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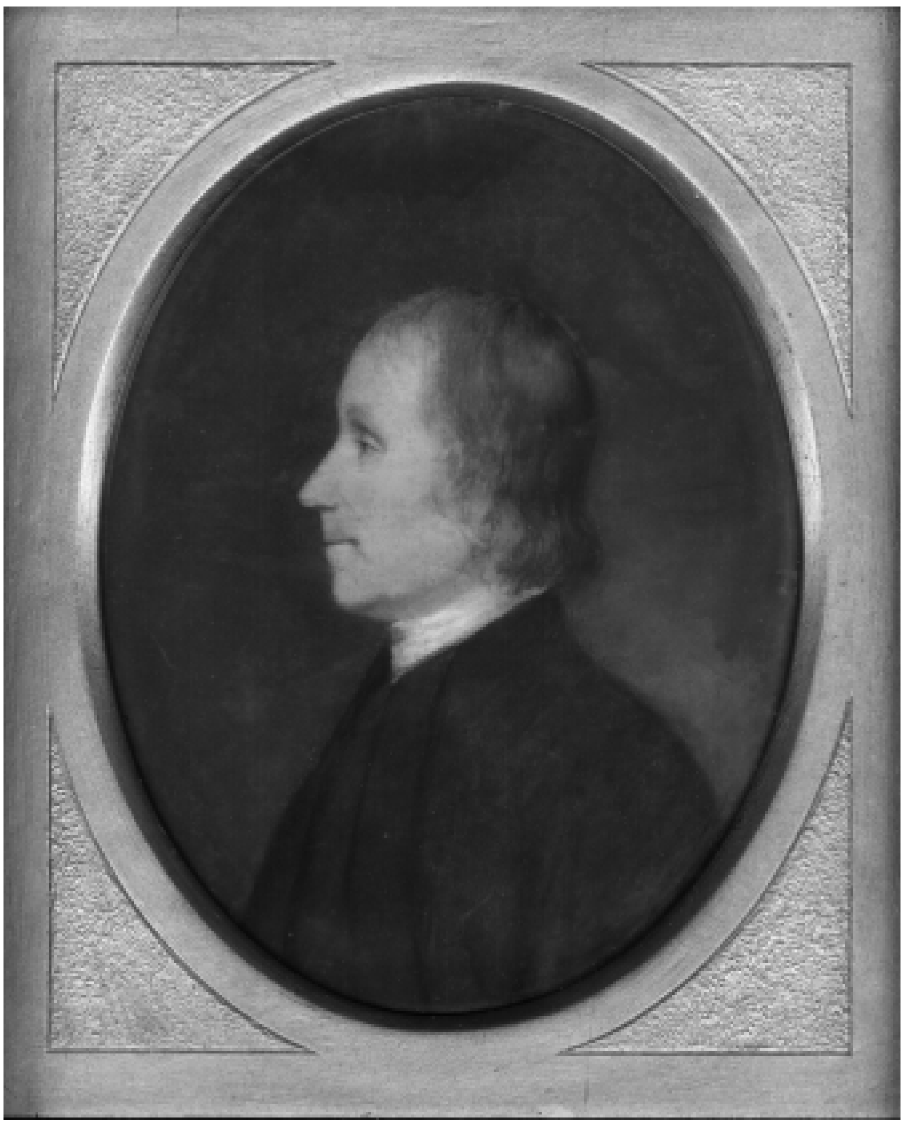

BULLETIN FOR THE HISTORY OF CHEMISTRY

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The Cover…Copy of oil painting of Joseph Priestley by Ellen Wallace Sharples, William L. Clements Library, University of Michigan

JOSEPH PRIESTLEY, NATURAL PHILOSOPHER*

Robert E. Schofield

In this two hundredth anniversary year of his death, we are met to celebrate the life and career of Joseph Priestley—and most of us celebrate the wrong man, for the wrong reasons. We celebrate the pneumatic chemist who, in a flurry of random experiments made over a period of five years, isolated and partially identified nine new gases, including oxygen—and the man who spent roughly five times as long perversely fighting the new chemistry based on his own discoveries. This man, as Georges Cuvier was to put it in the éloge written for the Académie Nationale des Sciences, was a father of modern chemistry but refused to recognize his own daughter (1).

Now some small part of that picture *is* true: Priestley did isolate and partially describe nine new gases, and that does justify some celebration (2). But the major and false part of the picture is the continuing consequence of a scenario created for us by that master of rhetoric and public relations, Antoine Lavoisier, and his followers. Their campaign for personal recognition and the new chemistry required the destruction of the old chemistry and the denigration of its major defender (3). It was the Lavoisians who created the caricature slavishly adopted for nearly two centuries by chemists and historians of chemistry.

Douglas McKie, the popular biographer of Lavoisier, has summarized their version (4):

> As an experimenter, Priestley has been represented as an amateur and dilettante chemist, capriciously flitting from one haphazard experiment to another, and despite the scientific absurdity of his method, having the good fortune to make classic discoveries; and as a theorist, he has been described as ingenuously weaving these discoveries into the tattered fabric of the phlogiston theory, to which he was so blindly devoted that no amount of hostile evidence could convince him of its falsity. . . .Both these views are inexact; the first entirely so . . and the second requires qualification.

Now the Lavoisians were not entirely to blame. They were justly elated at their quite remarkable achievement and dismayed at Priestley's continued opposition—an

NOTE FROM THE EDITOR

Most of this issue of the *Bulletin* is devoted to papers presented at the symposium held at the 228th national American Chemical Society meeting in Philadelphia in August, 2004. Organized by Dr. James J. Bohning and Dr. R. A. Olofson and titled "Joseph Priestley, Universal Catalyst: A Bicentennial Celebration of his Life," the program provided a broad perspective of Priestley the 'whole man.' As the symposium participants demonstrated, Priestley was only secondarily a practicing scientist whose concerns and scholarly pursuits spanned the fields of religion, education, social change, and, inevitably, political life.

opposition, moreover, in the apparent framework of confusing appeals to contradictory applications of phlogiston theory. Frederic Holmes has suggested, however, that Priestley differed from Lavoisier, not because he was defending Georg Stahl's discredited chemical theory of phlogiston, but because he was defending his own collection of phlogistic explanations for a number of phenomena never considered by Stahl. Holmes was certainly on the right track here but could have gone much further, as John McEvoy did in declaring (5):

> So long as 'science' is viewed in isolation from its cultural content . . . will Priestley's scientific thought be found wanting. For the order, unity, and aim of his natural philosophy does not derive from any narrowly defined chemical principles or problems . . . When placed in a wider intellectual context, Priestley's scientific thought takes on a very different complexion. . . . [He] subjects his scientific conceptualizations to the dictates and demands of intellectual principles that are far wider in scope than eighteenth-century chemistry and that seek to encompass the totality of reality . . . . Order informs apparent chaos when this methodology is located in the overall programme of an earnest study of nature that promised to reveal the greater glory of God . . .

In short, Priestley was not a scientist nor—you will, I trust excuse his lapse—a chemist, something which he several times explicitly denied being (6). Priestley was a Natural Philosopher, which he defined as an investigator of the Wisdom of God in the Works and Laws of Nature (7). It is well to keep in mind that Priestley was, by profession, a minister—for an aberrant, Unitarian, Christianity, if you will, but nonetheless a calling which he thought the most important and most satisfying of any that existed. He chiefly valued his work in natural philosophy for the discoveries which lent authority to his religious opinions. He perhaps never quite realized the extent to which that work informed his religious opinions; or was it *vice versa*?

