneer in investigating Priestley's millenarianism. That accolade should be bestowed upon Clarke Garrett.[16] More recently, W.H. Oliver and Jack Fruchtman Jr. have probed further aspects of Priestley's concern with the future, while John Passmore and Robert Nisbet have had interesting things to say about the relationship between Priestley's ideas and ideas of progress in general.[17] My interest in Priestley's millenarianism and that of his contemporaries arose from a study of toleration. Priestley's views however only make historical sense in the context of his millenarian aspirations and expectations. Since Garrett and Oliver both offer broad accounts of Priestley's millenarian views,[18] I shall concentrate on drawing out the implications of the claim that millenarianism is central to his thought, and in particular show why his idea of progress was not framed in a way which would have been congenial to subsequent generations of Unitarians and to our more secular age.[18]

In his *Institutes of natural and revealed religion*, Priestley wrote, "I do not hesitate to rank Hartley's *Observations on man* among the greatest efforts of human genius ..."[19] David Hartley's synthesis of psychology, physiology and millenarian eschatology profoundly influenced Priestley. In 1771, Priestley published an essay in the *Theological Repository* later incorporated into the *Institutes* on the 'Analogy between the methods by which the perfection and happiness of men are promoted, according to the dispensations of natural and revealed religion'. This was a thoroughly Hartleian venture, and his conclusion agreed with that of his master: nature and scripture revealed the beneficent design of Providence, which both in a general and particular sense is "calculated to raise, improve and bless the human race."[20] Through the association of ideas, God had provided the means for the continual improvement of mankind. But, besides a beneficent ordinary or general providence, one also saw an extraordinary or particular providence working towards the same end:

> we see a most glorious apparatus for accomplishing this great end, for enlarging the comprehension of the human mind, and raising us to the highest pitch of perfection and excellence.[21]

Neither Hartley nor Priestley saw man advancing uninterruptedly towards the millennium. They did not develop a meliorist view of progress, by which man would, by his own efforts, inaugurate the millennium, and according to which Christ would only return to earth for the Last Judgement at the end of the millennial period. That is, they were not postmillennialists, rather they were premillennialists: they envisaged Christ coming again at the beginning of the millennium, which would be inaugurated by great apocalyptic events involving the downfall of Anti-Christ.[22] I have suggested elsewhere that there is an inconsistency between, on the one hand, Hartley's associationism, by which all those "who had eaten of the tree of knowledge of good and evil" could once again be restored to the paradisiacal state, and on the other his insistence that God's dramatic intervention was necessary to "ring in the thousand years of peace". Yet there are, despite his own associationism, compelling reasons for Priestley's premillenialism, as I shall attempt to demonstrate.[23]

In his analogy between natural and revealed religion, Priestley argued that through the former we learn that the stock of mankind's happiness was growing ceaselessly, and that only time was necessary for "mere man" to arrive at a pitch of excellence of which we can have no clear perception. Yet, such were the mental disciplines necessary for the attainment of happiness and virtue, it appeared that temporary pains and evils would not be completely overcome until the arrival of "a better world".[24] That intimation was confirmed by revealed religion through which God revealed His will to man in order that he might have a hope for the future which transcends his immediate ills and sufferings. A true Christian,

> may see his body decaying with old age, wasting with a disorder, or mangled with torture, and every way at the mercy of his enraged persecutors; but he rejoices in the firm belief and expectation of its rising again *incorruptible* at the last day, and when *Christ, who is the resurrection and the life, shall appear, he also shall appear with him in glory*.[25]

At the time Priestley wrote this, he was not a literal premillenialist; he believed that Christ would come figuratively to inaugurate the millennium. Although he was a thorough-going providential optimist, he had a lively sense of the ebb and flow of good and evil in the tide of man's fortune, and he was unable to believe that reason alone could transform man's situation and

introduce the paradisiacal state. For that to occur, man needed not only to pay attention to the revealed will of God, but he also needed the assistance of a particular providence.

In the preface to his *History and present state of electricity with original experiments* of 1767, Priestley contrasted civil, natural, and scientific history. The civil historian saw not only "the prospect of gradual improvement during the rise of great empires", but also "the disagreeable reverse". Although divine providence was forever "conducting things to a more perfect and glorious state" and thereby sheds "a more agreeable light on the more gloomy parts of history", Priestley conceded that it took "great strength of mind" to see this: all too often "the feelings of the heart ... over power the conclusions of the head". In contrast, the natural historian had an uninterrupted view of progress, and had witnessed the gradual maturation and perfection of living things. But the historian of science had the best of all possible worlds. He was able to perceive the human understanding at "its greatest advantage, grasping at the noblest objects" and working towards them by "acquiring to itself the powers of nature." Yet, although he portrayed the work of the experimental philosopher as "both pleasing to the imagination, and improving to the heart", he followed Hartley in cautioning against the single-minded pursuit of science:

> we must make frequent intervals and interruptions; else the study of science, without a view to God and our duty, and from a vain desire of applause, will get possession of our hearts...[26]

Thus the experimental philosopher could not be relied upon to inaugurate the millennium. It was revelation which provided "the most useful information" concerning God's "nature, perfections and government, concerning our duty here, and our expectations hereafter".[27]

Later, in his *Discourse on the evidence of divine revelation* of 1794, Priestley argued that reason aided by revelation could bring men to a proper view of Christianity and enable them to reform their conduct in order to fit themselves for a future state. He saw this as possible "without any supernatural operation".[28] Nevertheless, if men could thus prepare themselves for a future state, he did not believe that they would be able to bring it about unassisted.[29] It was particularly instructive to note that even when he viewed the recent progress of knowledge he was not disposed to offer a natural explanation for it; he believed that the rapidity of progress indicated that it was the work of a particular providence. The gradualist vision of the postmillennialist was too neat, one might say too Augustan, for Priestley. Besides, it lacked that dramatic sense of the calamities that could befall all men, virtuous and vicious alike, which informed his view of things, and which was derived primarily from his reflections upon biblical history. Moreover, like Hartley he believed that he was witnessing the beginning of the catastrophes and upheavals which would lead to the Second Coming.[30] In the context of the times, and within the millennial interpretative framework, there was surely as much to recommend in the premillennialist view as the post millennialist. At any rate, it was hardly likely that Priestley would adopt the latter when he could detect the hand of a particular providence even in the progress of knowledge.[31] There is another reason, somewhat speculative, for his adopting the former rather than the latter view. His rejection of a gradualist view even of recent history suggests that he had a livelier sense of the apparent random nature of suffering than the post-millenialist. Although a providential optimist he did not display the calculated indifference to evil of a Dr. Pangloss. Even in the early years of the French Revolution, an event of which he highly approved, he noted that it might be "calamitous to many, perhaps to many innocent persons" though of course he went on to say that the result would be "eventually most glorious and happy".[32] It is indeed true that all millennialists could offer solace and the prospect of future rewards for the suffering innocent (as well as punishment for the guilty), but Priestley increasingly appears to have envisaged that there would be a special reward awaiting the suffering innocent for he suggested that they would attain eternal life at the Second Coming, when there would be a preliminary judgement and first resurrection.[33] This was not a prospect which postmillenialists could offer, for they envisaged no such dramatic installation of the millennium.

Tuveson has argued that postmillennialists prepared the way for a secular idea of progress, whereas premillennialists were gloomy and fatalistic.[34] Alan Heimert developed such views in his study of religion in America from the Great Awakening through to the American Revolution where he argued that the premillennialists were pessimistic and socially conservative.[35] It hardly needs saying that this sort of categorization is irrelevant to Priestley's millenarianism even if it is appropriate in the American instance.[36] Priestley was an enthusiast for progress and was temperamentally optimistic. It was, as already noted, partly his wonder at the pace of progress that led him to believe that a particular providence was at work hastening the way to the millennium. He did not in consequence of his premillennialism abandon his attachment to reason. Reason was not in conflict with revelation. It was a gift of God, being His revelation working by other means.[37] In the past, revelation had been the means of reinforcing reason by miraculous example, and it continued to be an essential guide. In the preface to his *Letters to a philosophical unbeliever* of 1787 he wrote,

> Nothing, therefore, that I have advanced in this work, can be at all understood to lessen the great value of revelation, even admitting, what is far from being probable, that, in some very distant age of the world, men might have attained to a full persuasion concerning all the great truths of religion as the unity of God, the doctrine of a resurrection to immortal life, and a state of future retribution. What the most enlightened of our race had conjectured concerning these things, in fact, led them farther from the truth, than nearer to it, and never made much impression on the generality of mankind.[38]

Priestley conceded, in his *Institutes*, that one might arrive at some approximation of the doctrines of

revelation, but even in the case of the *"duty of men"*, he argued that, although one could arrive at a "tolerable system" of morals, "the particulars were such as can only be said to have been *discoverable* by nature, since they were not actually *discovered* by it".[39] As regards the doctrines of futurity, of rewards and punishments, only revelation furnished certainty.[40]

Priestley was deeply suspicious of any intellectual activity which was self-contained. For him, all things were related. He delighted in both diversity and uniformity, and detected the hand of God in all aspects of existence. He believed that wonderful prospects were opening up for the scientist, who was still as yet a climber at the foot of the alps. But the prospect could also be wearisome. In his *Experiments and observations* of 1774, he quoted Pope's *Essay on criticism*:

> And the first clouds and mountains seem the last,
> But those attain'd, we tremble to survey
> The growing labours of the lengthened way.
> Th'increasing prospect tires our wandr'ing eyes,
> Hills peep o'er hills, and Alps on Alps arise.[41]

However, the scientist who approached his task in a religious spirit, who fully acknowledged the "infinite and inexhaustible" nature of God's works, would not weary. He would accept his ignorance, do his best to remedy it, worrying neither about mistakes nor about his reputation.[42] As in life generally, in which virtue often went unrewarded, so in science too, discoveries may well go by chance to the scientist who deserved it least.[43] The true scientist would be a religious man who devoted himself to his task out of "a supreme veneration for the God of nature", and "from a love of his fellow-creatures".[44] An infidel scientist was almost a contradiction in terms, for an infidel had no concern for the morrow, or as Priestley put it, "if a man expects to *die* like a dog, it cannot but be supposed that he will also *live* like one."[45] Nor would a vague natural religion do; he complained that,

> so many of those persons who are joined with us in the investigation of natural phenomena ... should attend with rapture to the voice of nature, and not raise their thought beyond this to the author of nature.[46]

True philsophy led away from infidelity, through natural religion to revealed religion.[47] There a scientist would learn of the prospect of a future life and work in the millennium and beyond. Christian virtue made better scientists and the proper pursuit of science was profoundly religious.[48]

This is not to say that Priestley was not immensely impressed with progress in recent history, nor that he did not believe that the dissemination of knowledge was essential for the inauguration of the millennium. Hartley provided evidence "in the way of natural causes" for his belief that rational Christianity was spreading rapidly and at an ever-increasing rate throughout the world. He dated the increase of knowledge from the sixteenth century, beginning with "the coincidence of the three remarkable events, of the Reformation, the invention of printing and the restoration of letters".[49] Since then, the development of world commerce had opened up new channels of communication for future apostles.[50] Yet, although many parallels may be drawn between Hartley's and Priestley's applause for progress and condemnation of the obstacles in its way and the views of secular progressivists such as Condorcet, they were a long way from elevating reason to the status of providence. Nisbet, following Tuveson, has argued that it was easy "to let God slip away entirely" from the postmillennialist view of things.[51] If Priestley had appreciated this, it would have provided a further reason for his rejection of postmillennialism. But it is doubtful whether he saw things in such terms. He did not view postmillennialists as a separate species; they spoke a common language and shared the same outlook. All millennialists viewed the progress of reason and truth as evidence of God's beneficence rather than as the primary cause of progress. In his *Letters to a philosophical unbeliever*, Priestley noted the great advances of "civilization and good government ... in Europe", the progress of knowledge, and the increasing liberty of thought which offered the pleasing prospect of truth prevailing throughout the world.[52] He added:

> We have no occasion to consider by what means these advantages have accrued to mankind: for whatever the *secondary causes* may have been, they could not have operated without the kind provision of the first and proper cause of all; and therefore, they are to be considered as arguments of his benevolence or of the preference that he gives to happiness before misery.[53]

Whatever difference existed between Priestley and postmillennialists, there was a much greater gulf between his idea of progress and the secular idea, and it is difficult to imagine how God could ever have slipped away from his vision of the future.

Because Priestley traced all things to God and His revealed will, he occupied himself but little with the means by which progress could be procured or with details about the future paradise.[54] God would look after all things, and man's prime responsibility was evangelical: he should spread Christian truth and oppose all those things which he considered impeded its progress. This conditioned his attitude to government and politics, which differed considerably from that of the more worldly *philosophes*.

Priestley's *Essay on the first principles of government* of 1768 was concerned with the role which government could appropriately play in assisting man's progress. But although he appears to have shared the characteristic belief of the *philosophes* that legislation was the key to man's moral progress, and although he appears to have a very modern attitude to government in his description of it as a "great instrument of ... progress", a closer look reveals differences, not to say inconsistencies, which can be traced back to his concern with ends not means and above all with one prime end, the millenium.[55] He argued that the best form of government would be that which most effectively assisted progress towards the end of all things, an end which he described as "glorious and paradisiacal, beyond

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Fig 6 'Repeal of the Test Act', 1790. (BM Catalogue 7629)

what our imaginations can now conceive."[56] It is in this special sense that he conceived of government as an instrument of progress:

> Government being the great instrument of *this* progress of the human species towards *this* glorious state, that form of government will have a just claim to our approbation which favours this progress, and that must be condemned in which it is retarded.[57]

Since the prerequisite for inaugurating the millennium was the conversion of the world, and ultimately of the Jews, the prime concern of government should be the facilitation of the truth. This led Priestley to the seemingly paradoxical conclusion that that government which interferes least in the lives of its citizens would be the most effective instrument of progress, for he believed it to be "an universal maxim, that the more liberty is given to every thing which is in a state of growth, the more perfect it will become".[58]

For Priestley, the purpose of government and of all endeavour was to lay the path to paradise, and yet, as already noted, he speculated very little upon what sort of place that paradise would be. For much of the time he did not feel the need: the broad outlines were in the Bible, and the rest could be left to God. No secular utopian could be so confident.[59] However, in his *Letters to Burke* of 1791 Priestley was more than usually explicit. Buoyed up by the American and French Revolutions, he believed that the millennium was on the way, and he ventured an outline. Government would take "no more upon it than the general good requires", and in particular would no longer interfere in religion.[60] Men would be left "in the enjoyment of as many of their *natural rights* as possible".There would be no church establishments, no extravagant public ceremonies, and no standing armies, though citizens would be trained to defend their liberty. Imperial territories and ambitions would be abandoned in preference for mutually advantageous trade. In the coming era of cheap, "simple" and minimal but beneficial government, of peace and prosperity, truth would flourish and prejudice disappear.[61] This was the state of things which was not only foretold by revelation, but was also one "which good sense, and the prevailing spirit of commerce, aided by Christianity, and true philosophy, cannot fail to effect in time."[62]

Priestley was hardly more precise than that. His demands for government based upon utility and natural rights lack precision and definition because he was convinced that all good things cohere in the scheme of beneficent providence. Thus, for example, he did not probe with any acuity the question as to whether individual happiness was compatible with the happiness of the greatest number. He wrote in the *Institutes*,

> Strictly speaking, there are no more than two just and independent rules of human conduct, according to the light of nature, one of which is obedience to the will of God, and the other a regard to our own real happiness; for another rule, which is a regard to the good of others, exactly coincides with a regard to the will of God; since all that we know of the will of God, according to the light of nature, is his desire that all his creatures should be happy, and therefore that they should all contribute to the happiness of each other ...[63]

Priestley was similarly cavalier in his attitude to politics. He knew clearly enough what he wanted: the elimination of all obstacles in the way of knowledge and the progress of truth. He knew clearly enough, too, what that required: the downfall of the existing establishment in church and state. Civil establishments of religion perpetuated prejudice and superstition, and hindered the development of a Christianity purged of the errors and accretions of the ages. Again, he believed that his views had the sanction of revelation. Following Hartley, he identified the Roman Catholic Church as "the mother of Harlots", and argued that all other churches, since they had "copied her example" were more or less corrupt.[64] He went further by singling out the Church of England as being more contaminated by Catholicism than any other established church. He concluded that church and state should be separated, and that there should be complete toleration for all religions.[65] The purpose of this was to create a situation in which religion would have to appeal to its adherents on the basis of its doctrines and not on account of its social and or political advantages. In these circumstances, truth would rapidly prevail.[66] But it is one thing to be clear in one's aspirations, and quite another to attain them. That required considerable political skill, more especially as those aims were virtually unattainable. Priestley hardly recognized universal toleration and disestablishment as political issues, and he chose as far as possible not to become involved in politics because he regarded his scientific and theological studies as more important. Instead he wrote propaganda for the cause, and undoubtedly by such means won over many Dissenters to universal toleration as well as to Unitarianism. However the timing of his pamphlets was often highly political, though inept, and their contents contained political advice harmful to the causes which they were intended to support. Yet Priestley cheerfully soldiered on quite unperturbed. The only aspect of politics which he understood was political debate. He did not recognize the importance of compromise and manoeuvre. In an important sense, his millenarianism led him to ignore the political. If progress did not occur through the counsels of reason, it would occur through Divine intervention. Certainly one should work to achieve improvements by natural means, but they would occur anyway for the millennium was coming. Thus when Priestley wrote his impolitic *Letter to Pitt* in 1787, the Reverend William Hunter was quite right to detect the apocalyptic frame of his politics: he reminded the leader of Rational Dissent, "The Millennium is not come".[67]

The most impolitic part of Priestley's millenarianism was that it carried a threat which could not be sidestepped. The millennium would be prepared by natural means, primarily through the progress of knowledge and the development of truth. All forms of knowledge were relevant to this process. He wrote in his *Experiments and observations on different kinds of air* of 1774:

> It was ill policy in Leo the Xth. to patronize polite literature. He was cherishing an enemy in disguise.

> And the English hierarchy (if there be anything unsound in its constitution) has equal reason to tremble even at an air pump, or an electrical machine.[68]

But if the opponents of reason proved stubborn and recalcitrant they were doomed anyway, and indeed by their very opposition to enlightenment would ensure that their downfall was the more complete. This notion occurred in Hartley.[69] In Priestley it was omnipresent. It crept into the preface of his *Experiments and observations* cited above:

> all the efforts of the interested friends of corrupt establishments of all kinds will be ineffectual for their support in this enlightened age: though, by retarding their downfall, they may make the final ruin of them more complete and glorious.[70]

Most of all, however, it provided the hallmark for his political writing and sermons. This was the context in which he used the gunpowder metaphor, which earned him such notoriety as an enemy of the establishment as the caricatures demonstrate.[71] Priestley's opponents found his combination of enlightened reasonableness and Biblical prophecy thoroughly discomforting. Here it is, in operation against one of his most trenchant critics, Edmund Burke. First, the reasonableness, which concluded his *Letters to Burke*:

> If this be a dream, it is, however, a pleasing one, and has nothing in it malignant, or unfriendly to any. All that I look to promises no exclusive advantage to myself, or my friends; but an equal field for every generous exertion to *all*, and it makes the great object of all our exertions to be the public good.[72]

Second the prophecy, which preceded the above by one page:

> If you, Sir, together with your old or your new friends, can steer the ship of the state through the storm, which we all see to be approaching, you will have more wisdom and steadiness than has yet been found in any who have hitherto been at the head of our affairs. And if, in these circumstances, you can save the *church*, as well as the *state*, you will deserve no less than canonization, and St. EDMUND will be the greatest name in the calendar.[73]

Had Priestley adopted a consistently gradualist view of the inauguration of the millennium, had there not been an element of worldly pessimism in his cosmic optimism, he might have paid closer attention to the problems of political philosophy and the dilemmas involved in political action. As it was, he was an infuriating opponent and a well-nigh impossible ally precisely because his confidence rested on the mutually supportive pillars of human and divine agency. Yet given the nature of his religion and his profound devotion to it, one can at least understand why he thought and acted as he did. Although he believed that human reason was in harmony with divine will, and believed that true Christianity was rational, his religion was not that cold religion of the head portrayed by subsequent generations and most notably the Victorians.[74] Such a portrait emerged by ignoring the apocalyptic dimension of his Christianity. Priestley himself did not make the mistake of separating out the ethics of Jesus from the eschatology. He could not adopt a secular idea of progress, because the future for him lay in the recovery of a religion which had been buried in the layers of the past.[75] He could not endorse the notion of the millennium developing by natural means, primarily through the progress of knowledge, because it left too many unanswered questions about the course of history and above all about the fate of true Christianity. If Christianity were God's last word, revealing divine reason to man, why had it made such poor headway? Why had it submitted to the forces of ignorance and superstition? Even though Priestley argued that Christianity in its most corrupt form was preferable to heathenism, and even though he identified those forces which held Christianity in thrall, the question puzzled him deeply.[76] He was forced to conclude that the reason why true Christianity lay for so long "under a cloud" lay in "the unsearchable wisdom of God".[77] Since, however, God was beneficent, He would ensure that all things would come right in the end, that is, in the millennium and beyond. The millennium would herald in a new era of justice and peace, in which truth would at last be able to progress unassisted. In his vision of progress *in* the millennium, Priestley came closest to the views of the postmillennialists and the secular progressivists. John Passmore has argued that Priestley and Hartley were feeling their way towards a theory of progress of natural development.[78] I have suggested that it is difficult to envisage how that could have been accomplished within his overall scheme of progress to and through the millennium. He would have had to re-write his history, his political and moral philosophy, his theology, and probably his science too.

Priestley's work makes most sense when viewed in its own terms, and is, moreover, more intelligible in its entirety than in its particular aspects. To us, there are many crucial questions which he fails to pursue, and, of course, it is illuminating to study these. Far better to have Priestley warts - and - all than the one-sided picture of the Victorians; anyone who has studied the iconography of Priestley will know that his left profile was quite different from his right! But in the process of close examination it is important not to lose sight of the whole man. The imminent prospect of the millennium proved an inspiration for his life and work. In seeking to recover true Christianity, he created a fascinating synthesis of eighteenth-century and Christian enlightenment.

Schweitzer feared that Christ's teaching *in toto* could not be made relevant to the twentieth century. Priestley had attempted to reconcile reason and revelation. This was in the tradition of his beloved early church, for it was St. Paul, after all, who reminded the Corinthians, "I would rather speak five intelligible words, for the benefit of others as well as myself, than thousands of words in the language of ecstasy".[79] Today the language of prophecy is as unintelligible as the language of ecstasy. That is the measure of the divide not only between our age and that of the early Christians but also between our age and that of the Rational Dissenters of the late eighteenth century.

Notes and References

1 Albert Schweitzer, *Geschichte der Leben-Jesus-forschung*, Tubingen, 1913, pp. 515, 554-55 cited in Sir Malcom Knox, *A layman's quest*, London, George Allen & Unwin, 1969, p. 124.

2 Knox, op.cit., note 1 above, pp.124, pp.124-125. Knox points out that Schweitzer's own solution to the problem was unclear. For Schweitzer's continued insistence on the centrality of the problem and a suggested solution, see his introduction to the third edition of *The quest of the historical Jesus*, London, Adam & Charles Black, 1954, pp. xiv-xvi.

3 Jeffrey Cox, *The English churches in a secular society; Lambeth 1870-1930*, New York and London, Oxford University Press, 1982, p. 257.

4 Thomas Newton, *Dissertation on the prophecies which have remarkably been fulfilled*, New York, 2 vols, 1794, vol.2, p.103, cited in James W. Davidson, *The logic of millenial thought. Eighteenth-century New England*, New Haven and London, Yale University Press, 1977, p.266.

5 Frank E. Manuel, *A portrait of Isaac Newton*, London, Frederick Muller Ltd., 1980, pp. 124 and 417 n.10.

6 James Martineau, *The seat of authority in religion*, London and New York, Longmans, Green & Co., 3rd ed. 1891, pp. 327,355,565.

7 Alexander Gordon, *Heads of English Unitarian history with appended lectures on Baxter and Priestley*, London, Philip Green, 1895, pp. 115-6.

8 Ibid., pp. 104-105.

9 Clarke Garrett, 'Priestley, the millennium and the French Revolution', *J. Hist. Ideas*, 1973, 34: 62-63. Gordon was conversant with the scholarly millenarian tradition for he was also the biographer of Joseph Mede for the *D.N.B.*. Richard Brothers (1757-1824) became convinced that he was Prince of the Hebrews and nephew of the Almighty and predicted that the millennium would arrive on 19 November 1795. On the popular millenarian tradition see, J.F.C. Harrison, *The second coming, popular millenarianism, 1780-1850*, London and Henley, Routledge and Kegan Paul, 1979; and Garrett, op.cit.

10 Ernest L. Tuveson, *Millennium and utopia*, Berkeley, University of California Press, 1949; John B. Bury, *The idea of progress; an inquiry into its origin and growth*, London, Macmillan, 1920.

11 Notably, but by no means solely, by Frank E. Manuel, op.cit., note 5 above.

12 Margaret C. Jacob, *The Newtonians and the English Revolution*, Hassocks, Sussex, The Harvester Press, 1976.

13 J.G.A. Pocock, *The Machiavellian moment. Florentine political thought and the Atlantic republican tradition*, Princeton and London, Princeton University Press, 1975.

14 Roy Porter & Mikulas Teich eds., *The Enlightenment in national context*, Cambridge University Press, 1981, ch.3, 'The Enlightenment in France', pp.50-51. It should be noted that Professor Hampson is using the term "millenarian" to describe aspirations for a republic of virtue achieved by a "quasi-super human legislator".

15 This is not to deny the widespread anxiety today about the shape and indeed possibility of a future, nor that there are ideas in contemporary apocalyptic thought drawn from the Christian millenarian tradition, but it is to suggest that the relationship between the scholarly study of millenarianism and current apocalyptic thought is tenuous.

16 Garrett, op.cit., note 9 above; idem., *Respectable folly. Millenarians and the French Revolution in France and England*, Baltimore and London, The Johns Hopkins University Press, 1975, esp. chs. 6 and 7.

17 W.H. Oliver, *Prophets and millennialists. The uses of Biblical prophecy in England from the 1790s to the 1840s*, Auckland and Oxford University Presses, 1978; Jack Fruchtman, Jr., 'Politics and the apocalypse: the republic and the millennium in late eighteenth-century English political thought' in Harry C. Payne (ed.), *Studies in eighteenth century culture*, Madison, 1981, vol. 10, pp. 153-64; 'Joseph Priestley and early English Zionism', *Enlightenment and Dissent*, 1983, 2: 39-46; John Passmore, *The perfectibility of man*, London, Duckworth, 1970; Robert F. Nisbet, *History of the idea of progress*, London Heinemann, 1980. This paper was written before the appearance of Dr. Fruchtman's challenging monograph, *The apocalyptic politics of Richard Price and Joseph Priestley: a study in late eighteenth-century English republican millennialism*, Philadelphia, The American Philosophical Society, 1983.

18 Garrett, op.cit., note 16 above, ch.6, pp. 121-143; Oliver op.cit., note 17 above, pp. 42-46.

19 *The institutes of natural and revealed religion*, 3 vols., 1772-1774 in John Towill Rutt (ed.), *The theological and miscellaneous works of Joseph Priestley*, London, 25 vols, 1817-1831, vol. 2, p.257. Rutt used the 2nd. edition, Birmingham 1782, of *The institutes*. The whole passage reads: " ... I am most astonished that any person should write upon the subject of the *human mind*, without taking notice of so capital a performance as that of Dr. Hartley; who, beginning where Mr. Locke left it, has raised a system that is equally amazing for its simplicity and extent. For my own part, I do not hesitate to rank Hartley's *Observation's on Man* among the greatest efforts of human genius; and considering the great importance of the object of it, I am clearly of the opinion that it is, without exception, the most valuable production of the mind of man."

20 Ibid., vol.2 p.238.

21 Ibid., pp. 238-239.

22 I use the distinction between premillenialism and postmillenialism in this paper as a means of clarifying certain attitudes to the way in which millennial progress will occur. I am not suggesting that there existed two separate and well-defined millennial traditions in English Dissent at this time.

23 M.H. Fitzpatrick, 'Rational Dissent in the late eighteenth century with particular reference to the growth of toleration', University of Wales, PhD. thesis, 1982, p.49.

24 Rutt, op.cit., note 19 above, vol. 2, p.237.

25 Ibid., p.242.

26 Joseph Priestley, *The history and present state of electricity, with original experiments*, London, J. Dodsley, J. Johnson, B. Davenport, & T. Cadell, 1767, pp. iii-v, xxii.

27 Joseph Priestley, *A familiar illustration of certain passages of scripture*, Leeds 1770, Rutt, op.cit., note 19 above, vol. 2, p.481.

28 Rutt, op.cit., note 19 above, vol. 25, p.358.

29 Ibid., vol. 15, *The present state of Europe compared with ancient prophecies; a sermon preached at the Gravel Pit Meeting in Hackney, February 28, 1794, being the day appointed for a general fast*, pp. 533-543.

30 Hartley, towards the end of his life, informed Lady Charlotte Wentworth that he did not expect to witness the Second Coming, but that she, a young woman, probably would. Priestley, also in the evening of his life, said something similar to Thomas Belsham: "You may probably live to see it; I shall not. It cannot, I think, be more than twenty years." Richard Watson, *Anecdotes of the life and times of Richard Watson, Bishop of Llandaff*, London, T. Cadell & W. Davies, 2nd ed., 2 vols, 1818, vol.I, pp.264-265; Thomas Belsham, *Memoirs of the late Reverend Theophilus Lindsey, M.A.*, London, J. Johnson & Co., 1812 p.375 n..

31 H. Laboucheix, *Richard Price as moral philosopher and political theorist*, tr. S. & D. Raphael, Oxford, The Voltaire Foundation at the Taylor Institution, 1982, p.104, notes Priestley's relative pessimism in comparison with the views of Richard Price concerning the unenlightened state of mankind.

32 Joseph Priestley, *Letters to the Right Honourable Edmund Burke occasioned by his Reflections on the Revolution in France*, corr., Birmingham, Thomas Pearson, 2nd ed., 1791, p.154.

33 See, *A sermon preached at the Gravel Pit Meeting, in Hackney, April 19th, 1793, being the day appointed for a general fast*, Rutt, op.cit., note 19 above, vol.15, p.517; and *Discourses on the evidences of revealed religion*, ibid., vol.15, pp.298-299. In both these works Priestley turned his attention to the consolations available in the forthcoming trials.

34 Tuveson's thesis concerning the evolution of a secular from a religious idea of progress is the theme of his *Millennium and utopia*, Berkeley and L.A., University of California Press, 1949. Later, in his *Redeemer nation*, Chicago and London, University of Chicago Press 1968, he developed the distinction between postmillennialists and premillennialists, whom he describes as millenarians and millennialists respectively.

35 Alan Heimert, *Religion and the American mind*, Cambridge, Mass., Harvard University Press, 1966, ch.2, esp. pp. 61-66.

36 On the dangers of creating stereotypes out of the distinction between pre- and postmillennialists, see J.W. Davidson, *The logic of millennial thought*, Yale University Press, 1977, pp. 28-36, 270-280.

37 See for example Joseph Priestley, *An appeal to the serious and candid professors of Christianity*, Rutt, op. cit., note 19 above, vol. 2, p.384.

38 Joseph Priestley, *Letters to a philosophical unbeliever*, 1787, 2 vols, repr. in one, New York & London, Garland Publishing Inc., 1974, p.xix.

39 Rutt, op. cit., note 19 above, vol. 2, p.341.

40 Ibid., vol. 2, p.342.

41 Joseph Priestley, *Experiments and observations on different kinds of air*, London, J. Johnson, 1774, vol.I, p.viii.

42 Ibid., pp.vii,ix.

43 Ibid., p.xi. Priestley compared scientific investigation to hunting, "where it sometimes happens that those who have beat the ground the most, and are consequently the best acquainted with it, weary themselves without starting any game; when it may fall in the way of a mere passenger ..."

44 Ibid., p.xii. See also, Priestley, op. cit., note 26 above, p.v.

45 Priestley, *The institutes* Rutt, op. cit., note 19 above, vol. 2, p.68. Priestley's views on this point changed little over the years. In his *Letters to Mr. Volney. occasioned by a work of his entitled Ruins, and by his letter to the author*, Philadelphia, 1797, pp.10-11, he suggested, "The man who enters fully ... into the spirit of infidelity, will have little respect for the liberal pursuits of science. Expecting to exist but a few years, he will naturally say, what is your history, your philosophy, or your astronomy to me." cited in James J. Hoecker, 'Joseph Priestley and the reification of religion', *The Price-Priestley Newsletter*, 1978, 2: 66, n.18; see also, Priestley, op.cit., note 38 above, pref., pp.vi-ix, & pp.27-30.

46 Priestley, op. cit., note 38 above, p. v.

47 Ibid., pp.vi-ix.

48 Priestley, op.cit., note 26 above, pp.xx-xxii. He wrote, "What great and exalted beings would philosophers be, would they but let the objects about which they are conversant have their proper moral effect upon their minds! A life spent in the contemplation of the productions of divine power, wisdom, and goodness, would be a life of devotion. The more we see of the wonderful structure of the world, and of the laws of nature, the more clearly do we comprehend their admirable uses, to make all the percipient creation happy: a sentiment, which cannot but fill the heart with unbounded love, gratitude, and joy."

49 David Hartley, *Observations on man, his frame, his duty, and his expectations*, Bath, R. Crutwell, 5th. ed., 1810, vol. 2, p.389.

50 Ibid.,

51 Nisbet, op.cit., note 17 above, p.129.

52 Priestley, op.cit., note 38 above, pp.82-83.

53 Ibid., pp.83-84.

54 Priestley did not participate significantly in that trend in the 1790s, detected by Davidson, in which "expositors ... focused increasingly on the qualities of the millennial reign instead of the history of redemption as a whole", op.cit., note 36 above, pp.271-272.

55 Joseph Priestley, *An essay on the first principles of government, and on the nature of political, civil and religious liberty*, London, J. Johnson, 2nd.ed., 1771, pp.2-3,5.

56 Ibid., p.5.

57 Ibid.

58 Ibid., pp.258-259. Priestley was not entirely consistent in his attitude towards government, for in certain respects his outlook remained paternalistic. See Margaret Canovan, 'Paternalistic liberalism: Joseph Priestley on rank and inequality', *Enlightenment and Dissent*, 1983, 2: 23-35.

59 Of the utopians, William Godwin comes closest to Priestley in his emphasis upon the conditions necessary for the creation of utopia and in his attachment to individual liberty and the pursuit of truth. For his relations with the Rational Dissenters see my, 'William Godwin and the Rational Dissenters', *The Price-Priestley Newsletter*, 1979, 3: 4-28.

60 Priestley, op. cit., note 32 above, p.145.

61 Ibid., pp.143-155.

62 Ibid., p.150.

63 Rutt, op. cit., note 19 above, vol. 2, p.25.

64 Hartley, op. cit., note 49 above, vol. 2, p.383.

65 Joseph Priestley, *A letter of advice to those Dissenters who conduct the application to Parliament for relief from certain penal laws*, 1773, Rutt, op. cit., note 19 above, vol. 22, p.459. For a discussion of Priestley's attitude to the Church of England, see Fitzpatrick, op. cit., note 23 above, esp., ch. 7.

66 Joseph Priestley, *Letters to the author of remarks on several late publications relative to the Dissenters, in a letter to Dr. Priestley*, London, J. Johnson, 1770, p.16. On the relationship of Priestley's views to those of other Rational Dissenters, see my 'Toleration and Truth', *Enlightenment and Dissent*, 1982, 1: 3-32.

67 William Hunter, *A letter to Dr. Priestley, F.R.S. &c In answer to his letter to the Rt. Hon William Pitt*, London, 1787, p.8. Hunter wrote of Priestley, "And so deeply wrought is the persuasion into the mind of our sagacious author that he is now impatiently *looking for this better state of things*, in full expectation of its speedy appearance."

68 Priestley, op. cit., note 41 above, p.xiv.

69 Hartley, op. cit., note 49 above, vol. 2, p.383: "The corrupt governors of the several churches will ever oppose the true gospel, and in so doing will bring ruin upon themselves."

70 Priestley, op. cit., note 41 above, p.xiv.

71 In *The importance and extent of free inquiry in matters of religion*, Birmingham, M. Swinney, 1785, Priestley suggested (pp.40-41), that the Rational Dissenters were, by "the present silent propagation of truth", "Laying gunpowder, grain by grain, under the old building of error and superstition (the church establishment), which a single spark may hereafter inflame, so as to produce an instantaneous explosion; in consequence of which that edifice, the erection of which has been the work of ages, may be overturned in a moment, and so effectually as that the same foundation can never be built upon again." On Priestley's treatment by caricaturists see my 'Priestley in caricature", In *Oxygen and the Conversion of future feedstocks*, Proceedings of the Third BOC Priestley Conference, London, Royal Society of Chemistry, 1983, pp. 347-369.

72 Priestley, op. cit., note 32 above, p.155.

73 Ibid., p.154.

74 On the attitude of Victorian Unitarians towards Priestley, see C. Gordon Bolam, Jeremy Goring, H.L. Short and Roger Thomas, *The English Presbyterians. From Elizabethan Puritanism to modern Unitarianism*, London, George Allen & Unwin, 1968, esp. pp. 255-260.

75 On this point see Hoecker, op. cit., note 45 above, pp. 51-53; & Margaret Canovan, 'The irony of history: Priestley's rational theology', *The Price-Priestley Newsletter*, 1980, 4: 18.

76 *The institutes*, in Rutt, op. cit., note 19 above, vol. 2, pp. 97-98.

77 Joseph Priestley *The proper constitution of a Christian church*, 1782, in Rutt, op. cit., note 19 above, vol. 15, p.24.

78 John Passmore op. cit., note 17 above, pp. 210-211.

79 I Corinthians XIV, 19.

Fig 7 Globe electrical machine to Priestley's design, possibly his own.
Catalogue 18 (see page 101)

Priestley and the Politics of Spirit

SIMON SCHAFFER

"Facts are seditious things,
When they touch courts and kings,
Armies are raised ..."
- *God Save Great Tom Paine* (1792)

This paper is concerned with Joseph Priestley's attempt to construct facts in natural knowledge and to use them in politics. In this concern I am influenced by an observation of Ludwik Fleck who wrote that "a *fact* thus represents a *stylized signal of resistance in thinking*. Because the thought style is carried on by the thought collective, this "fact" can be designated in brief as the *signal of resistance by the thought collective.*"[1] Priestley attempted to build facts which could act as just such signals of resistance. Because they were unassailable, facts were of immediate use in furthering the interests of a series of groups with which Priestley aligned himself. There is a fundamental relationship between Priestley's use of natural knowledge to control nature and his attempt to build such control into politics and theology. Here I shall be concerned with three problems in the interpretation of Priestley's work. First, the puzzle which arises in contemplating the "revolutionary" label attached by contemporaries and by historians to Priestley's place in politics and science; second, the relation between Priestley's natural philosophy and that of the groups with which he allied himself; and finally, I shall explore the relation between Priestley's conception of a "system" in nature and in civil society and his conception of the powers in matter and their relation with God. The problem of revolution is considered first. I shall argue that Priestley broke with an existing, entrenched practice of natural philosophy which he labelled as corrupt. Contemporaries made two readings of this break, both of which were profoundly important at the end of the eighteenth century. One was the doctrine of the *system*, which licensed a practice of association between enlightened intellectuals who were capable of comprehending the true system of natural and civil philosophy. The other was the practice of *performance*, which connected with radical doctrines of political revolt. These two practices correspond to two idealized social settings. The first is the club, in which a few literati, bound in a tightly knit group, contemplate the civil and natural order and describe its laws as a theoretical single harmonious system. The second is the theatre in which a single, heroic performer demonstrates spectacular experimental effects for a wondering audience. These two readings were extracted from Priestley's texts of the 1770s, notably the *Disquisitions relating to matter and spirit* and the exchanges with Richard Price. I shall show how these strategies can be found in Priestley's work on earthquakes and on the atmosphere. Throughout the analysis I shall draw attention to the way in which constructed "facts" were used in Priestley's arguments against "prejudice" and "corruption".