Priestley's denial of the Trinity was partly based on the conviction that primitive Christianity had been corrupted by a mixture of Eastern religions (notably Hinduism), Platonism, and Gnosticism, all of which held that the body was an imperfect container for Divine Spirit. There was, he thought, no historical justification for a belief in the existence of the spirit of Christ prior to the creation of the world. The philosophical justification for that belief was based upon the false principle of duality, which held that substances could be divided into the material and the spiritual, each totally and absolutely different from the other. Priestley was led to a denial that there was any essential difference between body and spirit (or soul). He was a monist.

It was not his primary concern to discuss the fundamental nature of matter, but to prove the uniform composition of man. He wished to demonstrate that mind, or the principle of perception and thought, is not a substance distinct from the body, but the result of corporeal organization. This monistic assumption was, he claimed, independent of any consideration of the internal structure of matter, "about which we know very little, having few data to argue from." (8) But, like Isaac Newton, who followed his declaration: *Hypothesis non fingo*, with hypotheses on the nature of the aether, Priestley could not resist speculations on the nature of matter.

In fact, Priestley had been intrigued by the ultimate nature of matter long before he articulated his monism. His *History and Present State of Electricity* (1767) was prefaced by the statement (9):

> Hitherto philosophy has been chiefly conversant about the more sensible properties of bodies; electricity, together with chymistry, and the doctrine of light and colors, seems to be giving us an inlet into their internal structure on which all their sensible properties depend.

Later in the same work, his first scientific publication, Priestley wrote (9):

> …chymistry and electricity are both conversant about the latent and less obvious properties of bodies; and yet their relation to one another has been little considered . . . . Among other branches of Natural Philosophy, let the doctrine of LIGHT AND COLOURS be also particularly attended to. It was this that Newton thought would be the key to other, at present occult properties of bodies.

It should then come as no surprise that Priestley's next major scientific book was *The History and Present State of Discoveries relating to Vision, Light, and Colours*, for short, *History of Optics* (1772), nor that this work should contain speculations on the nature of matter. These speculations took something of the form of the elaborate matter theory of the Jugo-Slavian astronomer and philosopher, Roger Joseph Boscovich, whose *Theoria Philosophiae Naturalis* of 1758 was to capture the imagination of physicists, such as Michael Faraday, James Clerk Maxwell, and J. J. Thomson into the twentieth century. Because that theory contained no provisions for quantification or verification, it has also earned the scorn of philosophers and historians, for whom Priestley's "Boscovicheanism" is yet another excuse for his belittlement. But Priestley's "Boscovicheanism," like Boscovich's *Theoria* itself, had its roots in the speculations of Isaac Newton.

Starting from the corpuscular theories of the seventeenth century, which had held that all matter was ultimately the same, manifesting differences only in the sizes, shapes, and motions of its ultimate particles, Newton had added the concept of forces—of attraction and repulsion. In those "bold and eccentric thoughts" of the Queries to his *Opticks*, particularly numbers 20 to 23 of the Latin edition of 1706, Newton had even argued that the same particles might alternate attractive and repulsive forces at different distances (10). That argument was taken up by several eighteenth-century Newtonians, including John Rowning, whose *Compendious System of Natural Philosophy* (1737-43) Priestley had used as a student at Daventry Academy in the early 1750s and as a reference in his *History of Optics* in 1772; John Michell, whom Priestley knew in Leeds, and consulted for the *History of Optics*, was another dynamic corpuscularian; and, most important, Stephen Hales, whose *Vegetable Staticks* Priestley read in 1770 and found his major early inspiration for pneumatic experiments, had written there (11):

> If all the parts of matter were only endued with a strongly attracting power, whole nature would then immediately become one unactive cohering lump; wherefore it was absolutely necessary, in order to the actuating and enlivening this vast mass of attracting matter, that there should be every where intermix'd with it a due proportion of strongly repelling elastick particles, which might enliven the whole mass . . . .

It is hardly surprising that Priestley should adopt some form of this Newtonian-Rowning-Hales-Michell-Boscovich theory for his own metaphysical speculations on a theory of matter.

His most complete exposition of that theory is probably that in his printed debate with the theologian and mathematician, Richard Price (12):

> Suppose . . . 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 . . . carrying their peculiar spheres of attraction and repulsion along with them . . . these spheres may be diversified infinitely so as to correspond to all the kinds of bodies that we are acquainted with . . . A compages of these centers placed within the sphere of each other's attraction will constitute a body that we term compact and two of these bodies will, on their approach meet with a repulsion, or resistance, sufficient to . . . appear perfectly hard . . . Matter is by this means resolved into nothing but the divine agency, exerted according to certain rules.

And if his opponents chose to call this "matter" by the name of spirit, Priestley would not object; all he was contending for was a conjunction of powers so as not needlessly to multiply substances.

It was a mistake, for Priestley's reputation as a theologian, that *he* did not adopt the name "spirit," for his persistence in using the term "matter" led the orthodox to claim he was an atheist—which he clearly was not—and even offended the transcendental Unitarians of the nineteenth century. It was an even greater mistake, for his reputation as a scientist, that he did not attack Lavoisian chemistry on monistic, corpuscular grounds. He had used monistic arguments against the Scottish Common-Sense philosophers, whose proposal of a "vain multiplication" of separate, arbitrary, instinctive principles of perception not only denied the agreeable simplicity shown in other parts of nature, but also forestalled any attempt to examine the ultimate nature of perception (13). Consider then the possibilities of a monistic attack on the taxanomic chemistry of Lavoisier, with its endless multiplication of separate, arbitrary, determinate elements, forestalling any investigation as to why they differed or how they interacted. Such an attack could not have defeated the new chemistry, but, at least, its proposer would not have gone down in history as a benighted supporter of phlogiston.

Priestley never explicitly attacked Lavoisian chemistry on metaphysical grounds, although there are suggestions throughout his work that he had larger aims than an exploration of the permutations and combinations of substance that were to characterize the chemistry of his day. In 1776 he wrote (14):

> This is not now a business of air only . . . but appears to be of much greater magnitude and extent, so as to diffuse light upon the most general principles of natural knowledge, and especially those about which chymistry is particularly conversant. And it will not now be thought very assuming to say that . . . we may perhaps discover principles of more extensive influence that even that of gravity itself.

And in the following year (15):

> The reason of my great expectations from this mode of experimenting is simply this, that, by exhibiting substances in the form of air, we have an opportunity of examining them in a less compounded state, and are advanced one step nearer to their primitive elements.

There is even one published reference to the dynamic corpuscularity of his matter theory (16):

> I went upon the idea, that the change of consistence in water was brought about by extending the bounds of the repulsion of its particles, and at the same time preventing their actually receding from each other, till the spheres of attraction within those of repulsion should reach them. The hypothesis may still be not amiss, though I did not properly act upon it.

And, finally, there is one comment, of 1801, that may be an oblique philosophical attack on Lavoisian chemistry (17):

> A knowledge of the elements which enter into the composition of natural substances, is but a small part of what it is desirable to investigate with respect to them, the principle, and the mode of their composition: as how it is that they become hard or soft, elastic or non-elastic, solid or fluid, &c. &c. &c. is quite another subject, of which we have, as yet, very little knowledge, or rather none at all.

Priestley's negative responses to Lavoisian chemistry were soon overshadowed by political events: the 1791 Birmingham Riots and the 1794 French Republican execution of Lavoisier. Most of those responses were, therefore, contained in the forty-five papers and four pamphlets Priestley published during his decade in the United States—more scientific items than he had published during all his years in England. These items are sometimes cited by title, but the contents were ignored by his contemporaries and by modern historians of chemistry alike. They were ignored because Priestley was "wrong," because a few errors were insufficient to overturn an otherwise successful system, and because explanations were later (sometimes much later) found for Priestley's objections.

Attacks on Priestley's phlogistic chemistry have emphasized errors and incongruities; and there were plenty of these, but they seldom involved experimental error. Verbruggen has effectively answered any suggestion that Priestley's resistance to Lavoisier was based on imperfections of his experiments compared to those of Lavoisier. In the accuracy of his observations, Priestley was superior, or equal, to his contemporaries, particularly Lavoisier (18). That resistance focused, instead, on the experimental errors in Lavoisian chemistry, errors equal in their numbers to those found in the chemistry of Stahl.

Of the four essentials in Lavoisier's new theory of combustion, for example, only that on change of weight has survived its publication in 1785. In 1794 the Dutch chemists, Deiman, van Troostwyk, Nieuwland, and Bondt, found combustion taking place in the absence of oxygen. Oxygen is not, as named by Lavoisier, an acid former, for Priestley and others demonstrated that marine acid (hydrochloric acid) contained no oxygen. Moreover, if phlogiston was to be attacked, for its lack of weight, so also should light and heat, each named a material element in Lavoisier's system.

Despite the titles given his American pneumatic publications—*The Doctrine of Phlogiston established and that of the Composition of Water refuted* (1803) (19), for example—few were, in fact, concerted defenses of phlogiston. They were, instead, detailed attacks on French chemistry; and Priestley developed a disconcerting instinct for weaknesses in the French system. He had a knack for selecting substances with widely varying properties (the multiple oxides, for example, of sulfur, phosphorus, and nitrogen) to question Lavoisian views that the properties of compounds reflected the elements composing them (19):

> Substances possessed of very different properties may be composed of the same elements, in different proportions, and different modes of combination.

Metallic calxes were not all oxides. Reduction of ferrosopheric oxide (finery cinder) produced inflammable air, without the presence of water. When William Cruickshank identified this heavy inflammable air

"Dr. Priestley began his career of discovery without any general knowledge of chemistry, and with a very imperfect apparatus. His characteristics were ardent zeal and the most unwearied industry. He exposed all the substances he could procure to chemical agencies, and brought forward his results as they occurred, without attempting logical methods or scientific arrangement. His hypotheses were usually founded upon a few loose analogies; but he changed them with facility; and being framed without much effort, they were relinquished with little regret. He possessed in the highest degree ingenuousness and the love of truth. His manipulations, though never very refined, were always simple, and often ingenious. Chemistry owes to him some of her most important instruments of research, and many of her most useful combinations; and no single person ever discovered so many new and curious substances."—Humphrey Davy, *Elements of Chemical Philosophy*, 1812.

as a separate species of air, carbon monoxide, in 1801, Priestley declared, somewhat ingenuously, that he had found that air as early as 1772. Moreover, its designation did not solve a problem for the Lavoisians; it increased their number. Priestley could not understand why the chemists in Paris boasted of a finding that abandoned a critical part of the new chemistry: that water was essential to the formation of inflammable air; and he quoted from Lavoisier's *Elements* to that point (19).

The salient issue, for the Priestley detractors, has usually been his attack on the nature of the composition of water. Nothing seems more revealing of prejudice and experimental incapacity than Priestley's insistence, from the 1780s to the 1800s, that the combination of hydrogen and oxygen sometimes produced an acid. But the evidence is clear that, in experiment after experiment, Priestley and his critics did produce a weak nitric acid from that combination. The explanation, as Henry Cavendish early showed, was due to nitrogen impurities in the gases used. But when Priestley deliberately introduced quantities of nitrogen into the hydrogen-oxygen mixture, he all but eliminated production of the acid! In time, he could produce pure water or acid, at will, by varying the quantity of nitrogen or hydrogen and/or the intensity of the combustion in his experiments. Unable to explain his work, the Lavoisians ignored it. Thanks to the physical chemistry which Priestley's questions sometimes seem to have previsioned, the explanation is to be found in the different energies of combination of oxygen with hydrogen and with nitrogen.

Priestley's experiments were sound, but in the end the failure of his criticisms lay precisely in his dependence upon those experiments. He had a particularly virulent infection of that eighteenth-century British obsession with Francis Bacon and mistakenly believed that experiments could stand by themselves, with interpretation devoid of theoretical implications. He had a persistent and erroneous conviction that he could invalidate the new system by disproving the experiments of antiphlogistonists. But the new chemistry was not an assembly of experimental results; it was the result of assumptions about the nature of chemical processes, which professionalized chemistry but eliminated it from the expansive range of Priestley's Natural Philosophy.

By all means, let us celebrate the Priestley who, in the course of a magnificent research vision, by the momentum of experimental design, the pursuit of analogy, and extraordinary observational skills, *did* isolate and partially describe nine new gases. Let us also celebrate the Priestley whose enunciation of an inverse-square law of electrical attraction inspired the classic experiments of Henry Cavendish; whose reference to the purification of air by vegetation inspired the photosynthesis studies of Ingenhousz, Senebier, and Saussure; whose phlogistic explanation of respiration inspired the oxidation-respiration work of Lavoisier and LaPlace; and whose constant attacks on the antiphlogistionists—in the face of almost universal opprobrium—forced the tightening of their experimental evidence. Let us celebrate the man whose observations of gaseous diffusion, for all his misunderstandings of them, encouraged the investigations of John Dalton and of William Graham into the chemical problems of the kinetic theory of gases. We should honor the man whose "materialist" view of matter as spirit, or powers, his insistence that quantities, time and temperature, were involved in differentiating chemical processes, and his persuasion that material differences could be explained by the arrangements of the matter of which things were made, which all foreshadow the chemistry that developed, once the improvements of the Lavoisian system had been assimilated.

Above all, let us celebrate the man whose persistent freedom of speech and of religion forced his exile to this country; the man who, despite his homesickness for the land of his birth, could praise the constitution of the land of his refuge and who affectively thanked Thomas Jefferson that, for the first time in his life, he lived in a country where the government was friendly to him.

REFERENCES AND NOTES

***** This paper is based on the presentation at the symposium at the Philadelphia ACS Meeting, Philadelphia, 2005, HIST 025.

1. In his "eulogy" for the National Academy of Sciences, Paris, translated in the *Monthly Repository*, ***1806***, *1*, 216-219, 328-334.
2. Alkaline air (ammonia, NH_3), Dephlogisticated air (oxygen, O_2), Depleted nitrous air (nitrous oxide, N_2O), Fluor acid air (silicon tetrafluoride, SiF_4), Heavy inflammable air (carbon monoxide, CO), Nitrous air (nitric oxide, NO), Marine acid air (hydrochloric acid, HCl), Phlogisticated nitrous air (nitrogen dioxide, NO_2), and Vitriolic acid air (sulphur dioxide, SO_2).
3. Henry Guerlac, Lavoisier's most perceptive biographer, had noted that a marked aspect of Lavoisier's character was his ambition, his overwhelming self-confidence, and his craving for public recognition. He described Lavoisier's *Traité Elementaire de Chemie* (1789) as a "propaganda instrument:" see Guerlac, Antoine

Lavoisier, in the Dictionary of Scientific Biography VIII, pp. 66-91. When the experiments on the composition and decomposition of water were successfully repeated by a committee of the French Academy in 1790, Lavoisier staged a dramatic scene, with Madame Lavoisier, dressed as a priestess, burning Stahl's *Fundamenta Chemiae Dogmaticae* on an altar while musicians played a requiem.