At a first reading Priestley seems to have been a revolutionary in politics who resisted a revolution in chemistry. This issue has been variously handled by historians. Some have dissolved the problem by showing how Priestley's chemistry was really Jacobin. Others have exacerbated it by making Priestley's chemistry ultra-reactionary (or "physicalist" as Schofield labels it). Most historians have merely contemplated the difficulty without confronting it.[2] Chemistry, however, was perceived by contemporaries as an integral part of the Revolution: "The present age is a chemical age. Revolutions are not organic, rather they are universal chemical movements", wrote Schlegel. "Our Chemists have proved themselves the greatest of all Revolutionists", agreed Richard Carlile from Dorchester Gaol.[3] Equally, enemies of the new chemistry made out a radical purpose behind its power. In 1793 Jean André De Luc wrote that "The French spirit of domination has begun in chemistry and it is in chemistry as well that we must begin to demolish their edifice". John Christie has explained how for the arch-paranoid John Robison, the French chemistry was a front for the Revolution, and how the old monarch, Joseph Black, had been overthrown by

"the Revolutionary Committee assembled at Paris in 1787 ... not more to promote Science than to fix the Scientific dominion of the Gallic philosophers, by making us forget everything which was not derived from them".[4] In England the connection which was perceived between matter theory, theology and politics was an integral element in the anti-Jacobin campaign against Priestley and his alleged allies throughout the 1790s. Whence Edmund Burke:

> The geometricians and the chemists bring, the one from the dry bones of their diagrams, and the other from the soot of their furnaces, dispositions that make them worse than indifferent about those feelings and habitudes which are the support of the moral world ... While the Morveaux and Priestleys are proceeding with these experiments .... the analytical legislators and constitution vendors are quite as busy in their trade.

By contrast however Edward Gibbon advised Priestley to stick to chemistry lest worse penalties follow, while, in July 1791, Gillray drew Priestley telling his victim, George III on the guillotine, of the mortality of the soul as a consolation for the fate that awaited the erstwhile monarch: "a Man ought to be glad of the opportunity of dying, if by that means he can serve his country in bringing about a Glorious Revolution".[5]

In his texts Priestley made the close link between natural knowledge and political effect. The "true philosophy" would bring about "the social millenium", he told Burke. In the preface to his experiments on air Priestley inserted a statement which was often cited afterwards: "this rapid progress of knowledge ... will, I doubt not, be the means, under God, of extirpating *all* error and prejudice, and of putting an end to all undue and usurped authority in the business of religion as well as of *science*". Priestley declared that "the English hierarchy (if there be anything unsound in its constitution) has equal reason to tremble at an air pump, or an electrical machine".[6] This was not a typical statement for an English natural philosopher of the 1770s. On the contrary, Priestley's ambitious claim for the *radical* effect of the practice of natural philosophy stands in stark contrast to earlier experimental natural philosophy in England. Initially, such a practice was displayed as an effective method of social control, of moral instruction, in the lessons of court Whig political theology. Natural philosophers such as Desaguliers (who composed *The Newtonian Philosophy the best model of government*) and Benjamin Martin explicitly linked their public work on active powers in matter with the established political order. Priestley broke with this earlier practice at all levels: political, theological and ontological.[7]

Early eighteenth century experimental natural philosophers developed the practice of the public display of active powers, which, since divine, could astonish audiences with the obvious work of God. Natural philosophers greeted Franklin's work on lightning in 1752 in the following terms: "Here is a step further towards the discovery of that Wonderful Matter which Nature has kept hid from us since the Creation of the World. The fable of Prometheus is verify'd". There were four determining characteristics of this practice. First, it linked active powers in matter with divine energy. "Causes very general must have been designed by the almighty Author of Nature for the production of very great effects"; a power such as electricity was interpreted as "the immediate officer of Almighty God". Second, such active powers were to be produced by the operation of the natural philosopher, who thus partook of the power of divinity, as Nollet wrote; "thunder is, in the hands of Nature, what Electricity is in ours, and the marvels of which we dispose at present in our own degree are little imitations of those great effects which frighten us: all depends on the same mechanism". Third, the lessons of a divinely legitimated morality could be learnt by exposure to such a performance. "A Man will naturally ask himself, what is the Power that puts the Balls in Motion, and what is the Light that illuminates them?" According to Richard Symes, "you cannot after such discoveries treat Christians with contempt ... What a proof you then always have before your eyes of the enduring state of fire, and ... what a proof is this of the ever enduring state of the Soul". Finally, experimental natural philosophy relied on the single authoritative experience of such powers, not on a series of experiments. It concerned itself with the passively experiencing mind of the audience, not with that of the active experimenter.[8] In the mid-eighteenth century some saw such a practice as dangerous. It was assailed by Tory clerics as subversive and, occasionally, by those in control of metropolitan science as a mixture of charlatanry and license. Yet this practice was an intimate part of emulative and Whig culture in the period. Touring lecturers reinforced moral lessons preached elsewhere by Anglican priests and court politicians. The possible rewards were membership of the Royal Society and recognition in polite circles. This was the set of practices which Priestley's work of the 1770s both exploited and disrupted.[9]

Electricity was the most important of the range of powers available for natural philosophers. It was dramatic, effective, and divine, "miraculous", as the *Gentleman's Magazine* put it in the 1740s. Priestley's first contacts from Warrington with the natural philosophical establishment involved him at once with the problem of electrical display. In his *The history and present state of electricity* of 1767 he described the practice in some detail. "Electrical experiments" he said "are, of all others, the cleanest, the most elegant, that the compass of philosophy exhibits". He wrote of their "amazing variety" and the "most pleasing and surprising appearances for the entertainment of one's friends". "Philosophical instruments are an endless fund of knowledge", Priestley explained, contrasting electrical machines with "globes, the orrery and others" and linking electrical machines with "the air pump, condensing engine, pyrometer, &c." in which he could "exhibit the operations of nature, that is of the God of nature himself".[10] Priestley drew attention to the enormous income available to electrical performers, to their ability to "imitate in miniature all the known effects of that tremendous power" and "drawing lightning from the clouds into a private room and amusing themselves at their leisure". He noted "So far are philosophers from laughing to see the astonishment

Fig 8 Cylinder electrical machine, said to have been owned by Priestley. In the collections of the Science Museum, London (1930-698).

of the vulgar at these experiments, that they cannot help viewing them with equal, if not greater astonishment themselves".[11] Priestley's text on electricity, his first on natural philosophy was, at least in part, designed to codify the practice of public display, by listing standard experiments, by describing basic electrical apparatus, and by directing experiments towards entertainment. However, this text also *broke* with many of the preconditions of acceptable natural philosophy, and systematically broke the connection which natural philosophers had hitherto exploited between God's direct power and that of the performer. This break also sundered the old political connections of experimental natural philosophy. In turn Priestley, directly or indirectly, influenced a group of lecturers and performers who explicitly used their work for new, radical purposes.

Typical of this group was Adam Walker, encouraged to take up lecturing by Priestley himself. In Walker's lectures a matter theory, derived from Priestley's writings of the 1770s, was linked with a much more radical politics than that of Whig lecturers of the earlier eighteenth century. The display of active powers was used by Walker to show the corrupting effects of all governments on their citizens, not to show the divine origin of the power of governments. "The soul of man" he wrote "is an active principle full of design, forward to execute, and zealous after fame, qualities that are no friend to government". Walker's displays were designed to show an innate active power in human nature which resisted state power:

> In all our experiments, we find that NATURE will not suffer herself to be violated with impunity; her struggles to restore the lost equilibrium of air, of fire &c. are not more conspicuous to the philosophic eye than those she makes against the fury and madness of those curses of mankind called conquerors!

Walker emphasised that governments controlled and corrupted the inborn faculties of "instinctive consciousness" turning the simple lessons of nature to the state's own end. In this way he reversed the aim of natural philosophy and mobilised the practice for radical effect.[12] Similarly, lecturers such as Erasmus Darwin or Thomas Beddoes exploited the new range of active powers which Priestley described. In a pamphlet of 1792 defending the September massacres of that same year, Beddoes contrasted the behaviour of the Paris revolutionaries with the "sanguinary spirit" of the English Tory "design to roast Dr Priestley alive (although but one man, and that man a Unitarian and a Philosopher)". Beddoes's work in his Pneumatic Institution and the links he made between the reform of medicine and of politics were notorious in the 1790s.[13] Darwin's texts on contractive and dynamic powers in nature were also deployed for radical political effect, and in his *Temple of Nature* he asked if "a dignified pantomime" might "be contrived, even in this age, as might strike the spectators with awe, and at the same time explain many philosophical truths by imagery, and thus both amuse and instruct?"[14] These projects drew plentifully on Priestley's conception of a new natural philosophy, and Priestley himself influenced their development either directly, as in the case of Walker and Darwin, or by publication, as in the texts on pneumatics upon which Beddoes drew plentifully. Ultimately, Priestley's role as patron and propagandist for such a practice was fundamental for the radical sciences of the early nineteenth century. The connections which he developed between matter theory, the "religion of progress" and millenarianism were visible in the work of men such as Richard Phillips, the Leicester printer, member of the radical Adelphi Society, and London publisher, or the egregious Richard Carlile, promoter of public lectures at the London Rotunda on subjects such as cosmology, "universalism", and radical politics. By the 1830s, while orthodox science branded Priestley as a wild revolutionary, his texts were read by radicals as licensing the subversive practice of a new form of natural philosophy. As Patterson has observed, "experiments with electricity had become confounded in the public mind with the construction of infernal machines".[15]

However, this radical turn was by no means the only possible reading of Priestley's texts. His break with Whig natural philosophy provided a resource for another use of natural knowledge. It was by breaking a link between God and active powers, as the Whig natural philosophers understood it, that Priestley had allowed the development of radical practices, but by attacking the notion of the single, dramatic experience of these powers, Priestley also opened a space for the development of a practice which displayed the system of nature to the enlightened eye. This concept of the system was not connected with radical politics: on the contrary, it posited a small group of practitioners who alone could perceive the "invisible hand" which linked a multitude of merely apparent wonders. In France, of course, the struggle between radical performers (such as Marat or Mesmer) and the theorists of the system (such as the members of the Société Royale de Médecine) dominated the politics of natural knowledge from the 1770s. In Scotland, the Edinburgh literati had, by the mid-century, begun to work out a model of nature and civil society as a controlled system of facts. This model was a fundamental ideological resource. This development allowed them to read Priestley as being preoccupied with the same problem, even if in many areas of theology and politics his works were perceived as atheistical. In his *History of electricity* Priestley outlined the connection between the solidity of the fact and the contemplation of a series of associated natural effects, not a single moment of display. Priestley declared: "Every *fact* has a real, though unseen connection with every other fact; and when all the facts belonging to any branch of science are collected, the system will form itself". In this way "the temple of science" could be painstakingly constructed, and, as he wrote in his *Lectures on history*, "knowledge will also increase, and accumulate, and will diffuse itself to the lower ranks of society". For this reason, philosophers should not rely on wonder but instead should take "frequent opportunities of seeing the same things and viewing them in every light". The principle of association would do the rest.[16]

For élites in France and Scotland, the concept of medical and natural philosophical police worked against performers such as Marat or Mesmer or the

scandalous James Price by claiming to discover "only the power of the imagination" in their displays. The doctrine of mental power discovering interconnected facts was used against direct experience of real power in matter.[17] In Scotland, the concept of the system licensed the social strategies of association and of elite culture which developed in Edinburgh, Glasgow and Aberdeen. Typical texts included those of Adam Smith, composed in the 1750s but published posthumously under the editorship of Black and Hutton, in which the contrast with English natural philosophy was spelt out:

> though it is the end of philosophy to allay that wonder, which either the unusual or seemingly disjointed appearances of nature excite, yet she never triumphs so much, as when, in order to connect together a few, in themselves perhaps, inconsiderable objects, she has, if I may say so, created another constitution of things, more natural indeed, and such as the imagination may more easily attend to, but more new, more contrary to common opinion and expectation than any of those appearances themselves.

For Smith "a system is an imaginary machine invented to connect together in fancy those different movements and effects which are already in reality performed". It was argued that only the few, divorced from the common phenomena, could make out this system and see the "invisible hand", the "one great connecting principle", which dominated the effects of power. This practice stood in contrast with that of the radical performer, the solitary exploiter of such powers directly.[18]

The system was made in the club-like structure of Enlightenment Edinburgh. In their preface to the first volume of the proceedings of the Edinburgh Philosophical Society, Hume and Monro wrote in exactly these terms of "the united judgments of men" which "correct and confirm each other by communication, their frequent intercourse excites emulation from the comparison of different phaenomena remarked by different persons". Similarly, James Hutton produced an important series of texts in the 1790s which displayed the whole Earth as just such a system, designed to become an object of human knowledge, which alone could comprehend the systematic unity of the machine. "Order is not a thing", Hutton wrote, "it is the action of mind". "Only by studying *things in general*" could the philosopher "arrive at this perfection of his nature", and in this work the single spectacle was described as illusory and deceptive: "a volcano is not made on purpose to frighten superstitious people into fits of piety and devotion", Hutton argued, but instead "to prevent the unnecessary elevation of land and fatal effects of earthquakes".[19] Hutton's practice, however, did not escape the criticisms levelled at Jacobin natural philosophy. Where the latter divorced God from the *display of active power*, Hutton, is was argued, did the same by denying that divinity was visible in the *individual phenomenon*. The mineowner, John Williams, attacked Hutton for claiming "we do not see the Supreme Being with our Bodily eyes", stating "this is rebellion against lawful authority, which must soon end in anarchy, confusion and misery, and so does our intellectual rebellion".[20]

I have outlined two ways in which Priestley's work was interpreted and exploited. Previously historians have attempted to show how these readings were in fact a unity in Priestley's own texts. My concern here, in contrast, is to see what resources existed in writings such as the *Disquisitions* for making a break with existing natural philosophy either towards the display of active powers for radical purposes or towards the detection of a system emergent from a series of ordered phenomena. In this examination I again draw attention to Priestley's emphasis on the role of fixed facts as the fundamental item of useful knowledge in natural philosophy, religion and politics. Priestley announced that such facts worked well precisely because the same facts could be used in all realms of knowledge and, by extension, of political struggle:

> The three doctrines of materialism, of that which is commonly called Socinianism, and of philosophical necessity, are equally parts of one system, being equally founded on just observations of nature and fair deductions from Scripture.

In a remarkable letter to Price, Priestley contrasted his own political campaigns with those of Price. Priestley held that Price's were ineffective because they were solely secular, while his own arguments were potent because they derived political lessons from religious truths. "Supposing me to be a defender of Christian truth", he explained,

> my object gives me an advantage that your excellent political writings cannot give you. All your observations may be just, and your advice most excellent, and yet your country, the safety and happiness of which you have at heart, being in the hands of infatuated men, may go to ruin; whereas Christian truth is a cause founded upon a rock.[21]

He dealt with the issue of the production of facts by investigating how they were made and how they were used. It was here that he registered his break with Whig natural philosophy, and even with Newton, the patron saint of that practice. It was this project, the establishing of fixed facts, which made the generation of assent the most central problem for Priestley.

The history of political struggle and religious controversy was a fruitful source for Priestley in the examination of assent, in the same way as were his histories of natural philosophy. In all these histories Priestley showed how assent had been fairly produced and how it had been illegitimately imposed. Priestley held that in the case of men of "candour" the declaration of matters of facts would automatically convince them. He reminded Price of the connection between what Priestley called the "appeal to candour" in dissenting politics and in philosophical debate:

> all that candour requires is that we never impute to our adversary a bad intention or a design to mislead, and also that we admit his general good understanding, though liable to be misled by unperceived

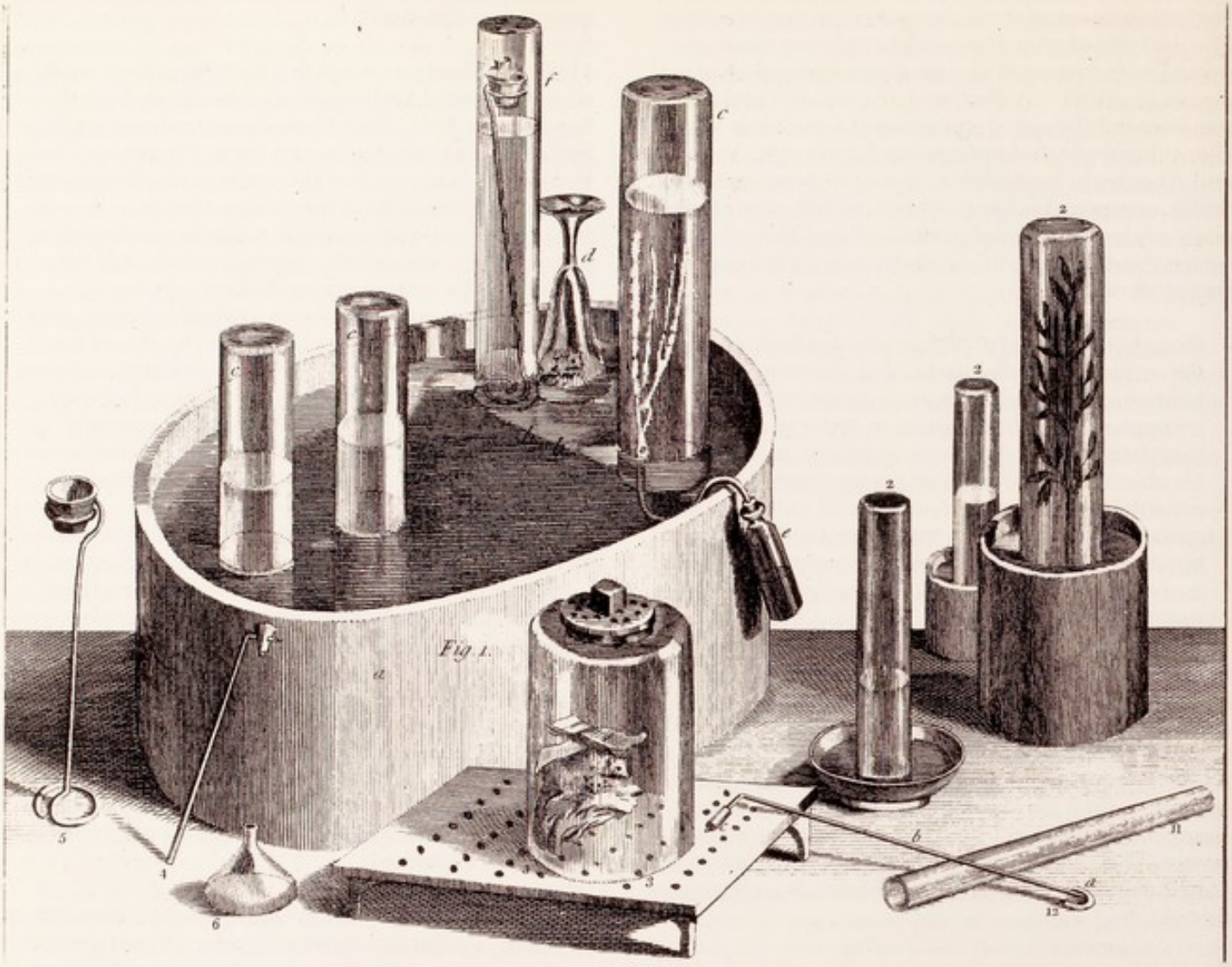

Fig 9 Priestley's pneumatic trough, plate from *Experiments and Observations on Different Kinds of Air*, 1774.
Catalogue 27 (see page 102)

> biases and prejudices from the influences of which the wisest and best of men are not exempt.

Priestley held up the community of Rational Dissenters as an ideal of how honest citizens should reach agreement.[22] As part of his examination of the generation of assent, Priestley announced his break with early eighteenth century English natural philosophy in which he claimed even the mind of the philosopher itself became an object of wonder. For workers in this tradition this postulate was fundamental in the construction of knowledge. Priestley wrote:

> Were it possible to trace the succession of ideas in the mind of Sir Isaac Newton, during the time he made his greatest discoveries, I make no doubt but our amazement at the extent of his genius would a little subside.

The synthetic method and the heroism of the wonderful genius were obstacles to true knowledge and could not be used to generate assent: "an opinion of the greater equality of mankind, in point of genius, would be of real service in the present age".[23]

In his own presentation of the facts of knowledge of matter and spirit, for example, Priestley constructed a hierarchy of methods of acquiescence. On the one hand, many beliefs were "innocent" even if false; on the other hand, truth often involved a break with vulgar conceptions or direct experience. Experience could be an obstacle as well as being a source of knowledge. Whig natural philosophy was unreliable because it used experience directly; thus it failed to break through prejudice and overcome corruption, and, at best, it reaffirmed beliefs which were merely innocent. Walker used this argument of Priestley's to radical effect showing that governors would "find in [human minds] an instinctive consciousness" which was "capable of being stamped by any mode of superstition best suited to wrap it in favour of government" through belief in "invisible and incomprehensible objects, rather than their natural ones, by which their force is divided and consequently weaken'd".[24] In the *Disquisitions* Priestley catalogued many of these "innocent" beliefs, for instance a "grosser sort" of materialism which "has however been maintained by many pious Christians, and which was certainly the real belief of most of the early Fathers" and also the notion of "living in heaven", a belief which was wrong but safe. He further argued that "provided that every person is fully satisfied that his own ideas of the Divine essence are consistent with the *known attributes of Divinity* they must necessarily be equally safe and equally innocent".[25] It was now important to show how to move from such innocent beliefs to a firmer form of knowledge.

Such firmer knowledge was to be built by overcoming immediate experience. In many cases Priestley wrote of the break which had made the facts of natural knowledge possible. In his repeated descriptions approving the way that John Michell had developed his notion of matter and power by breaking with, or inverting, Andrew Baxter's philosophical immaterialism, Priestley made this point clear. This break "was calculated to throw the greatest light on the constituent principles of human nature". Baxter had claimed to "change our Physicks a little and establish a new Theory of matter". He had complained of "an unaccountable prejudice to be entertained by reasonable men and philosophers, that no designing cause, but such a passive and necessary one as matter, could observe such regularity and proportion". Hence, contesting the prejudice, Baxter wrote that "the motion excited in matter must arise from a substance purely spiritual". This conclusion was used as a prohibition of mortalism: "an infinitely just Being could no more annihilate [the soul] at death than [He could] effect a contradiction". Priestley wrote of Michell's reading of Baxter's claim that since this "spirit" was the only *visible* entity it might be the only real entity. Experience, *well controlled*, could break through the obstacles of this immaterialist system.[26] But if it was a matter of simple sensation, how had a system such as Baxter's ever emerged or survived? Once again, Priestley wrote of the obstacles of direct experience, when *uncontrolled*. In the *Disquisitions* he appealed to "the vulgar" who "consider spirit as a thin aerial substance", and who must see through the illusion of "the modern idea of a proper immaterial being". This "modern idea" was "not firmly established before Descartes". The origin of the concept of soul was a tendency to explain life by some "invisible agent". A liquor with "very active powers" is also believed to contain a "spirit". Remarkable pneumatic phenomena are attributed ignorantly to a gaseous "spirit". The soul was always identified with "breath". Hence, Priestley argued, the superstition of transmigration and the belief in "the contagion of matter". The ancients had described the soul "as what we should now call *an attenuated kind of matter*". So, finally, Priestley's enemies had realised that "the soul and body being in reality the same kind of substance", they "must die together". And to avoid this politically unacceptable consequence they constructed doctrines of dualism and of mediation, both of which Priestley now rejected. Matter "has been supposed to be" an "inert substance" and this view would only be destroyed by an organised return to the primitive pneumatic phenomena which had been corrupted by immaterialists for their own ends.[27]

This was the context in which Priestley's statements about the relation between power and matter were read. In his histories, Priestley had outlined the paths by which previous natural philosophers had reached a position where "the unknown properties of certain bodies, communicated to them by the Divine Being, the mechanical cause of which they scarce attempted to explain". In the *Disquisitions*, Priestley's argument gradually moved from an understanding of divine power to the separation of those powers from God's direct action, thus severing a link made in earlier natural philosophy. "I ascribe every thing to God, and, whether mediately or immediately makes very little difference", he wrote. Yet "the action of the Deity in preserving such a substance in being, will be a different thing from the Deity himself", and, ultimately, "from whatever source these powers are derived, or by whatever being they are communicated, matter cannot exist without them", and would indeed "cease to exist" were these powers withdrawn.[28] Priestley

satirised Baxter's position precisely by appealing to the *use* of matter, to its systemic character: "since matter *does* exist, it must be of some use, though Mr Baxter's general hypothesis ... leaves so very little to it, that it might very well have been spared". Priestley brought out the function rather than the activity of matter here: "pity that so mischevious a thing as he everywhere represents matter to be, should have been introduced at all".[29] Priestley's text could then be read as suggesting a range of powers, simultaneously mental and physical, which formed a system accessible to understanding but problematically related to display and experience. Price objected that "attraction and repulsion" were "totally different" from "perception, consciousness and judgment". He asked "what connexion can there be between them?". Priestley appealed to David Hartley's authority here: the connection between mental powers and physical powers was mediated in pneumatics since the history of doctrines of the soul showed how pneumatics had been the source of and the obstacle to knowledge of the mind and since such airs "seem at first to be in a kind of intermediate state between vegetable and animal substances".[30]

Priestley's texts suggested three ways in which the old natural philosophy could be broken and solid facts in natural knowledge established. First, he presented a range of powers, at once mental and physical, which were not to be displayed in a singlular fashion but connected in a natural and mental economy. Second, the mental powers were as subject to "observation and experiment" as were the material powers, "though we ourselves are the subject of the observations and experiments". The unity of powers was granted by a unity of *knowledge*, not a necessary unity in *matter itself*. Finally, because this economy of powers emerged as an item of knowledge, the mind of the philosopher would itself be the place where enlightenment would occur. Thus the performer could either break up the ordinary prejudices of an audience by a return to simple series of experiments, or else join with other workers in a collaborative enterprise from which a knowledge of the system would emerge.[31]

This presentation in Priestley's texts only emerged from 1774 onwards. Until then, Priestley could be read as a conventional natural philosopher. McEvoy has written that "Socinianism, determinism, associationism were all clearly present in Priestley's mind by the time of his first publication in electricity" and that "Priestley's acquiescence in the traditional dualism prior to 1774 ... merely reflects his early neglect of the relevant metaphysical issues".[32] Indeed, in the first volume of his *Institutes of natural and revealed religion* of 1772, Priestley can be read as maintaining adherence to such "traditions". Matter was "sluggish and inert" and thus not capable of being "the original cause and fountain of life, action and motion to all other beings". "The divine will" was celebrated in a Baxterian fashion; paraphrasing the classic General Scholium of the second edition of the *Principia* of 1713, Priestley then wrote of God as "*omnipresent*", since "tho' being a *spirit*, He can have no proper relation to place, and much less to one particular place more than another". "We cannot but conclude that God is an *immaterial* being, or *spirit*", he wrote. Priestley also wrote of the "sleep of the soul" and of a "future state" as an integral part of *natural* as well as revealed religion.[33] By the later 1770s these views were substantially revised. The future state was a matter of revelation alone; "one who believes in a soul *may not*, but one who disbelieves that doctrine *cannot* be a papist" he told Price. God was "far from being immaterial", Priestley declared, and that "how *matter* differs from *spirit* ... no way concerns me, or true philosophy, to maintain that there is any such difference". These were important changes of view and they were read as such by many of Priestley's audience. Furthermore, they licensed new forms of practice in the production of natural knowledge, and in turn made possible a new range of attack on those practices.[34]

There are many examples from Priestley's own practice which display the new relation he attempted to construct between powers and their systemic function. Two such examples are Priestley's investigation of the electrical production of earthquakes and his investigation of the restoration of the atmosphere. In both cases Priestley's report presented connected matters of fact without reference to the divine causation of the facts. The succession of phenomena displayed the function of the active power, not the production of that power by divine action. Thus facts in natural knowledge were fixed by a network of connected phenomena, not by the strength or efficacy of the phenomenon itself. Here Priestley cited David Hartley's conception of the path of natural philosophy: at the end of his preface to the *History of electricity*, Priestley alluded to Hartley's opinion that: "the greatest and noblest use of philosophical speculation is the discipline of the heart, and the opportunity it affords of inculcating benevolent and pious sentiments upon the mind". Natural philosophy was presented, now, as a self-enlightening practice, producing morality for the mind by a period of experience. The mind was not illuminated by being a member of a wondering audience. Hartley was a fundamental resource for this description of the use of natural philosophical practice. The *Observations on man* were important, moreover, not merely because of their doctrines of association and of mental power, but because of the connection they then displayed with millenial politics. "Every thing looks like the approach of that dismal catastrophe described, I may say predicted, by Dr Hartley", Priestley wrote. In the journal *The Theological Repository*, Priestley's allies linked "our present disquisitions on matter and spirit" with their faith in an imminent earthly millenium, not "a government over spirits in regions above the atmosphere", and ultimately, this view of political change dominated both reactions to the French Revolution and to the stability of the Earth itself.[35]

There was for Priestley and his allies an intimate relation between revolutions in the state and in nature. But sunspots or comets or earthquakes were not read as simple "signs", rather as *philosophically* comprehensible analogues of civil revolution. As Hartley had explained, "the present circumstances of the world are extraordinary and critical beyond what has ever happened".[36] Hence to display the function of earthquakes, for example, was not to defuse their

interpretative significance. During the eighteenth century, natural philosophers worked on the electrical cause of earthquakes as an evident mark of a fundamentally divine act. Priestley, however, showed the function of earthquakes in a single system, and he did so by building physical models which could function as an analogue of that system. This work was shared with Cavallo, Barletti and Beccaria, all of whom showed the function of earthquakes by displaying their electrical cause and then fitting this into a model of the system, and by constructing models of the earth and of cities.[37] Priestley's work in establishing facts about earthquakes began by contesting the view that ice was a non-conductor. This report was sent to John Canton in 1766, and, in his *History of electricity*, Priestley reprinted a lengthy discussion of experiments on the conduction of electricity through the surface of bodies like ice which could be used to display the systemic nature of such conduction.[38]

In this same *History* Priestley also reported the construction by Beccaria and Stukeley of models of earthquakes. In Beccaria's model a shock discharged through a Franklin "sandwich" of glass and metal, producing strong vibrations. Beccaria held that earthquakes followed the flow of electricity between unequally charged parts of the earth's body. Stukeley, who argued that earthquakes were produced by the discharge of electricity from non-electric clouds to Earth, had been attacked in the 1750s for seeming to remove the moral effects of earthquakes by giving them secondary causes. Priestley responded that Stukeley, by showing the function of earthquakes in a natural economy, also showed how a deeper divine purpose could be made out. In addition, since earthquakes were merely "caused by the discharge of redundant electricity from the surface of the Earth" across areas made damp by rainfall, it might be possible to prevent them "by kites constantly flying very high with wires in the strings, so as to promote an easy communication between the earth and the upper regions of the atmosphere".[39] Priestley reported that he had begun the investigation of conduction in ice, and had been drawn to examine the surface conduction of electricity across flesh and then water. The phenomenal resemblance between the agitation of the surface of the water and that reported by Stukeley in earthquakes then suggested to Priestley that he examine further this analogy. A brass ball suspended in a bottle placed on ice was seen to oscillate wildly when the ice had electricity passed through it. Priestley "afterwards diversified this apparatus" with further pendulums, boards floating in water, and bladders on the ice, "this last method seemed to answer the best of any". He wrote that

> the board representing the earth, and the water the sea, the phenomena of them both during an earthquake may be imitated at the same time; pillars &c. being erected upon the board, and the electric flash being made to pass either over the board, over the water, or over them both. This makes a very fine experiment.

Throughout this testimony, Priestley persistently qualified the aim of his work. He showed how the transmission of a charge across the surface was not produced in metals, and how the strength of the battery was crucial, even if "a moderate force was sufficient to ascertain the facts".[40]

This work on the transmission of electricity across the surface of water and ice was transformed by the successive elaboration of a model of the Earth's surface into a fixed fact about the production of earthquakes. That fact was then deployed against alternative models of earthquakes, including those of Stukeley and of Beccaria, and ultimately fitted into a picture of the system of atmospheric electricity and its circulation. In his correspondence, and in the work of some of his followers, this model was developed in considerable detail. Priestley told Andrew Oliver that "the Sun and the comets, as well as the earth, have *proper electric atmospheres*", and this could explain cometary motion. Adam Walker wrote of a balance between the power of light and electricity and that of gravity in the solar system.[41] Priestley wrote much about the analogy between electricity and phlogiston, apologising to Beccaria for doubting this connection and announcing that "this *revivification of metals* by electricity completes the proof of the electric matter being, or containing phlogiston". He described his work on the conductivity of charcoal and mephitic air as initial evidence for this connection, despite their "ambiguous" status. Here again Hartley's texts were an important source for Priestley's claim that material and vital powers were intimately linked. Hartley argued that muscular vibrations were analogous to electrical vibration, and were perhaps excited by such vibration. Texts such as these and those of Priestley himself were used by the Scots, such as Leslie, to argue for the identity of plogiston and electricity: Leslie cited Priestley's reports of the revivification of metals by electricity, of the diminution of air by electrical sparks, of the lack of gravity, of the effects on animals of dephlogisticated air and of electric shock, of the saturation of electric conductors with phlogiston, and of their similar effects on lime and on vegetable juices.[42]

The most influential of all the texts in which matters of fact about electrical phenomena were integrated into a natural system was Priestley's 'Speculations arising from the consideration of the similarity of the Electric matter and phlogiston' of 1775. It was soon translated into Italian in *Scelti d'Opusculi Interessanti*. Here Priestley provided the evidence which Leslie and the Scots had exploited, and wrote of the brain as "the great laboratory and repository" for conversion of phlogiston to electrical fluid. He systematically listed all the phenomena which he had produced as matters of fact about the behaviour of electrical fluids to show how these phenomena fitted into a single economy:

> We were astonished to the highest degree by the discovery of the similarity of electricity with lightning, and the aurora borealis, with the connexion it seems to have with water-spouts, hurricanes, and earthquakes, and also with the part that is probably assigned to it in the system of vegetation, and other of the most important processes in nature.[43]

A similar trajectory can be detected in Priestley's work in pneumatics, and such work cannot be separated

from his other projects in systematic natural philosophy. In his detailed studies of Priestley's publications on airs, McEvoy has shown how these works deployed the concept of "benevolence" in the natural economy. "Benevolence" was a principle which was only visible, Priestley held, in his own pneumatic cosmology, a cosmology established on the basis of unchallengeable chemical facts. In fact, Priestley's pneumatics and his engagement with Lavoisier exemplify the strategy of the production of matters of fact which should settle dispute and command assent, and which then acquired their meaning by incorporation into a described natural economy. Polemically, Priestley responded to Lavoisier through an emphasis on the individual and irrefutable fact, which was to have no further necessary implication, while simultaneously integrating those facts into a much richer picture of a system of nature.[44] This strategy enabled Priestley to dispute Lavoisier's version of Priestley's reports, such as those on the effect of the agitation of inflammable air in water. Lavoisier wrote of Priestley's view that such air "appears to differ in nothing from common air" while Priestley argued that he had just listed a set of facts: "a candle burned in this air as in common air, only more faintly; but that, by the test of nitrous air, it did not appear to be as good as common air; and that by longer agitation it extinguished a candle". Here facts were valuable resources in polemic, but meaningful only inside the system.[45]

The connection with political dispute was very close. Priestley told the French chemists in June 1796 that "you would not I am persuaded, have your reign to resemble that of Robespierre," and that "we hope you had rather gain us by persuasion, than silence us by power". He wrote that if French chemistry did ultimately manage to persuade its critics then, "there will be no Vendée in your dominion". Keir told Priestley that "there are wonderful resources in the dispute about phlogiston, by which either party can evade, so that I am less sanguine than you are in hopes of seeing it terminated".[46] Keir's remark was accurate: the openness of the dispute with the French tested Priestley's tactic of the display of facts which he had produced by revealing again and again the impossibility of closing debate, of reproducing experiments, or replicating apparently closed observation. Facts were fluid, not fixed, in this exchange. "Speculation is a cheap commodity", Priestley grumbled in 1777. The same fate was encountered by Priestley and his allies in the campaign for emancipation of Dissent. In the mid 1770s the Rational Dissenters abandoned an appeal to the "candour" of the government and, instead, demanded what they described as the "rights of humanity". "Cancel the obnoxious name of Christian and ask for the common rights of humanity", Priestley declared in 1773. The events of the late 1770s and 1780s destroyed the political basis of this campaign. It did not prove possible to pass a full Relief Bill after Catholic Emancipation and the Gordon riots, and Priestley's plain facts did not sway the civil power. Thus through the 1780s writers such as Price, Enfield and Towers joined with Priestley's declaration of faith in the effect of the unfolding of the whole system of civil and natural philosophy. "This is surely a reason not for remaining inactive, but for going on with an accelerated motion towards perfection. This acceleration is as natural in the moral as in the natural world". Ultimately this "silent propagation of the truth" was to be compared to "a train of gunpowder to which the match will one day be laid to blow up the fabric of error".[47]

In political and in chemical polemic, Priestley worked out the tactics of the production of facts and the display of the system. Single uncontestable facts were effective because allegedly indefeasible; the system worked because by gradual progress it must impress itself upon the associating mind. Neither in politics nor in natural philosophy did these strategies ever sit securely together. An excellent example of this unease was the nitrous air test for the virtue of an air. "Spoiled" air would leave more than two volumes when shaken with nitrous air above water: this seemed to be a phenomenal fact of natural virtue. The exchange with the French showed how vulnerable it was. Lavoisier and his co-workers did not share Priestley's conceptual scheme so they could not see the meaning of the nitrous air test. Only the use of the test in Priestley's theory of an aerial economy could show its ultimate function. In 1772 Priestley told Price that the restoration of air "extracted from nitre" by "washing it in rain water" was a fact which "appears more extraordinary to me than it can do you or anybody else". In 1782 he told De Luc that since the largest part of the air "would be furnished by volcano's from calcareous matter in the earth", this "might perhaps be the original atmosphere of this Earth before it was purified by the growth of plants which according to Moses, or explained by your excellent theory, were created a long time before any land animals". For De Luc the atmosphere was "a chemical laboratory" whose processes were those Priestley had charted. In his pneumatics Priestley converted experimental tests of "goodness" by nitrous air into a systemic and economic set of functions: "it becomes a great object of philosophical inquiry to ... discover what provision there is made in nature for remedying the injury which the atmosphere receives". The universe became a laboratory, rather than a theatre, and its behaviour therefore aped that of Priestley's experiments.[48]

There were numerous places in Priestley's work where the laboratory model of the universe did its work. In his controversies with Percival and IngenHousz in the late 1770s, Priestley attacked experimental work rather than reported facts, arguing that "one clear instance of the melioration of air in these circumstances should weigh against a hundred cases in which the air is made worse by it". He told Benjamin Vaughan that even when other natural philosophers agreed in the significance of the nitrous air test, they nevertheless performed it incompetently: "I am astonished and provoked at the little care with which some persons make experiments, and the confidence with which they report them".[49] In his experiments on the restoration of air above plants grown in water, his identification of the tell-tale "green matter" as inorganic, and subsequently as a product whose formation was stimulated by ambient phlogiston, was portrayed as a simple fact, a report of observation. He contested his opponents' work by referring to their experimental practice, not by adopting their reports as superficially

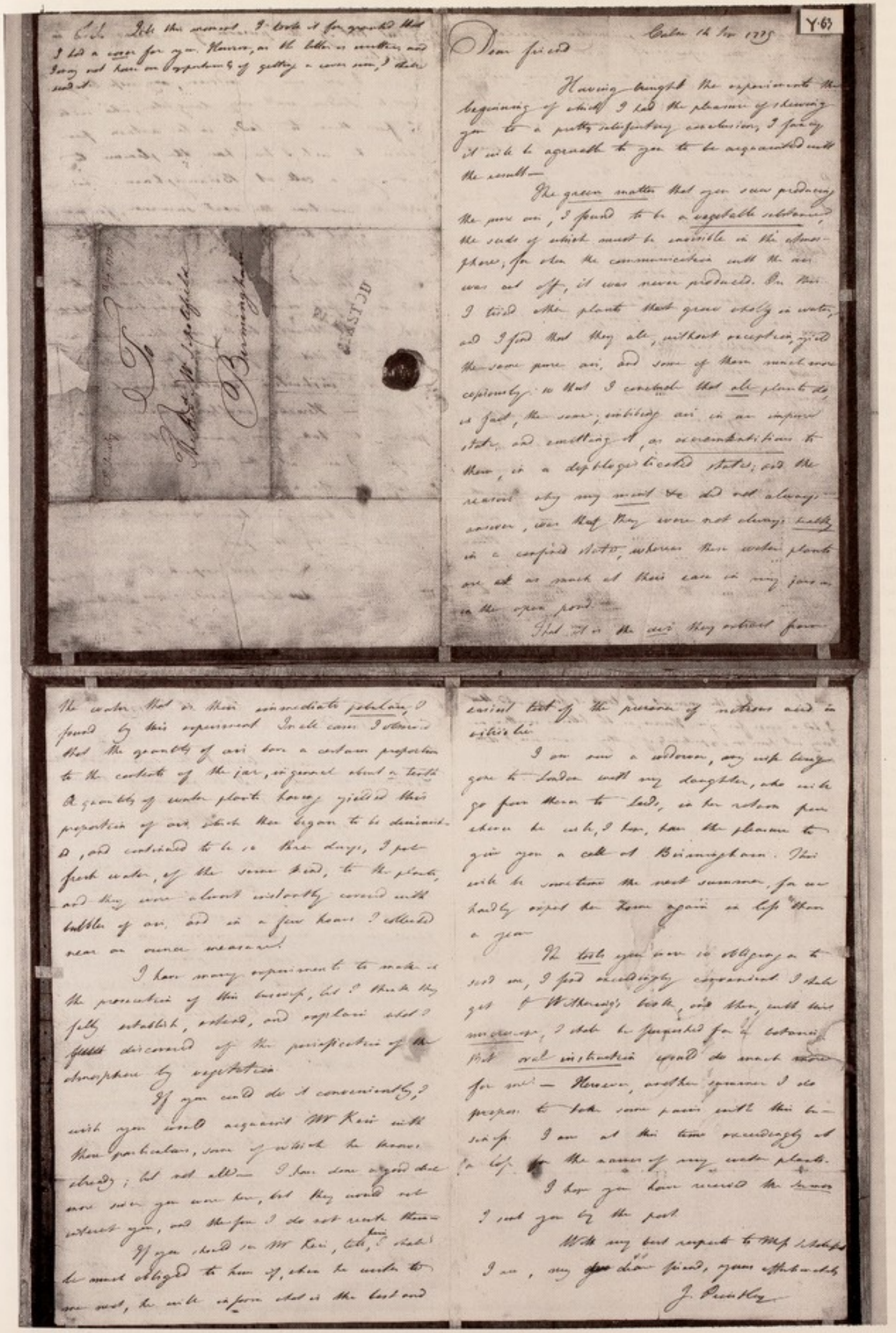

Fig 10 Letter, Priestley to Radcliffe Scholefield, dated Calne, 14 September 1779.
Catalogue 14 (see page 100)

reliable. Thus in this programme no phenomenon could ever be conclusive on its own, but all phenomena would have to stand on their own when analyzed by any critic. Such critiques always depend on Priestley's model of the distribution of the reports of experiments through the community of workers. Thus he insisted that there was a "great difference between *seeing* and *reading*", and that however expert, all his colleagues nevertheless were "surprised to see me actually make the experiments". The systematicity of an experimental programme could overcome these problems: a published report of a sustained series of trial would compel assent, and even allow replication. He told Rotheram that "the directions I have given are sufficient to allow any person to do everything after me". Finally, of course, it was the goal-directed programme which Priestley conducted which was to be celebrated by the physician John Pringle in his eulogy of Priestley's pneumatics in 1774: "From these discoveries we are assured that no vegetable grows in vain, but that from the oak of the forest to the grass of the field every individual plant is serviceable."[50]

I have argued that Priestley's interventions in natural philosophy could be used as resources to make possible different forms of natural knowledge, ranging from Jacobin lecturing to systematic medical policing. Thus, in pneumatics, Priestley's work could be deployed as part of a model system of physiological-medical knowledge and control, in which no event was terrifying and all natural phenomena, if well understood, were to be displayed as ultimately purposive. Such a system of circulation and control matches that of J.C. Lettsom in bureaucratic philanthropy. In this reading of Priestley, earthquakes were not moral lessons, they were part of a system which ultimately could restore the atmosphere and provide for human and animal consumption. This model was linked with the notion of the universe as a laboratory: to control these dangers it was necessary to refer knowledge to those few sites where it was generated, the select laboratories and select societies of the Enlightenment. Alternatively, by breaking direct and unmediated links between the individual phenomenon and the agency of power, public lecturers could now turn Whig natural philosophy to radical, and ultimately Jacobin ends. Beddoes's Pneumatic Institution or Loutherbourg's clinic can be contrasted with a system of police. These political and cultural contexts were crucial for the interpretation of Priestley's work. Historians have analysed in some detail the links between pneumatic chemistry, the debate on the health of towns and of their air, and the economic function of mineral water spas in the eighteenth century. "Elastic and healthful air", Smollett's "fragrant aether", could become a resource for a wide range of practitioners: economic entrepreneurs, cultural masters of ceremonies, charlatans and Jacobins. Further, this repertoire of uses dominated the way in which Priestley himself could conduct political or natural philosophical debate. The generation of fixed facts was designed to fix a certain kind of dispute and to appeal to a certain form of assent.[51]

Priestley's audience could choose the model of the universe as laboratory, and then command that model by manipulating its constituents. Alternatively, radicals contested this model by contrasting the natural economy, the laboratory of the universe, with the imperfect and corrupt state. Natural philosophy was intimately bound up with the social relations of groups of its practitioners. Priestley's practical technology of fixed matters of fact was designed to offer a means by which such communities could join together in a progressive, liberating campaign. This explains his own concentration on the difficulties of replication of experiments, and on the importance of correct organization of diffusion and production of natural knowledge. The effects of Priestley's campaigns were visible in the case of Tuscan reform and Tuscan science. Felice Fontana and his allies in government such as Francesco Gianni adopted Priestley's theory of pneumatics through their adoption of his technology of air tests. The Florentines connected these projects with those drawn from Priestley's contacts such as Arthur Young and the physiocrats. Fontana exploited the nitrous air test, formalized it as an effective machine called initially, an "evaerometer", and then used the instrument as an emblem and resource in their campaign to revolutionize the Tuscan economy, by draining and "purifying" the air of the marshes in the Tuscan Maremma. The project failed, not because of the mosquitoes, but because of *mal aria* (bad air). The Tuscans used Priestley's pneumatics in equivalent campaigns to raise agricultural production by solving the problems of crop disease and epidemic plague. The atmosphere became a central site of political and economic policy, as it was to do in Britain in the 1830s. The link with chemical dispute was such that in 1785 the Florentine police were forced to intervene in a public contest over the performance and the interpretation of French experiments on the generation of respirable air from water. Throughout this period Priestley's claim that there were close connections between political reform, public performance and instrumental technique was eminently confirmed.[52]

Priestley's use of fixed facts as an invaluable item of exchange between experimenters and between dissenters was scarcely original. Yet its importance in the formation of contemporary images of Priestley as hero or villain can scarcely be underestimated. This practical perspective should inform at least three key areas of future research: the close connection between progress in natural knowledge and the politics of spirit, through which the millenium would be achieved; the ubiquitous priority disputes which infected Priestley's career, and in which he took such a disingenuous role; finally, the mode of the discoverer to which Priestley contributed, and which, in turn, came to sustain a lengthy tradition of the unprepared discoverer as the hero of scientific progress. Priestley's fascination about all these themes was life-long. In one of his more touching letters, written to the young Humphry Davy in 1801, Priestley affirmed that he had indeed begun his "experiments on the subject of *air*" without "any previous knowledge of chemistry" and also carefully pointed out at least two points in Davy's work where Priestley had been wrongly cheated of priority: the experiment of the "conducting power of charcoal", Preistley reminded Davy, "was one of the earliest I made". While these claims might be challenged by

historians, who seek to ascertain the true character of Priestley's education in science, it is as important to understand the way in which our own images of his work were so painstakingly constructed and reinforced.[53]

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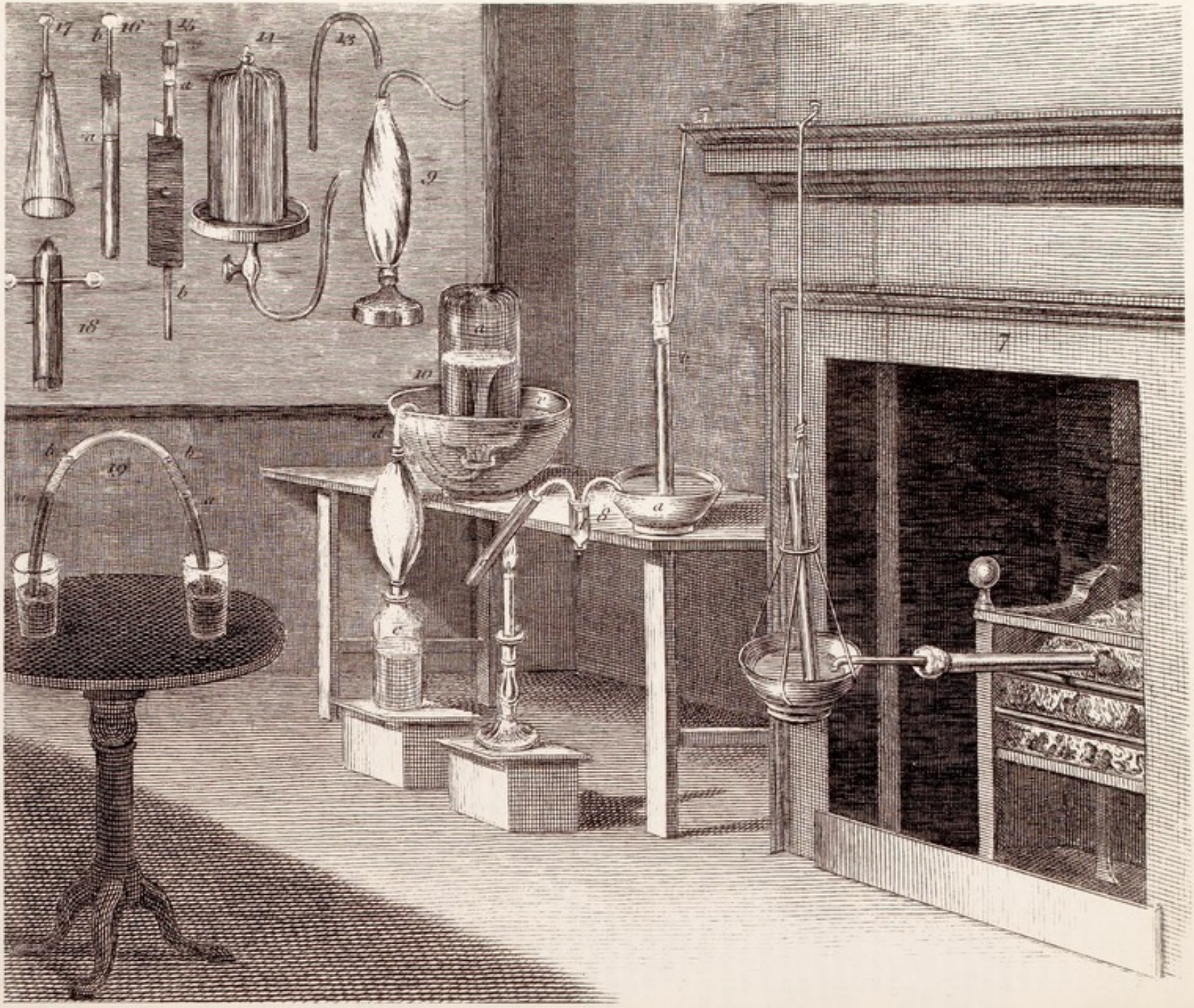

Fig 11 Priestley's laboratory at Calne(?), plate from *Experiments and Observations on Different Kinds of Air*, 1774. Catalogue 27 (see page 102)

Causes and Laws, Powers and Principles: The Metaphysical Foundations of Priestley's Concept of Phlogiston

JOHN G. McEVOY

Religion gave meaning to Priestley's existence. It guided him through life and consoled him in death. As the only "sufficient foundation" of a virtuous life and a happy death, religion ranked above all other human affairs in Priestley's estimation. In a radical mood, he could proclaim that "no kind of knowledge, besides that of religion, deserves the name."[1] Far from distracting from his scientific energies - as some scholars have supposed - his religious preoccupations elevated natural philosophy to a place of overriding significance in his thought.[2] Indeed, the most general consequence of Priestley's theism places upon man a moral duty to use his rational faculties to understand nature. Priestley's religious vision links natural philosophy to man's spiritual enlightenment and moral edification, and thereby gives scientific significance to his claim that religion is the only kind of knowledge worth having. With proselytizing zeal, he used reason and revelation to support the view that the cultivation of natural knowledge is essential to a virtuous life and a happy death. He insisted that, unless we accept the fate of Faust, the pursuit of knowledge must not become an end in itself, but must be tempered by a concern for our religious and social duties. However, he was equally convinced that, when approached in the right way and kept in its proper place, natural philosophy has no equal as a rational means to a virtuous and happy end. Clearly, for Priestley, science is an integral part of religion:

> But when the pursuit of truth is directed to this higher rule, and entered upon with a view to the glory of God, and the good of mankind, there is no enjoyment more worthy of our natures or more conducive to their purification and perfection.[3]

In accord with the dictates of "this higher rule", Priestley related science to a "set of moral and metaphysical principles" designed to "heighten the feelings of virtue" by impressing "the mind with ideas of *simplicity, comprehensiveness, symmetry, beauty,* etc."[4] Within this philosophical framework, Priestley saw the pursuit of natural knowledge as leading to the cultivation of piety and benevolence in man, the comprehension of nature and the removal of obscurity, and the enlightenment and amelioration of man's estate through the elimination of prejudice and hardship.[5] As I have argued elsewhere, Priestley's early work in electricity and mature work in pneumatic chemistry can be understood fully only by reference to this broader intellectual context.[6] This is also true of Priestley's final scientific role in the Chemical Revolution, which has been distorted and misrepresented by the failure of scholars to take cognizance of the metaphysical, epistemological, theological, methodological, moral and political dimensions of his natural philosophy. While recognizing the interconnectedness of Priestley's system of thought, this study will concentrate on the narrower task of articulating the ontological and epistemological aspects of his concept of phlogiston.[7] By elucidating the deeper structure of Priestley's chemical thought, I hope to indicate the reasonableness of his opposition to the oxygen theory, the complexity and nuances of the oxygen-phlogiston dialectic, and the oversimplifications that characterize past and present views of the cognitive structure and dynamics of this famous scientific conflict.

Priestley's basic intellectual commitment is to be found in his conception of the rationality of Christianity, which impelled him to comprehend his unfolding experience of the world in terms of a conceptual framework that embodies the symbiotic harmony of faith and reason. This dual commitment to reason and revelation shaped the basic categories of Priestley's thought and placed him in the vanguard of Rational Dissent. Accordingly, he argued that the way to obtain religious knowledge is through a rational analysis of nature and scripture, and not by abandoning reason to dogma and mystery.[8] For Priestley, faith is the rational outcome of consistent rational enquiry and contains nothing either paradoxical or "contrary to all *natural appearances*."[9] The congruence of faith and reason was so complete in Priestley's mind that he could proclaim that "Christianity will be no obstruction to anything that is truly rational ... and whatever

is not rational, ought to be abandoned on principles that are even not Christian."[10]

Rational Dissent gives expression to the unusual synoptic power of Priestley's mind and serves to demonstrate how "the three doctrines of *materialism* ... *Socinianism* and of philosophical *necessity*, are equally parts of *one system*," based on a rational understanding of nature and Scripture[11] The harmonious union of these three epistemologically independent doctrines in a philosophical monism is the most significant feature of Priestley's theory of matter. The connection between Priestley's theory of matter and doctrine of causation clarifies the ontological basis of his Stahlian chemistry of "powers" and "principles", which contrasts vividly with the classificatory logic inherent in Lavoisier's concept of an element. Priestley's determinism is the basis of his doctrine of "primary and secondary causes," which is the metaphysical link between his ontology of lawful powers and his sensationalist epistemology of "facts" and "theories". This epistemological framework is shaped by his associationistic view of the mind, which is grounded in the doctrines of materialism and necessity. Furthermore, Priestley's sensationalist epistemology reinforces Lavoisier's view that a chemical element is a "simple substance", isolable in the laboratory and detectable by the balance. However, this concept of an element is at odds with Priestley's theistic ontology of generic powers. The underlying tension so generated in the conceptual foundations of Priestley's chemical thought surfaced in the technical and theoretical problems associated with his attempt to isolate phlogiston in the laboratory. Priestley responded to the spate of "antiphlogistic" criticisms relating to the unisolability of phlogiston by showing that they were equally applicable to the oxygen theory. On this and every other level of analysis, Priestley could find no rational ground for choosing between phlogiston and oxygen. Although he favoured the phlogiston theory, ultimately he adopted an epistemic stance of critical detachment towards any theory - an attitude which is incompatible with the view of Priestley's theoretical entrenchment held by many historians of the Chemical Revolution.[12] In so relating Priestley's natural philosophy to this broader philosophical nexus, it also becomes apparent how recent attempts to interpret his chemistry as an articulation of the Newtonian paradigm are wide of the mark. In fact, Priestley's science was part of a broad spectrum of eighteenth century "natural philosophies which sought to erode key aspects of the Newtonian world-view."[13]

Priestley's entire intellectual system was sustained by his view of God's attributes and causal relation to the world. In his mature theism he sought a rational grounding for the world in God's nature and creative act. More specifically, Priestley related the intelligibility of nature to its structure as a deterministic system of benevolence. This view of the world grew out of the basic principles of his Rational Dissent (Socinianism, determinism and materialism), which were formed by the systematic logic inherent in his mature opposition to the voluntarist theology of his Calvinist youth. According to this voluntarist tradition, the sole attribute of God that the human mind can comprehend is his omnipotence. Nature is the unconditional result of the sheer and arbitrary power of the Divine Will. Reality is ultimately unintelligible to the human mind, which cannot comprehend the unique causal relation between an immaterial, timeless Deity and a material, temporal creation. In *An appeal to the serious and candid professors of Christianity*, Priestley related this voluntarist view of the "arbitrary dictates" and "secret decrees of the Almighty" to the Calvinist doctrines of predestination, the Atonement, and the natural depravity of man.[14] In this seminal document, he insisted that these doctrines encourage moral fatalism by denying man any ability to comprehend the Divine Will and so shape his eternal destiny. In rejecting these articles of faith, Priestley linked the perfectibility and happiness of mankind to the intelligibility of the universe.

By the time he entered the Daventry Academy in 1752, Priestley was convinced that the Calvinist "dread and terror" of a vengeful, capricious God, and consequent disdain for his "doomed" offspring, corrupt the "love of God and mankind" which is essential to "virtue".[15] In contrast, the mature Priestley linked virtue to knowledge and knowledge to benevolence and piety. Under the compelling and pervasive influence of David Hartley's *Observations on man*, Priestley replaced the "gloomy" doctrine of man's natural depravity with a view of the perfectibility of human beings through their increasing awareness of the operation of God's benevolent will in the universe.[16] In the Doctrine of Philosophical Necessity, he gave systematic formulation to his view of the moral perfectibility and happiness of human beings living in a world designed and sustained by God to maximize their happiness.[17] Subsequently, he established an intimate relation between this deterministic view of man and the doctrine of materialism, which, by denying the "pre-existence of souls" and, hence, the "Divinity of Christ," undermined the Calvinist doctrine of the Atonement.[18] Priestley further articulated his cosmic optimism and psychological perfectibilism in the associationistic view of the mind, which he grounded in his materialism and universal determinism. Finally, he related all these views to his Socinianism, which served to base his mortalism and anti-trinitarianism on a rational understanding of the Scriptures.

Priestley gave complete expression to his determinism and materialism in a philosophical monism which viewed nature as the necessary outcome of God's immanent creativity. To this end, he embraced a monistic view of God and nature instead of the voluntarist dualism of an immaterial, timeless Deity transcending the material and temporal creation. In this vein, Priestley rejected the voluntarist doctrine of *creation ex nihilo*, according to which nature is the unconditional result of the sheer and arbitrary power of the Divine Will, in favour of a rationalist explanation of God's creative act in terms of the Divine attributes.[19] He thus insisted that God no more than man is possessed of a *"self- determining will."*[20] Besides being unable to act in defiance of logic to produce "impossibilities," God is "subject to a moral Necessity and to the Perfection of his own nature"[21] Priestley grounded his view of the intelligibility of nature in a conception of the necessity

of God's creative act, which he viewed as determined by attributes other than the arbitrary power of the Divine Will.

For our purposes, it is important to realize that Priestley's theism embodies a principle of the intelligibility of nature, according to which the mind can know how the world is causally related to God. This opinion is contrary to the voluntarist hypothesis, which provides no rational grounds for an account of creation, conceiving, as it does, that God transcends the world, both in perfection and in power. In contrast, Priestley's determinism and materialism are designed to elucidate the causal relation between God and the world in which he is fully actualized. Since all things necessarily flow from the Divine nature, they are necessarily linked in a deterministic chain. If nature devolves for a necessary creative act, natural philosophy will give content to our conception of God and his causal relation to the world. These sentiments are fully expressed in Priestley's materialism, which develops a monistic interpretation of reality, in which matter is an expression of God's continuous activation of nature arising necessarily from the creative act. In rejecting all dualisms, of God and nature, mind and matter, good and evil, as irrational and unchristian, Priestley's view maintains that the "Divine Being, and his energy, are absolutely necessary to that of every other being."[22] Although Priestley's conventional religous sentiments preserve an element of Divine transcendence that distinguishes his theism from Spinoza's pantheism, nevertheless his monistic view of reality emphasizes the "presence" of God in "His productions", rather than His distance from them.[23] In Priestley's view, the "power" of God is "the very *life and soul* of everything that exists."[24]

Priestley's rationalist theology also sustains the view that the unfolding of God's power in the world conforms to the necessary dictates of his other attributes, a consideration of which throws light not only on God's creative act but also on the product of that causal activity. Accordingly, the "immutability" of the Divine Being requires that God "could not but have acted from all eternity," which means that the world must be coeval and coexstensive with its infinitely perfect creator. Like himself, the "works" of God are "infinite and inexhaustible", and nature is governed by a principle of plenitude.[25] Also, since "goodness or benevolence" is "the great governing spring or principle of action in the Divine Being", God produces and maintains a world that mirrors his benevolent nature.[26] Finally, the simplicity and uniformity of nature is a result of the fact that its diverse effects are the products of God's immutable action and eternal design.[27] In this manner, Priestley's theism grounds his natural philosophy in an ontology of Divine powers, structured according to the necessary dictates of Divine benevolence, plentitude and simplicity.

Priestley's theism relates to his natural philosophy in a variety of ways. Firstly, his theistic view of nature as a deterministic system of benevolence ascribes moral significance to natural knowledge by linking epistemic progress to spiritual enlightenment. This analysis is fully expressed in the Doctrine of Philosophical Necessity, which also relates Priestley's view of God's immutable activitiy and eternal design to the scientific aim of constructing a single set of "simple and general laws," relating to "both the material and intellectual world."[28] However, Priestley's theism also implies that nature is ruled by a principle of plenitude, or epistemic novelty, which renders this reductive, explanatory objective forever inaccessible to the finite human mind. At this point, Priestley's theistic thought reflects Hartley's opinion that "the absolute Perfection of God seems to imply both entire Uniformity, and Infinite Variety in his Works."[29] God uses means of economy and simplicity to produce effects of inexhaustible richness and fecundity. Consequently, Priestley's methodological thought embodies a dynamic tension between his recognition of the ultimate significance of the search for simple laws in science and his keen sense of the epistemic limits and liabilities inherent in the generalizing activity of the human mind. Corresponding to this methodological polarity is an ontological commitment which emphasizes the hierarchical structure of a world in which God's immutable action unfolds, through an ordered system of "general principles" (or powers), to produce the "diverse effects" of nature. This theistic ontology of hierarchical powers is fully expressed in Priestley's view of matter as a plenum of intensive powers extended in space, and forms the basis of his chemistry of principles. Finally, Priestley's theistic doctrine of plenitude reinforces the nominalism inherent in his Lockean sensationalism. Priestley's nominalist sensibilities shape his methodological thought in a way that places severe constraints on the epistemic significance of theorizing in natural philosophy and which relates epistemic progress to the accumulation and inductive ordering of "new facts". Priestley's empiricist opposition to the role of theoretical genius in natural philosophy is reinforced by his associationistic belief in the epistemic equality of all men, which is also an integral part of his Dissenting politics of liberal individualism. A detailed articulation of Priestley's theistic principles and their implications for natural philosophy is contained in his doctrines of determinism, causation and associationism. These doctrines will be considered insofar as they relate to Priestley's view of the ontological foundations of phlogiston.

Determinism plays a central role in Priestley's intellectual system. Consistent with his denial of a separate and immaterial soul, Priestley opposed the view that freedom of the will exists outside the nexus of universal determinism. He maintained that "there is some *fixed law of nature respecting the will*, as well as ... everything else in the constitution of nature," so that there is "a necessary connection between all things ... as much in the intellectual, as in the natural world."[30] All events in the world make "one connected *chain of causes and effects*, originally established by the Deity."[31] More specifically, Priestley's theism led him to view man as part of a deterministic system of benevolence, in which all things are linked to the fecundity and benevolence of the divine creation. According to Priestley's mechanistic theory of the mind and intellectualist view of the will, man's growing awareness of his benevolent environment leads inevitably to his greater happiness, virtue and moral perfectibility. Furthermore, besides

constituting "a perfect coincidence between *true religion* and *philosophy*," Priestley's determinism articulates his theistic view of the philosopher's search for nature's causal powers and lawful structure.[32]

The metaphysical foundations of Priestley's view of nature's lawfulness are laid down in his discussion of the differences between "*Necessity*" and the "*predestination* of Christians and Mohamets." Ultimately, this point of contrast relates to the difference between Priestley's conception of the rationality and intelligibility of God's creative act and the voluntarist emphasis on God's supernatural power. In the first place, Priestley insisted that although the doctrine of "*predestination*" - "which is the same thing as the *fate* of the Heathens" - involves "an idea of the certainty of the final event of some things," it contains "no idea of the necessary connection of all the preceding means to bring about the designed end."[33] In developing this point, he proceeded to distinguish between events "coming to pass by means of natural causes" and God interposing "to make sure of the event."[34] According to this distinction, the true sense in which the world, emanating from Divine nature, is deterministic is expressed in the conception of nature's lawful system of causes and effects, according to which things come about by the internal necessity of God's continuously active power, and not by the external necessity of God's direct intervention. For these reasons, Priestley insisted that the Doctrine of Necessity must be distinguished from the "notion of predestination as maintained by Luther, Calvin and ... the Jansenists." All these thinkers, he maintained, suppose God to act by external necessity, whereby he uses "supernatural means" to ensure that "a certain train of events should absolutely take place."[35] However, external necessity presupposes a voluntarist theology, which relates God's intervention to "*his own glory* and sovereign good will," independent of "any reason of *preference*."[36] This doctrine is fundamentally opposed to Priestley's view that God's rational power and will operates through a deterministic system of laws governed by the necessary dictates of the Divine nature.

The theistic foundations and moral implications of Priestley's view of nature's lawful structure are further articulated in his theodicy. Priestley's rationalist theism places greater value on the present world of systemic benevolence and "temporary evils" than on a possible, lawless world bereft of all evil thanks to "a constant and momentary interference" of the Almighty.[37] In this hypothetical paradise, in which God eschews "general methods of acting," human beings would be unable to better themselves by contemplating the wisdom of God. In contrast, Priestley saw the Divine wisdom expressing itself in the real world through "a system of wonderfully general and simple laws, so that innumerable ends are gained by the fewest means, and the greatest good produced with the least possible evil."[38] It follows that the sufferings and evils of this life are an integral part of God's benevolent plan, which links the intelligibility of nature to the moral and intellectual perfectibility of man. Whereas the Calvinist doctrine of predestination emphasizes the unintelligibilty of God's absolute power and incomprehensible design, Priestley's conception of how God's wise benevolence expresses itself in a system of general laws articulates his view of an intelligible world emanating deterministically from the internal necessity of God's sustaining presence.

The monistic implications of the Doctrine of Philosophical Necessity further articulate the causal ontology inherent in Priestley's theism. Unlike the Doctrine of Philosophical Liberty and the Manichean heresy, which both recognize a principle in the world - contingency and evil, respectively - that is independent of God, the Doctrine of Philosophical Necessity posits a deterministic monism in which "good and evil ... have ... the same author" and "conspire to the same end - the happiness of the creation."[39] This view is given ontological substance in Priestley's claim that "no powers of nature can take place" and "no creature whatever can exist, without the Divine agency; so that we can no more *continue*, than we could *begin* to exist without the Divine will."[40] God's creative act is continuously expressing itself through the "powers of nature," so that the "*necessary determination*" of things is "according to the established laws of nature."[41] Once nature is established in terms of immutable laws sustained by God's internal necessity, causes and effects must come about as they do, unless these laws are changed or suspended by God.

In broad terms, Priestley's natural philosophy rests on a deterministic ontology of powers which expresses God's sustaining immanence and guarantees the ultimate intelligibility and lawlike nature of the created world. As will be shown more fully below, Priestley's theistic thought supports the causal presuppositions inherent in his materialism in a way that reinforces the causal ontology of the phlogiston theory. The immanence and intelligibility of the Divine will (or "power") provides the ultimate rationale for Priestley's view of matter as a nexus of powers, the configurations of which constitute the causal agents, or "general principles", which make up the "general system" of nature. In discovering the powers of nature and their interrelations, natural philosophy comprehends how the world is causally related to God. In rejecting the voluntarist view of God's trancendent power and perfection, Priestley shaped the basic ontological categories of his scientific thought in accord with his rationalist belief that God is fully actualized in his creative act. Priestley's theistic emphasis on God's immanent causal activity (or "power") in nature conditions his view that the aim of science involves a search for nature's causal agents, which is inextricably related to the elucidation of its lawful structure.

In relating the phlogiston theory to this metaphysical framework, Priestley upheld and reinforced the causal ontology that characterized the Stahlian chemistry of "property-bearing principles" which flourished prior to the emergence of Lavoisier's classificatory logic of "simple substances." Although this clash of incompatible ontologies constituted a dominant polarity in the debate between Priestley and "the Lavoisians", it did not occur across an unintelligible divide of incommensurable commitments. Rather, as will be shown below, just as Lavoisier's classificatory logic of specific simple substances is compromised by his lingering

involvement in the traditional chemistry of generic principles so Priestley's causal ontology of principles is distorted by the innovative logic of simple substances inherent in the empiricist epistemology he shared with Lavoisier. Priestley's ontology of materialistic powers interacts with his epistemology of sensations to produce a pervasive conceptual tension in his thought, not unlike that between his theistic insistence on nature's unity and his recognition of its multiplicity and variety. The incongruent relation between Priestley's ontology and epistemology is metaphysically grounded on his doctrine of *"primary and secondary causes,"* which also relates his theory of nature's causal powers to his view of its lawful structure.

Priestley held two separate doctrines of determinism. In the first doctrine, events are necessarily determined once necessary and sufficient conditions are established within the framework of space and time. This theory of causation emphasizes nature's lawful structure, according to which events could not happen otherwise. In this view, "the circumstances preceding any change, are called the *causes* of that change."[42] Whether in the intellectual or in the material world, "the only reason that we can have to believe in any *cause*, and that it acts *necessarily*, is, that it acts *certainly* or *invariably*."[43] Priestley maintained that the characteristics of antecedent causes (or "circumstances") are such that there is absolute certainty the effects will follow by internal necessity unless the laws of nature are suspended by God. Priestley's view of the intimate relation between God's internal necessity and nature's lawful structure underlies his nomic analysis of causal necessity, according to which "when we say that two events, or appearances, are *necessarily connected*, all that we mean is, that some more general law of nature must be violated before these events can be separated."[44]

Priestley's nomic analysis of necessity does not exhaust his concept of causation however. This analysis is restricted to the domain of "secondary causes", which is reducible to the more ultimate realm of "primary causes" in Priestley's thought. He argued that the established system of natural rules and laws indicates that the "cause of moving iron is in the magnet, though the magnet is not the primary, but only the proximate, or secondary cause of that effect."[45] The "real" cause of movement in the iron is not the magnet itself, but the "higher" power of magnetism, which inheres in the magnet itself, but the "higher" power of magnetism, which inheres in the magnet and comes "ultimately from God, the original cause of all things."[46] This view of nature's determinism refers the efficacy of its "primary causes" to the necessary and continuous action of God's power in the world. From the necessity of Divine nature all material things are determined to exist and to act. The power whereby material things operate is the internal power of God himself.

The Doctrine of Philosophical Necessity also posits an epistemological connection between the realms of primary and secondary causation. Accordingly, Priestley argued that cognitive access to the domain of "primary causes" is indirect and is mediated by an understanding of nature's "secondary" lawfulness. Part of Priestley's deterministic argument against free-will, or a "self-determining power" of the mind, involves the claim that "power, universally requires both *objects* and proper *circumstances*."[47] For example, the *"power of burning"* cannot operate "without something to burn, and this being placed within its sphere of action."[48] Similarly, just as the *"power of thinking*, or *judging*," requires ideas "to think and form a judgement upon," so the "power of *willing*" is "exerted one way rather than another" depending upon the motivational "circumstances" in which it operates.[49] All of nature's "powers," whether "corporeal or intellectual," are "called forth" in determinate "circumstances" to produce determined effects. Since the existence of *"all powers"* can be proved only "by their actual *operations*," it follows that *"effects* are the only evidences of *powers*, or *causes*."[50] The observation of a lawlike relation between a "circumstance" and an "effect" in the realm of "secondary" causation is the only basis for inferring the existence of an underlying "primary" power, deterministically operating to connect circumstances with effects.

The doctrine of primary and secondary causes establishes the metaphysical link between Priestley's ontology of powers and laws and his epistemology of facts and theories. According to this view, natural philosophy determines indirectly nature's underlying causal powers by constructing the appropriate theoretical representation of its overt lawful structure. To this end, it seeks to construct a system of "simple and general laws" in which observed "facts" are "reducible" to a set of "general rules."[51] As will be shown below, this marriage of ontological and epistemological categories proved incongruent in Priestley's thought only when he sought to relate a primary ontology of generic powers to the secondary categories of substance and causation inherent to his sensationalist epistemology. Adopting an epistemic stance similar to Lavoisier's doctrine of simple substances, Priestley tried, in 1783, to identify phlogiston - the generic principle (power) of inflammability - with a specific inflammable substance, namely inflammable air. However, this endeavour proved futile, and Priestley soon reverted to the more appropriate procedure of determining the presence and action of phlogiston through its lawful effects. This methodological retreat notwithstanding, the doctrine of primary and secondary causes continued to provide Priestley with a metaphysical link between the ontological objectives and epistemological procedures of his natural philosophy. These objectives and procedures are more fully developed in his materialism and associationism.

Priestley's vision of the Divine Will as continuously active in the creation and preservation of the world is most fully expressed in his concept of the "nature of matter." Growing out of his philosophical reflection on materialism, Priestley's theory of matter integrates his concept of man, his mechanical view of thought and the doctrines of determinism and causation in a fully articulated system of philosophical monism.[52] His view of matter also contains a reductive analysis of nature's primary causal powers, which further articulates the metaphysical foundations of his natural philosophy.

In rejecting current Newtonian and Christian views of the duality of matter and spirit, Priestley argued for a monistic materialism, in which matter is defined as "a substance possessed of the property of *extension* and the powers of *attraction* and *repulsion*."[53] He further insisted that the powers essential to matter are not "*self-existent* in it", but are dependent on the continuous and necessary activation of the Divine Being.[54] Body and spirit are equally manifestations of the Divine power. Priestley achieved this ontological reduction of reality to the Divine power by defining matter as a nexus of powers, by reducing man's nature to a comprehensible "uniform composition" that is part of physical reality, and by identifying man and nature with one and the same manifestation of Divine power.[55] This reduction enabled him to bring his materialism into harmony with his cosmic optimism and psychological perfectibilism, since man develops according to the deterministic laws of his Divinely constituted material nature.

Priestley's view of matter as a nexus of powers of attraction and repulsion articulates his conception of the link between nature's causally active "general principles" and the sustaining immanence of the Deity:

> Suppose then that the Divine Being, when he created *matter*, only fixed certain *centers of various attractions and repulsions*, extending indefinitely in all directions, the whole effect of them to be upon each other; these centers approaching to or receding from each other, and consequently carrying their peculiar spheres of attraction and repulsion along with them, according to certain definite circumstances; it cannot be denied that these spheres may be diversified infinitely, so as to correspond to all kinds of bodies that we are acquainted with, or that are possible: for all effects in which bodies are concerned, and of which we can be sensible by our eyes, touch, etc., may be resolved into attraction and repulsion.[56]

Insofar as bodies are reducible to complexes of interlocking "centres" of "powers of attraction and repulsion" emanating from the Divine energy, it follows that the properties of any object, at whatever level of analysis they occur, are continuously sustained by God's causal activity. The particular size, shape, texture, hardness, etc., of an object, as well as its generic properties, such as inflammability, alkalinity, acidity, elasticity and causticity, are equally reducible to constellations of "spheres of attraction and repulsion" inhering in, and sustained by, the Divine Being. On this analysis, the "difference between *acids* and *alkalis*, *metals* and *earths*, etc." is reduced to different "*modes* of attraction and repulsion."[57] Since nature's effects are the result of Divinely sustained "*centres of various attractions and repulsions*," it is the business of natural philosophy to determine and classify the enduring configurations and constellations of power whereby these pristine "*centres*" constitute the causal agents, or "general principles," involved in the "general system" of nature.

Priestley's view of matter as a nexus of "powers of attraction and repulsion" clarifies the theistic dimensions of the causal presuppositions inherent in his chemical ontology of property-bearing principles. All of nature's powers are reducible to powers of attraction and repulsion created by and inhering in the Deity. Furthermore, Priestley's ontology of causal powers is structured according to the principle of hierarchical simplicity, which arises out of the conceptual tension between his theistic sense of nature's unitary structure and his equally strong awareness of its multiplicity and variety. On this view, nature's simplicity is revealed in the reduction of its "diverse effects" to God's immutable action and eternal design by means of a causal chain that emphasizes the hierarchical relation between universality, generality and particularlity. Starting with the particularity of sensationalist experience, natural philosophy reveals how "a vast variety" of nature's effects proceed from "the same general principles, operating in different circumstances."[58] Furthermore, the interrelations and adaptations of causal powers, such as phlogiston, heat, light, electricity and magnetism, in the "general system of nature" are "marks of design," which indicate the underlying presence and "necessity of a *designing cause*."[59] By "constantly ascending in this chain of cause and effect," we ultimately "consider all secondary and inferior causes, as nothing more than the various methods by which the Supreme Cause acts, in order to bring about his great design."[60] In ascending this causal ladder, we do not reach back to a temporal First Cause, but move from "particulars to general." This is an epistemic process of moving from the particularity of nature's "effects," conceived in nominalist terms, through the generality of causally active "general principles," to the universality of God's immutable action and eternal design. In this manner, the phenomena of nature are viewed as the causal result of an intelligible system of powers, or principles, the ultimate source of which is the necessary and continuous activity of an inexhaustible and benevolent Deity.