4. D. McKie, "Joseph Priestley (1733-1804), Chemist," *Science Progress*, **1933**, No. 109, 17. Note that Henry Cavendish has also been accused of experimenting without rhyme or reason, but his most recent biography has demonstrated implicit large goals, not understood by his contemporaries: see C. Jungnickel and R. McCormmach, Cavendish: the Experimental Life, *Memoirs*, American Philosophical Society, Philadelphia, PA, 1996, 220.
5. F. L. Holmes, "The 'Revolution in Chemistry and Physics:' Overthrow of a Reigning Paradigm or Competition between Contemporary Research Programs?" *Isis*, **2000**, *91*, 735-753; J. G. McEvoy, "Joseph Priestley, 'Aerial Philosopher,' Metaphysics and Methodology in Priestley's Chemical Thought, from 1772 to 1781," *Ambix*, **1979**, *26*, 34-35.
6. In *Philosophical Empiricism*, J. Johnson, London, 1775, p 26: "Not being a practical chemist, having never had a proper laboratory, or seen much of the usual processes;" in a letter to James Keir, February 4, 1778: "My walk is between what is call'd chemistry, and other branches of Natural Philosophy; in *Experiments and Observations relating to various Branches of Natural Philosophy*, J. Johnson, London, 1779, p 39: "Not being a professed chemist, and attending only to such articles in that branch of knowledge as my own pursuits are particularly connected with . . . illustrations of chemical processes are not as likely to occur to me as they are to others;" in a letter to Giovanni Fabrioni, October. 17, 1779: "My knowledge of chymistry is very imperfect;" and as late as September 14, 1794, when he wrote to Benjamin Rush that, should he be selected for the professorship of chemistry at the University of Pennsylvania, he was unprepared to give anything but a general course in natural philosophy.
7. In his *Heads of Lectures on a Course of Experimental Philosophy*, J. Johnson, London, 1794.
8. See the arguments in Priestley's *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,* J. Johnson, London, 1777.
9. J. Priestley. *History and Present State of Electricity*, J. Dodsley, J. Johnson, B. Davenport, and T. Cadell, London, 1767, xiii, 502-3.
10. The quoted description of Newton's thoughts is that of Priestley, in *Experiments and Observations on different Kinds of Air*, J. Johnson, London, 2nd ed., 1775, 259. For a fuller discussion of Newtonian matter theories, see R. E. Schofield, *Mechanism and Materialism*, Princeton University Press, Princeton, NJ, 1970.
11. S. Hales, *Statical Essays: Containing Vegetable Staticks; or, an Account of some Statical Experiments on the Sap in Vegetables* . . . also *A Specimen of an Attempt to Analyse the Air*, W. Innys, R. Manby, T. Woodward, and J. Peele, 3rd ed., 1738, 314.
12. J. Priestley, *A Free Discussion of the Doctrines of Materialism, and Philosophical Necessity, In a Correspondence between Dr. Price, and Dr. Priestley*, J. Johnson and T. Cadell, 1778, 247-8, 250.
13. See J. Priestley, *An Examination of Dr. Reid's Inquiry into the Human Mind, on the Principles of Common Sense* . . . J. Johnson, London, 1775.
14. J. Priestley, *Experiments and Observations on different Kinds of Air*, J. Johnson, London, 2nd ed., 1776, Vol. 2, vii-viii.
15. J. Priestley, *Experiments and Observations on different Kinds of Air*, J. Johnson, London, 1777, Vol. 3, ix. One might note that Thomas Graham made a similar observation in his "Speculative Ideas respecting the Constitution of Matter," *Proc. R. Soc., London*, **1863**, *12*, 620-623.
16. J. Priestley. *Experiments and Observations relating to various Branches of Natural Philosophy*, J. Johnson, London, 1779, 408.
17. J. Priestley. "Miscellaneous Observations relating to the Doctrine of Air," *New York Medical Repository*, **1802**, *5*, 266.
18. F. Verbruggen. "How to Explain Priestley's Defense of Phlogiston," *Janus*, **1972**, *59*, 47-69.
19. J. B Priestley, *The Doctrine of Phlogiston established and that of the Composition of Water refuted*, 1803.
20. In papers published in the *New York Medical Repository* in 1801, in response to the publication by Cruickshank of his identification of carbon monoxide

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PHLOGISTON THEORY AND CHEMICAL REVOLUTIONS

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Introduction

Joseph Priestley was born in 1733 near Birstall, County of Yorkshire, in England. Above the door of his birthplace is the plaque (Fig. 1) that states simply "Joseph Priestley: discoverer of oxygen was born on this site AD 1733.

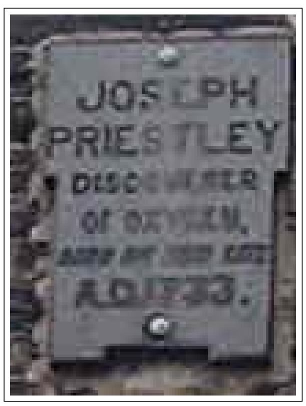

Figure 1. *Plaque above the front door of 5, Owler Lane, Fieldhead, Birstall, the birthplace of Joseph Priestley.*

Priestley is famous among scientists mainly for his discovery of oxygen, but he also achieved many other great "firsts" in science. In this presentation, emphasis will be placed on that aspect of his work for which he became "infamous". Priestley adopted, developed, and advanced the theory of phlogiston to explain why materials react with oxygen. He continually had to refine the theory, but in the end, he died ignominiously in the eyes of the developing community of chemical scientists. To his dying day, he refused to acknowledge the nonexistence of phlogiston as the driving force for chemical reactions.

The story begins with reference to Batley Grammar School (Fig. 2) where, according to his memoirs, Priestley learned religion, classics, and literacy. He had no formal education in either science or history, as humanities were not taught at the schools in England in the early 18^{th} century.

In the mid 18^{th} century, unlike the present, there was no conflict between science and religion because in those days there was virtually no physical science. One could argue that history is best understood if taught backwards; this is especially true in understanding the history of science. Now, we know essentially everything chemists need to know about atoms and molecules, mass and energetics, to explain the symbolism of chemical equations and the reasons why chemical changes occur. Historians of science tend to start with alchemy and work forward but then stop when science is no longer susceptible to historical reinterpretation. One consequence of this approach to the history of science is that the credit for scientific advance is allocated by contemporaries in an unscientific, often political, manner and is rarely subjected to revision. Priestley, for example, deduced and published the inverse square law of force between electric charges, 20 years before Coulomb, to whom history has credited the discovery. Now it is enshrined in the modern scientific literature, the credit cannot be reallocated.

Coulomb's Law is one of many examples where historians of science have not been kind to Joseph Priestley. This essay is an attempt to re-evaluate Priestley's contributions to physical chemistry 200 years ago concerning the first theory of the driving force of chemical reactions: "phlogiston."

Every chemist knows that Priestley discovered oxygen (1). Some chemists now know that he also discovered and characterized nine other gases, including ammonia. Priestley's contributions to physical chemistry or the science of chemical and physical change, however, are largely unknown. Seventy-five years before Faraday, for example, Priestley decomposed the ammonia he had discovered into hydrogen and nitrogen by using electricity. Besides Coulomb's law 20 years before Coulomb (2) Priestley published many other original firsts. His innovations include a description of atoms 40 years before Dalton (3), hypothesis of division of atoms 150 years before Rutherford (4), forces between atoms 100 years before van der Waals (5), and prediction of black holes 200 years before Stephen Hawking (6). Priestley also first discovered and described the process of photosynthesis and the carbon cycle. He investigated the solubility of carbon dioxide in water and went on to invent the process of carbonation or fizzy drinks industry.

Despite this life of extraordinarily diverse scientific discovery, Priestley died in 1804, "stubborn and stupid," the last of the phlogistonists. He might have been stubborn, but one has to question whether someone who had achieved so much in his life could be so naïve. If, as he surely did, Priestley honestly believed that chemical reactions were driven by phlogiston, particularly since Lavoisier and his antiphlogistonists had "proven" that it cannot exist (7), there must be more substance to the theory.