This analysis of the ontological foundations of Priestley's natural philosophy is inconsistent with a prevalent interpretation that relates his chemistry to the physicalist principles of Newtonian dynamic corpuscularity. According to Robert Schofield and Arnold Thackray, Priestley's scientific thought is characterized by a quest for "fundamental physicomathetmatical explanations," which is at odds with Lavoisier's view of the relative autonomy of chemistry. On this view, Lavoisier's explanatory successes arose out of a Stahlian rejection of Newtonian physicalism in favour of the "materialist" search for the "permutations and combinations" of relatively indestructible "elements with property-bearing characteristics related to the realm of laboratory experience."[61] In contrast, Priestley is seen as rejecting the shallow triumphs of Lavoisier's materialism and returning to the "mechanistic" programme of Newtonian dynamic corpuscularity, which denied any permanent identity to the chemical elements and emphasized "the fundamental significance of determining the ultimate constituents of matter in its mechanistic modes and operations."[62] According to Schofield, the Newtonian search for microscopic forces was embodied in Priestley's adherence to Boscovich's view of matter as consisting

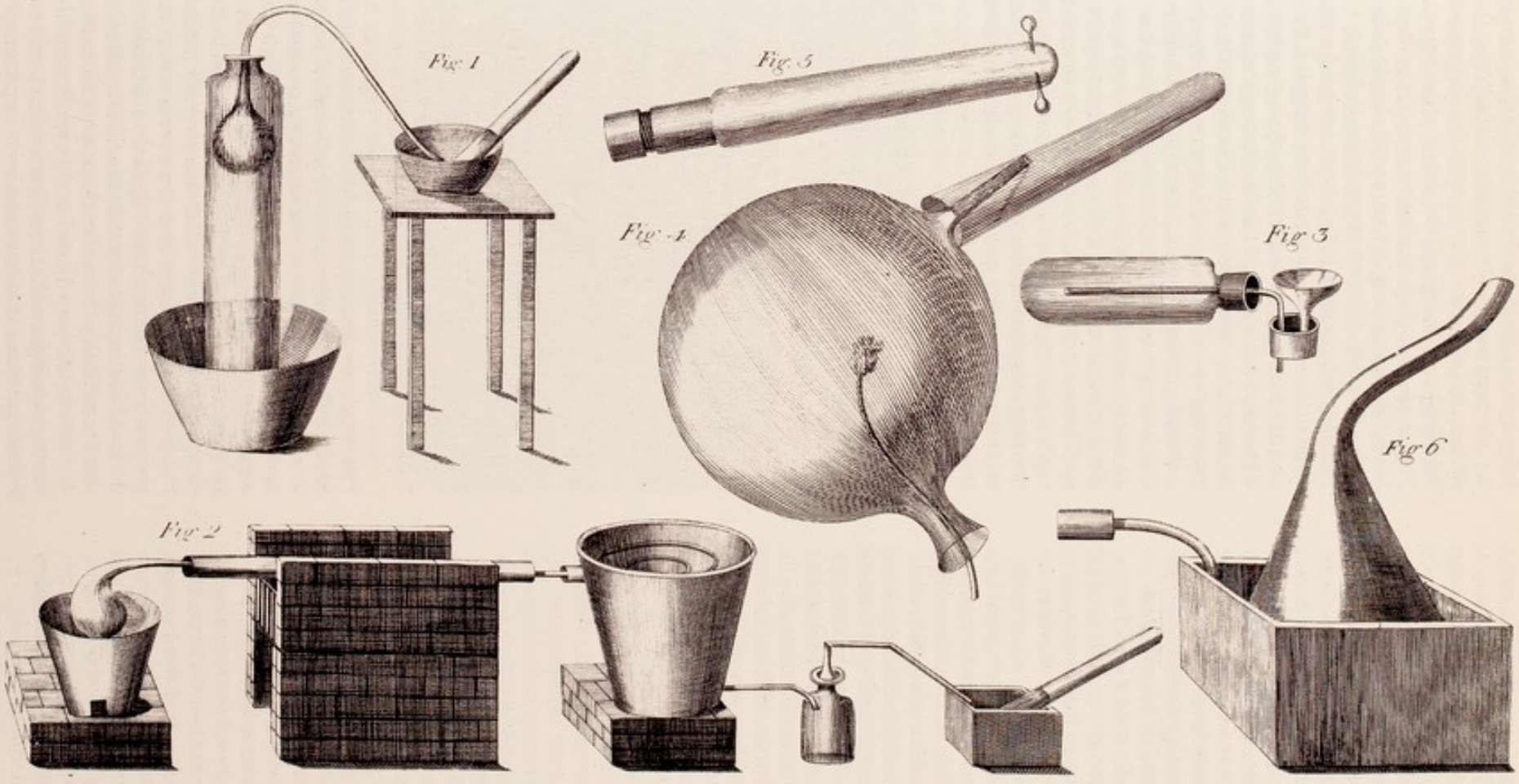

Fig 12 Priestley's apparatus for experiments with gases, plate from *Experiments and observations relating to various branches of natural philosophy* (1786)

of "physical indivisible points" surrounded by forces of attraction and repulsion.[63] In conformity with an earlier historiographical devaluation of Priestley's role in the Chemical Revolution these historians blame Priestley's mechanistic sensibilities for his 'tragic failure' to appreciate the new direction that Lavoisier was giving to chemistry.[64]

Besides being manifestly at odds with the textual evidence, the imposition of this Newtonian framework on Priestley's scientific thought constitutes a grave distortion of the philosophical presuppositions of his natural philosophy, which are decidedly anti-Newtonian.[65] In the first place, Priestley's rationalist principles led him to oppose Clarke's and Newton's voluntarist theology and the associated doctrine of self-determinacy. Like Leibniz, Priestley denied any "self-determining power" (or freedom) of the will, and insisted on the necessity of God's creative act.[66] Priestley's uncompromising attitude towards dualism further reinforced his opposition to the Newtonian principles of the Boyle lecturers. He read Bentley, Clarke, Keill, Rowning and Baxter only to reject them, for their religious apologetics was predicated on the dualities of God and nature, mind and matter, atoms and forces.[67] Along with such early eighteenth-century "free thinkers" as John Toland, Matthew Tindal and Anthony Collins, Priestley opposed the Newtonian doctrine of passive, inert matter with a view of matter's intrinsic activity and sentience.[68] Finally, any attempt to relate Priestley's chemistry to the principles of the Newtonian paradigm ignores the implications of Priestley's epistemic commitments, which exclude any reference to an invisible realm of microscopic forces and atoms. Indeed, in order to avoid the speculative ignorance and guess-work "attending the consideration of the *internal structure of matter*," Priestley rejected Boscovich's reference to "physical indivisible points" and restricted his thought to those features of matter which "well-examined appearances proved."[69] He insisted that, beyond such "narrow bounds," the "metaphysician has no business to speculate any further, and the natural philosopher will find, I imagine, but few *data* for further speculation."[70] In so rejecting the invisible realm of the Newtonians Priestley insisted that any theory of matter be reducible to sensible "powers of attraction and repulsion."

Although Priestley's notion of "general principles," or generic powers, involved him in a general ontological commitment to causal agents active in nature to produce determined effects in diverse circumstances, it carried no theoretical commitment to any specific kinds of physical entities, such as substances, structures, forces or particles. Within the specific domain of chemistry, however, Priestley identified these causal agents with such "property-bearing substances" as phlogiston, heat, light and electricity. Priestley, no less than Lavoisier, rejected a chemistry based on "the mechanical permutation of ultimate particles." Schofield's characterization of the Stahlian principles underlying Lavoisier's chemical thought applies equally well to Priestley who favoured "a fairly clear notion of constant constituents in chemical operations ... based on the reification in some permanent material form, as principles or elements, of such qualities as acidity, alkalinity, combustibility ... and metalicity."[71] Within this framework, Priestley sought to defend Stahl's view of phlogiston as the principle of inflammibility inhering in all combustible substances and transferable from one body to another according to the laws of chemical affinity.[72] Contrary to the suggestion of Schofield and Thackray, the causal ontology of Priestley's phlogistic chemistry was closer than Lavoisier's classificatory concept of simple substances to the Stahlian doctrine of generic principles. Priestley's opposition to Lavoisier occurred within the mainstream of eighteenth century chemical thought and did not involve the intrusion of a "neo-physicalist" dimension arising out of the fluctuating fortunes of the Newtonian research program. The theoretical differences between Priestley and Lavoisier occurred within a shared ontological domain and involved differing emphases on a common conceptual matrix formed by an uneasy association of the disparate concepts of an element involved in the notions of "general principles" and "simple substances." In Priestley's case, this conceptual pastiche arose out of his attempt to relate the ontology of generic principles to the sensationalist account of substance and causation he inherited from the Humean tradition.

According to Priestley's sensationalist epistemology, the mind's cognitive encounter with the world begins with the particularity and multiplicity of sensationalist experience.[73] Hartley and Priestley developed and refined Locke's rejection of innate ideas and reduced the content and activity of the mind to the lawful association of ideas originating in experience. In accord with the Doctrine of Philosophical Necessity, Priestley viewed each and every individual as the deterministic consquence of the "universal and simple law of association" and the diverse experiential circumstances of their lives. Within this psychological framework, Priestley analyzed all complex ideas into their constituent sensations. His analysis reduced the essence of reasoning to a psychological event in a "passive" mind, which mirrors, and is governed by, events in the external world. Priestley's views on phlogiston were conditioned by the concepts of substance, causation and rationality which arose out of these epistemological commitments.

Priestley's nominalistic sensationalism contains a narrowly inductivist conception of rationality, according to which an adequate scientific theory consists of a deductive set of "general propositions," each one of which "is proved by an induction of a sufficient number of particulars which are comprised in it."[74] According to Priestley, "all that is properly meant by a *theory* exclusive of *hypothesis* is a number of general propositions, comprehending all the particular ones, deduced from single experiments."[75] Progress towards this theoretical goal requires the maintenance of a strict distinction between "facts" and "hypotheses," between propositions that have been inductively established and those that have not been so proven.[76] Within this view of the narrow scope of our theoretical understanding, Priestley criticized "the Antiphlogistians" for their unwarranted theoretical entrenchment and called upon the scientific community to eschew all

speculation and hypotheses and to concentrate on the proliferation of "new facts."[77]

Priestley was confident that this inductivist strategy would culminate eventually in the reduction of the complexity and diversity of nature's effects to a set of "simple and general laws."[78] His epistemic optimism embraced the hope that "ultimately, one great comprehensive law shall be found to govern both the material and the intellectual world."[79] According to Priestley's doctrine of primary and secondary causes, nature's hierarchical system of general laws is a "secondary" manifestation of the unfolding of God's immutable action and eternal design in the "general principles" that produce the diverse effects of nature. According to his sensationalism, natural philosophy comprehends nature's lawful structure and underlying causal activity by construcing a theory in which "particular facts" are "comprised" in "general propositions."[80] On this analysis, the presence and action of phlogiston, as the generic principle of inflammability, is determined and described in an inductively adequate, theoretical representation of the nomic properties and interactions of specific inflammable substances. However, Priestley's programme of determining and comprehending phlogiston by its lawful manifestations is complicated by his epistemological understanding of its identity as a material substance; and this understanding involves a confused conflation of the "primary" and "secondary" aspects of phlogiston's causal agency in the world.

Priestley distinguished substances and properties according to their "mode of being."[81] Substances inhere in themselves, whereas properties exist only insofar as they inhere in substances. Water, for example, has an independent existence in a way that none of its properties, such as wetness, ever can. Denied any Lockean "substratum" by Priestley's reductive sensationalism, substances inhere in themselves only insofar as they are reducible to constantly conjoined sets of sensible properties, distinguishable from their "variable adjuncts."[82] It follows that, unlike properties, which "belong to some *thing*," substances are isolable from one another, or can be obtained in a "free state" in the laboratory.[83] Besides being isolable, material substances have weight, which is a measure of their conserved quantity.[84] Within this regulative framework, Priestley characterized chemistry as that branch of natural philosophy which is concerned with the properties of substances and their causal agency.

According to the causal presuppositions of Priestley's scientific thought, the aim of natural philosophy is to determine "those circumstances in which any appearance in nature is certainly and invariably produced."[85] As a branch of natural philosophy, chemistry concentrates on the changes made in the properties of substances by "the addition of other *substances*," that is by the addition of "things that are the objects of our senses, being *visible*, *tangible*, and having *weight*, etc."[86] In contrast, non-chemical changes in the properties of bodies are "occasioned either by a change of texture in the substance itself, or the addition of something that is not the object of our senses."[87] For example, while the magnetization of steel by "another magnet" involves changes in the texture of the steel, the difference "between hot and cold substances" may be traced to an imperceptible fluid. Priestley insisted that, since neither of these causal agents present themselves in isolation from the substance in which they inhere, or between which they are transferred, they are not identifiable with "objects of our senses" and, hence, are not "what are properly called substances."[88] As such, these nonsubstantial causal agents, and the changes they produce, are not appropriate objects of chemical enquiry. Elsewhere, Priestley emphasized the gravimetric characterization of chemical substances when he claimed that, since the "principle of heat" adds nothing "to the *weight* of bodies, it can hardly be called an *element* in their composition."[89] He also thought that physical and chemical processes are distinguishable by the kinds of changes they produce in the properties of objects. Whereas, for example, the properties of bodies remain more or less the same during magnetic, electric and thermal changes, all objects undergo a radical transformation during chemical reactions. For instance, "neither water nor oil of vitriol will separately dissolve iron, so as to produce inflammable air, but both together will do it."[90] In this manner, Priestley made his own contribution to the long list of eighteenth century definitions of chemistry, claiming that a chemical combination is the union of several heterogeneous substances, reacting according to definite laws of affinity, to produce a new compound which possesses properties very different from the substances that combined to form it.[91] Within this overall perspective, Priestley sought to identify phlogiston with a "real substance," which has "weight" and "certain affinities by means of which it is transferred from one body to another," thereby causing a "remarkable difference in [their] properties."[92]

Priestley's view of the identity of phlogiston is further conditioned by the sensationalist analysis of causation that characterizes his doctrine of secondary causes. On the metaphysical level, Priestley sought to defend his deterministic ontology of powers and causal principles against the sceptical challenge inherent in Hume's subjectivization of causal necessity.[93] While he agreed with Hume that all ideas are derived from sensations, he argued, against Hume, that the idea of nature's causal power is not created by a "determination of the mind," but by the properties of bodies presented to the mind. Accordingly, Priestley insisted that the "idea of power or causation ... corresponds to something *real* in the relation of things that suggest it."[94] Despite this opposition to Hume's analysis of causal necessity, however, Priestley adopted Hume's empiricist language in his epistemological analysis of causation, claiming that "we naturally attend to the circumstances in which such appearances always arise and cannot help considering them as the cause of these appearances."[95] Within this mode of thought, Priestley sought to identify the principle of inflammability with the perceptible "circumstance" in which an "earth" is transformed into a metal.[96]

Clearly, a number of epistemological and definitional constraints operated on Priestley's chemical thought to favour the identification of phlogiston with a specific inflammable substance, which can be isolated

in the laboratory and detected by the balance. As early as 1774, Priestley registered the unease he felt as a sensationalist believing in the existence of a substance that is irreducible to sensible properties. At that time, he sought to alleviate his embarrassment by suggesting that although phlogiston is unisolable "in a quiescent state," it may be considered as "exhibited alone" when it is in "motion" in the form of one or other of its "modifications," such as "light" or the "electric matter."[97] However, Priestley failed to explore this speculative route; and he left the problem of phlogiston's identity in abeyance for several years. Indeed, it took external developments in the chemical community to rekindle Priestley's interest in the ontological status of phlogiston and to raise his hopes, in the early 1780s, of identifying it with a "real substance." Although these hopes were short-lived, the ontological and epistemological issues highlighted by them had a lasting influence on Priestley's role in the Chemical Revolution.

In 1782, Richard Kirwan suggested that phlogiston is identical with inflammable air obtained from metal and dilute acid mixtures (hydrogen).[98] A year later, Priestley supported this conclusion when he argued that the total absorption of inflammable air during the "revivification" of "minium" by a "burning lense" over water indicates that this air is "wholly and simply" the phlogiston necessary to revive the metallic lead from its earth.[99] Repeating this result with the earths of other metals, Priestley concluded that inflammable air is "nothing besides *phlogiston in the form of air.*"[100] Although Priestley remained secure in this conclusion for less than two years, nevertheless his attempt to identify the generic principle of inflammability with a specific inflammable substance is an important indicator of structural tensions in the conceptual foundations of his phlogistic chemistry. Moreover these tensions relate to patterns of categorical change in the development of eighteenth century chemical theorizing.

The elements of early eighteenth century chemistry were generic principles, which designated kinds of being, or types of qualities. Arising out of a complex intermingling of quasi-Platonic and Aristotelian intellectual currents, this conception of "reified essences" characterized the Stahlian research programme which dominated much of theoretical chemistry prior to the time of Lavoisier.[101] "Conceived more as metaphysical entities, than as specific substances to be handled in the laboratory," these "property-conferring principles" were regarded as unobtainable in "the free-state."[102] They were thought to be apprehendable only by their effects. As the eighteenth century wore on, however, there was an increasing tendency to make these hypothetical principles "more real in operation and they came to be thought of as obtainable *in impure forms* as the end products of analysis."[103] The chemical thought of P.J. Macquer represents this transitional point.[104] Eventually, these elementary principles were transformed into classes of specific substances which were isolable in the laboratory. In this process, the principle of Earth became the class of specific earth, the element Air gave way to a multiplicity of airs and elementary Water became plain water.[105] This "century-long transition away from the metaphysical towards the operational concept of the element" culminated in Lavoisier's pragmatic definition of an element as "the last point which laboratory analysis is capable of reaching."[106] This operational concept of a chemical element was also favoured by Priestley's sensationalist view of material substances.

Among late eighteenth century adherents to the phlogiston theory, phlogiston resisted the change of identity undergone by other generic principles. Nevertheless, phlogiston was not totally immune to the obliterating influences of this conceptual transformation, as can be seen in the pervasive desire to identify it with a specific substance isolable in the laboratory. During the last quarter of the eighteenth century, it was generally recognized, by both supporters and opponents of the phlogiston theory, that the presence of phlogiston in any substance could never be demonstrated until it was separated from that substance and obtained in "the free state." It was generally agreed that, until such a time, the phlogiston theory would be involved in a vicious circle of reasoning, wherein belief in the existence of phlogiston in a given substance is justified solely by reference to the properties it is designed to explain.[107] By identifying phlogiston with a specific inflammable substance that could be separated from presumed phlogistic materials, Kirwan and Priestley hoped to provide the chemical community with a criterion for the independent testability of the existence of phlogiston in inflammable bodies. Priestley also hoped that this conceptual manoeuvre would bring phlogiston in line with his conception of a material substance. The identification of phlogiston with inflammable air also provided a rational basis for the "resurrection of poor phlogiston" among the members of the Lunar Society in the early 1780s.[108] As Kirwan insisted, phlogiston "was no longer to be regarded as a mere hypothetical substance, since it could be exhibited in an aerial form in as great a degree of purity as any other air."[109] Unfortunately, this euphoric sense of epistemic edification was short lived, and Priestley was soon forced to defend the more traditional notion of phlogiston as an unisolable, generic principle.

In 1785, Priestley observed the production of "copious" amounts of water when he repeated his earlier experiment on the revivification of minium in inflammable air in a trough of mercury. To explain this result, he suggested that inflammable air is a compound of phlogiston and "water, or anything soluble in water."[110] He rejected his earlier view of the identity of phlogiston and inflammable air as a simple empirical error, arising out of his inability to detect the formation of water when the reaction occurred over water.[111] However, it should be realized that this hypothesis is also ruled out on conceptual grounds relating to the logical incompatibility between Priestley's ontology of generic principles and epistemology of sensations. As a generic principle, phlogiston has to be considered as "generally" the cause of inflammability, a view that is incompatible with the Humean analysis of causation inherent in Priestley's sensationalism. As W.R. Grove pointed out, if "we regard causation as invariable sequence, we can find no case in which a given ante-

cedent is the only antecedent to a given sequence," and thus there is no "abstract causation"[112] Accordingly, Priestley's Humean identification of generic phlogiston with the perceptible "circumstances" that accompany the transformation of an earth into a metal fails to differentiate the variety of specific inflammable substances that can react with an earth in this manner. To identify phlogiston with one of these specific substances is to deny the others their chemical specificity. It is not surprising, therefore, that when Kirwan and Priestley regarded the inflammable air from metal and dilute acid mixtures as "the true and only principle of inflammability in any substance," they treated other inflammable airs as "impure forms" of this pristine principle.[113] However, when Priestley reverted to the traditional view of phlogiston - as a generic principle invariably present through varying perceptible circumstances - he was able to accommodate the chemical specificity of the different kinds of inflammable air, viewing them as compounds of phlogiston and individuating "*solid* substances."[114] More generally, by the mid-1780s, Priestley defended the view that, "in all combustible substances, there is a principle capable of being transferred to other substances, which, when united to the calces of metals, makes them to be metals, and which united to oil of vitriol (deprived of its water) makes it to be sulphur."[115] In accord with his doctrine of primary causes, Priestley thus reverted to the traditional view of phlogiston as an unisolable principle, or causal power, inhering in inflammable substances as the generative cause of their characteristic generic property.

Although by 1786 Priestley had abandoned any hope of isolating phlogiston, he continued to argue for a few more years that "phlogiston ... no doubt having weight, ... perfectly corresponds to the definition of a substance, having certain affinities by means of which it is transferred from one body to another, as much as the different acids."[116] However, after more years of experimental frustration, Priestley was forced to recognize his inability to detect phlogiston by the balance; so that, by 1791, he was suggesting that water, which is the "proper basis of every kind of air," may be "all that has, or can be ascertained by *weight* in most of them."[117] Eventually, he defended "the hypothesis of water being the basis of every kind of air, the difference between them depending upon the addition of some principle which we are not able to ascertain by weight."[118] By 1796, it was apparent to Priestley, as well as the rest of the scientific community, that phlogiston was neither isolable in the laboratory nor detectable by the balance. In reaching this conclusion, Priestley had clearly failed to bring his ontology of generic principles into line with his epistemology of material substances. In accord with his doctrine of primary and secondary causes, he was forced to resort to the procedure of detecting the existence of phlogiston by its lawful effects. In particular, he sought to justify his continued belief in the substantive existence of phlogiston by appealing to the chemical nature of the phenomena it was designed to explain. For example, the transformation of oil of vitriol into sulphur and calces into metals by the addition of phlogiston involves not only the property of inflammability, but such a remarkable metamorphosis that the properties of the products cannot be predicted on the basis of our knowledge of the reactants.[119] It followed from these facts and Priestley's definition of chemistry that phlogiston must be a real material substance, the weight of which is simply too small to be detected by the balance.

By 1794, Priestley had completely reverted to a chemical ontology of generic principles, devoid of any reference to simple substances. This is clearly evident in his speculations on "the component and elementary parts of all substances":

> ... I shall here observe that according to the latest observations, the following appear to be the elements which compose all natural substances, viz. *dephlogisticated air*, or the *acidifying principle; phlogiston*, or the *alkaline principle*; the different *earths*, and the principles of *heat*, *light* and *electricity*. Besides these, there are the following principles which have not been proved to be substances, vix. *attraction*, *repulsion*and *magnetism*. By the help of these principles we are able, according to the present state of natural knowledge, to explain all the appearances that have yet occurred to us.[120]

In the same ontological vein, Priestley spent the last ten years or more of his life defending a view which differentiated airs according to variations in the "mode of arrangement" of water and the "phlogistic ... and antiphlogistic principles" in their composition.[121] Elsewhere, he also speculated on the existence of an "earthly principle" viewing it as the generic ingredient in the "different earths" mentioned in the above list of elements.[122] None of these statements on the nature and identity of the chemical elements contain any construable references to "simple substances." While such simple substances as the metals and nonmetals of Lavoisier's *Table of elements* are excluded from Priestley's phlogistic classification of elementary bodies, Lavoisier's principles of heat, light and acidity are readily incorporated into his scheme of things. Similarly, Lavoisier's muted and somewhat reticent ruminations on the existence of a principle of alkalinity are in striking contrast with Priestley's open recognition of this generic principle.[123]

The "Antiphlogistons" were quick to exploit Priestley's failure to translate the phlogiston theory into the language of "simple substances" that was inherent in Lavoisier's operational definition of a chemical element. Many critics agreed with an anonymous reviewer of the first edition of Priestley's *The doctrine of phlogiston established and that of the composition of water refuted* who emphasized the epistemological shortcomings of Priestley's position in a manner reminiscent of Lavoisier's earlier accusations of vagueness, imprecision and explanatory vacuity in the phlogiston theory:

> Phlogiston, as treated by our author, does not appear that well-defined and distinct substance which the apparatus of the laboratory can exhibit, and the mind precisely comprehend: but is veiled or disguised under so many different forms of being, and discordant modes of expression, that we hardly know what to think of it.[124]

This reviewer went on to insist that insofar as phlogiston is not identified with a specific, isolable substance, it is "a mere creature of the imagination whose existence has never been proved." For similar reasons, John MacLean was convinced that his readers would "prefer the antiphlogistic doctrine":

> Indeed, you may adopt it with safety; for from being a plain relation of facts, it is founded on no ideal principle, no creature of the imagination; it is propt by no vague supposition, by no random conjecture; it is dependent upon nothing whose existence cannot be actually demonstrated; whose properties cannot be submitted to the most rigorous examination; and whose quantity cannot be determined by the tests of weight and measure.[125]

Although Priestley found it impossible to deny the validity of this criticism of the phlogiston theory, he sought to mitigate its destructive effect by attacking MacLean's assumption that it was not equally applicable to the oxygen theory. Prieslty pointed out that the generic ontology inherent in Lavoisier's principles of heat, light, electricity and acidity violates the empiricist epistemology of simple substances no less than does phlogiston. The oxygen theory posited the same kind of hypthetical, unisolable and imponderable entities that "the Lavoisions" castigated in the phlogiston theory. However, whereas Priestley openly canvassed and reflected upon these foundational problems, his protagonists ignored them, or sought to conceal them beneath a veneer of rhetorical mystification:

> The phlogistic theory is not without its difficulties. The chief of them is that we are not able to ascertain the *weight* of phlogiston, or indeed that of the oxygenous principle. But neither do any of us pretend to have weighed *light*, or the element of *heat*, though we do not doubt that they are properly called *substances*, capable by their addition, or abstraction, of making great changes in the properties of bodies, and of being transmitted from one substance to another.[126]

Despite "the great use that the French chemists [made] of scales and weights," they were unable to "weigh either their *calorique or light*."[127] Priestley found it natural to ask "why may not *phlogiston* also escape their researches, when they employ the same instruments in their investigation?"[128] Furthermore, he insisted that the inability of natural philosophers to isolate phlogiston "is nothing extraordinary." For "few things in nature can be so exhibited. Certainly not the principles of *acidity* and *alkalinity*. These are always found combined with some other substance. But do we therefore say that such principles do not exist or that their existence cannot be demonstrated."[129]

Priestley's position here is double-edged. On the one hand, his doctrine of primary and secondary causes accommodated Richard Watson's claim that "there are powers in nature which cannot otherwise become the objects of sense, than by the effects they produce; and of this kind is phlogiston."[130] On the other, however, Priestley wished to emphasize the fact that, by adhering to such an ontology of powers, or principles, the oxygen theory and the phlogiston theory were equally at odds with their avowed commitment to the empiricist analysis of material substances. Contrary to the partisan claims of Lavoisier and his followers, Priestley called for a more even-handed recognition of the fact that neither "hypothesis" was "without its difficulties." Although he preferred the phlogiston theory, Priestley did not defend traditional dogma in the Chemical Revolution so much as attack the newly established orthodoxy of his rivals. Throughout this intellectual upheaval, Priestley emphasized the empirical and conceptual shortcomings of the oxygen theory and sought to restrict its proper use to the heuristic generation of "new facts," from which a "general theory" would emerge sometime in the distant future. Contrary to his historical image as a theoretical dogmatist in the Chemical Revolution, Priestley maintained a judicious sense of the narrow limits of our finite theoretical understanding.[131] He insisted that, until the formulation of a "perfect theory," theoretical scepticism is an essential ingredient of the pious, humble, inductive approach to God's infinite creation; and this mode of inquiry is indispensable to the pursuit of knowledge and the perfectibility of man.[132]

Priestley's ontological criticism of the oxygen theory is made credible by recent scholarly accounts of Lavoisier's inability to make a clean break with the Stahlian tradition he wished to overthrow. It is now clear that some of the central elements of Lavoisier's system, such as caloric and the acidifying principle function more like generic principles than the kind of simple substances they are supposed to denote.[133] Indeed, C.E. Perrin wishes to argue that Lavoisier's theoretical vision included the construction of a *Table of Elements* in which the generic principles in the first group are individuated by combining with the simple substances in the other two groups, which contain metals and non-metals respectively.[134] However, some historians of science still fail to relate these scholarly results to an adequate appreciation of Priestley's position in the Chemical Revolution. Maintaining the Whiggish view of scientific progress upheld by Lavoisier and his followers, some scholars deny that the unisolable and "imponderable" caloric played a "constitutive role" in Lavoisier's chemistry. According the Charles Gillispie and Robert Schofield, for example, caloric was a non-Newtonian, imponderable fluid, which "played the part, not of a chemical body, but only of a physical or better a mathematical body" in Lavoisier's theory.[135] The claim that caloric "played no constituent part in chemical change" is essential to Gillispie's view of Lavoisier as a champion of "objectivity," who gave to chemistry its quantitative basis in "weighted masses."[136] This interpretation of caloric is also part of Le Grand's claim that although oxygen functioned as the "acidifying principle" in Lavoisier's chemistry, it "differed from phlogiston and other 'principles' in that the former was a ponderable substance and could be isolated in the gaseous form.."[137] Now, Lavoisier's "acidifying principle" can be chemically identified with oxygen gas, and thereby epistemologically differentiated from imponderable and unisolable phlogiston, only if caloric, the other constituent in Lavoisier's oxygen, can be viewed in a "purely physical role," or treated as a "mathematical

body" similar to Newton's mathematical force of gravity. This line of reasoning supports the idea that Priestley's interpretation of the oxygen theory as a chemistry of "imponderables" merely reflects the retrogressive character of his own, phlogistic mode of conceptualization, which prevented him from appreciating the "primacy of quantitative" considerations inherent in the new chemistry developed by Lavoisier.[138]

Fortunately, a closer examination of the historical record does not support this Whiggish bias against Priestley and the phlogiston theory. Contrary to the claims of Metzger, Gillispie and Schofield, Lavoisier viewed subtle caloric as a ponderable fluid, which, like all matter, obeys the law of universal gravitation.[139] Though not an imponderable fluid in the strict sense, caloric was, like Priestley's phlogiston, regarded as "operationally imponderable," insofar as its weight was too small to be detected by Lavoisier's balance.[140] As a genuine material substance, then, caloric must, in the absence of specific arguments to the contrary, be capable of acting as a chemical agent. No such arguments were forthcoming from Lavoisier, however, who clearly made the principle of heat, light, fluidity and elasticity an integral part of chemical reactions involving changes of state. As R.J. Morris has noted, Lavoisier's explanations of such reactions "treated caloric as behaving like any other elementary substance capable of entering into and being released from chemical combinations according to the laws of elective affinity."[141] The crucial role of caloric in Lavoisier's theory of combustion is further highlighted in his distinction between "vital air" and its "oxigène" base: "we do not therefore affirm, that vital air combines with metals to form metallic calces, because this manner of speaking would not be sufficiently accurate; but we say, when a metal is heated to a certain temperature ... it becomes capable of decomposing vital air, from which it seizes the base, namely *oxigène*, and sets the other principle, namely caloric, at liberty."[142] Furthermore, the ineluctable chemical identity and function of caloric in Lavoisier's explanation of heat, light and elasticity is also entailed as an (unintended) consequence of his analysis of "vital air," which implies that insofar as caloric combines with the "acidifying principle" to produce a neutral gas it must function as an alkaline substance. These reflections on both the objective structure of the oxygen theory and Lavoisier's subjective interpretations of it lead to the inescapable conclusion that caloric functioned as a *chemical* agent in the "French system."

Clearly, Priestley had ample justification for his view of the oxygen theory as a chemistry of "imponderables," at odds with the avowed ontological and epistemological commitments of its supporters. As he realized, the same was also true of the phlogiston theory. While many of Priestley's scientific contemporaries allowed their eagerness to embrace the new scientific paradigm to bias their treatment of these philosophical issues, Priestley's sensitivity to the interrelations of science and philosophy gave him a more balanced view of the relative merits and problems of these competing theories. He thus resisted the one-sided view of Lavoisier and his scientific and historical progeny, according to which the Chemical Revolution was essentially a clash between the conservative and obscurantist forces of speculative metaphysics that supported phlogiston and the revolutionary current of scientific empiricism associated with the oxygen theory. Although he favoured the phlogiston theory, Priestley's methodological principles emphasized the heuristic value of all hypotheses in the development of science. Ultimately, Priestley's empiricist sensibilities valued the Chemical Revolution for the proliferation of "new facts" through the formulation and interaction of competing theories and hypotheses. Priestley had a more-subtle and profound comprehension of the philosophical principles and implications of science than that entertained by his more illustrious and successful scientific adversaries.

A more general conclusion deriving from this study relates to the nature of scientific change. It suggests a view that must be distinguished not only from the traditional, "gradualist" image of scientific progress through the cumulative accretion of experimental technique and empirical knowledge, but also from more recent attempts to stress the "revolutionary" nature of scientific development.[143] In rejecting inductivist, or Whiggish, accounts of scientific progress in terms of a gradual increase in empirical knowledge, the revolutionary school of thought stresses the cognitive discontinuities inherent in the theoretical and conceptual upheavals which characterize the development of science.[144] On this view, the Chemical Revolution involves an incommensurable difference between the principles, rules, standards, concepts and problems of its competing paradigms. More specifically, T.S. Kuhn subsumes the "substantive [i.e., ontological] differences" between the oxygen theory and the phlogiston theory under the relation of incommensurability.[145] In reaching this conclusion, however, Kuhn has allowed the significant cognitive differences and incompatibilities between these competing paradigms to obscure the equally significant similarities and continuities between the thought of Priestley and Lavoisier. The difference between Lavoisier's chemistry of "simple substances" and Priestley's philosophy of "general principles" is more gradual than the language of incommensurability would suggest. As shown above, the considerable conceptual incongruities between these rival perspectives did not prevent Lavoisier from including principles in his list of elements, nor prevent Priestley from attempting to map the ontology of principles onto the logic of simple substances. As this example indicates, the conceptual development of science is a more gradual and confused affair than that implied in the revolutionary image of successive "logically autonomous, internally consistent, and self-contained models of discourse."[146]

On the other hand, the gradualist image of continuity and cumulative growth must not be allowed to obscure those elements of disjunction and discontinuity that do characterize conceptual development. In this instance, it should be realized that while Priestley's chemical thought was almost completely dominated by the logic of principles, Lavoisier succeeded in interpreting an important set of problems according to the

logic of simple substances. Although Lavoisier explained the generic properties of acidity, elasticity and alkalinity in terms of the action of generic principles, he never attempted to explain inflammability in this manner. Contrary to Priestley and other phlogistic chemists, Lavoisier did not regard inflammability as a property in need of explaining. He sought to explain the phenomenon of combustion rather than the property of combustibility (inflammability). Thus, he did not trace the cause of combustion to a principle inhering in the combustible or in the oxygen gas with which it combines during combustion. Rather, he explained the phenomenon of combustion in terms of a relation of affinity that pertains - between the combustible and the caloric and oxygen principle in the oxygen gas - at the moment of combustion.[147] By so eliminating the generic principle of inflammability from chemistry, Lavoisier was able to characterize the metals and nonmetals as simple substances, which were defined and characterized in terms of their relations to oxygen gas and the products of combustion. Working within this conceptual framework, Lavoisier's disciples succeeded in eliminating the last vestiges of the chemistry of principles from his theory of acidity.[148] Lavoisier's intellectual progeny finally eliminated all remains of the traditional ontology of principles from his chemistry by emphasizing and extending the logic of simple substances, which characterized the revolutionary dimension of his thought.

Even then, however, this transition did not constitute a discontinuous break with the past. Lavoisier's revolutionary struggle with tradition left its mark on his intellectual legacy. In particular, his elimination of the cause of inflammability from the domain of chemistry's appropriate problems did not involve an incommensurable break with the data-base and problem-field of the phlogiston theory. Although the problem of inflammability is not explicitly retained by the oxygen theory, it continues to exert an influence, nevertheless, by the very mode of its elimination. The elimination of this problem and its phlogistic solution from the domain of chemistry forced Lavoisier, through the pressure of shared empirical constraints, to answer a previously unasked question. Lavoisier's continuing need to explain such reactions as the production of inflammable air from dilute metal-acid solutions without recourse to the principle of inflammability focused his attention on the (previously unproblematic) nature and composition of water.[149] Lavoisier's solution to this problem was a conceptual cornerstone of the oxygen theory and an integral part of its subsequent development.[150] The oxygen theory did not simply "replace" the phlogiston theory so much as evolve out of its critical demise.

The general view of scientific change that emerges from this study of the ontological underpinnings of the Chemical Revolution is supported and developed by an examination (not given here) of the epistemological, methodological and constitutive dimensions of the debate between Priestley and "the Lavoisians."[151] At the risk of sounding pretentious, I would like to suggest that these considerations ultimately point to a simple truth of "dialectics." So viewed, the history of science is beyond the comprehension of the "metaphysical" understanding, in which the object of investigation is "fixed, rigid, given once for all" and is viewed in terms of "absolutely, irreconcilable antitheses."[152] Contrary to the one-sided, "metaphysical" opinions of the "gradualists" on the one hand and the "revolutionaries" on the other, problems and solutions are neither completely retained in a continuous process of cumulative accretion, nor are they gratuitously eliminated in the diachronic convulsions that characterize the theoretical discontinuum. Rather, they are transformed in a process which simultaneously preserves the old and creates the new. Science conforms neither to the "gradualist" vision of cumulative growth nor to the "revolutionary" slogans of discontinuous breaks and incommensurable transitions. Its nature can be captured only in a vocabulary that does justice to the dynamic transformation of concepts, problems and solutions which lies at the heart of the historical development of scientific knowledge. Science is not a lifeless stockpile of ageless wisdom; nor is it a series of fleeting and unrelated perspectives. Instead, the history of science is "proof of dialectics." As such, it goes through "a real historical evolution," which involves a movement of "progressive or retrogressive changes."[153] Science is, at least in part, an evolving cognitive system, in which permanence and change, identity and difference, continuity and discontinuity are interrelated aspects of the continual transformation of a dynamic totality.

Notes and References

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1 Joseph Priestley, *Institutes of natural and revealed religion*, Birmingham, 2nd edn., 2 vols., 1782, cited in John Towill Rutt (ed.), *The theological and miscellaneous works of Joseph Priestley, LL.D., F.R.S., etc.*, London, G. Smallfield, 25 vols., 1817-1835, vol. 2, p.xv.

2 For examples of the traditional view of the dissonant relation between Priestley's science and religion see Francis Jeffrey, 'Review of memoirs of Joseph Priestley', *Edin. Rev.*, 1807, 9: 137-161; Anne Holt, *A life of Joseph Priestley*, London, Oxford University Press, 1931, pp.108-109; Basil Willey, *The eighteenth century background. Studies on the idea of nature in the thought of the period*, London, Chatto and Windus, 1980, pp.169-170.

3 Joseph Priestley, *The history and present state of electricity with original experiments*, London, J. Dodsley, J. Johnson, B. Davenport, and T. Cadell, 1767, p.xxiii. As on so many occasions, Priestley is, here, quoting from David Hartley, *Observations on man, his frame, his duty, and his expectations*, London, J. Leake and W. Frederick, 2 vols., 1749, vol.2, pp.255-6.

4 Joseph Priestley, *A free discussion of the doctrines of materialism and philosophical necessity, in a correspondence between Dr. Price and Dr. Priestley, etc.*, London, 1778, in Rutt op.cit., note 1 above, vol.4, p.8.

5 See Joseph Priestley, *Experiments and observations on different kinds of air*, London, J. Johnson, 3 vols., 1774-1777, vol.1, titlepage.

6 See John G. McEvoy, 'Electricity, knowledge and the nature of progress in Priestley's thought', *Brit. J. Hist. Sci.*, 1979, *12*: 1-30; 'Joseph Priestley, "aerial philosopher": metaphysics and methodology in Priestley's chemical thought, from 1772-1781, Part 1' *Ambix*, 1978, *25*: 1-55; 'Part II', ibid.: 93-116; 'Part III', ibid.: 153-75; 'Part IV', ibid., 1979, *26*: 16-38.

7 For a more comprehensive exploration of the totality of Priestley's thought, see J.G. McEvoy and J.E. McGuire, 'God and nature: Priestley's way of Rational Dissent', *Hist. Stud. Phys. Sci.*, New Jersey, Princeton University Press, 1975, *6*: 325-404. A more complete picture of Priestley's role in the Chemical Revolution will be given in my *Joseph Priestley and the Chemical Revolution, 1783-1804* (in preparation).

8 See, for example, Joseph Priestley, *An appeal to the serious and candid professors of christianity*, London, 6th edn., 1791, in Rutt op. cit., note 1 above, vol.2, p.385.

9 See Joseph Priestley, *Disquisitions relating to matter and spirit*, London, 2nd edn. 1782, in Rutt op. cit., note 1 above, vol.3, p.204; Priestley, op. cit., note 4 above, p.143.

10 Joseph Priestley, *Letters to a philosophical unbeliever*, Birmingham, 1787, in Rutt, op. cit., note 1 above, vol. 4, p.446.

11 Priestley, op. cit., note 9 above, p.220.

12 For a summary and criticism of this view see McEvoy, 'Aerial philosopher; Part 1', op. cit., note 6 above, pp. 1-5; 'Enlightenment and dissent in science: Joseph Priestley and the limits of theoretical reasoning', *Enlightenment and Dissent*, 1983, *2*: 47-67.