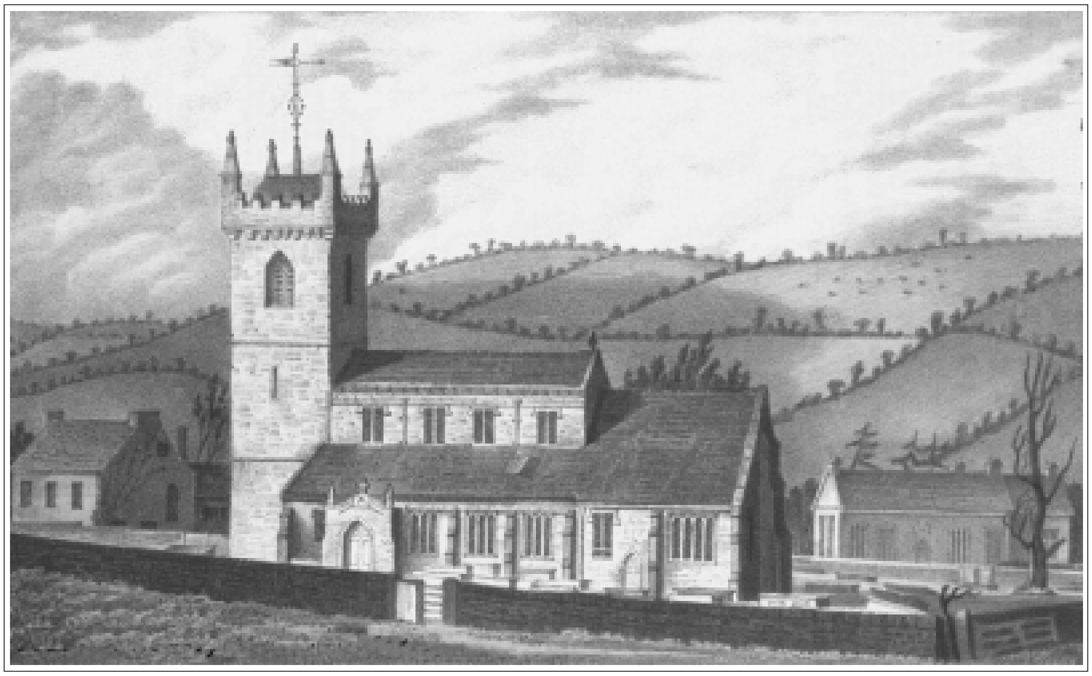

Figure 2. *An old lithograph from 1836 showing the vicarage, the Parish Church, and Batley Grammar School to the right that Priestley attended from 1744-1749.*

Here a modern interpretation of phlogiston is presented. It may be argued that phlogiston was the first reasonable scientific theory of chemical change, 100 years before Gibbs got it right. The antiphlogistonists, by contrast, had nothing to contribute to physical chemistry in the form of an answer to the question, "Why do chemical reactions take place?" They were the founding fathers of "inorganic chemistry," but physical chemistry centers around why and how chemicals react.

By use of Ellingham diagrams, a modern platform for describing the thermodynamic equilibrium of reactions of elements with oxygen, lines of thought of the protagonists of phlogiston theory can be scrutinized. The concept of a state function, for example, which is central to thermodynamics, was first introduced by Black in the caloric theory of heat (8). Both caloric theory and phlogiston theory of combustion, when revisited in the light of modern thermodynamics, can help to explain Priestley's dogged adherence to the theory until the day he died in 1804.

Every thermodynamic material does indeed have a constitutive state function, ("phlogiston"?), which can be given a definition: "minus the Gibbs chemical potential of oxygen within the material." It has the dimensions of (free) energy per mole of oxygen, and measures its oxidation propensity. While the antiphlogistonists may have been the first inorganic chemists, Priestley's conceptual interpretation of phlogiston was the first attempt at the physical chemistry of reactions. If phlogiston is regarded as an alternative description of "Gibbs free energy," the theory appears to be an intuitively accurate description, as could reasonably be expected at that time, and remains essentially correct today given its precise thermodynamic definition.

Caloric: as a State Function

We now know that the understanding of chemical reactions is inextricably dependent upon an understanding of the concept of "heat." A big step forward in the 18th century was the introduction of the concept of a state function, "caloric," by Joseph Black (8). Unfortunately, there was no understanding of the difference between energy the state function and heat, which is energy on the move.

Prior to the advent of thermodynamics, around 1850, all scholars of science believed in the caloric theory: that heat was a conserved fluid with no mass. It was present in various amounts in all materials and flowed from high to low concentrations. The caloric content depended on temperature and physical state; gases had a high caloric content and solids a low caloric content. The basic misconception was that caloric was a conserved substance which was particulate, had a mass, and hence could be "neither created nor destroyed." We now know that "substance" to be the thermodynamic state function internal energy, or enthalpy. Heat itself is NOT energy, but energy on the move and not a state function.

Of great fundamental relevance, however, and largely overlooked by historians of science, is the fact that Black had for the first time, it appears, introduced the concept of a state function. The properties of a material (in this case the caloric content) depend only upon its equilibrium state and not on its processing history. The total energy of a material is the thermodynamic state function called the "internal energy." Only differences in energy between two states can be defined and measured. If those two states are at the same pressure, the energy difference is called the "enthalpy." This thermodynamic state function can be identified with Black's "caloric."

Background to Phlogiston

The concept of phlogiston was introduced around 1700 by the German natural philosopher Georg Ernst Stahl. Until then it was believed by the alchemists that everything was made up of just four elements: earth, water, air, and fire. Observations of combustion by various solid materials, however. showed that the many different kinds of earth required a fifth element that explained why, for example, some materials burn in air much more readily than others. Different kinds of earth, i.e. solids, were deemed to contain variable quantities of "phlogiston" which, from Greek, literally means "fire of the earth." The precise definition of phlogiston was not clear; some philosophers regarded phlogiston and fire as being synonymous. When a solid burned, it simply transferred its phlogiston to the air. Phlogiston was a concept Joseph Priestley adopted, developed further, and adhered to throughout his life as a natural scientist.

By the mid 1700s natural philosophers such as Priestley were beginning to write down chemical equations. Almost all of the earliest chemical reactions studied by Priestley and his contemporaries involved oxygen.

charcoal (+ Π) + air = fixed air(CO_2) + phlogisticated air
metal (+ Π) + air = calx (pure base) + phlogisticated air
charcoal (+Π) + calx = metal (+Π) + fixed air
metal (+ Π) + water = calx + inflammable air (Π)
metal (+ Π) + acid = salt + inflammable air (Π)
mercury (+Π) + dephlogisticated air = calx of mercury
inflammable air (+Π) + dephlogisticated air = water

Table 1. *A list of some early chemical equations; the symbol Π is used to represent phlogiston.*

The first attempts at chemical equations, as seen in Table 1, generally involved a material containing its phlogiston reacting with air, so as to give up its phlogiston, which would appear in one of the products. Besides his most famous discovery of all, oxygen, Priestley went on to discover and characterize the reactions involving nine gases. He isolated pure oxygen by heating the oxide of mercury. In keeping with the phlogiston concept, air that was capable of reacting with a solid to accept the transfer of phlogiston was aptly named "dephlogisticated air."