13 Steven Shapin, 'History of science and its sociological reconstructions', *Hist. Sci.*, 1982, *20*: 184. For a detailed discussion of this "movement away from Newtonian matter theory" see C.B. Wilde, 'Matter and Spirit as natural symbols in eighteenth century British natural philosophy', *Brit. J. Hist. Sci.*, 1982, *15*: 1-131 (esp. p.1)

14 See Priestley, op. cit., note 8 above, pp. 385-403. Although references are here made to the 1791 edition, Priestley's *Appeal* was first published in 1770. As such, it represents an important milestone in Priestley's struggle to liberate himself from the "gloomy" Calvinism of his youth. This text is significant insofar as it portrays the formation of the generative principles of Priestley's mature thought. These principles emerged in a process of critical self-transcendence, in which Priestley jettisoned an inherited set of "moral and metaphysical" doctrines which were diametrically opposed to the rational and optimistic sentiments of his fully developed Enlightenment philosophy.

15 Ibid., p.402. See also Joseph Priestley, *Memoirs of Joseph Priestley to the year 1795, written by himself, etc.*, London, 1786, in Rutt, op. cit., note 1 above, vol.1, pp. 21-28.

16 See Priestley, op. cit., note 15 above, p.24. David Hartley's *Observations on man his frame, his duty and his expectations* had a profound influence on the formation and development of the basic categories of Priestley's thought. This text, which Priestley first encountered at the Daventry Academy in the early 1750s, shook him from the "gloomy" slumber of Calvinist orthodoxy and gave him "reason to embrace what is generally called the heterodox side of almost every question." (ibid, pp. 24-25). Priestley was "more indebted to this one treatise, than to all the books [he] ever read beside, the Scriptures excepted.", Joseph Priestley, *An examination of Dr. Reid's Inquiry into the human mind on the principles of common sense', Dr. Beattie's 'Essay on the nature and immutability of truth', and Dr. Oswald's 'Appeal to common sense in behalf of religion'*, London, 2nd edn. 1775, in Rutt, op.cit., note 1 above, vol. 3, p.10.

17 For a fuller discussion of these themes in Priestley's thought see McEvoy and McGuire, op. cit., note 7 above.

18 See Priestley, op. cit., note 8 above, and op. cit., note 4 above, p.10.

19 For Priestley's rationalist views of Divine causation see op. cit., note 1 above, pp.1-25.

20 See, for example, Joseph Priestley, *Letters to Rev. Mr. John Palmer and Jacob Bryant, Esq. in defense of the illustrations of philosophical necessity* in Rutt, op. cit., note 1 above, vol.4, p.200.

21 Hartley, op. cit., note 3 above, vol.2, p.36.

22 Priestley, op. cit., note 9 above, p.241.

23 See ibid. for Priestley's discussion of the 'fine' distinction between his own theological views and the pantheistic heresy of Spinoza.

24 Ibid.

25 See, for example, Priestley, op. cit., note 1 above, p.5 and op. cit., note 3 above, pp. iii-iv.

26 See Priestley, op. cit., note 1 above, pp. 17-21.

27 See Priestley, op. cit., note 3 above, pp. 441-442; Joseph Priestley, *Hartley's theory of the human mind, on the principle of the association of ideas, with essays relating to the subject of it*, London, 2nd edn., 1790 in Rutt, op. cit., note 1 above, vol.3, pp. 184-185.

28 Priestley, op. cit., note 27 above, p.185.

29 Hartley, op. cit., note 3 above, vol.2, pp. 36-37.

30 Joseph Priestley, *The doctrine of philosophical necessity illustrated; being an appendix to the disquisitions relating to matter and spirit*, London, 2nd edn. 1782, in Rutt, op. cit., note 1 above, vol.3, p.462.

31 Ibid., p.455.

32 Ibid., p.451.

33 Ibid., p.455.

34 Ibid.

35 Ibid.; Joseph Priestley, *A philosophical inquiry concerning human liberty, by Anthony Collins, Esq., 1715. Republished with a preface*, Birmingham, 1790, in Rutt op. cit., note 1 above, vol. 4, p.260.

36 Priestley, op. cit., note 30 above, p.533.

37 Priestley, op. cit., note 10 above, pp.354-355.

38 Ibid., p.355.

39 Priestley, op. cit., note 1 above, p.16.

40 Ibid., p.15.

41 Priestley, op. cit., note 30 above, p.462.

42 Ibid., p.463.

43 Ibid., p.466.

44 Priestley, op. cit., note 10 above, p.403.

45 Priestley, op. cit., note 4 above, p.107.

46 Ibid.

47 Priestley, op. cit., note 20 above, p.170.

48 Ibid., p.171.

49 Ibid.

50 Ibid., p.208.

51 See for example J. Priestley, op. cit., note 27 above, p.185.

52 For a fuller discussion of the interrelations and ramifications of Priestley's theory of matter see McEvoy and McGuire, op. cit., note 7 above, pp.290-296.

53 Priestley, op. cit., note 9 above, p.219.

54 Ibid., p.224.

55 See, for example, ibid., pp.241-262 and 301.

56 Ibid., p.239.

57 Priestley, op. cit., note 4 above, p.24.

58 Priestley, op. cit., note 3 above, p.442.

59 Joseph Priestley, 'Observations and experiments relating to equivocal, or spontaneous generation', *Trans. Am. Phil. Soc.*, 1809, *6*: 129.

60 Priestley, op. cit., note 3 above, pp. 441-442.

61 Arnold Thackray, *Atoms and powers: an essay on Newtonian matter-theory and the development of chemistry*, Cambridge, Mass., Harvard University Press, 1970, pp. 175-176. See also Robert E. Schofield, *Mechanism and materialism: British natural philosophy in an age of reason*, New Jersey, Princeton University Press, 1970, pp. 230-261.

62 R.E. Schofield, op. cit., note 61 above, pp. 272-273. For further discussions of the differences between Newtonian physicalism and Stahlian anti-reductionism in eighteenth century chemistry see Thomas S. Kuhn, 'Robert Boyle and structural chemistry in the seventeenth century,' *Isis*, 1952, *43*: 12-36; A.L. Donovon, *Philosophical chemistry in the Scottish Enlightenment*, Edinburgh University Press, 1975, pp. 31-33.

63 See for example, Robert E. Schofield, 'Joseph Priestley, natural philosopher', *Ambix*, 1968, *15*: 1-15; 'Boscovich and Priestley's theory of matter', in Lancelot Law Whyte (ed.), *Roger Joseph Boscovich, S.J., F.R.S., 1711-1787. Studies of his life and work on the 250th anniversary of his birth*, New York, Fordham University Press, 1961, pp. 168-177.

64 See McEvoy, 'Enlightenment' op. cit., note 12 above, for references to the traditional view of Priestley's obstructionist role in the Chemical Revolution.

65 For an exegetical criticism of Schofield's view of Priestley as a Newtonian physicalist see, John G. McEvoy, 'Joseph Priestley, natural philosopher: some comments on Professor Schofield's views', *Ambix*, 1968, *15*: 115-133.

66 For Leibniz's rationalist attack on Newtonian voluntarism see H.G. Alexander (ed.), *The Leibniz-Clarke Correspondence*, Manchester University Press, 1956. See also Steven Shapin, 'Of gods and kings: natural philosophy and politics in the Leibniz-Clarke dispute', *Isis*, 1981, *72*: 187-215.

67 Priestley's critical remarks on these thinkers are scattered throughout Priestley, op. cit., note 9 above.

68 For an outline of the views of Toland, Tindall and Collins see Shapin, op. cit., note 66 above.

69 Priestley, op. cit., note 9 above, p.237.

70 Ibid., p.238.

71 Schofield, op. cit., note 61 above, pp. 214-215.

72 See, for example text above note 115 below.

73 Priestley's views on the workings of the mind and its relation to the world are found in Priestley, op. cit., note 16 above, pp. 2-24 and op. cit., note 27 above, pp. 168-200. A more complete treatment of Priestley's psychologistic epistemology in relation to the views of Locke and Hartley can be found in McEvoy and McGuire, op. cit., note 7 above, pp. 348-374.

74 Priestley, op. cit., note 16 above, p.125.

75 Joseph Priestley, *Experiments and observations relating to various branches of natural philosophy with a continuation of the observations on air*, Birmingham, J. Johnson, 3 vols., 1779-86, vol. 2, p.vii.

76 See for example, Priestley, op. cit., note 5 above, vol. 2, p.xx and vol. 3, pp. xi, xxvii; Priestley, op. cit., note 75 above, vol. 2, pp. 325-366.

77 See, for example, Joseph Priestley, *The doctrine of phlogiston established and that of the composition of water refuted*, Northumberland, for P. Byrne, Philadelphia, 2nd end., 1803, p.ix; Priestley, op. cit., note 5 above, vol. 3, p.xxix; Priestley, op. cit., note 75 above, vol. 1, pp. x-xi and vol. 3, pp. xxii-xxiii. For a fuller discussion of the epistemic dimensions of Priestley's role in the Chemical Revolution see McEvoy, op. cit., note 12 above.

78 See note 51 above.

79 Ibid.

80 Joseph Priestley, *Miscellaneous observations relating to education*, London, J. Johnson, 1778, p.258.

81 Priestley, op. cit., note 9 above, p.297. See also John Locke, *An essay concerning human understanding*, 4th edn., edited by P.H. Nidditch, Oxford, The Clarendon Press, 1975, Bk. 2, Ch. 23.

82 Priestley, op. cit., note 16 above, p.15. See also Priestley, op. cit., note 9 above, p.297.

83 See Joseph Priestley, *Heads of lectures on a course of experimental philosphy, particularly including chemistry; delivered at the New College in Hackney*, London, J. Johnson, 1794, pp. 3-4 and 9-10.

84 See notes 86 and 89 below. For a criticism of the view that Priestley's theory of matter led him to undervalue mass and hence fail to appreciate the new quantitative basis that Lavoisier was giving to chemistry see McEvoy, op. cit., note 65 above, pp. 122-123. For a general discussion of the influence of Newton's principle of the conservation of matter on eighteenth century chemistry see Hélène Metzger, *Newton, Stahl, Boerhaave et la doctrine chimique*, Paris, F. Alcan, 1930, pp. 20-33.

85 Priestley, op. cit., note 3 above, pp. 433-444.

86 Priestley, op. cit., note 83 above, p.4.

87 Ibid.

88 Ibid., pp 4-6.

89 Priestley, op. cit., note 75 above, vol. 3, p.403.

90 Priestley, op. cit., note 83 above, pp. 5-6.

91 See for example, ibid. and Priestley, op. cit., note 75 above, vol. 3, p.418. For some views on eighteenth century definitions of chemistry see A.M. Duncan, 'Styles of language and modes of chemical thought', *Ambix*, 1981, *28*: 83-107; Donovan, op. cit., note 62 above, pp. 93-102.

92 Priestley, op. cit., note 75 above, vol. 3, p.418. See, also, notes 86 above and 116 below.

93 See, especially, Priestley, op. cit., note 10 above, pp. 398-404. For a fuller discussion of Priestley's response to Hume see McEvoy and McGuire, op. cit., note 7 above, pp. 365-368.

94 Priestley, op. cit., note 10 above, p.399.

95 Priestley, op. cit., note 3 above, p.442.

96 See Priestley, op. cit., note 83 above, p.3. See, also, notes 98 to 100 below.

97 Priestley, op. cit., note 5 above, vol. 1, pp. 282-283.

98 Richard Kirwan, 'Continuation of the experiments and observations on the specific gravities and attractive powers of various saline substances', *Phil. Trans., R. Soc.*, 1782, *72*: 179-236 (especially, pp. 195-211).

99 Joseph Priestley, 'Experiments relating to phlogiston and the seeming conversion of water into air', *Phil. Trans., R. Soc.*, 1783, *73*: 398-434 (especially, 398-412).

100 Ibid., 408.

101 For an interesting account of the "origins and antecedents of the general doctrine of property-conferring principles" see D.R. Oldroyd, 'The doctrine of property-conferring principles in chemistry: origins and antecedents', *Organon*, 1976/7, *12/13*: 139-55. See also D.R. Oldroyd 'An examination of G.E. Stahl's philosophical principles of universal chemistry', *Ambix*, 1973, *20*: 36-57. Another perspective on the chemistry of "principles" can be found in R.E. Schofield, op. cit., note 61 above, chapter 9 and A. Thackray, op. cit., note 61 above, pp. 171-75. Of course, the classical investigations of Hélène Metzger remain unsurpassed: see 'La théorie de la composition des sels et la théorie de la combustion d'apres Stahl et ses disciples', *Isis*, 1927, *9*: 294-325; op. cit., note 84 above; *Les doctrines chimique en France du début du XVIIe a la fin du XVIIIe siècle*, Paris, Presses Universitaires, 1923.

102 Robert Siegfried and Betty Jo Dobbs, 'Composition, a neglected aspect of the chemical revolution', *Ann. Sci.* 1968, *24*: 276. See also D.R. Oldroyd, 'doctrine', op. cit., note 101 above, pp. 139-140; 'Stahl', op. cit., note 101 above, pp. 44-45 and 52; 'Mineralogy and the Chemical Revolution', *Centaurus*, 1975, *21*: 55; Maurice Daumas, *Lavoisier, théoricien et expérimentateur*, Paris, Presses Universitaires de France, 1955, pp. 158-159; Martin Fichman, 'French Stahlism and chemical studies of air, 1750-1770', *Ambix*, 1971, *18*: 106; Metzger op. cit., note 84 above, pp. 18-82, 118-125.

103 Siegfried and Dobbs, op. cit., note 102 above, p.276.

104 Ibid., 277.

105 For an excellent account of this conceptual development *within* pre-Lavoiserian, phlogistic chemistry see D.R. Oldroyd, 'Some phlogistic mineralogical schemes, illustrative of the evolution of the concept of 'Earth' in the 17th and 18th centuries', *Ann. Sci.*, 1974, *31*: 269-305. See also D.R. Oldroyd, 'A note on the status of A.F. Constedt's simple earths and his analytical methods', *Isis*, 1974, *65*: 506-12; McEvoy, 'aerial philosopher, Part 1', op. cit., note 6 above, pp. 39-45; Siegfried and Dobbs, op. cit., note 102 above, pp. 277-278.

106 Siegfried and Dobbs, op. cit., note 102 above, pp. 278-283.

107 See Charleton Perrin, 'Early opposition to the phlogiston theory: two anonymous attacks', *Brit. J. Hist. Sci.*, 1970, *5*: 130. See also text above notes 124-132 below.

108 Robert E. Schofield, *The Lunar Society of Birmingham: a social history of provincial science and industry in eighteenth century England*, Oxford, The Clarendon Press, 1963, p.290.

109 Richard Kirwan, *An essay on phlogiston and the constitution of acids; to which are added notes defending and establishing the antiphlogistic theory .. by Messrs. de Morveau, Lavoisier, de la Place, Monge, Berthollet and de Fourcroy, translated into English [by W. Nicholson]; with additional remarks and replies by the author*, London, J. Johnson, 1789, p. 5.

110 Priestley, op. cit., note 75 above, vol. 3, pp. 7, 26.

111 Ibid., pp. 7-8.

112 William Robert Grove, *On the correlation of physical forces: being the substance of lectures, delivered in the London Institution in the year 1843*, London, Longman, Brown, Green, and Longman, 4th edn., 1862, p.12.

113 Kirwan, op. cit., note 98 above, pp. 198 and 201. See also McEvoy, 'aerial philosopher, Part IV', op. cit., note 6 above, pp. 21-24.

114 Priestley, op. cit., note 75 above, vol. 3, pp. 153-154. (See also pp. 155-158).

115 Ibid., p.426.

116 Joseph Priestley, 'Experiments and observations relating to the principle of acidity, the composition of water, and phlogiston,' *Phil. Trans., R. Soc.*, 1788, *78*: 156; *Experiments and observations on different kinds of air, and other branches of natural philosophy, connected with the subject, in three volumes, being the former six volumes abridged and methodised, with many additions*, Birmingham, J. Johnson, 1790, vol. 3, p.552. Even at this time, however, Priestley harboured doubts, which crystallized later, about the possibility of isolating and weighing phlogiston. See ibid., p.553.

117 Joseph Priestley, *Experiments on the generation of air from water; to which are prefixed experiments relating to the decomposition of dephlogisticated and inflammable air*, London, J. Johnson, 1793, p.37. See also 'Further experiments relating to the decomposition of dephlogisticated and inflammable air', *Phil. Trans., R. Soc.*, 1791, *81*: 211.

118 Joseph Priestley, 'Experiments on the production of air by the freezing of water,' *New York Med. Rep.*, 1801 (2nd edn. 1808), *4*: 21.

119 See texts above note 90 to 92 above.

120 Priestley, op. cit., note 83 above, pp. 8-9.

121 See for example, J. Priestley, *air*, op. cit., note 116 above, vol. 3, pp. 533-560; Priestley, 'principle of acidity,' op. cit., note 116 above, pp. 156-157; J. Priestley, op. cit., note 118, p.21.

122 See for example Priestley, op. cit., note 75 above, vol. 2, pp. 149-150; McEvoy, 'aerial philosopher, Part III', op. cit., note 6 above, p.171.

123 For a discussion of Lavoisier's view of "azote" as the principle of alkalinity see C.E. Perrin, 'Lavoisier's Table of the Elements: a reappraisal', *Ambix*, 1973, *20*: 95-105.

124 'Review of the doctrine of phlogiston established, and that of the composition of water refuted. By Joseph Priestley, LL.D., F.R.S., etc., Northumberland, Kennedy, 1800', *New York Med. Rep.*, 1800, *3*: 383. See also A. Lavoisier, 'Reflexions sur le phlogistique pour servir de dévelopment à la théoire de la combustion et de la calcination', *Mem. Acad. Roy.Sci.*, 1783, 523.

125 William Foster (ed.), *Considerations on the doctrine of phlogiston, and the decomposition of water by Joseph Priestley, LL.D., F.R.S. Philadelphia, 1796. And two lectures on combustion and an examination of Doctor Priestley's consideration on the doctrine of phlogiston by John MacLean, M.D.*, Philadelphia, 1797, New Jersey, Princeton University Press, 1924, p.116.

126 Joseph Priestley, *Experiments and observations relating to the analysis of atmospherical air; also further experiments relating to the generation of air from water. Read before The American Philosophical Society, Feb. 5th and 19th 1796, and printed in their Transactions. To which are added considerations on the doctrine of phlogiston, and the decomposition of water, addressed to Messrs. Berthollet, etc.*, London, J. Johnson, 1796, pp. 58-59.

127 Joseph Priestley, 'On the red precipitate of mercury', *New York Med. Rep.*, 1799, *2*: 157.

128 Ibid.

129 Joseph Priestley, 'A letter correcting a review of his text on phlogiston,' *New York Med. Rep.*, 1801, *4*: 103.

130 Richard Watson, *Chemical essays, etc.*, London, T. Evans, 6th edn., 5 vols., 1793, vol. 1, p.167.

131 For a fuller account of the epistemological foundations and scientific implications of Priestley's anti-theoreticism see McEvoy, 'Enlightenment', op. cit., note 12 above.

132 See, for example Priestley, op. cit., note 5 above.

133 See Daumas, op. cit., note 102 above, ch. 7; Hélène Metzger, *La philosophie de la matiere chez Lavoisier*, Paris, Hermann, 1935; Maurice Crosland, 'Lavoisier's theory of acidity', *Isis*, 1973, *64*: 306-325, (especially, pp. 321-323); H.E. LeGrand, 'Lavoisier's oxygen theory of acidity', *Ann. Sci.*, 1972, *29*: 1-18; Robert Siegfried, 'The discovery of potassium and sodium and the problem of the chemical elements', *Isis*, 1963, *54*: 247-258 (especially, pp. 248-249).

134 See Perrin, op. cit., note 123 above, pp. 95-101.

135 Charles Coulton Gillispie, *The edge of objectivity: an essay in the history of scientific ideas*, New Jersey, Princeton University Press, 1960, p.238; Schofield, op. cit., note 61 above, pp. 28-29.

136 Gillispie, op. cit., note 135 above, p.237.

137 See LeGrand, op. cit., note 133 above, p.9

138 For this view of Priestley's role in the Chemical Revolution see, for example, Gillispie, op. cit., note 135 above, p.237; J.A. Passmore (ed.), *Priestley's writings in philosophy, science and politics*, New York, Collier, MacMillan, 1965, p.21; R.E. Schofield, 'natural philosopher', op. cit., note 63 above, pp.12-14; Stephen E. Toulmin, 'Crucial experiments: Priestley and Lavoisier', *J. Hist. Ideas*, 1957, *18*: 215-217.

139 See, for example Lavoisier, op. cit., note 124 above, p.509.

140 For an excellent discussion of the nature and function of caloric in Lavoisier's chemistry see Robert J. Morris, 'Lavoisier and the caloric theory', *Brit. J. Hist. Sci.*, 1972, *6*: 1-38. On the materiality of caloric see especially pp. 32-34.

141 Ibid., p.34.

142 L.B. Guyton de Morveau, A. Lavoisier, C.L. Berthollet and A.F. de Fourcroy, *Methode de nomenclature chimique ... On y a joint un nouveau system de caracteres chimiques adaptes a cette nomenclature par M.M. Hassenfratz et Adet*, Paris Cuchet, 1787, pp. 294-296.

143 For a description and discussion of these two schools of thought see Larry Laudan, *Progress and its problems toward a theory of scientific growth*, Berkeley and Los Angeles, University of California Press, 1977, pp. 139-140. Laudan tries to capture "both sorts of insights" in a model of scientific change according to which the paradigmatic discontinuities that occur at the level of "explanation or problem solutions" are offset by the "shared empirical problems which establish the important connections between successive research traditions" (p.140). This view presents science as a more static polarized activity than that suggested in the model outlined below, which seeks a complete integration of the continuous and discontinuous aspects of scientific change in a unitary, dynamic process of transformation, occurring at every cognitive level.

144 See, for example, Thomas S. Kuhn, *The structure of scientific revolutions*, University of Chicago Press, 2nd edn., 1970, pp. 1-9.

145 Ibid., p.103.

146 Neal C. Gillespie, *Charles Darwin and the problem of creation*, University of Chicago Press, 1979, p.4. This present study endorses Gillespie's view that this assumption underlies current quandaries concerning the rationality of theory-change in science.

147 See, for example, Antoine Lavoisier, *Elements of chemistry in a new systematic order, containing all the modern discoveries*, translated by Robert Kerr, Edinburgh, 1790, pp. 414-418.

148 See Siegfried and Dobbs, op. cit., note 102 above, p.291.

149 For a discussion of the emergence and theoretical implications of Lavoisier's view of the composition of water see, for example, Douglas McKie, *Antoine Lavoisier, scientist, economist, social reformer*, New York, H. Schuman, 1952, pp. 159-176; Alan Musgrave 'Why did oxygen supplant phlogiston? Research programmes in the Chemical Revolution', in C. Howson (ed.), *Method and appraisal in the physical sciences. The critical background to modern science, 1800-1905*, Cambridge University Press, 1976, pp. 181-209.

150 Just as Lavoisier thought that it was impossible to doubt his view of the composition of water (see, for example Guyton de Morveau et al., op. cit., note 142 above, p.288), so Priestley recognized that the "antiphlogistic theory ... received its greatest support from the supposed discovery that water is resolvable into two principles, one that of *oxygen*, the base of the dephlogisticated air, and the other (because it has no other origin than water) *hydrogen*, or that which with the addition of *calorique*, or the element of *heat*, constitutes inflammable air." (Priestley op. cit., note 77 above, p.58). Much of Priestley's theoretical activities and empirical investigations during the Chemical Revolution were predicated on the assumption that rejection of the "decomposition of water" entailed acceptance of the "doctrine of phlogiston." To Priestley's mind, the oxygen theory and the phlogiston theory represented mutually exclusive and collectively exhaustive ways of doing chemistry.

151 I hope to give documentary justification for this claim in my forthcoming book on Priestley's role in the Chemical Revolution (see op. cit., note 7 above).

152 Frederick Engels, *Socialism, utopian and scientific in Karl Marx and Frederick Engels selected works in one volume*, New York, International Publishers, 1968, p.411.

153 Ibid., p.413.

Fig 13 Medal depicting Priestley, the reverse being a transcription of his memorial tablet at the New Meeting, Birmingham. Dated 1804. Catalogue 16 (see page 100)

Progress, Liberty and Utility: The Political Philosophy of Joseph Priestley

D. O. THOMAS

There were many subjects which excited the curiosity and stimulated the industry of Joseph Priestley, and there were few of these to which he did not make original contributions. The study of political institutions and of the ideas that shape them was no exception. The fact that he was a Dissenter would quite naturally lead him to take a keen interest in politics, but, like many another Dissenter, despite the handicaps he suffered and the adverse discrimination he experienced, he still rejoiced in the good fortune of living in a society that enjoyed the benefits, the stability, the security and the freedom established by the constitutional developments that followed the Glorious Revolution of 1688. For the greater part of his career he remained a stout defender of the Whig tradition of the balanced constitution, and it was not until the French Revolution that he was tempted to advocate more radical solutions to political problems. Although the post-revolutionary settlement bore heavily upon the Dissenters, especially upon those who did not share orthodox Trinitarian beliefs, Priestley believed that the way forward lay in remedying the deficiencies of what he conceived to be a basically sound political structure rather than in seeking a more radical transformation.

At first sight it would seem as though Priestley based his defence of the settlement of 1688 on the solid foundations established by John Locke's *Two treatises of government* and buttressed by the teachings of those whom Caroline Robbins has identified collectively as the Commonwealthmen.[1] Priestley certainly believed himself to be following in Locke's footsteps and there are many elements in his teaching that he explicitly endorsed: the rejection of Divine Right, the acceptance of a secular foundation for political authority, the doctrine of inalienable natural rights, the theory of the social compact as a basis for political obligation, the concept of a fiduciary trust of government, the notions of limited government and of the separation of powers, and the legitimacy of organized resistance to the abuse of power. But, perhaps, what most influenced Priestley was the attempt embodied in Locke's *Letter on toleration* to separate the secular from the spiritual and confine the responsiblities of the magistrate to the former. From the Commowealthmen, notably Algernon Sidney, John Trenchard and Thomas Gordon, he derived a profound hostility to absolute monarchy and arbitrary rule, a deep distrust of all those who exercise political power, the conviction that is is essential to limit and indeed minimize the activities of government, a firm persuasion of the need to exercise constant vigilance to prevent corruption, and a pronounced aversion to the Established Church.

But however large his debt to these predecessors, Priestley was not content merely to restate the dominant elements in the traditions of the Whigs and the Commonwealthmen. Although his political philosophy is based upon their teachings, he succeeded in transforming them in such a way that his work constitutes an important stage in the development of a strikingly different political philosophy - a liberalism based primarly on the concept of a continuous progress to be acheived by a hardheaded appeal to the criterion of utility. In this paper I shall attempt to state some of the elements in this transformation.

Throughout all of Priestley's work, whether in his writings on science, on theology, on morals and politics, on history, on literary criticism or on linguistics, there is manifest an abiding passion for the discovery of truth. Inspired by the achievements of the natural scientists in the late seventeenth and early eighteenth centuries, he believed that by the use of methods that had proved so abundantly successful in the sciences, similar successes could be achieved in all fields of human enquiry, and that these achievements would usher in an era of ever-increasing knowledge, wisdom, virtue, prosperity and happiness.

The growth in knowledge had been and would continue to be steadily progressive. What scientists knew in his own day, he believed, was a marked improvement upon what was available to previous generations, and knowledge that would be available to future generations, would dwarf present attainments. The kind of objectivity he found in the physical sciences

was, he held, also to be found in morals and politics, so that it can be confidently expected that the methods that have been successful in the sciences will also be successful in the resolution of practical problems. Priestley had no doubt whatsoever that the state of civilization in the eighteenth century showed an appreciable advance upon previous eras. In his *Lectures in history and general policy* he writes:

> That the state of the world at present, and particularly the state of Europe, is vastly preferable to what it was in any former period, is evident from the very first view of things. A thousand circumstances shew how inferior the ancients were to the moderns in religious knowledge, in science in general, in government, in laws, both the laws of nations, and those of particular states, in arts, in commerce, in the conveniences of life in manners, and in consequence of all these, in *happiness*.[2]

Again, in the same work, while commenting on the development of European civilization from the beginning of the sixteenth century, he writes:

> Now also manufactures began to be multiplied, the arts of life were brought to a greater degree of perfection, luxury was beyond conception increased, and at this time politeness and humanity are improved to such a degree as distinguishes the present race of Europeans from their ancestors, almost as much as men in general are distinguished from brute beasts. I may add, that in consequence of these improvements, happiness is vastly increased, and this part of the world is now a paradise in comparison with what it was.[3]

Priestley also had no doubt that what was true of the past would be true of the future. By the acquisition and application of knowledge;

> men will make their situation in this world abundantly more easy and comfortable; they will probably prolong their existence in it, and will grow daily more happy, each in himself, and more able (and I believe, more disposed) to communicate happiness to others. Thus, whatever was the beginning of this world, the end will be glorious and paradisaical, beyond what our imaginations can now conceive.[4]

When the doctrine of progress was first espoused by Christian apologists, it was soon realized that it could constitute a threat to orthodox beliefs. If man's condition, his circumstances, his nature and his knowledge gradually improve through time, what becomes of the claim that the ultimate truth has already once and for all time been revealed by God in the teachings of Jesus Christ? If all things admit of indefinite improvement might it not be expected that this is also true of our moral and religious beliefs and that the Christian revelation itself might eventually be superseded? Are we not faced with a dilemma: either the Christian revelation is true for all time, in which case the doctrine of progress cannot apply to religious and moral principles, or the doctrine of progress does so apply, in which case the Christian revelation will become obsolete?

Edmund Law, Bishop of Carlisle, appreciated the danger in his *Considerations on the theory of religion*, which was first published in 1745. Although he maintained that knowledge in religion, as in the arts and sciences, is progressive so that as we "continually advance in the study of God's Works, so shall we come to a proportionably better understanding of his Word", he was careful to explain that,

> When I mention *improvements* in religions, I do not intend a discovery of new points, or improving upon the original revelation itself, in any thing essential to the general doctrine of salvation: but only a more perfect comprehension of what was formerly delivered; a view of the extent and excellence of this great mystery concealed from former ages; and which, though given almost all at once, yet was received but partially; at least by the bulk of mankind, ... and soon adulterated to such a degree, as ... may take yet far more time to rectify.[5]

Progress in religion, according to Law, is to be found not in improving the original revelation but in recovering its pristine state by removing the corruptions that have obscured it. Priestley may well have been influenced by the way in which Law accommodated the doctrine of progress to the Christian revelation, because although he affirms that the doctrine of a perpetual progress towards a better state of things is scriptural, he denies that Christ's teaching, being perfectly adapted to man's requirements, either needs to be or can be improved.[6] The Christian revelation in itself, as distinct from what men have made of it, is not subject to the doctrine of progress. As Margaret Canovan has noted Priestley claimed that his concern was with 'not a progressive *religion*, but a *progressive reformation* of corrupted religion'.[7]

But despite Priestley's disclaimers, there remains a continuous tension in his thought between, on the one hand, the claim that in the Christian revelation we have a complete embodiment of all that is required for human salvation, and on the other, the claim that our moral and political knowledge is capable of indefinite improvement. The claim that the function of political institutions is to defend the enjoyment of a moral order whose requirements are universal in time and place, and known to be such, is in conflict with the claim that it is the function of political institutions to enable men to acquire the knowledge that will lead them to the realization of a perfect society.

For Priestley the agency of man's redemption is an increase in virtue mediated by an increase in the acquisition and application of knowledge. An essential precondition of that growth is the enjoyment of intellectual liberty. If the truth is to be secured men must be strenuous in submitting all their beliefs and opinions to the tests of reason. God does not require us to accept what we do not understand, and even Christian doctrines must be seen to withstand the tests of rational criticism. As he wrote in *Unitarianism explained and defended*, which he published in his retirement in America;

> Christianity, besides being proved to be true, and indeed, as a necessary step in the proof of its truth, must be shewn to be *rational*, such as men of good sense can receive without abandoning the use of their reason, or making a sacrifice of it to what is called *faith*. The author of our religion required no such sacrifice. He required of his disciples, that they should both *hear and understand* (Mark vii.14) what he delivered, which implies that he taught nothing that they were not capable of understanding, and which it was not their duty to endeavour to understand.[8]

But if all things are to be made clear it is essential that men should enjoy the fullest possible liberty to enquire, discuss and publish. It is only from the open and vigorous contest of opinion that the truth can emerge, that fruitful developments can take place in the sciences, and that Christ's teaching can be recovered from the accretions of prejudice and superstition. Like Milton, Priestley believed that the ultimate victory of the truth is inevitable, provided liberty is enjoyed. As he assured William Pitt, when censuring him for failing to support the application for the repeal of the Test and Corporation Acts 1787:

> The consequence of free discussion would, in time, produce a rational and permanent uniformity. For truth, we need not doubt, will finally prevail in every contest.[9]

Thus is can be seen that Priestley was convinced that the truth is accessible to rational enquiry, and that, granted freedom of expression, it will gradually come to be accepted. It should be noted that in laying such a great emphasis upon the importance of intellectual liberty, Priestley does so in a remarkable individualist way. Progress in science is to be achieved pre-eminently by individuals (not by organized groups, certainly not by committees) conducting experiments and evaluating each other's results; progress in religion is to be achieved by each individual relying upon his own understanding and following his own conscience. The search for truth in all spheres, but especially in religion, is an obligation laid upon every one. Since progress in religion is so heavily dependent upon the development of the understanding, it is also heavily dependent on the enjoyment of liberty.

John Locke, it will be remembered, had sought to extend religious toleration by separating the spiritual from the secular and by attempting to confine the magistrate's responsibilities to the latter. Civil society should be responsible for maintaining law and order, defending society from external aggression, administering justice, and guaranteeing to each individual the safe enjoyment of his natural rights, particularly his rights to property. The magistrate has no responsibility for promoting a man's spiritual welfare, other than by securing the undisturbed enjoyment of the right to freedom of worship. But in attempting to separate the spiritual from the secular Locke did not find it feasible to exclude the magistrate from all responsibility for the regulation of beliefs and opinions; he made some exceptions to complete liberty. The magistrate was not to tolerate those doctrines that are contrary to the good morals necessary for the preservation of society; neither is he to tolerate those whose doctrines are likely to subvert the state, for example, those who attack the contractarian basis of political obligation by holding that faith is not to be kept with heretics; nor is he to tolerate those who hold allegiance to a foreign power. Above all, the magistrate cannot tolerate the atheist "for the taking away of God even only in thought, dissolves all".[10]

Building on Locke's foundations Priestley sought to make freedom of worship fully complete by discarding Locke's reservations and exceptions. Like fellow-Dissenters Richard Price[11] and Philip Furneaux[12] he maintained that the magistrate should have no responsibility at all for the control of opinion, but should confine himself to intervening only where overt actions violate the moral law, or threaten the safety of the state. Atheism held no terrors for Priestley, not because he thought that it was innocuous - on the contrary, it could do damage by taking away the important sanction for morality that belief in a future life of rewards and punishments provides, but because he believed that it was irrational and easily refuted. Neither did Priestley share Locke's apprehensions about tolerating Roman Catholics. Priestley was foremost among the Rational Dissenters in advocating toleration for Roman Catholics. He did so not because he showed sympathy for their doctrines, but because he was convinced that, provided there was complete freedom of discussion and debate on theological matters, toleration of the Catholics would present no threat to the security of the state. Two years before Priestley published his *Essay* Pope Clement XIII had refused to acknowledge Charles Edward Stuart as the legitimate heir to the English throne - a fact which doubtless helped to make Priestley's position more acceptable to his fellow Dissenters.[13]Priestley's willingness to remove all restrictions upon freedom of enquiry and freedom of expression illustrate his supreme confidence in the efficacy of the appeal to reason. The success enjoyed by the natural sciences in the seventeenth and early eighteenth century and his belief that the structure of knowledge is the same in all fields of enquiry led him to believe that the methods used by the scientists would lead to the discovery of practical principles that are universally valid.

Priestley's confidence in the capacity of reason and man's willingness to rely upon it is clearly shown in his definition and evaluation of liberty. In *An essay on the first principles of government*, where he makes a sharp distinction between civil and political liberty, he defines civil liberty,

> that power over their own actions, which the members of the state reserve to themselves, and which their officers must not infringe ... [It] extends no farther than to a man's own conduct, and signifies the right he has to be exempt from the control of society, or its agents; that is, the power he has of providing for his own advantage and happiness.[14]

Political liberty, by contrast,

> consists in the power, which the members of the state reserve to themselves, of arriving at the public

SECTION II.

OF

POLITICAL LIBERTY.

IN countries where every member of the ſociety enjoys an equal power of arriving at the ſupreme offices, and conſequently of directing the ſtrength and the ſentiments of the whole community, there is a ſtate of the moſt perfect political liberty. On the other hand, in countries where a man is, by his birth or fortune, excluded from theſe offices, or from a power of voting for proper perſons to fill them; that man, whatever be the form of the government, or whatever civil liberty, or power over his own actions he may have, has no power over thoſe of another; he has no ſhare in the government, and therefore has no political liberty at all.

Nay

Fig 14 From Priestley's *An Essay on the First Principles of Government* (second edition, 1771).

offices, or, at least, of having votes in the nomination of those who will fill them ... [It], therefore, is equivalent to the right of magistracy, being the claim that any member of the state hath, to have his private opinion or judgment become that of the public, and thereby control the actions of other.[15]

There are several features of these definitions worth noticing. First, civil liberty for Priestley is quite simply the absence of social controls - to be exempt from the control of society or of its agents. A man is free to the extent to which he is free from interference by the state to do what he thinks is to his advantage. Now since the term liberty is an honorific one, any definition of it embodies a value judgement. The value judgement that Priestley makes in this instance is that the condition of not being controlled by society or the State is itself a good (a good, as we shall see because of the beneficial consequences that result from being free). But though liberty is a good, it is not the only good, and it can conflict with other goods. The right to liberty is not therefore indefeasible. The liberty to do those actions which invade the rights of others ought to be restricted. Some social controls are therefore ligitimate. The point I want to emphasize here is that although Priestley admits that it is right to circumscribe the liberty of the individual to prevent his invading the rights of others, his definition requires that when this is done it is recognized that the liberty of the individual is being restricted. Where the state intervenes, quite properly, to prevent individuals invading each other's rights, the correct description of what occurs is that liberties are being limited, not that no restriction or limitation of liberty takes place.

The force of this way of defining civil liberty (and of the value judgement it embodies) can be more readily appreciated if we compare it with those offered by some of his predecessors. For Locke, according to *The second treatise*, a man enjoys freedom in society when he is governed in accordance with settled laws established by the authorized constitutional procedures, and when those laws do not violate his natural rights.[16] Locke sees freedom as the absence of arbitrariness, but arbitrariness can show itself in different ways, either where the executive violates the laws that have been determined by a properly constituted legislative, or where the legislative itself pursues objects that are inconsistent with the true end of government. For Locke any restriction by the State, any control that is not arbitrary in the sense that I have referred to, does not constitute an invasion of freedom.

The originality of Priestley's definition becomes more apparent if we compare his definition with that of Montesquieu, for whom freedom is the liberty to do what one is permitted to do within the moral law, and not to be constrained to do what the moral law does not require.[17] This implies both that being restrained from doing what one ought not to do, and being contrained to do what one ought to do, are not invasions of one's liberty. Here again, the definition presupposes the existence of a moral order, and affirms that liberty is the freedom to act within the constraints of that order. One further example must suffice; as Margaret Canovan has shown, liberty for John Brown, whose programme for education first stimulated Priestley to write on the question of liberty, is the freedom to act within the constraints of a socially accepted moral order.[18] The change which Priestley introduces in the concept of civil liberty, especially when considered together with his concept of progress and his utilitarianism, permits a much greater degree of flexiblity in his political prescriptions. Precisely because his definition of civil liberty does not commit him to an established consensus of moral values, it allows for the possiblity of far-reaching changes in those values.

But although Priestley defines civil liberty in terms of an absence of controls, and although he regards the absence of such controls as a value, it would be a mistake to suppose that he held that their absence is an absolute value. When man leaves the state of nature, to secure for himself the benefits of civil society he submits to the necessity of accepting some constraints upon his natural liberty - otherwise civil society could not be maintained. The point is that these constraints are seen as constraints upon liberty and not just as preconditions for its enjoyment. The significance of Priestley's definition of civil liberty in the development of a liberal political philosophy is that he frees the definition of liberty from the supposition that it can only be enjoyed within the framework of an established moral order.[19] Liberty is not defined as the freedom to be rational within the customarily accepted criteria for rationality, neither is it the freedom to be moral according to the received ideas of what morality requires. Liberty is simply not being restricted or controlled. It is of course tempting to see in Priestley's conception of a community of scientists and philosophers regulating their activities simply by an appeal to the tests of reason, as a precursor of Godwin's conception of a political society which abjures the use of coercion, but Priestley was no anarchist in Godwin's mould. Although the scope he allowed to government is aggressively minimalist, he does not advocate the rejection of political authority.

As a principle for the division of functions, Priestley maintains that the state should be allowed to do what can best be done by the state, and the individuals should be allowed to do what can best be done by them. Even though at one point in his *Essay* Priestley maintains that government is "the great instrument of this progress of the human species towards the paradisaical state in the hand of divine providence",[20] when we examine in detail what he thinks can safely be entrusted to government we find that his recommendations are strikingly sparse: the defence of the realm, the provisions of law and order, the administration of justice and the provision of these public works that cannot be secured by individual initiatives. As Harold Laski pointed out in this context, "we ... find that the main business of government is non-interference".[21] No doubt Priestley's ardent wish to limit the role of government is heavily influenced by his interests as a Dissenter - this can be seen in his hostility to Church establishments and to all attempts by government to restrain freedom of enquiry. But this is not the only reason why he was fearful of government

activity. From the Commonwealthmen he inherited a deep suspicion and distrust of all who seek and exercise political power.

A further important feature of Priestley's definition of civil liberty is that it conflates the absence of control with the possession of a power. This conflation implies that if a person is not restrained from doing what he wants to do, he will be able to do it; he will not need assistance from social institutions. This emphasis upon individual self-sufficiency is a reflection of his Protestant conviction that all that the faithful need in interpreting the scriptures is their own critical intelligence. Religion, however, is not the only field in which the individual is self-sufficient. He is thought to be so over a wide range of practical concerns. Scientific activity is largely seen by Priestley to be an activity carried on primarily by individuals who circulate their findings and dispute their conclusions with each other.[22]

Another feature of Priestley's definition of civil liberty is that it is conceived to be logically dependent of political liberty, that is, of participation in the government of society. He allowed that it is conceivable that men may enjoy a high degree of civil liberty under an autocrat, just as it is conceivable that a man may be insecure in the enjoyment of his civil liberties in a society which boasts a high level of political participation. Priestley claimed that the view that civil liberties are *necessarily* safer in the hands of the majority is a myth. Harold Laski thought that Priestley supposed that when men left the state of nature to establish civil society, they received some measure of political liberty in compensation for the loss of some of their natural liberties.[23] But this is misleading. What Priestley supposed men receive in exchange for the loss of some of their natural liberties is a measure of security for the enjoyment of the liberties they retain. Obtaining some measure of political liberty may be part of the exchange, but is not necessarily so. Priestley was willing to concede that some measure of political liberty is a powerful defence for civil liberties, for the reason that those whose interests are not represented in the political process are likely to see them disregarded and neglected. But he did not think that this consideration was a sufficient reason for building the notion of political liberty into a notion of civil liberty: whether or not political liberty is a defence of civil liberty is a contingent matter. There are some circumstances in which political participation is a strong aid in defence of civil liberties, but there are others in which it is not. To identify civil and political liberty, to attempt to integrate them into one definition just leads to confusion. Of the two liberties, civil and political, Priestley had no doubt which is the more important, political liberty is valuable because and to the extent that it secures civil liberty. In his *Additional observations*, Richard Price took an opposing view. He maintained that civil liberty logically entails political liberty - a man only enjoys civil liberty if he either participates in the government of his society or if he has a vote in the choice of a representative.[24] If he does not participate in this way he is a slave. Price thought that one of the reasons why a person should play a part, however small, in the government of his society is that political participation affords some security that one's interests are not being neglected and one's rights are not being invaded. But it is not the sole reason. Political institutions are not to be judged by their consequences alone. The argument for democracy is not solely that of all the available forms of government it is the one most likely to have beneficial and equitable results. There is an intrinsic moral fittingness in the concept of self-government. It is morally fitting that a man should rely upon his own judgement, it is morally appropriate that he should play a part in the government of his society. With such 'a priori' principles, with such deontological or non-utilitarian criteria, Priestley would have nothing to do. Political institutions must stand or fall by the test of utility.

This perhaps is a convenient point to introduce what seems to be Priestley's major contribution to the development, if not the transformation of the Whig and Commonwealth traditions, namely his thoroughgoing application of the principle of utility. In his *Essay* Priestley claims that it is a matter of surprise that political philosophers have not paid sufficient attention to the principle of utility, even though it is manifest that it is the principle that is always resorted to in the resolution of practical disputes. It is also, Priestley maintains, the principle that inspires the workings of Providence. In the government of His creation the Deity is actuated by no other principle than a consideration for the happiness of His creatures.[25] All the more reason then that men should accept it as the exclusive foundation of their moral and political philosophies:

> Virtue and right conduct in those affections and actions which terminate in the public good; justice and veracity, for instance, have nothing intrinsically excellent in them, separate from their relation to the happiness of mankind; and the whole system of right to power, property, and everything else in society, must be regulated by the same consideration: the decisive question, when any of these subjects are examined, being What is it that the good of the community requires?[26]

Priestley wrote that paragraph in 1768. More than two decades later in his controversy with Edmund Burke he repeated the same basic claim;

> To make the *public good* the standard of right or wrong, in whatever relates to society and government, besides being the most natural and rational of all rules, has the farther recommendation of being the easiest of application.[27]

It is, of course, well known that Jeremy Bentham claimed to have derived his famous phrase 'the greatest happiness of the greates number' from Priestley's work, but the phrase does not occur in the *Essay*, nor as far as I know elsewhere in Priestley's writings. He does, however, come sufficiently close to it to make it plausible that Priestley was Bentham's inspiration. For example, in the *Essay* he writes;

> It must necessarily be understood, therefore, whether it be expressed or not, that all people live in society for their mutual advantage; so that the good and happiness of the members, that is the majority of the members of any state is the great standard by which everything relating to that state must finally be determined.[28]

One curious feature of Priestley's writing on this topic is that he seems to be blissfully unaware of the difficulties occasioned by the different formulations he gives of the basic principle of utility. It makes a great deal of difference whether we say that the good of the whole of society is the determinant of policy, or whether it is the good of the majority. Sometimes he avoids the difficulty by supposing that there is some kind of pre-established harmony that secures the coherence of individual goods and the coherence of individual goods with the public good:

> We are so made, as social beings, that every man provides the most effectually for his own happiness, when he cultivates those sentiments and pursues that conduct, which, at the same time, most eminently conduce to the welfare of those with whom he is connected.[29]

At other times Priestley admits that the goods and interests of individuals may conflict, and then he is quite unabashed in affirming that the interests of the individual are to be sacrificed for the good of the whole.[30]

Similar difficulties arise with his treatment of natural rights. Traditionally the concept of a natural right had been used to provide the individual with a defence against the encroachments of government. The notion had this function in the thought of Locke - men sought the security of civil society in order to protect the rights they enjoyed in the state of nature, and these are rights which the legislative and the executive must not infringe. It is not altogether clear however how Locke reconciles the claim that the natural rights of the individual must be protected, with the claim they may be regulated within society, although it is clear that he employs the notion of a natural right to defend the individual against the encroachments of government. Priestley frequently appeals to the notion of a natural right, but he evades the difficulties that arise whenever natural rights may be thought to conflict with considerations of the public good, by supposing that natural rights have their foundation in the public good and cannot be conceived to conflict with it. An insidious consequence of supposing that all interests are harmonized in one over-arching public good, is that is obscures the possibility that there may be real clashes of interest, and leaves the individual defenceless against those who are alleged to represent the public interest.

Perhaps most surprising of all is the realization that for Priestley the most cherished liberties, freedom of inquiry and freedom of worship have, like all other rights, their foundations in utility, and that in theory, at least, Priestley would have to admit that circumstances may arise in which the pursuit of the public good would require the circumscription of these liberties. The freedom to enquire and the freedom of worship are hardly secure if the right to enjoy them is made to depend simply on the contingency that they serve the public good.

At the beginning of this paper I suggested that Priestley introduced into the thought of the Whigs and the Commonwealthmen, elements that were to serve in the transformation of those traditions into a philosophy of liberalism. The chief of these are the doctrine of progress, which disturbed the conviction that the established moral order is of universal and sempiternal validity, and which challenged the authority of the Christian revelation; his redefinition of civil liberty - simply as the absence of social control - which liberated the concept of freedom from its anchorage in the belief that there is an unchanging moral order, and thereby promoted a more flexible attitude to moral and political rules; and, perhaps, more importantly, by his adoption of the principle of utility as the foundation of all moral, political and religious rules, of our rights, duties and liberties. The adoption of this principle was to dissolve allegiance to the traditions of natural law and natural rights and pave the way for the introduction of a liberalism based upon a hard-headed appeal to what is conceived to be in the public interest.

Notes and References

1 Caroline Robbins, *The eighteenth-century commonwealthman*, Cambridge, Mass., Harvard University Press, 1961.

2 Joseph Priestley, *Lectures on history and general policy*, London, J. Johnson, 2 vols. 1793, vol. 2, p.442.

3 Joseph Priestley, *Lectures on history and general policy*, Birmingham, 1788, vol. 2, pp.24, 25.

4 Joseph Priestley, *An essay on the first principles of government*, London, J. Johnson, 2nd ed., 1771, pp.4-5

5 Edmund Law, *Considerations on the theory of religion*, Cambridge, J. Robson et al., 6th ed., 1774, p.262.

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7 Margaret Canovan, 'The irony of history: Priestley's rational theology', *The Price-Priestley Newsletter*, 1980 4: 18, citing Joseph Priestley, *An history of the corruptions of Christianity*, in J.T. Rutt (ed.), *The theological and miscellaneous works of Joseph Priestley*, London, 25 vols., 1818-31, vol. 5, p.503.

8 Joseph Priestley, *Unitarianism explained and defended*, Philadelphia, J. Johnson, 1796, p.20.

9 Joseph Priestley, *A letter to the right honourable William Pitt on the subjects of toleration and church establishments*, London, Johnson, 1787, pp. 25-26.

10 John Locke, *Epistola de tolerantia: a letter on toleration*, edited by Raymond Klibansky, trans. J.W. Gough, Oxford, Clarendon Press, 1968, pp. 54-55 and 131-135.

11 Richard Price, *Britain's happiness and the proper improvement of it*, London, Millar, 1759, p.9.

12 Philip Furneaux, *Letters to the Honourable Mr. Justice Blackstone*, London, T. Cadell, 2nd ed., 1771, p.59.

13 Priestley, op. cit., note 4 above, p.135; Sir Charles Petrie, *The Jacobite movement*, London, Eyre and Spottiswoode, 1932, p.257; Martin Fitzpatrick, 'Joseph Priestley and the cause of universal toleration', *The Price-Priestley Newsletter*, 1977 1: 3-30.

14 Priestley, op. cit., note 4 above, pp. 9-10.

15 Ibid.

16 John Locke, *The second treatise*, edited by P. Laslett, Cambridge, Cambridge University Press, 1960, sect. 22.

17 "Dans un etat, c'est-a-dire dans une societé ou il y a des lois, la liberte ne peut consister qu'a pouvoir faire ce que l'on doit vouloir, et a n'etre point contraint de faire ce que l'on ne doit pas vouloir.", Baron de Montesquieu, *De l'esprit des lois*, Paris, Garniers Freres, n.d. ch.XI, sect.iii, p.162.

18 John Brown's views on education were published in *Thoughts on civil liberty, licentiousness and faction*, London, L. Davis et al., 1765, and in 'An appendix relative to a proposed code of education' published with his *On female character and education*, London, L Davis, 1765. Priestley first responded in 'Remarks on a code of education proposed by Dr. Brown, etc.' first published as an appendix to *An essay on a course of liberal education for civil and active life*, London, C. Henderson, 1765. See Margaret Canovan, 'Two concepts of liberty: eighteenth century style', *The Price-Priestley Newsletter*, 1978, 2: 27-43.

19 It is instructive to compare Priestley's definition of civil liberty with that given by Thomas Gordon in *Cato's Letters* in *The English libertarian heritage*, No.62, edited by David L. Jacobson, New York, The Bobbs-Merrill, Co. Ltd, 1965, p.127, "By Liberty, I understand the Power which every Man has over his own Actions, and his Right to enjoy the Fruit of his Labour, Art, and Industry as far as by it he hurts not the Society, or any Members of it, by taking from any Member, or by hindering him from enjoying what he himself enjoys". It will be noted that although there are some striking similarities between the two definitions, Priestley does not build into his definition the limits that Gordon builds into his.

20 Priestley, op. cit., note 4 above, p.5.

21 Harold J. Laski, *Political thought in England: Locke to Bentham*, London, Oxford University Press, 1948, p.127.

22 See John G. McEvoy, 'Enlightenment and science: Joseph Priestley and the limits of theoretical reasoning' *Enlightenment and Dissent*, 1983, 2: 54.

23 Laski, op. cit., note 21 above, p.127.

24 Richard Price, *Additional observations*, London, T. Cadell, 1777, pp.13-14.

25 Priestley, op. cit., note 4 above, pp.13 and 14.

26 Ibid., 1st ed., pp.18 and 19; 2nd ed., p.14.

27 Joseph Priestley *Letters to the right honourable Edmund Burke*, Birmingham, J. Johnson, 2nd ed., 1791, p.23.

28 Priestley, op. cit., note 4 above, pp.12-13.

29 Joseph Priestley *Institutes of natural and revealed religion*, London, C. Stower, 1806, vol.I, p.43.

30 See, for example, ibid, vol.I, p.28.

Priestley, Reid's Circle and the Third Organon of Human Reasoning

MICHAEL BARFOOT

This paper deals with some general aspects of the philosophical exchanges between Priestley and a small group of Scottish thinkers surrounding Thomas Reid. It begins with a discussion of Priestley's *An examination of Reid, Beattie and Oswald*.[1] Priestley's criticisms of common sense, and of Reid in particular, can be understood in terms of his use of a necessitarian theory of causal judgement. This emphasised men's knowledge of necessary connections in nature based upon the association of ideas. In this paper, I review some general aspects of the response to Priestley found in the writings of Reid and his Edinburgh colleagues, Dugald Stewart, James Gregory, and John Robison. The differences between Priestley and Reid's circle can actually be understood in terms of their shared commitment to a similar project. This was to develop a theologically sound scientific metaphysics which would integrate the truths and procedures of natural philosophy and the philosophy of the human mind. Their disagreement was over the use of alternative necessitarian and voluntarist strategies for achieving this end. Reid and his circle were committed to a voluntarist account of causal judgement which emphasised men's feeling of active power founded upon innate first principles or constitutional predispositions. Hence they challenged the scientific status, theological propriety and social utility of Priestley's necessitarian position. In broad context, the location of the dispute between Priestley and these common sense philosophers is David Hume's writings and their later eighteenth century reception.

The most persistent theme of Priestley's critique of Reid's *Inquiry* was that despite attacking Hume, Reid had "himself introduced almost universal scepticism and confusion".[2] Priestley saw Reid as a sceptic because, like Hume, Reid had denied the existence of necessary connections in nature. By imposing what Priestley called an "impassable gulph" between the mind, the contents of perception and external objects, Priestley suggested Reid was closer to Bishop Berkeley than the common sense realism he laid claim to.

Two features of Reid's scientific metaphysics confirmed this to Priestley. First, Reid denied things had a "real instrumentality of their own".[3] Secondly, because his theory of mind was founded upon "independent arbitrary instinctive principles",[4] men only had access to a "relative truth"[5] which was wholly dependent upon their constitution. Hence Priestley stated that the aim of his critique was to challenge the claims of common sense by "ascribing a little more to habit, and to the necessary connections and consequences of things".[6]

The kind of necessary connections Priestley had in mind were those founded upon the association of ideas. Priestley stated that all Reid's instinctive principles were really acquired by experience.[7] Priestley routinely accepted that there was an external world to which ideas corresponded by the mechanism of association. He acknowledged this was in fact a hypothesis; but said there was a "reasonable degree of evidence" for its truth.[8] But Reid had stumbled over this point. He considered scepticism was the inevitable outcome of sensationalist epistemology. Therefore to oppose Hume's doctrine of ideas and impressions, Reid had sought what Priestley called a "plenary assurance" based upon ultimate principles.[9] Priestley rejected this common sense epistemology of instinctively felt beliefs in favour of rational belief that "all the connections which had been supposed to exist between the several phenomena, powers and operations of the mind strictly had a real basis in nature".[10] However the opposite tendency was evident in Reid. Priestley wrote:

> Where all the rest of the world see the most clearly connected chain of reasoning, [Reid] is always ready to suspect that some link is wanting, and as ready to supply the imaginary defect, not with another link, but with something that is no proper part of a chain, but some invisible power to keep the two parts together.[11]

Priestley's adoption of a relational constant conjunction theory of causality lay at the basis of his system of

Fig 15 Wax medallion of Priestley, signed by Samuel Percy, dated 1788.
Catalogue 3 (see page 98)

philosophical necessity. He stated that the aim of his philosophy was to reduce the manifold experiences of nature into classes by inferring similar causes from similar effects on the basis of the association of ideas.

For Priestley, the means of displaying necessary connections between men's minds, ideas, sensations and material objects was David Hartley's physiology.[12] Priestley criticised Reid's apparent ignorance of Hartley in the *Inquiry*. He was incensed at Reid's parodying of what the latter called "engines of the nervous system" such as the doctrine of vibrations.[13] Priestley viewed Reid's nescience about necessary connections in the nervous system as another instance of his general philosophical scepticism. Instead of seeing Hartley's work as a reasonable physiological basis for the association of ideas, Reid had dismissed it. Priestley saw Reid as segregating the physiology and philosophy of mind so that the mind and the nervous system became problematically separated. Hence Reid needed to ground men's belief in the material world in terms of an instinctive principle antecedent to all experience.

Priestley also attacked common sense philosophy because of its rejection of moral necessity. He criticised Reid and his associates for advocating a corrupted Arminian doctrine of the will.[14] Their voluntarism emphasised that men had the power to do different actions where the antecedent motives and circumstances governing their conduct remained the same. Priestley stated this made morality unaccountable. Unless motives were constantly conjoined with actions, then men were not responsible for their acts. Hence Priestley advocated moral necessary connections in his alternative system of philosophical necessity in which men had liberty or the power to do what they willed.

Priestley also regarded his commitment to philosophical necessity as an essential basis for rational natural religion. Otherwise, it was impossible to provide rational proof of the being and attributes of the deity. Although Priestley placed greater stress upon an equally rational revealed religion, natural theology was also important. He saw it as a shop window to attract the passing philosophical unbeliever. Once inside, he might also be converted to rational christianity.[15] Therefore Priestley was concerned to develop the best arguments and proofs for it. This was another criterion for attacking the common sense philosphers.

Arguments about causality were central to natural religion. Priestley stated that even though Reid also made use of them, his denial of necessary connection led him to place too much emphasis upon the wrong "kind of faith" in the deity.[16] Priestley accused Beattie of failing to see that philosophical necessity was more consistent with natural religion than its voluntarist alternative.[17] But his greatest criticisms were reserved for James Oswald. By emphasising instinctive common sense, Oswald suggested that the premisses required to deduce the existence of a designing deity could never be proved. Priestley found it incredible that:

> any friend of religion should thus lend weapons to the common adversaries and in their name challenge all the powers of reason, ...[18]

In his *Examination*, Priestley did not rehearse the basis of his own rational reconstruction of natural religion. However, it is evident this followed from the same general principles as the rest of his thought. The truth of natural religion was to be resolved with reference to the association of ideas, formulated in terms of a theory of judgement about how men knew causes and effects in nature. As maxims about how to judge causes and effects, the rules of reasoning in philosophy dictated that men sought a unitary cause adequate to produce the manifold effects of nature including man himself.[19] Therefore men must infer a single godhead endowed with infinite power and intelligence to design, produce and sustain nature.[20]

As well as Priestley's stress upon ontological, physiological and moral necessary connection, he also embraced a form of logical necessary connection. Priestley considered that human judgements concerning the truth of propositions about nature were further instances of the association of ideas.[21] Nature, the mechanism of perception and human judgement were all equally necessary and in complete correspondence with one another. All these processes were at bottom the same kind of necessity for Priestley. By departing from the standard of philosophical necessity based upon the association of ideas, the common sense philosophers broke down the links between men's minds, the physiology of the nervous system, external nature and God.

In his *Examination*, Priestley's insistence upon necessary connections had several interrelated aspects. He variously put forward the claims of ontological, physiological, moral, natural theological and logical necessity. At the centre of his sytem of philosophical necessity lay a theory of judgement and evidence that was itself causal, necessary and founded upon the association of ideas.[22] On the basis of laws of reasoning, or what Priestley called the "rules of philosophising", men made causal judgements about God, nature and their fellow men. The chief criterion for these judgements was the constant conjunction between analogically similar causes and effects. Because human understanding was so formed, these manifold constant conjunctions were the basis of a reasonable belief in real necessary connections throughout nature:

> For a cause cannot be defined to be any thing but such previous circumstances as are constantly followed by a certain effect; the constancy of the result making us conclude that there must be a sufficient reason in the nature of things why it should be so produced in these circumstances.[23]

Applied to mind, this meant that although in practice a man's conduct might not be known in advance, in principle an acquaintance with his "disposition of mind", "precise situation", and "view of things" would enable a prediction about it to be successfully made. Alternatively, if circumstances remained the same, and a different effect followed from that expected from constant laws of nature, then this would imply an effect without a cause. However:

> if one effect might take place without a sufficient cause, another, and all effects, might have been without a cause; which entirely takes away the only argument for the being of a God.[24]

To illustrate his conception of the necessary determination of the will by motives, Priestley repeatedly compared it to the behaviour of a balance when weights of varying kind were placed in the opposing pans. Like weights, motives acted invariably and mechanically according to human physical laws. Thus:

> Strengthen the motive, and the action is more vigorous; diminish it, and its vigour is abated; change the motive, and the action is changed; entirely withdraw it, and the action ceases; introduce an opposite motive of equal weight, and all action is suspended ... As far as we can judge motives and actions do in all possible cases strictly correspond to each other.[25]

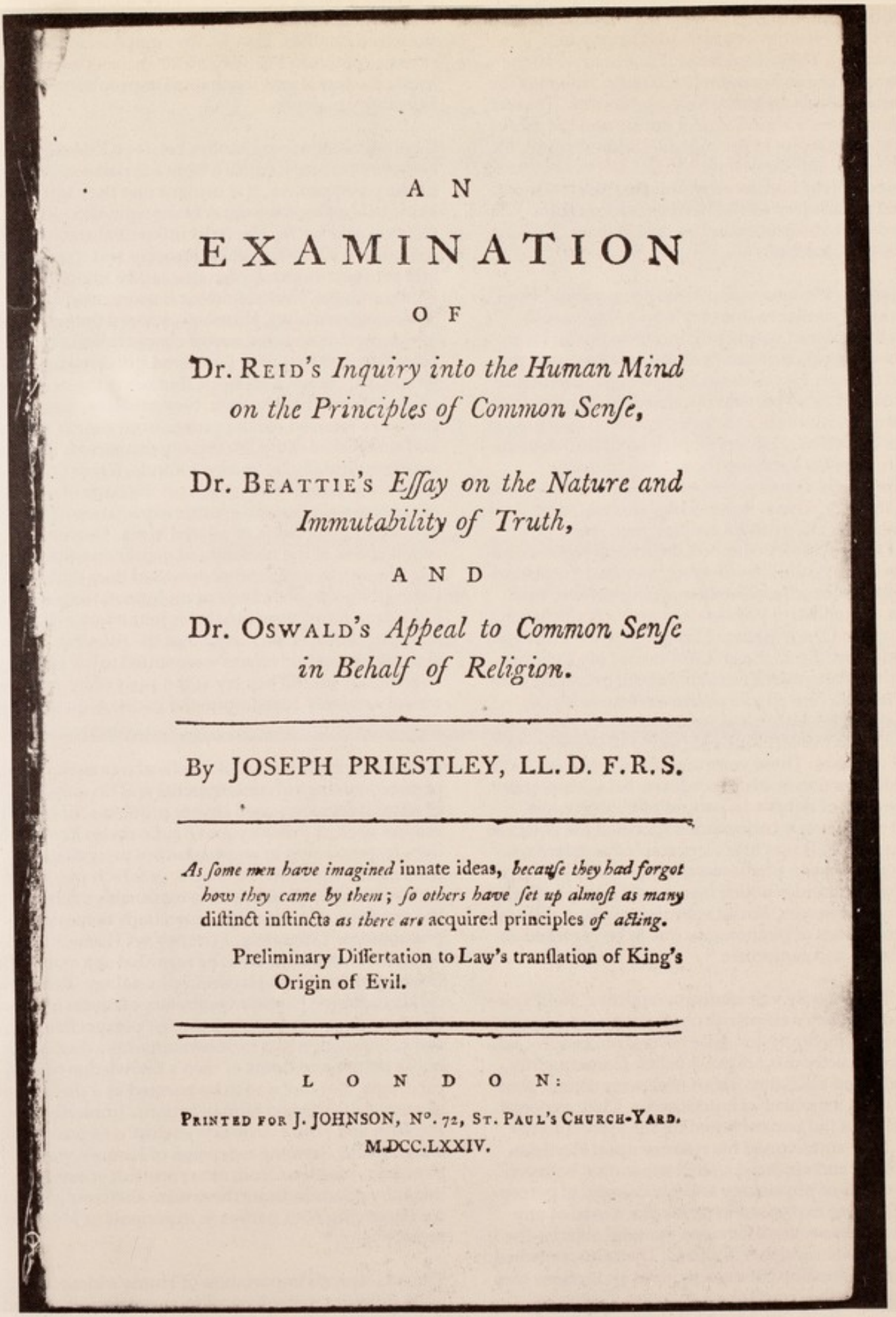
Priestley also made considerable use of arguments which appealed to linguistic usage. Common speech showed that men considered motives to be real causes and that this circumstance was implied in the idea of "agency".[26] In this sense, Priestley considered that the "vulgar" actually subscribed to philosophical necessity. Whereas the vulgar were Priestley's allies, common sense philosophers generally, and especially Reid, were perceived as opponents of his evolving system of philosophical necessity. Their views on the freedom of the will disrupted the accountability of men's reasoning and reduced men from being the necessary architects of their own experience to a contingent dependency upon the innate principles of their mental constitution.

An examination of Priestley's philosophical necessitarianism reveals substantial similarities with the views of Hume and Henry Home, Lord Kames. Although Priestley was critical of both men for lacking a scientific understanding of the association of ideas found in Hartley, and he also attacked Hume for his religious opinions, it seems likely that his presentation owed much to them. There is probably insufficient biographical information to confirm this directly in relation to Priestley's own non-conformist education and his subsequent role as a teacher in the dissenting academies.[27] But indirect evidence suggests that Priestley's scientific metaphysics may have been derived from Scottish necessitarian sources.[28] Certainly, Kames, Hume and Priestley endorsed the search for the scientific resolution of necessity. Each writer's willingness to employ forms of causal reasoning in moral subjects which were current in natural philosophy harmonised all three accounts of necessity. Furthermore, Priestley seems to have specifically made use of Hume's vocabulary of constant conjunction and necessary connection to 'new-model' necessitarianism. The central feature of this was the transposition of men's perception of constantly conjoined events into necessary connections of various kinds. Thus despite the limits of men's understanding, men had access to a form of certainty relative to the nature of men's minds.

The common sense reply to Priestley was not an immediate and direct one. When invited by his publisher to pen a reply, Reid is reputed to have said: "What, Mr. Creech, would you have me wrestle with a chimney sweeper!"[29] Reid implied that even if he emerged victorious in the ensuing public controversy, his own reputation would inevitably be blackened. Nevertheless, Reid did engage in a more surreptitious warfare. He attacked Priestley's views in his private papers;[30] while in his *Essays on the intellectual powers* and *Essays on the active powers*, Reid responded to Priestley, often via a denunciation of Hartley's physiology.[31] A similar concern to oppose Priestley can be found in Dugald Stewart, Professor of Moral Philosophy at Edinburgh University. In his *Elements of the philosophy of the human mind*, part one, published in 1790, Stewart popularised Reid's views and continued the attack upon physiological models of perception favoured by Priestley and Hartley.[32]

Whereas Reid and Stewart were more subtle in their attacks on Priestley, two other Edinburgh professors closely linked to Reid were less circumspect. James Gregory was Professor of the Theory and then the Practice of Medicine. In fact Gregory relished controversy. In his text-book on physiology and therapeutics, he also attacked Hartleian-inspired accounts of perception and the nervous sytem based upon vibrations and nervous fluids.[33] In unpublished essays, he sought to clarify the nature of physical causation and criticised necessitarianism generally.[34] He published an *Essay on the difference between the relation of motive and action and that of cause and effect in physics*.[35] Gregory claimed this was a scientific and demonstrative refutation of Priestley's system of moral necessity. Gregory was subsequently attacked by Alexander Crombie, and Thomas Cooper as well as local necessitarian sympathisers in Edinburgh such as James Hutton and John Allen.[36] John Robison was Professor of Natural Philosophy and no stranger to controversy either. In his *Proofs of a conspiracy*, he connected the French Revolution to free-masonry and drew parallels with the role of Priestley's rational dissent in Britain.[37] In his other books, encyclopaedia articles and lectures, Robison attacked Priestley's views.[38] He was concerned to clarify the conditions under which men made judgements about forces in natural philosophy. Also in conjunction with Dugald Stewart, he sought to re-appropriate Boscovich's theory of force from the connotations given to it by Priestley.[39]

A closer examination of these writers' criticisms indicates some variations of emphasis, according to their special areas of competence. Nevertheless, there were also considerable overlaps and strong thematic continuities underlying their particular remarks.[40] These actually stemmed from what Reid, Stewart, Gregory, and Robison had in common with Priestley. Like him, they displayed proficiency in a range of disciplines which extended beyond their professorial responsibilities. In particular, all four wrote extensively on subjects in metaphysics and natural philosophy. In this respect, Reid and his circle were engaged in a project that was fundamentally similar to Priestley's own: they were committed to the joint reform of the philosophy of mind and natural philosophy. This had



A N

EXAMINATION

O F

Dr. REID's *Inquiry into the Human Mind on the Principles of Common Senſe,*

Dr. BEATTIE's *Eſſay on the Nature and Immutability of Truth,*

A N D

Dr. OSWALD's *Appeal to Common Senſe in Behalf of Religion.*

By JOSEPH PRIESTLEY, LL.D. F.R.S.

As ſome men have imagined innate ideas, *becauſe they had forgot how they came by them; ſo others have ſet up almoſt as many* diſtinct inſtincts *as there are* acquired principles *of acting.*

Preliminary Diſſertation to Law's tranſlation of King's Origin of Evil.

L O N D O N:

PRINTED FOR J. JOHNSON, N°. 72, ST. PAUL'S CHURCH-YARD.
M.DCC.LXXIV.

Fig 16 Priestley's *An Examination of Dr Reid's Inquiry into the Human Mind* ... (1774).

two principal aspects. Firstly, they sought to apply the methodological insights of what they conceived of as Bacon's and Newton's natural philosophy to metaphysics. They considered this would make the philosophy of mind genuinely scientific. However the second aspect was perhaps more significant. This was to ground men's knowledge of nature and the role of natural philosophy in the human understanding. By referring the substances, causes and laws of nature to the nature of the human mind and the rules it obeyed, natural philosophy would itself be reformed and purged of its absurdities and inconsistencies. But how was this to be done?

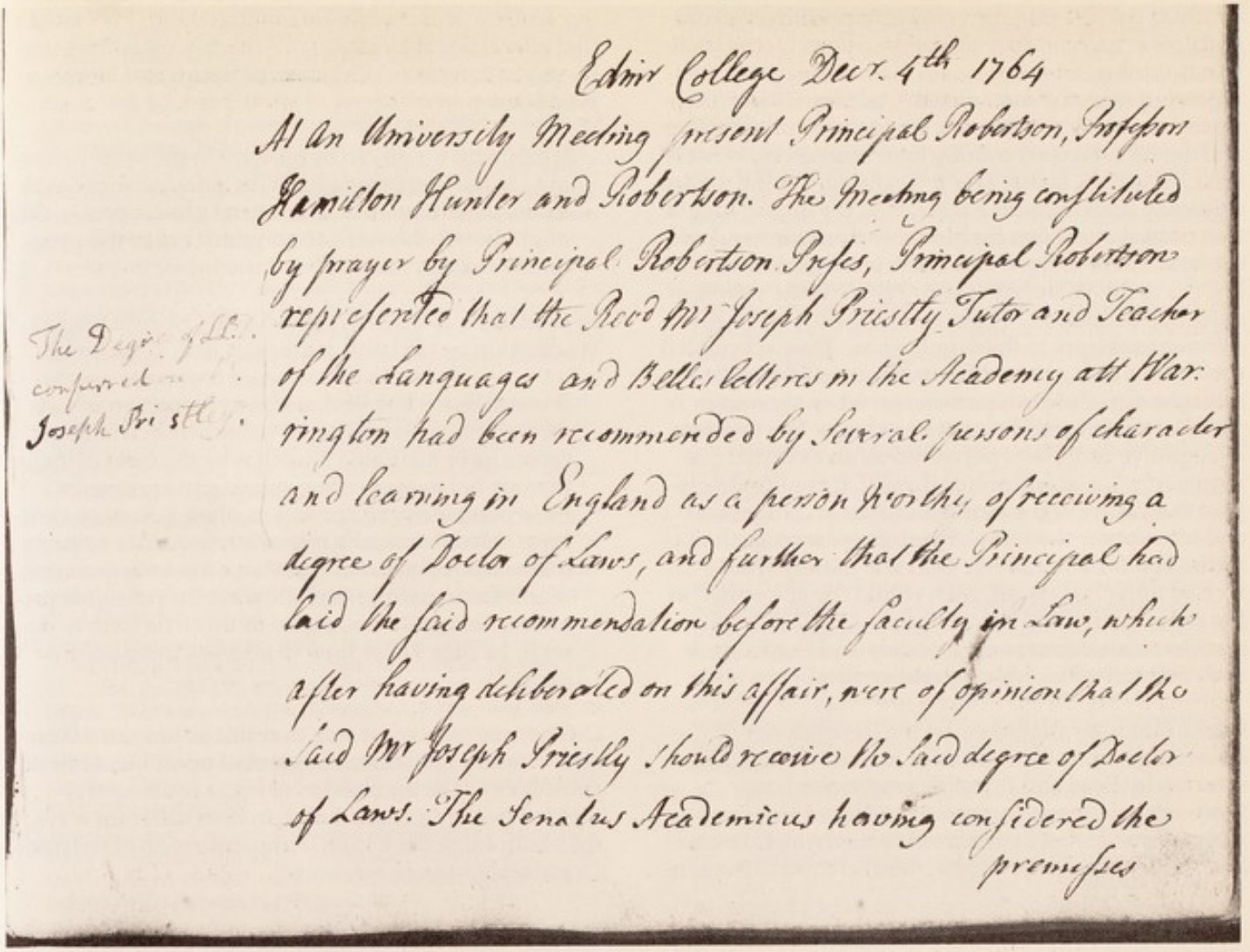
Once again, the means of realising this project was remarkably similar to Priestley's own. Men could know the order of nature and locate its power by an epistemological clarification of the way the mind perceived change. Hence the acknowledged importance of causation by all parties concerned. In practice, this meant a specification of the rules by which men judged causes and effects. However, instead of the necessitarian strategy for applying those rules found in Priestley, Reid's circle relied on an alternative voluntarist strategy. This is most clearly articulated by Reid and Stewart. They contended that men never perceived any necessary connections in nature. Nevertheless, as intrinsically active beings, men had the distinctive experience of freely willing change. Then, by means of instinctive principles in man's constitution, they inferred the existence of active powers throughout nature acting as the efficient causes of all change. Thus professing man's nescience about necessary connections was viewed as a positive resource by the members of Reid's circle. In metaphysics, it led to an emphasis on the continued supervision of nature by efficient causes. These were viewed in terms of God's immediate action or his subordinate beings maintaining the laws of nature. In natural philosophy, the denial of necessary connections specified the object of this discourse. It was to seek perceived constant conjunctions between phenomena expressed in terms of law-like regularities which men might metaphorically call physical causes. But all speculation about the real efficient causes of phenomena was to be regarded as hypothesis and conjecture.[41]

From their broadly voluntarist perspective, Reid's circle saw Priestley's emphasis upon necessary connections as bad metaphysics, false natural philosophy and a danger to orthodox religious belief. Consequently, they attacked his claims about necessary connections in nature in a number of crucial areas. They opposed his theory of judgement based on the association of ideas. They condemned his reliance upon Hartleian physiology and enforced a strict separation between the domains of physiology and philosophy of perception. This was expressed in terms of a denial of any necessary connections between material objects, the nervous system and men's minds. They also contested that the relationship between motives and actions was analogous to the constant conjunction of physical causes and effects, which was the cornerstone of Priestley's moral necessitarianism. Rather surprisingly, they virtually ignored Priestley's experimental research. Instead Robison and Stewart opposed Priestley's use of Boscovich and re-formulated the critique of contact action in conformity with their own preferred dualism. Finally, they emphasised the continuities between Priestley's and Hume's writings to imply the moral and theological impropriety of Priestley's position.

If we situate these exchanges between Priestley and his common sense critics within a broader eighteenth century perspective, it is evident that they were not alone in seeking the reform of metaphysics. After Newton and Locke, the most influential statement of the rules of reasoning in philosophy and the nature and process of causal inference can be found in Hume.[42] In the *Treatise* and his *Enquiry concerning human understanding*, Hume questioned the basis upon which men discovered causal connections in nature. Hume argued that men perceived the constant conjunction of causes and effects, but never the necessary connections between them. Nevertheless, men routinely inferred similar causes from similar effects and considered them necessarily connected. But this necessity actually lay in men's minds. It was the transition of the imagination made on the basis of customary past experience and a future expectation about the continued association of related ideas. However men might speak of the necessity of matter and the necessity of motives and actions provided they understood the contingent constraints upon human judgement. Despite their questionable basis in the human understanding, Hume considered that the rules for judging causes and effects were suited to the purposes of everyday life.[43] They lay at the basis of his own system of necessity based upon the constant conjunction of associated ideas.

Hume's sophisticated philosophical monism, his lack of direct ontological commitments and his questioning of natural religion posed severe problems for his successors such as Priestley and Reid's circle. Priestley's own response was to emphasise the naturalistic dimensions of Hume's thought, in which perceived constant conjunctions became reasonable evidence for the assertion of necessary connections between phenomena. Ultimately, Priestley set Hume's monist views to work within what he regarded as a materialist framework based on Hartleian physiology. Reid's circle also adopted Hume's vocabulary of causal relation, but they used it to sustain a dualist perspective. Constant conjunction was to be condoned as a description of the nature and limits of men's knowledge of physical events. But this was to be rejected as a description of mental events and human actions. Ironically, both Priestley and Reid's circle saw each other's position as a logical and alarming extension of Hume's views. However, reactions from other Scottish scientific metaphysicians indicate there were also clear grounds for classifying both parties as exponents of Humean metaphysics.[44]

The widespread importation of Hume's ideas into quite different metaphysical frameworks introduced considerable epistemological sophistication into these and other contemporary discussions of philosophy, science and religious belief. It also transformed the language of the actual debate itself. The emphasis



Edinr College Decr. 4th 1764

At an University Meeting present Principal Robertson, Professors Hamilton Hunter and Robertson. The Meeting being constituted by prayer by Principal Robertson Praes, Principal Robertson represented that the Revd Mr Joseph Priestly Tutor and Teacher of the Languages and Belles lettres in the Academy at Warrington had been recommended by several persons of character and learning in England as a person worthy of receiving a degree of Doctor of Laws, and further that the Principal had laid the said recommendation before the faculty of Law, which after having deliberated on this affair, were of opinion that the said Mr Joseph Priestly should receive the said degree of Doctor of Laws. The Senatus Academicus having considered the premisses

The Degree of LL. D. conferred on Joseph Priestley.

Fig 17 Extract from Edinburgh University Senate Minutes for 4th December 1764, recording Priestley's degree of Doctor of Letters. Catalogue 10 (see page 99)

upon the complex vocabulary of necessary connection, constant conjunction, physical cause, efficient cause and power had considerable implications for the traditional ontological categories of matter and spirit, making imputations of 'materialism', 'idealism', and 'scepticism' yet more problematic for both historical actors and the historians who study their utterances. What is clear, however, is that Hume's writings on the nature of human understanding reinforced the importance of two central questions for his contemporaries and successors. These were: 'How is the order of nature to be known in men's minds?'; and 'Where is the power of nature to be found?'. Priestley and Reid's circle gave different answers to these questions. They articulated their views using very different forms of scientific metaphysics. But both parties agreed on the wider social importance of the matters at issue. The problem of cognitive order was perceived as an essential prerequisite to social and political order. If men could display the nature and processes of human judgement and so uncover the basis of human reasoning, then truths about men, nature, God and society would receive universal assent. Men would then be united in the future pursuit of knowledge and truth. Despite their sectaian differences, Priestley and Reid's circle each subscribed to this progressive ideal.