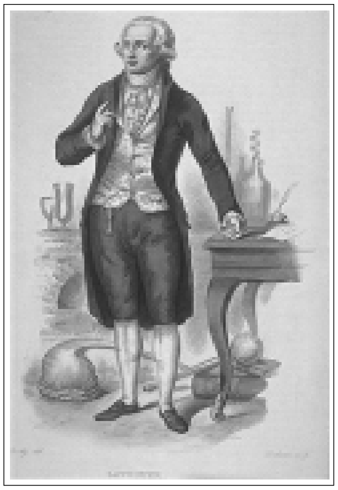

Figure 3. *Antoine Lavoisier (1743-1794) usurped Priestley's discovery and renamed his dephlogisticated air "oxygen."*

Soon after the time of his discovery of dephlogisticated air, Priestley met Lavoisier in Paris and told him of his discovery. Lavoisier, however, had invented a balance that could weigh very accurately to 0.0005 g. He was able to confirm that when inflammable air (hydrogen) reacted with dephlogisticated air (oxygen) to give water, there was no mass present except that of the reactants and products of the reaction (7).

Lavoisier had discovered the principle of "conservation of mass" in chemical reactions. He argued that since the mass of the reactants equals the mass of the products, in the reactions he investigated, there was no mass that could account for phlogiston. Phlogiston therefore could not exist. Phlogiston theory effectively died on September 5, 1775, the day Lavoisier presented his paper to the French Academy of Science, and as far as historians of science are concerned, has remained dead and buried. Lavoisier and the antiphlogistonists staged a ceremonial bonfire of all the old chemistry books based on the theory of phlogiston.

The empirical 1st law of thermodynamics, the mechanical equivalent of heat, was discovered in 1850 by Joule. The 2nd law and the concept of entropy were proposed around the same time by Clausius. It was not until Gibbs introduced the concept of chemical potential, however, in the late 1880s that the true driving force for all physical and chemical change was discovered. Gibbs was the first to explain why chemical reactions take place; he introduced the concept of Gibbs free energy and the related concept of chemical potential (9).

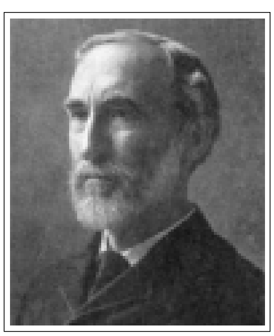

Figure 4. *The great American scientist J. W. Gibbs, who discovered the real driving force of chemical reactions.*

In 1885 the American mathematician and engineer J. Willard Gibbs finally applied the recently discovered and formulated laws of thermodynamics to explain why one chemical will react with another to form different compounds. Chemical reactions will take place in the direction of equilibrium until the Gibbs free energy of the reactants plus the products is a minimum. Then the reaction ceases.

Ellingham Diagrams

A modern platform for explaining the reactions of various elements with oxygen is the Ellingham diagram (10). These diagrams plot the Gibbs free energy difference between the element plus oxygen, and the metal oxide, and plot it as a function of temperature. The greater the Gibbs free energy difference, the greater the propensity of the element to react with oxygen.

Phlogiston: a Thermodynamic State Function

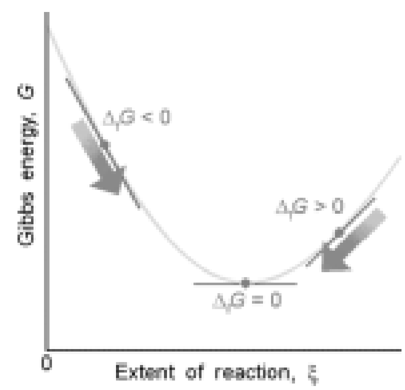

Figure 5. *Diagram showing that chemicals react until the Gibbs free energy reaches its minimum: at this point the Gibbs chemical potential of all the species within reactants and products is uniform, the total Gibbs free energy is at a minimum with respect to further change, and the reaction stops. Thus, not all the difference in "caloric content" between reactants and products is available as heat.*

In order to see the connection between caloric, phlogiston, and energy, we must now explain in further detail the concept of a state function. Energy in the form of heat (denoted by q) is not a property of a material, i.e. state function; it is energy on the move through or between materials. The total energy content of a chemical is a state function, because it depends only upon its equilibrium state of temperature and pressure. An alter-

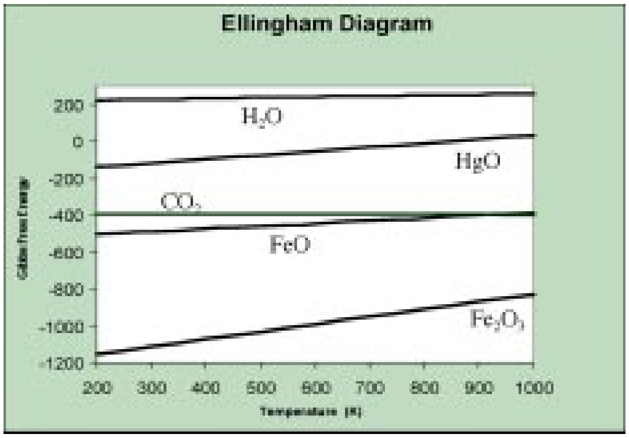

Figure 6. *Ellingham diagram for the chemical reaction of the elements hydrogen, mercury, carbon and iron, with oxygen. The Gibbs free energy change, in units of kilojoules per mole of oxygen, is plotted against reaction temperature in degrees Kelvin.*

native simple way of stating the 1st and 2nd laws of thermodynamics is to define the status of the energy as being a quantifiable function of state, being available or unavailable, in a material that changes when its state is changed. This change could be in a chemical reaction.

1st law $\Delta H = q$: enthalpy ("heat" content) [a state function]

2nd law $T/\Delta S = q$: entropy (unavailable "heat content") [a state function]

Some of the energy content of a chemical may be unavailable as heat when it burns, the amount of unavailable energy depending on the absolute temperature (T) at which it exists. A combination of the 1st and 2nd laws defines the Gibbs state function, which predicts the position of equilibrium of all chemical reactions (i.e., when $\Delta G = 0$):

1st + 2nd Law $\Delta G = \Delta H - T \Delta S$

Without changing the formal thermodynamic description of chemical reactions, we can readily redefine the Gibbs state function and give it and its two components names consistent with the caloric theory of "heat" and phlogiston theory of reactions of the 18th century. The change in Gibbs free energy for an oxidation is referred to as the chemical potential of oxygen within the material relative to its oxide.

We will simply alter the names and symbols of the energies and revert to specific rather than molar quantities (since phlogiston preceded the mole balance discovered in 1805 by Dalton) for reactions of an element with oxygen:

$$M + O = MO$$

There will be changes in the state functions for which we introduce the names "entropic energy," "caloric," and "phlogiston." The signs are conventional and can be reversed so that the phlogiston content is a positive concept.

entropic energy: $\Gamma = +T\,\Delta S/$ mol wt. of M
caloric: $C = \Delta H$ / mol wt. of M
phlogiston: $\Pi = -(C - \Gamma)$

Then, in the spirit of the Priestley equations in Table 1, we can write a simple chemical equation with a driving force on the left and heat given off on the right.

$$M + O + \Pi \text{ (phlogiston)} \rightarrow MO + C \text{ (caloric)}$$

Phlogiston is seen to be equivalent to minus the Gibbs free energy of the oxygen per unit mass of reactant. It is an extensive property of the material, depending upon its state (temperature and pressure). Phlogiston, in this definition, has dimensions of chemical potential, i.e. energy/mass (per mole equivalent of O_2).

We can now proceed to compute the phlogiston content of any element or compound or mixed material with respect to any of its oxidized states. Having done so, we can then plot the phlogiston content as a function of temperature for all elements in the spirit of Ellingham.

The interesting values of the phlogiston content in Fig. 7 reveal that the general theory of phlogiston was in many ways a reasonable description of the driving force of reactions with oxygen before the advent of chemical thermodynamics and Gibbs' chemical potential nomenclature.

The first observation that we make is that pure oxygen has no propensity to react with itself and its phlogiston content is zero at all temperatures. It is "dephlogisticated air!"