Hume famously remarked on the dependency of knowledge upon the science of human nature.[45] Two remarks by Reid and Priestley emphasise how thoroughly Hume's successors endorsed the programme established by Humean metaphysics. In his discussion of Aristotle's logic, Reid referred to the general search for the first principles of men's understanding and the sources of human judgement. He stated that after the first Organon of Aristotle, men had progressed to the second Organon of Bacon and Newton. He added:

> If inquisitive men can be brought to the same unanimity in the first principles of the other sciences as in those of mathematics and natural philosophy ... this might be considered a third grand era in the progress of human reason.[46]

In Priestley's *Lectures on Oratory and Criticism* read at Warrington in 1762 and published in 1777 he wrote:

> It is necessary likewise, as far as reasoning is concerned that a person be, in some sense, a logician before he be an orator; since it is by the rules of logic that we judge everything relating to arguments, their perspicuity or confusion, their fallacy or their force. More especially it is of consequence to every orator whose business is with men to be acquainted with human nature; that knowing the passions, prejudices, interests and views of those he hath to do with, he may know how to address them accordingly.[47]

Differences over what was to count as human nature and whether judgement depended upon innate first principles or the association of ideas continued to divide Priestley and Reid. But, in their different ways, they both subscribed to an imminent vision of the third Organon of human reasoning.

Notes and References

1 Joseph Priestley, *An examination of Dr. Reid's 'Inquiry into the human mind on the principles of common sense', Dr. Beattie's 'Essay on the nature and immutability of truth', and Dr. Oswald's 'An appeal to common sense in behalf of religion'*, London, J. Johnson, 1774. An account of Priestley's criticisms of common sense philosophy can be found in J.G. McEvoy and J.E. McGuire, 'God and nature: Priestley's way of rational dissent', *Hist. Stud. Phys. Sci.*, 1975, 6: 325-404, or 357-361. For a broader perspective on the exchanges see George Davie 'The social significance of the Scottish philosophy of common sense', *The Dow Lecture*, Edinburgh, T. & A. Constable Ltd., 1973.

2 Priestley, op. cit., note 1 above, p.5.

3 Ibid., pp. 45-46.

4 Ibid., p.6.

5 Ibid., p.47.

6 Ibid., p.19.

7 Ibid., pp. 23-24 and 9-18, where Priestley gave a list of the various instinctive principles Reid had put forward.

8 Ibid., p.liii.

9 Ibid., p.62.

10 Ibid., pp. 5-6.

11 Ibid., p.87.

12 See David Hartley, *Hartley's theory of the human mind on the principle of the association of ideas with essays relating to the subject of it by Joseph Priestley*, London, J. Johnson, 2nd ed., 1790.

13 Priestley, op. cit., note 1 above, p.101.

14 Ibid., p.xv. The vicissitudes of Calvinist, Arminian and Socinian accounts of liberty and necessity lie beyond the scope of this account. However, for a contemporary introduction to the complex theological issues at stake see George Hill, *Lectures in divinity*, Edinburgh and London, William Blackwood and Sons, 6th ed., 1854, pp. 392-458.

15 Ibid., pp. 45-46.

16 See Joseph Priestley, *Institutes of natural and revealed religion*, Birmingham, Pearson and Rollaston for J. Johnson, 2nd ed., 2 vols., 1782; also his *Letters to a philosophical unbeliever*, Birmingham, Pearson and Rollaston for J. Johnson, 2nd ed., 1787.

17 Priestley, op. cit., note 1 above, pp. 157-165.

18 Ibid., p.95. See also Richard Price, *A free discussion of the doctrines of materialism, and philosophical necessity, in a correspondence between Dr. Price and Dr. Priestley*, London, J. Johnson and T. Cadell, 1778, pp.xxvii-xxviii.

19 For the central importance Priestley gave to the rules of philosophising see *Disquisitions relating to matter and spirit, to which is added the history of the philosophical doctrine concerning the origin of the soul, and the nature of matter; with its influence on Christianity, especially with respect to the doctrine of the pre-existence of Christ*, London, J. Johnson, 1777, pp.1-9.

20 Priestley, *Letters*, op. cit., note 16 above, letters 2, 4 and 5, pp. 35-43 and 57-85.

21 Priestley, op. cit., note 1 above, 'Introductory observations on the nature and judgement and reasoning', pp.xliv-lxi.

22 See also Priestley, *Letters*, op. cit., note 16 above, letter 1, 'Of the nature of evidence', pp. 25-34. See also the discussion of Priestley's views in John G. McEvoy, 'Electricity, knowledge, and the nature of progress in Priestley's thought', *Brit. J. Hist. Sci.*, 1979, 12: 1-30.

23 Joseph Priestley, *The doctrines of philosophical necessity, illustrated, being an appendix to the 'Disquisitions relating to matter and spirit', to which is added an answer to the 'Letters on materialism', and on Hartley's theory of mind*, London, J. Johnson, 1777, p.11.

24 Ibid.

25 Ibid., p.31.

26 See ibid., section 5, 'Of the supposed consciousness of liberty, and the use of the term agent', pp. 44-56.

27 See Joseph Priestley, *Memoirs of Dr Joseph Priestley to the year 1795,*

written by himself: with a continuation, to the time of his decease, by his son Joseph Priestley; and observations on his writings by Thomas Cooper, President Judge of the 4th District of Pennsylvania; and the Rev. William Christie, London, J. Johnson, 2 vols., 1806-1807. See also A. Holt, *A life of Joseph Priestley*, London, Oxford University Press, 1938, pp. 1-48; F.W. Gibbs, *Joseph Priestley: an adventurer in science and champion of truth*, Westport, Connecticut, Greenwood Press Publishers, 1970, pp. 1-25; John Towill Rutt, *Life and correspondence of Joseph Priestley*, London, R. Hunter, M. Eaton and C. Fox, 2 vols., 1831; Robert E. Schofield, *A scientific autobiography of Joseph Priestley: selected scientific correspondence edited with commentary*, Cambridge, Massachusetts, The M.I.T. Press, 1966.

28 Priestley certainly showed considerable familiarity with Scottish writers such as Baxter, Hutcheson, Kames, Hume and Smith. For his criticisms of Hume see R.H. Popkin, 'Joseph Priestley's criticisms of David Hume's philosophy', *J. Hist. Phil.*, 1977, *15*: 437-447. However in his earlier writings Priestley was by no means uncomplimentary to Hume. See, for example, his *A course of lectures on oratory and criticism*, London, J. Johnson, 1777, pp. 60-61. Unfortunately, with the destruction of almost all Priestley's commonplace books, in which he kept a record of his reading, the extent of the Scottish influence upon him must remain a conjecture based upon ambiguous textual evidence.

29 See James Gregory, 'An answer to Messrs. Crombie, Priestley and Co.', Edinburgh University Library, MS.Gen.788D, pp. 1-2.

30 For example, see Thomas Reid, 'Draft of a paper entitled 'Observation on the modern system of materialism', Aberdeen University Library, MS.3061/1/4.

31 For example, see Thomas Reid, *The works of Thomas Reid*, edited by Sir William Hamilton, Edinburgh, Maclachlan, Stewart, and Co., 1846, pp. 248-257; 433-434; 603-604; 630-632. See also J.H. Faurot, 'Reid's answer to Joseph Priestley', *J. Hist. Ideas*, 1978, *39*: 285-292.

32 See Dugald Steward, *Elements of the philosophy of the human mind*, London, Thomas Tegg, 1843, pp.39-51. The first part was originally published in 1792.

33 James Gregory, *Conspectus medicinae theoreticae: or a view of the theory of medicine*, Edinburgh, Maclachlan, Stewart, & Co., and Oliver & Boyd, 2nd ed., 1844. The original latin edition was first published in two parts in 1778 and 1782.

34 For details see my 'James Gregory (1753-1821) and Scottish scientific metaphysics 1750-1800' Edinburgh Ph.D. thesis', 1983.

35 See James Gregory, 'Essay on the difference between the relation of motive and action, and that of cause and effect, in physics: on physical and mathematical principles', in *Philosophical and literary essays*, Edinburgh, T. Cadell and W. Creech, 2 vols., 1792, pp. 1-465.

36 See James Hutton *An investigation of the principles of knowledge, and the progress of reason, from sense to science and philosophy*, Edinburgh, A. Strahan and T. Cadell, 3 vols., 1794, especially vol. 3, pp. 212-245; John Allen, *Illustrations of Mr. Hume's essay concerning liberty and necessity in answer to Dr. Gregory in Edinburgh, by a necessitarian*, London, J. Johnson, 1795.

37 John Robison, *Proofs of a conspiracy against all the religions and governments of Europe carried on in the secret meetings of free masons, illuminati and reading societies*, Edinburgh, William Creech, T. Cadell junior, and W. Davies,1797, pp. 481-486. See also J.B. Morrell, 'Professors Robison and Playfair and the 'theophobia gallica': natural philosophy, religion and politics in Edinburgh 1789-1815', *Notes Rec. R. Soc. Lond.*, 1971, *26*: 43-63.

38 John Robison is currently under-researched. However, the best introduction to his writings in natural philosophy can be found in Crosbie Smith, 'Mechanical philosophy and the emergency of physics in Britain, 1800-1850', *Ann. Sci.*, 1976, *33*: 3-29. For details on Robison's life see John Playfair, 'Biographical account of the late John Robison Ll.D. F.R.S.E., *Trans. R. Soc. Edinb.*, 1815, *7*: 495-540.

39 See Robison's article 'Boscovich' in George Gleig, editor, *Supplement to the third edition of the Encyclopaedia Britannica*, Edinburgh, Thomson Bonar and John Brown, 2 vols., 1801, vol.1, pp.96-110; also the article 'Impulsion', ibid., pp.782-810, in which Robison reported a series of experiments he carried out with Reid. These investigated optical phenomena produced by the compression of two lenses together in a variety of circumstances (on pp.802-803). From the apparent difficulty of producing contact between the surfaces, Robison argued in support of Boscovich's critique of contact action. This is not to say, however, that Robison or Reid endorsed all aspects of Boscovich's theory.

40 I have referred to this group as 'Reid's circle', rather than common sense philosophers for two specific reasons. First, the term 'common sense' is frequently used as a synonym for eighteenth century Scottish philosophy as a whole, including Hume; whereas I wish to emphasise the way Reid's circle perceived themselves as opposing crucial aspects of Hume's views. Second, these men were definitely part of a circle who shared a common core of ideas. This is evident from biographical information and from textual evidence. This does not mean to say they spoke with a unanimous voice and it is very difficult to speak at all of a tradition of thought among highly individualist eighteenth century Scottish scientific metaphysicians. Differences of emphasis can be found between Gregory and Robison, on the one hand, and Reid and Robison on the other. Nevertheless, these differences are overshadowed by the united front they maintained against Priestley, Hume and other forms of Scottish necessitarianism.

41 See Reid, op. cit., note 30 above for an account of Reid's 'Newtonian' methodology and his critique of Priestley's particular use of the rules of philosophising. See also L.L. Landon, 'Thomas Reid and the Newtonian turn of British methodological thought', in Robert E. Butts and John W. Davis (eds.), *The methodological heritage of Newton*, Oxford, Basil Blackwood, 1970, pp.103-131.

42 See David Hume, *A treatise of human nature*, 2nd ed., edited by P.H. Nidditch, Oxford, University Press, 1978, Book 1, part 3, 'Of knowledge and probability', pp.69-179; and *An enquiry concerning human understanding*, 3rd ed., edited by P.H. Nidditch, Oxford, University Press, 1975, pp.60-108.

43 See especially ibid., *Treatise*, 'Rules by which to judge of causes and effects', 173-176; and *Enquiry*, p.36.

44 See, for example, James Burnett, Lord Monboddo, *Ancient metaphysics or the science of universals*, Edinburgh and London, T. Cadell and J. Balfour and Co., 6 vols., 1779-1799, especially the appendix to vol. 1, p.497-555. Despite Monboddo's own opposition to both Priestley and Hume, he considered that the metaphysics developed by Reid and other self-professed "Newtonians" was equally dangerous to "sound theism".

45 See Hume, op. cit., note 41 above, *Treatise*, 'Introduction, p.xv.

46 Reid, op. cit., note 31 above, 'Account of Aristotle's logic', p.713.

47 Priestley, op. cit., note 28 above, pp.3-4.

Priestley Displayed

R. G. W. ANDERSON

Few men of science have been commemorated as often as Joseph Priestley. As the focus of exhibitions, Priestley may well lead the field. Thus the exhibition mounted in 1983 for the Royal Society (and later shown at the Wellcome Institute for the History of Medicine) follows a tradition of iconolatry.[1] It is undeniable that Priestley is highly displayable: his bibliography includes 563 publications (books and journal articles);[2] there are substantial manuscript holdings in Great Britain and the United States;[3] Priestley was frequently depicted;[4] and, despite the destruction of his laboratory in 1791,[5] a reasonable quantity of scientific apparatus of acceptably certain provenance remains (see below). Even personalia seems rather plentiful.

Priestley apparatus survives in both Great Britain and the United States. The first steps which led to the preservation of some of the material were taken in 1811, when Thomas Cooper (1759-1839), who had emigrated to America with Priestley's sons in 1794, arranged for the purchase of certain items by Dickinson College, Carlisle, Pennsylvania.[6] Specifically mentioned in the minutes of the Board of Trustees of the College on 17 December 1811 are a reflecting telescope, a (burning) lens and an air gun, purchased from the Apparatus Fund for a total of $530. A letter of 25 December 1811 from Joseph Priestley Jnr to Cooper may be taken to indicate that other apparatus was also transferred, including an orrery. A member of the Dickinson College faculty, Charles F Himes, though he did not arrive at the College (as a student) until 1851, further specified that a refracting telescope by John Dollond and glassware (flasks with ground necks into which fitted curved glass tubes) had belonged to Joseph Priestley. The double burning lens (almost certainly made by Samuel Parker of Fleet Street, London), the Gregorian reflecting telescope signed *W. & S. Jones, 135 Holborn, London*, the air gun, the reflecting telescope and glassware are still in the possession of Dickinson College.

Shortly after the death of Priestley's grandson, also called Joseph Priestley (?-1883), the Secretary of the Smithsonian Institution, Spencer F. Baird (1823-1887) wrote to his widow asking if she would be prepared to deposit Priestley's apparatus, which had passed to her through the family, in the U.S. National Museum in Washington D.C. Her daughter, Frances D. Priestley, replied on her behalf agreeing to donate the material, mentioning at the same time that other items were scattered among various descendents.[7] This gift was accessioned as "Large collection of philosophical apparatus, belonging to the late Dr. Jos. Priestley".[8] The items are currently displayed in the National Museum of American History, Washington D.C., and consist of an electrical machine with accessories, an orrery and glassware. An additional Priestley item was donated by H.C. Bolton:[9] one of his walking canes. Special exhibitions were held in 1983 at Priestley's house at Northumberland, Pennsylvania, and at the Center for History of Chemistry, University of Pennsylvania, Philadelphia, to celebrate the 250th anniversary of Priestley's birth. The Center was instituted by the American Chemical Society, which traces its origins to a meeting at Priestley's Northumberland House in 1874; thus connections are nicely interwoven.

In Great Britain, Priestley artefacts do not have a pedigree as well established as those which survive in America, although, most impressively, Priestley's microscope is preserved, with its bill made out to Joseph Priestley by Benjamin Martin himself (see item 20 below). A globe electrical machine (no. 18) and an air pump (no. 31) have somewhat less satisfactory connections with Priestley. Perhaps less would be expected to survive in Great Britain: the annihilation of the laboratory in Birmingham occurred on 14 July 1791.[10] However, Priestley started to rebuild his facilities for experimentation and demonstration. On 10 January 1792 he appealed pathetically to Sir Joseph Banks "I shall be obliged to you if you will mention my situation to any of your friends whose laboratories are furnished, and who may have any thing to spare to set up a broken philosopher"[11], but by 2 June of the same year in a letter to Lavoisier the tone is more optimistic "I am now refitting my apparatus and about to resume

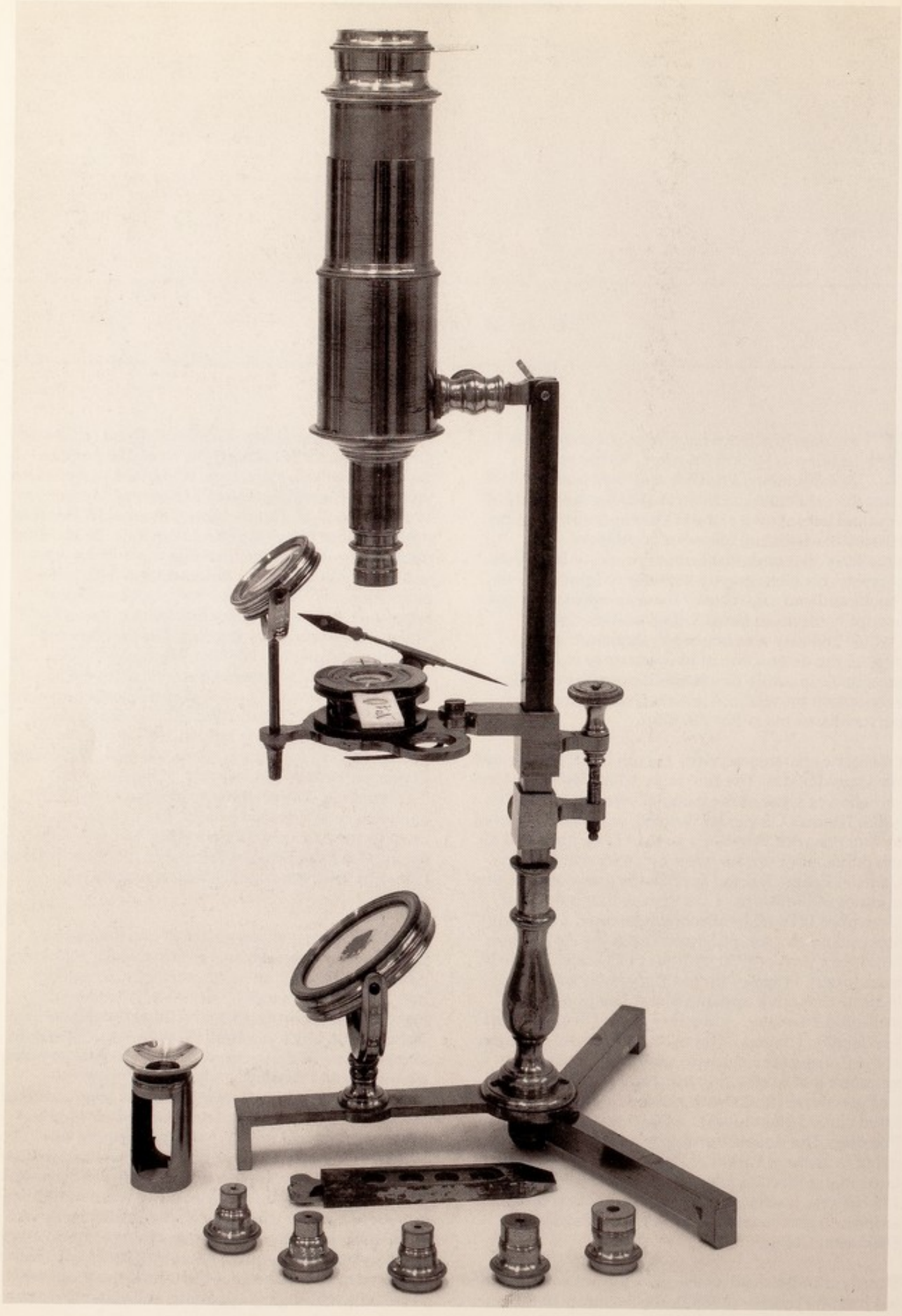


Fig 18 Priestley's microscope, supplied by Benjamin Martin in 1767.
Catalogue 20 (see page 101)

my usual pursuits."[12] It would seem certain that Priestley's Hackney laboratory fittings accompanied him to America when he sailed in 1794.[13] Priestley intended to set up a laboratory in his new surroundings (which he in fact did, see Catalogue item 44) and it would seem unlikely that he would leave behind any items which he had so laboriously worked to replace, and which would be more difficult to acquire when so far away from the centres of the instrument making trade, London and Paris.

Possibly the first exhibition to celebrate Priestley was that held at a soiree of the Royal Society at Burlington House on 3 March 1860. The antiquary James Yates F.R.S. (1789-1871), a Unitarian, had been assiduously collecting material which would help promote a fervent cause of his: the erection of a statue of Priestley at the newly constructed University Museum at Oxford. A scrapbook (a rather superior one, now in the Library of the Royal Society, see Catalogue item 44) was compiled by Yates which contained images of Priestley to guide the sculptor (E.B. Stephens of Pimlico). It is known that at this soiree, the 'Leeds portrait' (Catalogue item 1) was displayed.

Three portraits in oils, though not the Leeds portrait, were displayed at an exhibition held in Birmingham Town Hall from 30 November to 3 December 1904 as part of the celebrations marking the centenary of Priestley's death.[14] A total of 83 items were exhibited though these included six items for sale, including a large version of the Wedgwood medallion. It is interesting that the objects were gathered from as many as 22 sources. (The existence of several printed catalogues of Priestley relics allows changes of ownership to be easily traced and indicates the tendency of memorabilia to accumulate in fewer, and more public, hands.) The exhibits in this, and subsequent exhibitions, can be generally categorised under the headings: images of Priestley, illustrations of houses and chapels associated with him, books and pamphlets, manuscript letters, medals and tokens, objects with religious connections, caricatures, apparatus, and personalia.

Twenty eight years later a further exhibition to commemorate Priestley took place in Birmingham at the Art Gallery. The occasion was the meeting of the General Assembly of Unitarian and Free Christian Churches, in April 1932.[15] The organiser was the Reverend Hugh Warnock, helped by the City Librarian, and Curator. Perhaps surprisingly, this exhibition did not particularly concentrate on Priestley's large published theological output.

The next major exhibition featuring Priestley was again held at Birmingham, from 13 October to 27 November 1966, but this time as a part of a celebration to commemorate the bicentenary of the formation of the Lunar Society. Priestley, being one of its most prominent members was well represented. His microscope (Catalogue item 20), electrical machine (item 18) and his terrestial and celestial globes (from Manchester College, Oxford) were displayed.[16]

The bicentenary of the discovery of oxygen was celebrated in Leeds City Museums from 11 September to 26 October 1974 by an exhibition devoted entirely to Priestley and his work.[17] The exhibition included interesting items from three religious institutions, two of which were chapels where Priestley was Minister: the chapel (now the United Reform Church) at Needham Market, Suffolk; Mill Hill Chapel, Leeds; and Manchester College, Oxford (which traces it origins to a Unitarian society established in Manchester in 1786). The same anniversary was celebrated by the Science Museum, London, by a large exhibition, 'The Breath of Life'.[18] Curated by the Keeper of the Chemistry Department, Frank Greenaway, the exhibition dealt only in part with Priestley's work and the theme was extended and broadened to include substantial sections on anaesthetic gases, brought up to date.

The British Oxygen Company, through its Gases Division Trust, adopted the 200th anniversary of the discovery of oxygen by Priestley to establish a series of conferences sponsored for the Chemical Society. The second of these was held in Birmingham in 1980, where once again a major exhibition, 'Joseph Priestley in Birmingham', was held. Possibly this is the most scholarly Priestley exhibition to have been assembled and a useful catalogue was published.[19] Brief but interesting references are made here to "Visual evidence of Dr. Priestley in Birmingham". On similar lines, but in greater depth, an article published three years later alludes to "Visual evidence of Dr. Priestley in London".[20]

Perhaps it was inevitable with this widespread prior interest in Priestley that the 250th anniversary of his birth, in 1983, should prove to be a bumper year for exhibitions. In England, Manchester College, Oxford, mounted the first in the Bodleian Library.[21] All except one of its 43 items were from its own sources. Two of the manuscripts were of sermons written out in shorthand and one was of a hymn 'To God supreme and ever kind' which contains the lines "To you the book of Science fair Does all its riches spread". The other British exhibition was that mounted by R.G.W. Anderson and Ann K. Newmark (then both of the Science Museum, London) at the Royal Society and the Wellcome Institute for the History of Medicine. The Catalogue of that exhibition follows this introduction.

As briefly mentioned before, in the United States, the Pennsylvania Historical and Museum Commission sponsored an exhibition 'Joseph Priestley's 250th Birthday: his Gifts for all Ages' at Priestley's own house at Northumberland. This was held from 24 March to 11 December and focussed on Priestley's last ten years of life. Simultaneously in Philadelphia 'Joseph Priestley Enlightened Chemist' could be viewed. The catalogue claims that "This exhibit ... contains the most varied assembly of Priestley artifacts ever gathered in one place."[22] That is perhaps a claim difficult to quantify and thus prove or disprove, but certainly the aim of the organisers was to provide a broader setting for Priestley than had previously been attempted. It included a splendid series of caricatures, Priestley's Latin bible (lent by the Library Company of Philadelphia) and his air pump by Adams from the Franklin Insitute.

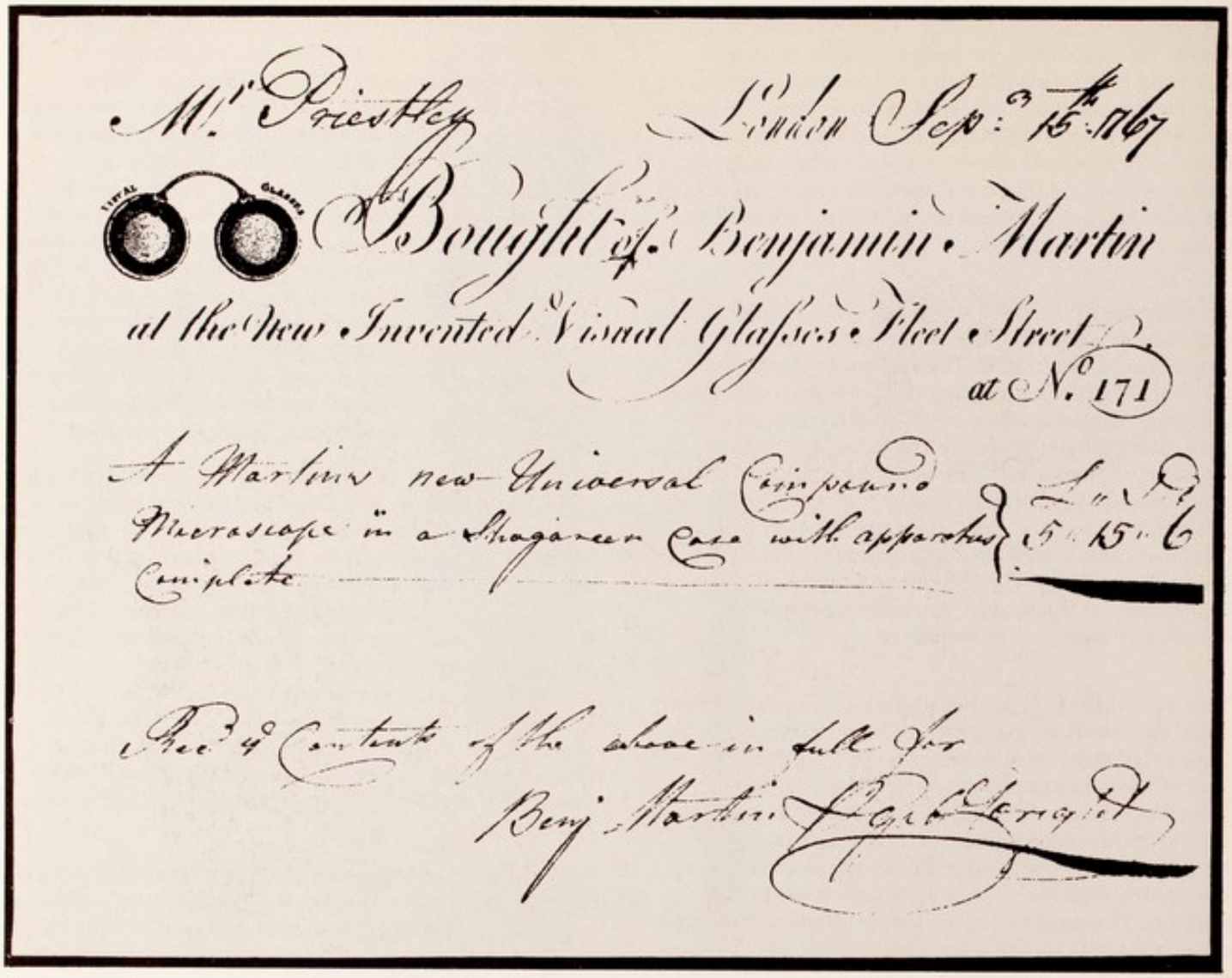


Fig 19 Receipt to Priestley for supply of a microscope and accessories, dated London, 15 September 1767.
Catalogue 20 (see page 101)

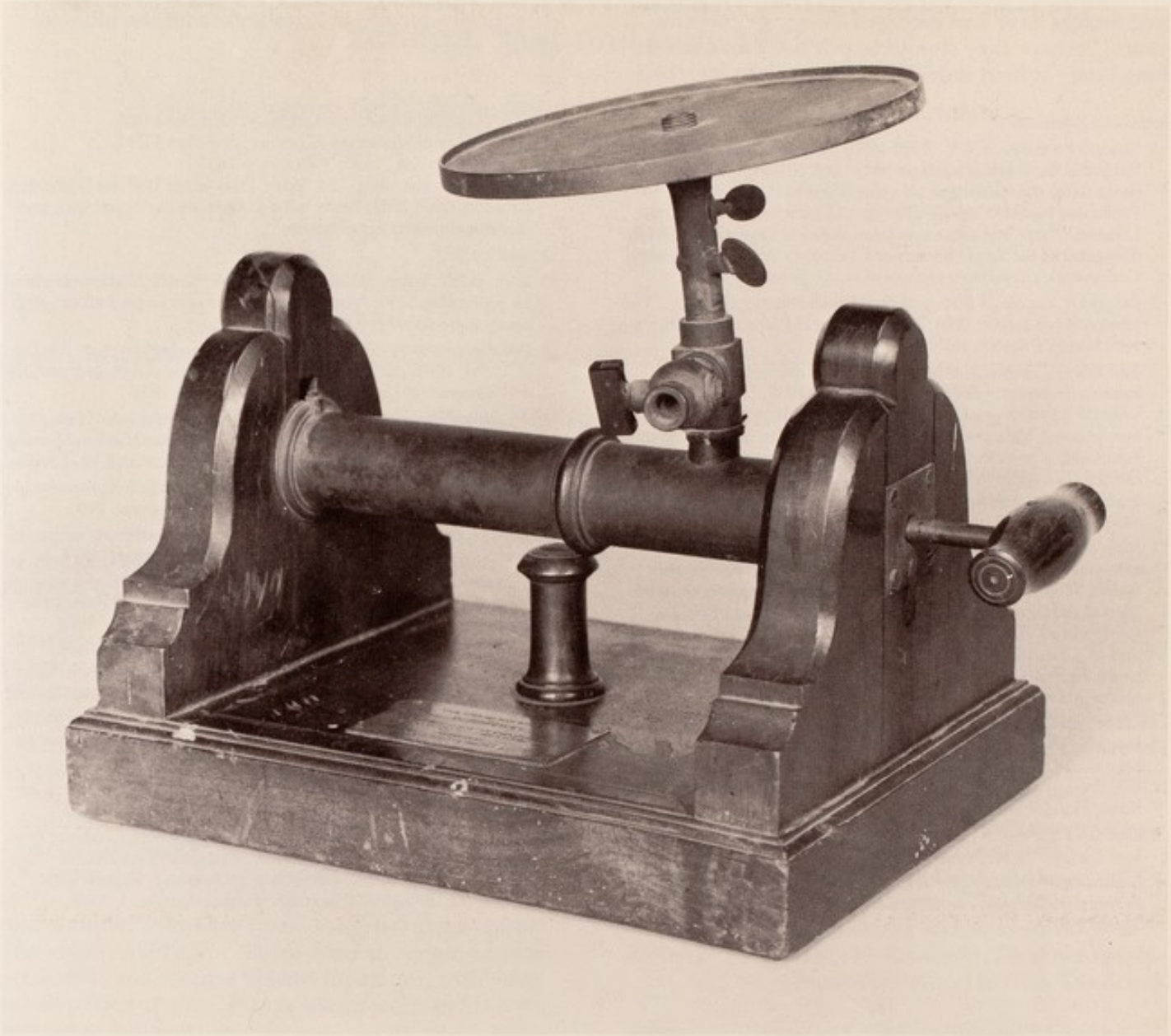


Fig 20 Priestley's air pump, probably constructed in Birmingham by Samuel Harrison, 1780-1791.
Catalogue 31 (see page 103)

It would really seem that Priestley relics, publications and images have had excellent showings over the years. Perhaps they should be put away for a good long time - at least until 2004. There might then be a strong argument, however, to bring together the Atlantically-separated Priestleyana for the ultimate show.

Notes and References

1 'Joseph Priestley, F.R.S. (1733-1804)' was the 1983 Review Exhibit at the Royal Society on 5 May and 23 June 1983. Between these dates the exhibition was displayed in the Library of the Wellcome Institute for the History of Medicine, Euston Road, London. There was also a special showing in September 1983 for delegates of the Royal Society of Chemistry 3rd BOC Priestley Conference attending a reception at the Royal Society.

2 Ronald E. Crook, *A Bibliography of Joseph Priestley*, London, The Library Association, 1966. The author has identified 230 libraries which hold Priestley publications.

3 The Royal Commission on Historical Manuscripts, *The manuscript papers of British Scientists 1600-1940*, London, Her Majesty's Stationery Office, 1982, pp. 71-72, indicates the location of some 550 items, though most locations cited in Robert E. Schofield, *A scientific autobiography of Joseph Priestley (1733-1804): selected scientific correspondence edited with commentary*, Cambridge, Mass., and London, M.I.T. Press, 1966, pp. ix-x and 333-345 are additional to these.

4 John McLachlan, *Joseph Priestley man of science 1733-1804: an iconography of a great Yorkshireman*, Braunton, Devon, Merlin Books, 1983, records 56 images of Priestley in a variety of media. Two of the portraits displayed in the Royal Society Review Exhibit in 1983 are not listed by McLachlan (Catalogue items 3 and 4). Caricatures in which Priestley is depicted are dealt with by M. Fitzpatrick, 'Priestley in Caricature', *Oxygen and the conversion of future feedstocks*, Proceedings of the Third BOC Conference, London, Royal Society of Chemistry, 1984, pp. 347-369.

5 Douglas McKie, 'Priestley's laboratory and library and other of his effects', *Notes and Records of the Royal Society*, 1956, *12*: 114-136, lists the apparatus in Priestley's Birmingham Laboratory at the time of its destruction.

6 Charles F Himes, *A catalog of Priestley apparatus at Dickinson College, Carlisle, Pennsylvania*, [Carlisle, n.d.]

7 Smithsonian Institution Archives, letter dated 27 April 1883 from Frances D. Priestley, Northumberland, Pennsylvania, to Spencer Baird.

8 U.S. National Museums Accession Number 13305.

9 U.S. National Museums Accession Number 33141.

10 Schofield op. cit., (note 3 above), p.263.

11 Ibid., p.262; see also p.265, letter, Priestley to William Withering, dated 15 April 1793: "after having replaced my apparatus, and recommenced by experiments ..."

12 Ibid., p.263.

13 Ibid., p.281, letter, Priestley to Benjamin Rush, Northumberland 14 September 1794: "Again my apparatus is so packed up, and ready to be conveyed hither."

14 *Priestley centenary celebration, Town Hall Birmingham, Nov. 30, Dec. 1, 2, & 3, 1904. Art exhibition. (Catalogue of the collection of pictures and memorials of Dr. Priestley)*, Birmingham, 1904.

15 A listing of the exhibits was published as 'Exhibition of Priestley Relics in the Art Gallery, Birmingham' *Unitarian Historical Society Transactions*, 1931-34, *5*: 220-222; the compiler was F.W. Lloyd.

16 Birmingham Museum and Art Gallery, *An exhibition to commemorate the bicentenary of the Lunar Society*, Birmingham, 1966.

17 Leeds City Museums, *The bicentenary of the discovery of oxygen by Joseph Priestley*, Leeds Leisure Services Department, 1974.

18 Science Museum, *The Breath of Life, an exhibition showing some of the medical consequences of the discovery of oxygen*, London, 1974; Idem., *Handlist of objects in special exhibition*, London, 1974.

19 Jennifer Tann, Stephen Price and Dorothy McCulla, *Joseph Priestley in Birmingham*, Birmingham, University of Aston, City of Birmingham Museums and Art Gallery and Birmingham Central Library, 1980.

20 William P. Griffith, 'Priestley in London', *Notes and Records of the Royal Society*, 1983, *38*: 1-16.

21 Barbara Smith and Michael Hill, *Joseph Priestley 1733-1804. Scientist, teacher, theologian*, Oxford, Manchester College, 1983.

22 David J Rhees, *Joseph Priestley Enlightened Chemist. Catalogue to an exhibit celebrating the 250th Birthday of Joseph Priestley and the inauguration of the Center for the History of Chemistry*, Philadelphia, Center for History of Chemistry Publication No. 1, 1983.

Catalogue of the Priestley Review Exhibit at the Royal Society, London, May and June 1983

Also displayed at the Wellcome Institute for the History of Medicine, London

COMPILED BY R. G. W. ANDERSON AND ANN K. NEWMARK

The objects displayed are listed below in ten small groups as follows:

Iconography	1-5
Personalia	6-9
Educational Matters	10-13
Religion	14-16
Electricity	17-19
Optics	20-22
Pneumatics	23-32
The Continent	33-36
The Lunar Society	37-40
America	41-44

Some standard reference works are given in the entries in an abbreviated form. These refer to certain objects specifically, and are given below their titles, with reference to page numbers, except where indicated below. They are as follows:

Bell R.C. Bell, *Commercial coins 1787-1804*, Newcastle upon Tyne, Corbitt and Hunter, 1963.

Crook Ronald E. Crook, *A bibliography of Joseph Priestley*, London, Library Association, 1966 (number refers to publication reference scheme)

Hawkins Edward Hawkins, A.W. Franks and H.A. Grueber *Medallic illustrations of the history of Great Britain and Ireland*, London, British Museum, 1885.

McClachan John McClachlan, *Joseph Priestley man of science 1733-1804: an iconography of a great Yorkshireman*, Braunton, Devon, Merlin Books, 1983. (number refers to page number followed by a serial number of portrait in a specific medium)

Reilly Robin Reilly and George Savage, *Wedgwood: the portrait medallions*, London, Barrie and Jenkins, 1973.

Robinson Norman H. Robinson, *The Royal Society catalogue of portraits*, London, The Royal Society, 1980.

Sellers Charles C. Sellers, *Benjamin Franklin in portraiture*, New Haven and London, Yale University Press, 1962

Schofield Robert E. Schofield, *A Scientific autobiography of Joseph Priestley (1733-1804)*, Cambridge Massachusetts and London, M.I.T. Press, 1966.

ICONOGRAPHY

1 Portrait of Joseph Priestley
(*McLachlan* 17/1; *Robinson* 244)
Oil on canvas
Artist unknown, ca. 1763

This is the earliest known portrait of Priestley and has been frequently referred to as the "Leeds portrait".[1] It was probably painted during his period at Warrington. There have been two suggestions as who the artist might have been. Benjamin Wilson F.R.S. (1721-1788) is one possibility, being both one of the best known portraitists of his time as well as the author of a treatise on electricity. The other is a member of the Rhodes family who painted portraits in the Leeds and Sheffield area.

At an early date the painting was in the possession of Priestley's widowed sister, Martha Crouch. She took it with her to Park House, Gildersome near Leeds in 1787 when she moved to keep house for her relative William Hudson. After her death in 1812 Hudson invited Ellen Bilbrough (née Priestley) and her husband to live with him. She died in 1865 and her two unmarried daughters went to live in Bury, taking the portrait with them.

In 1860 James Yates, F.R.S., who was a distant relation to Priestley, borrowed the portrait to enable the sculptor, E.B. Stephens, to carve a likeness of him for the Oxford University Museum. While the portrait was in Yates' hands, it was exhibited at a Royal Society soirée held at Burlington House on 3 March 1860 by Sir Benjamin Brodie P.R.S.

The portrait was presented to the Royal Society in 1960 by C.W. Knott.

The Royal Society

1 W. Cameron Walker, 'The Leeds Portrait of Joseph Priestley', *Nature* 1933, *131*: 876; Douglas McKie and W. Cameron Walker 'Earliest Portrait of Joseph Priestley', *Science Progress*, 1934, *28*: 456-60.

2 Portrait of Joseph Priestley [Fig. 3]
(*McLachlan* 46/3; *Reilly* 283)
Jasperware, white on blue ground
Impressed 'Priestley' and 'WEDGWOOD'
Attributed to William Hackwood, ca. 1779

Josiah Wedgwood (1730-1795), the manufacturer of ceramics, attended many of the Lunar Society's meetings and was a close friend of Priestley. He assisted Priestley both financially and by supplying him with ceramic apparatus for his researches free of charge. Wedgwood's interest in science arose primarily from the needs of his pottery business and he was elected to the Fellowship of the Royal Society in 1783 as a result of his researches into the field of pyrometry.

Wedgwood developed the Jasperware which he used for most of his medallions in the early 1770s. This medallion is thought to be modelled by William Hackwood, a craftsman who worked for Wedgwood from 1769 to 1832. A slightly earlier Wedgwood medallion was modelled by Giuseppe Ceracchi (1751-1801), also in 1779.

Science Museum (1983-88)

3 Portrait of Joseph Priestley [Fig. 15]
Modelled in wax, in glazed oval frame
Signed 'S. Percy 1788'

Samuel Percy was born in Dublin in 1750. He came to London about 1777 where he died in 1820.[1] He modelled a large number of portraits in polychrome wax including those of several members of the family of King George III.

Science Museum (1954-335)

1 For details of Percy and his works, see E.J. Pyke, *A biographical dictionary of wax modellers*, Oxford, Clarendon press, 1973, pp.103-5, and *Supplement*, London, E.J. Pyke, 1981, pp. 31, 32.

4 Portrait of Joseph Priestley (?)
Wooden medallion
Attributed to James Watt, dated 1809

James Watt (1736-1819) moved to Birmingham in 1774 where he was in partnership with Matthew Boulton. He had already patented his condensing steam engine in 1769 but made many improvements to it and to other machines of his invention.

As a member of the Lunar Society he was in close contact with Priestley who may have been instrumental in turning Watt's attention to problems of chemical composition. Certainly they corresponded at length on the effects of heat on water and on the composition of water.

This bust, which was catalogued as being of Priestley only in 1926, is dated 'Spring 1809' on the reverse in Watt's handwriting. Watt would have made it from a large plaster medallion on his reducing copying machine which is now in the Science Musuem. There are a large number of such portraits in the collection, presented to the Science Museum by Major J.M. Gibson-Watt. The bust has not previously been exhibited.

Science Museum (1926-1075/133)

5 Statue of Joseph Priestley
(*McLachlan* 58/2)
Painted plaster on wood
After the original marble statue by Francis John Williamson.

On 1 August 1874 a marble statue of Priestley was unveiled in Victoria Square, Birmingham to mark the centenary of the discovery of oxygen; the ceremony was performed by Professor T.H. Huxley. This is a small scale copy of that statue. Priestley is shown symbolically discovering oxygen with a burning glass (of "aesthetic proportions" rather than of realistic size) in his right hand. *The Birmingham Morning News*, in a poetic comment on the unveiling, published verses which began:

> "Seer of the late won renown,
> Lo! we have crown'd thee;
> Stand with the heart of the town
> Throbbing around thee;
> Stand 'mid the fashion and pride,
> Traffic and barter,
> God-lit apostle and guide,
> Champion, martyr."[1]

The statue was moved to Chamberlain Square in 1913, was cast in bronze in 1951, was removed and later restored to Chamberlain Square in 1980 after storage during reconstruction of the Birmingham Central Library.

This statuette was presented to the Royal Institute of Chemistry by Mrs Bedford McNeill in 1920. Until its amalgamation with the Chemical Society in 1980, this representation of Priestley appeared on the Institute's coat-of-arms; it is now incorporated in the badge of office of the Royal Society of Chemistry.

Royal Society of Chemistry

PERSONALIA

6 Priestley's spectacles and case

An attached silver plaque is engraved 'DR. PRIESTLEY, BORN 1733 DIED 1804'. These form part of a bequest to the Royal Society made in 1957 by William C. Priestley. Another pair of spectacles said to be Priestley's are preserved at Manchester College, Oxford.[1]

Royal Society

1 Barbara Smith and Michael Hill, *Joseph Priestley....scientist teacher and theologian*, Oxford, Manchester College, 1983, item 43.

7 Letter to William Turner at Wakefield, dated 10 July 1773.

Written just after he moved to Calne in Wiltshire to act as Librarian to Lord Shelburne, Priestley expresses his regrets at leaving Leeds and his friends there. At the time of writing he and his wife had not properly settled into their new house which required much to be done to make it comfortable. However he claims that 'everything at Calne wears a favourable aspect'. He bemoans the fact that his books have not yet arrived since he 'cannot be said to be settled till I have got them unpacked and am got to work at my experiments or something else'.

While waiting to resume his researches (at that time he was studying gases) he turned his attention to politics, reporting to Turner that he had written a pamphlet on the Dissenters' Bill.

Royal Society (MS 655.1)

8 Copley Medal of the Royal Society
(*Hawkins* ii 522,23)
Awarded to Joseph Priestley, 1773
Gold, designed by John Sigismund Tanner
Inscribed obverse: 'G. COPLEY, BART. DIGNISSIMO'
Inscribed reverse: 'SOCIETAS REG. LONDONI' and 'NULLIUS IN VERBA'

In 1709 Sir Geoffrey Copley provided a legacy which allowed a sum of money to be provided annually for an experiment demonstrated before the Royal Society. Council resolved in 1736 to convert this to a medal to be awarded for "the best Experiment produced within the Yr".

In 1767 Priestley was considered for the award on the basis of his recently published *History of electricity*.[1] Some opposed this on the grounds that the spirit in which Copley's legacy had been offered was not fulfilled by the book. However in November 1773 when the award for the previous year was being considered, Council voted unanimously "that the medal for the said year be given to the Revd. Joseph Priestley L.L.D. for his various Philosophical publications; and particularly for his disquisition concerning the different kinds of Air."

Royal Society

1 Douglas McKie, 'Joseph Priestley and the Copley Medal', *Ambix*, 1961, 9: 1-22.

9 An Appeal to the Public on Riots in Birmingham (1792)
(*Crook* PS/284)
Printed handbill

The handbill consists of two letters, on one side an open letter written by Joseph Priestley 'To the Inhabitants of the Town of Birmingham' from London, dated 19 July, and on the other a reprint of a letter sent to the editor of the Morning Chronicle by William Russell, dated 20 July. Russell was a metal merchant, a prominent Birmingham citizen and a close friend of Priestley.

The riot of 14 July was stimulated by a dinner attended by eighty one diners to celebrate the anniversary of the French Revolution. Seditious handbills were distributed beforehand by 'loyalists' opposed to republicanism and feelings mounted. Priestley decided not to attend the dinner. After the diners had dispersed, the windows of the Hotel in Temple Row were smashed and the mob moved on to Priestley's chapel, the New Meeting, and burned it down. The Priestleys, realising the danger, hurried to Russell's house. The mob eventually reached Fair Hill, Priestley's house, destroyed what they could, drank the contents of the cellar, and set fire to the building. Priestley escaped to Kidderminster.

Russell's letter was prompted by a false account in the Times which claimed that Priestley was present at the dinner and had proposed the first toast 'The King's head on a charger'. In his open letter, Priestley wrote:

> "You have destroyed the most truly valuable and useful apparatus of philosophical instruments that perhaps any individual, in this or any other country was ever possessed of ... But what I feel far more, you have destroyed manuscripts, which have been the result of the laborious study of many years, and which I shall never be able to recompose."

Wellcome Institute

EDUCATIONAL INTERESTS

10 A Chart of Biography
(*Crook* H/371)
Dated 1765

Priestley's Chart of Biography was devised as a teaching aid. It includes bars indicating the dates of historical figures in six categories: historians, antiquaries and lawyers; orators and critics; artists and poets; mathematicians and physicians, divines and metaphysicians; and statesmen and warriors. Though dated 2 February 1765, Priestley is described as a F.R.S., and so the chart must date from after 12 June 1766. This example was presented to the South Kensington Educational Museum by the Marquis of Kildare in 1881.

Priestley started work on the Chart when he was minister at Nantwich, though it was not ready for publication until 1764 when he was teaching at Warrington Academy. It was dedicated to the Academy's President, Lord Willoughby of Parnham. It met with immediate success, went through many editions, and was still in print in the 1820s. A descriptive book was published to be used in conjunction with the Chart.

Realising the didactic value of the Chart, Priestley's friends tried to secure him an honorary degree on the basis of it. A recommendation signed by Lord Willoughby and Samuel Chandler F.R.S. (an influential Dissenter) was sent to the University of Edinburgh. The degree of Doctor of Laws was conferred on Priestley on 4 December 1764, [Fig.17].

Science Museum Library

11 A Course of Lectures on Oratory and Criticism
(*Crook* EP/330)
Dated 1777, published in London

The Preface of this work explains:

> This course of Lectures was composed when I was Tutor in Languages and Belles Lettres in the Academy at Warrington, and was first delivered in the year 1762.

The lectures bridge Priestley's interest in education and his philosophical interest in psychology. They are dedicated to Viscount Fitzmaurice, the son of his patron the Earl of Shelburne, in whose employment Priestley was when the work was prepared for publication. Later editions were published

in Dublin (1781), London (1833) and a German translation (Leipzig 1779).
Royal Society

12 The Proper Objects of Education
(*Crook* EP/342)
Dated 1791, published in London

On 27 April 1791, Priestley delivered a discourse at New College, Hackney, considered to be a hot-bed of sedition by the establishment. In a fiery address, Priestley suggested that mankind was beginning to understand the meaning of the civil rights of men and the real purpose of civil government. In addition, the world needed to be rechristianized. The two main forces of the day were a spurious Christianity on the one hand, and infidelity on the other: modern reformers were in a similar position to that of the apostles.

Referring to the potential for education at New College, Priestley said:

> "Small, however, as is the field to which your labours are confined, yet, by assiduous culture, you may raise in it noble plants, which will amply reward your labour and expense. One cedar is of much more value than many inferior trees; and shall the new college but produce in philosophy one such man as Bacon or Newton, in morals a Locke or a Hartley ..."

A second edition of this work was published in London, also in 1791.
Wellcome Institute

13 Heads of Lectures on a Course of Experimental Philosophy
(*Crook* S/477)
Dated 1794, published in London

After the riots had forced Priestley to leave Birmingham, he settled in Hackney in September 1791, preaching at the dissenting chapel and lecturing on science and history at New College. Although he re-established his library and laboratory, and received £3,098 0s 6d in compensation, he was uneasy and eventually decided to follow his sons who had emigrated to America.

This book is the last to be published by Priestley in Britain. It is an outline of his Hackney course, and, dedicated to his students there, gives parting advice on the best way to conduct themselves in those times of stress and danger. An edition of this work was published in Dublin, also in 1794.
Royal Society

RELIGION

14 Letter to Radcliffe Scholefield dated 14 September 1779 [Fig. 10]
(*Schofield* 84)

Written from Calne this letter relates the latest of Priestley's researches on the production of oxygen by vegetable matter. He says

> "I have many experiments to make in the prosecution of this business, but I think they fully establish, extend, and explain what I first discovered of the purification of the atmosphere by vegetation."

The letter is addressed to the Reverend Radcliffe Scholefield, a dissenting clergyman in Birmingham. He and Priestley had been fellow students at the Daventry Academy. Scholefield was minister at the Old Meeting House when Priestley moved to Birmingham in 1780 and he was a member of a theological discussion group organised by Priestley that met fortnightly in Birmingham. He died in 1803.
Science Museum (1954-347)

15 Disquisitions relating to Matter and Spirit
(*Crook* PM/358)
Second edition, 1782, published in Birmingham

This work was originally published in 1777 when Priestley was working for Lord Shelburne. It contains the clearest statement of his scientific materialism in relation to his views on revelation, and forms the basis for subsequent theological deliberations. Priestley discusses the relation of matter to spirit, stating that it was "both absurd and modern" to maintain that "two substances that have no common property" are "yet capable of intimate connection and mutual action." He conjectures that man's seat of thought, his faculty of thinking, is a property inherent in the substance of his nervous system or his brain.

What Priestley had to say about the relation of matter to spirit in his Disquisitions was illuminating though controversial and, to some, heretical. Priestley claimed his argument to be biblically sound.
Wellcome Institute

16 Medal commemorating Priestley [Fig. 13]
(*McLachlan* 53/5)
Bronze 1804
Inscribed obverse 'JOSEPHUS PRIESTLEY. LLD. F.R.S....' and 'HALLIDAY F.'

Having left Wiltshire and Lord Shelburne, Priestley moved to Fair Hill in Birmingham in 1780. Shortly after he settled there he became minister at the dissenting chapel known as the New Meeting. In Birmingham he enjoyed the friendship of his fellow members of the Lunar Society and also had a large laboratory and valuable collection of philosophical instruments. He wrote that his time in Birmingham was the happiest in his life.

The reverse of the medal contains a description of his merits and a brief summary of events in his life as inscribed on the memorial tablet erected in the New Meeting. The medallist, Thomas Halliday (born c. 1789), worked in Newhall Street, Birmingham.
Science Museum (1973-416/61)

ELECTRICITY

17 History and Present State of Electricity
(*Crook* S/480)
1767, published in London

Priestley's scientific work was begun as an extension of his interests in education. This work was conceived as a methodological account of previous discoveries and as an assessment of contemporary electrical studies, and was intended to encourage further work on the subject. As such it was very successful: there were five distinct English editions and a Dutch, French and German edition in Priestley's lifetime.

In his *Memoirs* of 1795, Priestley wrote of his London visit in December 1765:

> "I was in this situation [at Warrington] when, going to London and being introduced to Dr. Price, Mr. Canton, Dr. Watson (the Physician) and Dr. Franklin, I was led to attend to the subject of experimental philosophy ...
> I mentioned to Dr. Franklin an idea ... of writing the history of discoveries in Electricity ... I told him I would willingly undertake it, provided I could be furnished with the books necessary for the purpose. This he readily undertook ..."

In his reading, Priesley made a serious attempt to consult primary sources, though he strongly favoured the then popular one-fluid theory of electricity as developed and demonstrated by Benjamin Franklin. When necessary and practical, Priestley conducted experiments to verify or elucidate the work of others.

Royal Society

18. Priestley's Globe Electrical Machine [Fig. 7]

When he was at Leeds, one of Joseph Priestley's major preoccupations was to design a cheap and simple electrical machine. The manufacture of these became a family enterprise, with his brother Timothy in Manchester turning the wooden legs, supervising the locally-made brass work and assisting with the assembly. The improved machines were advertised in Priestley's *Familiar introduction to the study of electricity*, stating that they would be on sale from March 1768.

This instrument was presented to the Royal Society in the nineteenth century by Dr. John Bostock, to whom it had been bequeathed by Dr. Robert Cappe of York. Cappe's father had been a friend of Joseph Priestley. The manufacture of the (unsigned) machine has been attributed to Priestley's friend, the well-known glass-maker William Parker of 69 Fleet Street, London, though this cannot be substantiated.

Globe machines were almost totally superseded by cylinder and plate machines by the 1780s. A cyclinder machine, also said to have been Priestley's, is at the Science Museum, London (1930-698).

Science Museum (1970-23), on loan from the Royal Society

19 Thunderhouse (made by Priestley?)

The thunder house was an accessory provided with electrical machines to demonstrate the destructive force of lightning and the efficacy of lightning conductors. On receiving a discharge, the house fell into several pieces if the lightning conductor had not been earthed. The device was first described by James Ferguson F.R.S. in 1770 who wrote "This was the first contrived by Dr. James Lind of Edinburgh, for verifying Dr. Franklin's method of preserving houses by means of metal rods". The inventor may either be James Lind (1716-1794) who discovered a cure for scurvy or James Lind F.R.S. (1736-1812) who was physician to King George III.

The provenance of this thunderhouse is admittedly weak. It was owned by W. Conrad Cooke (1843-1926) who lent it to the Special Loan Collection of Scientific Apparatus, exhibited at South Kensington in 1876. It was described as "said to be the first model of the kind, and to have been made by Dr. Priestley with his own hands" but there is no evidence for this. It was sold by auction in 1926 to R.T. Gunther, who purchased it for the Museum of the History of Science in Oxford, of which he was the founder.

Museum of the History of Science, Oxford

OPTICS

20 Priestley's microscope [Figs. 18 and 19]

This microscope with accessories was purchased by Joseph Priestley on 15 September 1767 from the instrument maker Benjamin Martin (1704-1782) for the sum of £5 15s 6d. A manuscript inventory and the receipt made out to Priestley survive with the instrument. Martin was a major supplier of instruments from his arrival in London in 1756 with a shop at 173 Fleet Street. In his *New Elements of Optics* of 1759, he proposed a new design for microscope lens systems incorporating four lenses.

Priestley referred to the use of the microscope in his work on photosynthesis. He observed that air whose quality was impaired by putrefaction, breathing of animals or burning of candles was restored by green matter which grew in water. This was said to be vegetable in nature by William Bewley (1725-1783) who showed that it "came most properly under the denomination of the Conferva", Priestley himself recording:

> "My own eyes have always been weak, I have, as much as possible, avoided the use of the microscope".

Science Museum (1954-332)

21 A Familiar Introduction to the Theory and Practice of Perspective
(*Crook*, S/475)
1770, published in London

This work, written while at Leeds, is dedicated to Sir Joshua Reynolds. It developed out of Priestley's experience of having prepared the original drawings for his *History and present state of electricity*. The text is strongly didactic, being suitable for young, inexperienced students as well as for fellow scientists. A second edition was published in London in 1780.

Royal Society

22 History and Present State of Discoveries relating to Vision, Light and Colours.
(*Crook* S/479)
1772, published in London

Priestley regarded this volume as the second of his planned complete survey of science, *The history of all the branches of experimental philosophy*, but he had difficulty in raising finance for its publication, and as it turned out, no further volumes were produced in the series.

In his survey of optics, Priestley gave clear descriptions of the development of the subject, at the same time adopting a critical attitude. Thus he took pleasure in writing about Newton's discoveries, though he criticised Newton's explanation of 'Newton's Rings' and R.J. Boscovich's attempts to explain the rainbow. He gave accounts of optical instruments, including Kircher's magic lantern and Lieberkuhn's solar microscope.

Priestley was interested in anatomy, and was anxious to locate the 'proper seat of vision'. Taking advantage of his friend William Hey's position as surgeon of the Leeds Infirmary, he was present at the post mortem of a girl who had been blind in one eye, and he noted that:

> "The optic nerve belonging to it was considerably smaller than the other; and [Mr Hey] informed me that, upon cutting it, he found it to be much harder, and cinericious."

Thus he was convinced that the retina was the centre where visual images are registered, and that these images are in turn transferred to the brain via the optic nerve.
A German edition of this work was published in Leipzig in 1775 and 1776.

Wellcome Institute

PNEUMATICS

23 'Observations of Different Kinds of Air' *in* Philosophical Transactions of the Royal Society, volume 62, 1772.
(*Crook* Per/672)

In 1767 Priestley moved to Leeds and, as a result of living adjacent to a brewery there, he became interested in the chemistry of gases. At that time he had a rudimentary

knowledge of chemistry, acquired whilst he was acting tutor at the Dissenting Academy at Warrington, from Dr. Matthew Turner. Priestley first published his results in a paper which was read to the Royal Society in 1772.

Priestley's initial researches were on fixed air (carbon dioxide) of which he was able to obtain a ready supply from the brewery. This lengthy paper begins with an account of the observations he made on fixed air and describes his method of impregnating water with it to produce artificial mineral waters. Priestley also gives an account of his many discoveries relating to a number of other gases. The paper concludes with a description of the apparatus he used in his researches and includes a plate illustrating it.

Royal Society

24 Letter to Dr. James Lind, dated 11 May 1772

Two problems associated with long sea voyages were the supply of "good" drinking water and the avoidance of scurvy. Captain James Lind had published *A treatise on the scurvy* in 1753 in which he said that fresh fruit and vegetables in the diet prevented scurvy. The underlying cause of the disease was understood to be putrefaction. In 1772 Priestley offered the Lords of the Admiralty his method of preparing artificial mineral water as a solution to these problems.

In his letter he offers advice on his process to Lind. He recommends that bottles of oil of vitriol (concentrated sulphuric acid) should be taken to sea in a vessel filled with potash. He also discusses the possibility of oil of vitriol passing into the carbonated water claiming that this does not appear to happen. He then suggests that the addition of a little chalk and oil of vitriol to the water in fact would improve the taste.

Finally he sends Lind his best wishes and prayers for his forthcoming voyage believing it to be

> 'next to Columbus, the boldest and noblest that ever was undertaken by man.'

Royal Society (655.2)

25 Apparatus used to prepare oxygen (reconstruction)

In 1774 Priestley procured a burning glass "of twelve inches diameter and twenty inches focal distance". He used this to focus the sun's rays on a number of substances in an attempt to produce new gases, a process he wrote that he was "very fond of". On Monday 1 August he obtained a new air from *mercurius calcinatus per se* which allowed a candle to burn with a "remarkably vigorous flame". He later distinguished it from nitrous air (nitrous oxide) which also supports combustion and, in March 1775, showed that it supported the respiration of a mouse for much longer than common air.

A double burning lens, procured by Priestley, survives at Dickinson College, Carlisle, Pennsylvania.

Science Museum (1923-11)

26 Priestley's pneumatic apparatus (reconstruction)

Priestley's chemical investigations at Leeds and at Calne in Wiltshire led to the discovery of many gases such as (using their modern names) oxygen, nitrogen, the oxides of nitrogen, carbon and sulphur, ammonia and hydrogen chloride. One of the reasons for his success lay in the apparatus he used to manipulate gases. He did not claim that his apparatus was innovatory however, stating that it was

> "nothing more than that of Dr. Hales, Dr. Brownrigg and Mr. Cavendish diversified and made a little more simple".

The apparatus comprising a pneumatic trough, gas jars, a container for mice etc, has been reconstructed from a plate which appears in *Experiments and observations on different kinds of air.*[1]

His oval trough contained a shelf on which to rest the gas jars. The underside of this shelf was excavated in the form of a funnel to allow gases to pass up into the jars.

Science Museum (1965-225)

1 The reconstructed apparatus is illustrated in A.D. Orange *Joseph Priestley*, Aylesbury, Shire Publications, 1974, page 31.

27 Experiments and Observations on Different Kinds of Air [Figs. 9 and 11]
(*Crook* S/451-53)
1774, 1775 and 1777, published in London

In 1770 Priestley wrote in a letter to the Reverend Theophilus Lindsey

> "I am now taking up some of Dr. Hale's enquiries concerning air".

His researches on gases were first published in *Philosophical Transactions of the Royal Sociey* in 1772. This was followed by the three volumes shown here, published between 1774 and 1777. The first volume was dedicated to the Right Honourable Earl of Shelburne to whom he had taken the post of librarian a year earlier. It was not originally entitled Volume I and it appears that Priestley did not initially anticipate the addition of two further volumes.

Experiments and observations was widely read, appearing in (basically) three editions, but it has a complicated publishing history, being produced with *Experiments and observations relating to various branches of natural philosophy* as a single work. It was published in translation in Milan (1774), Berlin (1775), Paris (1777 and 1789), Amsterdam (1778), Leipzig (in French, 1778-80), Vienna (1778; 79) and Vienna and Leipzig (1780-87). (See items 33-35.)

Royal Society

28 Description of a glass apparatus for making Mineral Waters in a letter to Dr. Priestley
By J.H. de Magellan, 1777, published in London

When Priestley spent a month in Paris in 1774 he reported that he was fortunate to have the company of Magellan who was also in Paris in the evenings.

Jean Hyacinth de Magellan was born in Portugal in 1722 and later settled in England where he died in 1790. It seems he was best known for his wide circle of friends and for acting as intermediary in disseminating new information. Indeed he was instrumental in keeping the French chemists informed of Priestley's researches.

In this letter to Priestley, dated 3 Jan 1777, he describes apparatus designed by a Mr. Blunt and by Dr. Nooth to make artificial mineral waters by Priestley's method. He reports that

> 'A very great number, above a thousand, of these machines have been sent to different parts, even to the East Indies'.

The letter also includes a description of some eudiometers designed by Magellan.

Wellcome Institute.

29 Dr. Nooth's apparatus for making artificial mineral waters, late eighteenth century

Joseph Black and William Brownrigg had shown that the gaseous constituent of mineral waters was fixed air (carbon dioxide). From 1767 Priestley, living in Leeds, had a ready source of carbon dioxide and attempted to produce artificial mineral waters by dissolving carbon dioxide in weak solution of salts. In 1772 he published a pamphlet describing his method of impregnating water. Carbon dioxide, generated from chalk and oil of vitriol (sulphuric acid), was collected in a bladder which was squeezed to force the gas through the salt solutions.

On 15 December 1774 John Mervin Nooth MD FRS read his paper 'The description of an apparatus for impregnating water with fixed air' to the Royal Society. Nooth credits Priestley with the invention of the method but points out that his apparatus requires considerable skill to operate. He also claims the Priestley's use of a bladder gives a "urinous taste" to the water. Priestley was deeply offended by these criticisms and refuted the latter vigorously!

Modifications to Nooth's apparatus were made by the instrument maker Mr. Parker, Priestley's friend and benefactor.[1] These included the stoppered openings in the lower two vessels so that further reagents might be added to the bottom vessel and the waters may be drawn from the middle vessel during the operation. The apparatus shown includes Mr. Parker's modifications, but unfortunately the valve is missing. By 1790 even Priestley recommended Nooth's apparatus for domestic use.

Science Museum

1 D. Zuck, 'Dr Nooth and his Apparatus'
British Journal of Anaesthesia, 1978, 50: 393-405

30 Medals depicting Priestley
(*McLachlan* 52/1)
Silver, 1783
Inscribed obverse 'JOSEPHUS PRIESTLEY' and 'I.G. HANCOCK F.'

The reverse of these medals depicts some of Priestley's philosophical apparatus. In the centre there is a pneumatic trough with gas jars, on the right there is an electrical machine while there is a furnace on the left. Beneath the trough there are several items of chemical apparatus.

John Gregory Hancock worked as a medallist and die sinker for Boulton at the Soho Mint in Birmingham between about 1775 and 1815. *The Birmingham Gazette* for 4 August 1783 announced the striking of these medals.

The medals form part of the Science Museum's Penn Gaskell collection of aeronautica, a collection related to ballooning. The date of 1783 which appears on the reverse is that of the first ascent by a hydrogen balloon. Priestley's researches on gases had helped to make this feat feasible.

Science Museum (1950-318/5 and 6)

31 Air Pump, c 1780-1791 [Fig. 20]

The brass plate bears the inscription:

> 'This air pump was made for Dr. Priestley by Mr Harrison the employer of Sir Josiah Mason when a young man presented [to the University of Birmingham] by Josiah Martyn Smith Esq".

Samuel Harrison (1759-1833) was a split ring maker with a workshop in Lancaster Street, Birmingham. He was a member of Priestley's congregation at the New Meeting and is known to have assisted Priestley with his experiments. Harrison also made balances, and is believed to have made the one for Henry Cavendish, which is now at the Royal Institution.

Royal Society of Chemistry.

32 Considerations on the Doctrine of Phlogiston and the Decomposition of Water Part I
(*Crook* S/441)
1796, published in Philadelphia

Priestley addressed this defence of the phlogiston theory;

> 'To Messrs. Berthollet, De la Place, Monge, Morgeau, Fourcroy, and Hassenfratz, The surviving Answerers of Mr. Kirwan'.

Richard Kirwan (1733-1812) published *An essay on phlogiston and the constitution of acids* in 1784. The 1789 edition of this work includes his replies to the principal advocates of the Antiphlogistic Theory, those mentioned above plus Lavoisier.

Priestley always claimed that he would abandon the phlogiston theory should the logic of so doing be proved to him. However he maintained his support of the theory on which he had based all his experimental work on gases to the end of his life. This work was published after his emigration to America. Part 2 was published in the following year and French editions were published in Philadelphia (1797) and Paris (1798).

Wellcome Institute

THE CONTINENT

33 Osservazioni del Dott. Priestley sopra differenti specie d'aria
(*Crook* S/514)
1774, published in Milan

The Italian translation of volume 1 of *Experiments and observations on different kinds of air* by Gio. Francesco Fromond was published in the same year as the English original.

Wellcome Institute

34 Experiences et Observations sur Différentes Espèces d'Air
(*Crook* S/496)
1777, published in Paris

Translated into French by Jacques Gibelin this work comprises five volumes. The first three volumes were published in 1777 and volumes IV and V appeared in 1780. Gibelin added some of his own notes and a general index.

Wellcome Institute

35 Dr. Priestley's Versuche und Beobachtungen uber vershiedene Theile der Naturlehre
(*Crook* S/508)
1780, published in Vienna and Leipzig

The first German translation of *Experiments and observations on different kinds of air* appeared in 1778-9. When Priestley wrote *Experiments and observations relating to various branches of natural philosophy* (1779-1786) he numbered them volumes IV, V and VI as a continuation of the earlier work. The volume shown here is the first of this three volume continuation.

Wellcome Institute

36 Diploma of the Imperial Academy of Sciences, St. Petersburg

Priestley was made a member of the Imperial Academy in December 1780. There were close links between the Academy and British scientists, several of whom taught in St. Petersburg.

The diploma is signed by Johann Albrecht Euler, who was the son of the mathematician Leonhard Euler, secretary of the Academy from 1766 to 1780.

Royal Society.

THE LUNAR SOCIETY

The Lunar Society was an informal club which met in Birmingham once a month at the time of the full moon. Members assembled at two in the afternoon, dined together, and dispersed at eight. No minutes were kept, so no accurate picture of what transpired can be drawn, but it is known that members discussed recently published scientific books, conducted experiments and talked about technological, scientific and medical matters. The Society started during the 1780s and continued until at least 1807.

Among those who attended was Joseph Priestley (until his enforced departure from Birmingham in 1791). Other members were the industrialist Matthew Boulton (1728-1809), the eccentric physician and man of letters Erasmus Darwin (1731-1802), the social reformer Thomas Day (1748-1789), the Irish landowner and educationalist Richard Lovell Edgworth (1744-1817), the merchant and gunsmith Samuel Galton (1753-1832), Robert Augustus Johnson (1745-1799), the industrial chemist James Keir (1735-1829), the natural philosopher and mathematician William Small (1734-1775), the botanist Jonathan Stokes (1755-1831), the engineer James Watt (1736-1819), the potter and man of science Josiah Wedgwood (1730-1795), the clock and instrument maker John Whitehurst (1713-1788) and the physician William Withering (1741-1799). These men formed a remarkable conjunction of wide-ranging intellectual talent in and around a provincial town of moderate size.

37 Mortar, 1779 or 1780
Stoneware
Inscribed 'Wedgwood & Bentley' and '2'

After reading Priestley's *Experiments and observations on different kinds of air*, Josiah Wedgwood made a note:

> The Dr. seems much at a loss for a mortar, not metal, for pounding in. Make him a deep one or two".[1]

It took Wedgwood about six months to perfect a mortar composition that was extremely hard, resistant to wear, impervious to the action of acids, and non-absorbant of oils, but by July 1779 he had succeeded. A year later he reported to his partner, Thomas Bentley, that:

> "Mortars [we] find go every where, we have about 20 dozn. upon the stocks & are getting more forward as fast as possible".

Wedgwood made a range of ceramic ware for scientists - such as retorts, distilling and melting pots, crucibles, funnels, syphons, tubes, evaporating pans, mortars, pestles and levigators - which he was prepared to provide free of charge in the interests of chemical research.

Science Museum (1977-658)

1 *Josiah Wedgwood: 'the Arts and Sciences United'* Barlaston, Staffordshire, Josiah Wedgwood & Sons, 1978, pp. 16-20, 29 item 8.

38 Retort
Stoneware, unglazed
Inscribed 'WEDGWOOD' and '3½'

Josiah Wedgwood also supplied retorts glazed on one or both sides, in a variety of sizes (the dimension refers to the diameter of the bowl).[1]

Initially Wedgwood provided chemical apparatus free of charge to scientists, but as time went on and news of the use which Priestley made of Wedgwood apparatus was disseminated through Priestley's publications the demand for such apparatus increased considerably from both home and overseas, and finally Wedgwood was obliged to charge for such products.

Science Museum (1914-653)

1 *Josiah Wedgwood: 'the Arts and Sciences United'*, Barlaston, Staffordshire, Josiah Wedgwood & Sons, 1978, pp. 16-20.

39 Halfpenny token
(*Bell* 205)
Bronze, manufactured by Matthew Boulton, 1793
Inscribed obverse: 'SUCCESS TO THE YORKSHIRE WOOLLEN MANUFACTORY'
Inscribed reverse: 'LEEDS HALFPENNY' and '1793'
Inscribed on edge: 'PAYABLE AT. H. BROWNBILL'S, SILVERSMITH'

Due to shortage of currency in the eighteenth century many industrialists resorted to using their own tokens. Realisation that there was no fine for counterfeiting unofficial currency led to large amounts of fraudulent coinage. By 1797 the government was compelled to sanction regal penny and twopenny pieces. These were struck at the Soho manufactory of Boulton and Watt; other tokens were declared illegal from that date.

Matthew Boulton (1728-1809) was interested in science from an early age and was probably one of the founder members of the Lunar Society. He built the Soho manufactory in Birmingham in 1762 where he made all kinds of metal goods. Later he was in partnership with James Watt. He was elected Fellow of the Royal Society in 1785.

The token shown here was struck in 1793 by Boulton for Henry Brownbill, a silversmith and watch maker at Leeds. The obverse shows Bishop Blaize, patron saint of woolcombers who was martyred about 300 AD. The reverse shows the Mixed-cloth Hall at Leeds, built in 1758, some nine years before Priestley moved there. The engraver was Jean-Pierre Droz (1746-1823) a Swiss who worked in Paris before accepting Boulton's offer of work at the Soho manufactory in the 1780s.

Science Museum (1977-381/15)

40 Withering botanical microscope
Brass, contained in wooden box

William Withering (1741-1799) was a member of the Lunar Society and a friend of Joseph Priestley. He is best remembered for recommending the drug digitalis, made from foxgloves, for certain heart conditions. In 1776 he published an influential work *A botanical arrangement of all the vegetables naturally growing in Great Britain*, which included a design for an elementary microscope. The 1792 edition included another design for a small portable instrument where the simple lens mount and circular stage are fixed to the pillar by hinges, and the pillar is attached to the inside of a hinged box lid. The instrument shown here is an example of the second design and may well have been made in Birmingham.

In a letter of 1779 to the Rev. Radcliffe Scholefield, Priestley remarks:

> "I shall get Dr. Withering's book, and then, with his microscope, I shall be furnished for a botanist. But oral instructions would do much more for me. However, another summer I do propose to take some pains with this business. I am at this time exceedingly at a loss for the names of my water plants."

Wellcome Museum of the History of Medicine (A99778)

AMERICA

41 Portrait of Benjamin Franklin
(*Sellers* 420; *Robinson* 122)
Oil on canvas
Joseph Wright, 1782

Benjamin Franklin (1706-1790) was born in America, the son of an English soap boiler. His training was as a printer, though he became active in politics. From1747 to 1755 he was involved in experimental philosophy, being especially interested in electricity. Franklin represented Americal colonial interests in London during the period 1757 to 1775 and it was at this time that he became acquainted with Joseph Priestley.

Priestley first met Franklin in 1765 when he was working on his *History of electricity*. Franklin encouraged his work and a year later helped to secure his election to the Royal Society. As Franklin had done before, Priestley constructed kites to study atmospheric electricity. Priestley's *Chart of history* of 1769 was dedicated to Franklin "In Testimony of Esteem & Friendship".

On his last day in England, Franklin passed the time with Priestley going over newspapers recently arrived from America, selecting articles which might be used to win sympathy for the cause of the incipient American Revolution.

Joseph Wright (1756-1793) was an American artist who was commissioned to paint the portrait by Richard Oswald (1705-1784), Lord Shelburne's agent in peace negotiations with Franklin in Paris. The original, lost in a shipwreck shortly after being completed, was a copy from a pastel by the French artist Joseph Siffred Duplessis. There are four further copies by Joseph Wright known (of which this is one) and several more by other hands. This example was presented to the Royal Society in 1790 by Caleb Whitefoord F.R.S., Secretary to the Peace Commission.

Royal Society

42 Letter from Priestley to his sister, 29 July 1794

This letter is addressed to Priestley's widowed sister, Martha Crouch, after his arrival at Northumberland, Pennsylvania, where he was to make his home.

His emigration to America caused something of a stir. Shortly after landing he received visits from the Governor of New York, Bishop Prevoost and many leading citizens. Newspapers published addresses of welcome. When he arrived in Philadelphia he was again "received with the most flattering attention by all persons of note". Though pressed to stay, he was deterred by the high cost of living and unhealthy conditions and travelled 120 miles west to the English settlement at Northumberland.

Priestley describes the place in a letter as "seemingly almost out of the world" and continues:

> "The Town is beautifully situated, between two branches of the Susquehannah, each as large as the Thames at London, bounded by rocks and hanging woods"

Royal Society (MS 655.3)

43 Medal commemorating Priestley's journey to America
(*McLachlan* 53/3)
Inscribed obverse: 'JOSEPHUS PRIESTLEY' and 'PHIPSON FECIT'
Inscribed reverse: 'MAGNUS CHRISTIANUS PHILOSOPHUS' and 'APR: VIII BRITTANIAE LITORA LINQUENS COLOMBIAM ADVENIT JUNII IV MDCCXCIV' and 'NATUS 13 MART. 1733 MORT 6 FEB. 1804'

This medal engraved by Phipson in Birmingham commemorates his voyage from the shores of Britain on 8 April to Columbia on 4 June 1794, a journey of eight weeks and one day Priestley described the voyage as an indifferent one due to almost constant contrary winds. He also reports that both he and his wife suffered from seasickness for a large part of the voyage.

The medal was issued in two editions: an earlier one of 1794 and this of 1804.

Science Museum (1915-318/4)

44 Plan of Dr. Priestley's House ... at Northumberland ... Pennsylvania *in* Memorials of Dr. Priestley Collected by James Yates F.R.S.
Ink and wash drawing, signed "Plann'd & drawn by T. Sambourne Surv^r^ LUZERNE County ... COPIES BY THOS. CHATFIELD CLARKE 137 LEADENHALL ST' .

The original drawing from which this was copied was dated July 1800.

In November 1794 Priestley decided to have a house built at Northumberland, Pennsylvania, and not to accept the post of professor of chemistry at Philadelphia which had been offered to him. The house was still not finished when his wife died in September 1796, but he resolved to complete it and live there with his son, Joseph junior. One of the rooms was fitted out as a laboratory and it was there that the experiments for his final ten papers, published in *Transactions of the American Philosophical Society*, were peformed.

In 1856 it was announced that it was intended that a statue of Priestley should be amongst those included in the new University Museum at Oxford. James Yates took charge of funds collected for the purpose, and he compiled this lavish scrapbook which contains engraved portraits (and other memorabilia) intended to assist the sculptor to produce a good likeness.

Royal Society

45 'Chemical Philosophers of the Present Day'
(*McLachlan* 22/4)

Engraving signed 'Opie and David pinxt.', 'Caldwell sculpt.' and 'London', Published 1 May, 1801, by Dr Thornton'.

Shown somewhat incongruously on the same plate as Lavoisier (whose theory of combustion he never accepted), Priestley is depicted in a cartouche which is surmounted by the American eagle.

The portrait of Priestley is taken from the oil painting by John Opie (in Manchester College, Oxford). The engraving appeared in R.J. Thornton *New illustrations of the sexual systems of Linnaeus* (1801).

Royal Society

46 Medal commemorating the bicentenary of Priestley's discovery of oxygen
Silver, 1974

This medal was struck by the Franklin Mint in the USA in 1974, 200 years after Priestley first prepared oxygen. It was produced for the centenary of the American Chemical Society which was founded in 1874. The obverse shows a portrait of Priestley, while the reverse portrays his preparation of oxygen. Priestley is shown heating mercuric oxide with a burning lens and the gas given off is being collected in a pneumatic trough.

Science Museum (1975-87)