Secondly we note that the phlogiston content of the element hydrogen is so great (above 200) that it is off the diagram. Some of the 18th-century phlogistonists actually believed that pure hydrogen was phlogiston. Such misconceptions are now quite understandable.

We also note that the phlogiston content of mercury is very close to zero; in fact it is positive up to 900 degrees and then it crosses zero and goes negative. It is this simple fact that enabled Joseph Priestley to discover pure oxygen in 1774 by heating the oxide of mercury

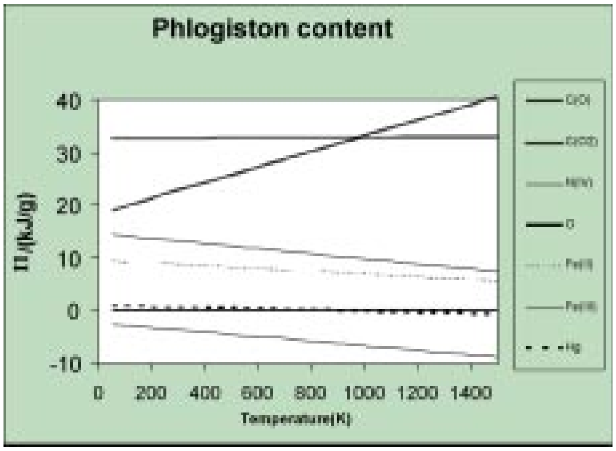

Figure 7. *Phlogiston content of carbon, nitrogen, oxygen, iron, and mercury calculated from thermodynamic tables as a function of temperature for a range of elements investigated by Priestley and his contemporaries. The line for hydrogen is too high for this scale (around 250 in the above units of kilojoule per mole of oxygen) compared to all other elements. Notice that the phlogiston content may be both positive or negative. It is negative in the case of nitrogen gas, hence the stability of the earths atmosphere.*

above 900 degrees. He could restore the phlogiston content of mercury and produce "dephlogisticated air."

Revolutions in Chemistry

The discovery of conserved quantities of mass and molecule equivalents in chemical reaction has been identified with the 1st and 2nd chemical "revolutions," respectively. But the real revolution, it seems, was yet to come. The conservation of mass discovered by Lavoisier (7), according to historians of chemistry, gave rise to the first chemical revolution. One could argue that it was the birth of chemistry. The atomic theory of Dalton and the concept of a molecular chemical equation, in the form of Dalton's law of constant proportions, then gave rise to the "2nd chemical revolution;" perhaps the beginning of the degeneration of chemistry, inorganic and organic chemistry, but the real revolution, and the subject of physical chemistry, was yet to come.

	Year AD	discoverer	balance
1st	1775	Lavoisier	mass
2nd	1804	Dalton	mole
3rd	1850	Hess	enthalpy or "caloric"
4th	1885	Gibbs	free energy or "phlogiston"

Table 2. *Chronology of "chemical revolutions" arising from the discoveries of mass and energy balances in chemical reactions.*

The protagonists of the first revolution in chemistry were the antiphlogistonists, but they failed to address the fundamental question, "Why do two chemicals react if there is no phlogiston?" The atomic theory of Dalton explains the mole balance in chemical equations, but, again, Dalton's atomic theory neglected to address the question of the driving force for chemical change.

Thermodynamics began with the conservation of energy, in the form of the 1st law of thermodynamics; the appropriate balance law for chemical reactions is Hess' law of constant heat summations. This is merely an alternative statement to "caloric is a state function." Science had to wait another 30 years after the advent of thermodynamics before Gibbs, proposed that the ultimate driving force for chemical equilibrium is the equality of chemical potential of any species on either side of the reaction. Alternatively, we can state that the reactants have zero phlogiston. This surely marks the 4th revolution in chemistry but the first real revolution in physical chemistry, and hence also in chemical engineering

Conclusions

In a Priestley publication of 1796, which he pointedly addressed to the list of French antiphlogistonists, Priestley wrote as follows in his conclusion (11):

> The phlogiston 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 but that they are properly 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.

It can be concluded here that, although the antiphlogistonists might have rightful claim to be the founding fathers of *inorganic chemistry*, they did not address the question of why chemical reactions take place. They ridiculed the phlogiston theory but had no replacement. We can now see why Priestley adhered stubbornly to the theory until his dying day. It was because he instinctively knew there had to be something to account for the propensity of elements to react with oxygen and for the variations in that propensity from one element to another. Priestley, it might be argued, was not the last phlogistonist, but the first physical chemist. One could speculate that if J. W. Gibbs had been a chemist rather than a mathematician and engineer, he might have given some credit to the phlogiston theory.

Gibbs theory, as it was originally published, was not easy for the uninitiated to understand. It took ten years before his great work was recognized as such by the scientific community (13). This could be yet another reason why historians of science have not been so kind to Priestley and his phlogiston; they themselves may not have fully understood the concepts of Gibbsian thermodynamics, or why chemicals react!

REFERENCES AND NOTES

1. J. Priestley, *Experiments and Observations on Different Kinds of Air*, J. Johnson, London, 1774.
2. J. Priestley, *History of the Present State of Electricity with Original Experiments*, J. Johnson, London, 1772.
3. J. Priestley, "On the Nature and Essential Properties of Matter," in *Disquisitions Relating to Matter and Spirit*, J. Johnson, London, 1777, Section II, p 5.
4. Ref. 3, p 6.
5. Ref. 3, p 7.
6. J. Priestley, "Observations Concerning the Velocity of Light," in *History and Present State of Discoveries Relating to Vision Light and Colours*, J. Johnson, London, 1772, Section III.
7. A. Lavoisier "Memoir on Combustion in General," *French Philos. Soc. J*., **1775.**
8. J. Robinson, Ed., *Lectures on the Elements of Chemistry, by Joseph Black*, University of Edinburgh, 1809.
9. J.W. Gibbs, *The Collected Scientific Papers*, *Thermodynamics*, Longmans Green, London and New York, 1906, Vol. I.
10. H. J. T. Ellingham, *J. Soc. Chem. Ind*., May, 1944. 125-133.
11. J. Priestley, "Considerations on the Doctrine of Phlogiston and the Decomposition of Water," Thomas Dobson, Philadelphia, PA, 1796.
12. T. L. Davis, "Priestley's Last Defense of Phlogiston," *J. Chem. Educ*., **1927,** *4*, 176.
13. C. E. Moore, A.. Smolinski, and B.Jaselskis, *Bull. Hist. Chem.* **2002**, *27*, 114-127.

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PANTISOCRACY AND PENNSYLVANIA: PLANS OF COLERIDGE AND SOUTHEY AND OF COOPER AND PRIESTLEY [(1)]

J. Edmund White

Introduction

During the period 1793-95, two plans for settlements in the central part of the State of Pennsylvania were proposed and pursued, each associated with the immigrations to that region of Dr. and Mrs. Joseph Priestley and their three sons. One of these plans—a refuge for English "friends of liberty"—involved a Priestley son and perhaps the father, whereas the other—a utopian "Pantisocracy"—was conceived and developed by several young poets, primarily Samuel Taylor Coleridge and Robert Southey. The two proposals are connected to some extent by the fact that the poets decided to establish their colony close to the Priestley settlement. A mutual friend had assured Coleridge that Dr. Priestley would join them (Coleridge to Southey, September 6, 1794) (2), and some writers have asserted that the poets were following Priestley. The extent to which the two projects were inter-related will be examined.

Biographers of the men involved have treated these episodes in their lives quite differently, but few have dealt carefully with the relationship between the two proposals: e.g., a) a recent excellent study of Dr. Priestley's emigration to America does not include any mention of pantisocracy (3); and b) editors and biographers of the poets often barely mention the Pennsylvania land scheme or, when they do, often get the details wrong. One thorough study of both proposals in 1947, by Mary Cathryne Park (4), is very valuable for the information she retrieved about the sites of the proposed settlements and the lands involved; but she assumed a participation by Dr. Priestley in the project not supported by the evidence, possibly because of some confusion between references to the father and the son. Thus it is important to distinguish between the two Joseph Priestleys; Cooper sometimes referred to them as "old Priestley" and "young Priestley," but, in this paper, the father will be "Dr. Priestley" and the son "Joseph."

Some questionable claims and some clearly incorrect statements have reappeared through the years. One illustration of such errors is found in a biography of Coleridge published in 1996 (5). Several pages are given to a description and good analysis of the concepts underlying Pantisocracy; but, then, it is stated incorrectly that Dr. Priestley "settled in Philadelphia, where he owned land," that, at the start of the Birmingham Riots, the mob followed him home from the meeting, and that Thomas Cooper was his son-in-law. Similar inaccuracies occur in a recent biography of Southey (1997), in which the author says that Priestley emigrated in 1791 and describes him as Cooper's father-in-law (6). The error about Cooper has reappeared many times from at least 1917 (7), but the claim is easily refuted. Dr. Priestley's one daughter, Sarah, married William Finch, and the couple remained in England. Thomas Cooper was <u>not</u> the Doctor's son-in-law.

Both schemes for settlements in the New World had their origins in dissatisfaction with the state of affairs in

England with regard to both religion and government. When the French Revolution began, the upper classes of England feared that the spirit of revolt would spill over the Channel. The long-established alliance of Church and State rose to meet this perceived threat, and oppression of all liberal voices increased. The young poets, especially Southey while still in his teens, were impressed by the social ideas of Godwin, by the goals of the French revolution, and by Dr. Priestley's writings on civil, religious, and political liberty. They were upset by the actions of the government and spoke out against them. In the public eye, they were associated with Priestley and other radicals, as shown by a Gillray caricature, published as a very large foldout in the *Anti-Jacobin Magazine and Review*, August, 1798, four years after the Doctor already had left the country (8, 9). Southey and Coleridge are shown with asses' heads, clearly a reference to the latter's poem, "To a Young Ass" (10), which includes the first mention in print of pantisocracy (11).

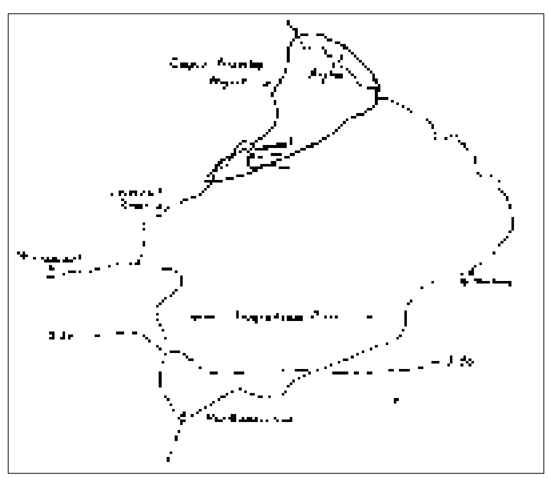
Emigration and the Cooper/Priestley Land Project

The Birmingham Riot of 1791 was the beginning of the end in England for Dr. Priestley and his sons. Joseph, the eldest, had been placed with a merchant in Manchester, but, in the winter of 1792, he was fired, and no one would risk giving him a position. In 1792 William, the second son, went to France, where his father had some money invested, and became a naturalized citizen. Although his father and older brother had considered joining him there, conditions in France worsened, and William left, early in 1793, for America. Six months later, on August 15, 1793, Joseph and Henry, the third Priestley son, left England for America. With them went Thomas Cooper, a political ally of their father and henceforth a family friend (12). Cooper was one of the most active radicals of the time, especially as an editor of the *Manchester Herald* (13). The emigrants had planned to visit friends in Kentucky and Boston and to look around before deciding where to settle. "We intended to have gone directly from Philadelphia to Kentucky" (14). After talking to John Vaughan, a friend from Birmingham now located in Philadelphia, they traveled instead into north and central Pennsylvania, were impressed with lands along the Susquehanna River, and soon had launched a major land development scheme. They contracted for over 200 "purchases" of 300 to 1,000 acres each and six of 25,000 to 216,000 acres, much of it in various partnerships of Joseph with several different people. The eventual total was about 700,000 acres. Some transactions are dated in 1795 and, curiously, even 1803 and 1804 (15).

The location of these "Cooper-Priestley" lands, in the upper middle part of Pennsylvania, is shown in the Figure, which is based on a drawing by Park (16) and includes modern cities and highways. Northumberland, the town in which Dr. Priestley would buy land and build his home, is about 40 miles north of Harrisburg and 110 miles northwest of Philadelphia at the juncture of the two forks of the Susquehanna River. Forksville, about 45 miles from Northumberland on the Loyalsock Creek and originally called "Cooper's Town," is where Joseph and Cooper built their first homes. The distance across the project is about 35 miles. On page 34, Park reproduced the actual Land Patent for a plot of 337 acres purchased by Joseph from Dr. Benjamin Rush, the well-known Revolutionary War figure who also speculated in land. All of these tracts were not bought; Park calls them purchases but does not describe financial arrangements. Many may have been merely options to buy, as implied by Dr. Priestley in a letter of September 14, 1794, as quoted in a letter from William Vaughan (17):

> What brought us here was the expectation of its being near the settlement that my Son & Mr. Cooper are projecting, & behold *that is all over*. When the lands came to be viewed they appeared not to be worth purchasing ...They were deceived by the Proprietors & by the Evidence that had appearance of being satisfactory ...

How much was Dr. Priestley involved in this project? Park decided that he had helped devise the plan and sent Joseph to buy the land, saying that the land purchases



Sketch showing location of Cooper/Priestley Project, based on Park (16) were "probably by his direction" and that "Priestley sent his son Joseph, his son-in-law Thomas Cooper," and others to find a place for "a proposed settlement of English friends of freedom and to purchase the lands chosen" (18). These statements seem to be contrary to the evidence

A few excerpts from a letter to John Vaughan in Philadelphia show Dr. Priestley's indecision as of February 6, 1793 (19):

> Such is the increasing bigotry and violence of the High church party in this country, that all my sons must leave it, and settle either in France or America. As my daughter, however, must remain here, I own I should incline to France, which is so much nearer.

He then admits that getting to France would be difficult at that time and then adds:

> My son Joseph . . . inclines to America…They think of going to Kentucky. As I shall, in all probability, follow my sons, I incline to the neighborhood of Boston, where, I imagine, the society will suit me best.

This letter was written about fourteen months before the Priestleys left England; at that time clearly no project or settlement was planned, and Pennsylvania was not mentioned. This state became the site only when, as mentioned, Cooper and the Priestley sons were diverted by John Vaughan to investigate the Susquehanna valley and then "decided upon their ambitious plan of purchasing lands in a consortium" (20). This statement implies that Graham also does not think the plan had been started back in England by Dr. Priestley.

On January 25, 1794, Dr. Priestley wrote to his brother-in-law, John Wilkinson, that the idea of buying the land came from John Vaughan, that he had definitely decided to go to America himself, and that he was "much interested in the scheme formed by Mr. Cooper and my sons in America" (21). In February, 1794, Cooper returned to England to get the rest of his family and to publish his book, *Some Information Respecting America*, which is organized as several letters "To a Friend" (22). In these, he compared possible sites for settlement, recommending Pennsylvania. The book provided a very complete set of directions for persons planning to emigrate, including tables of duties, comparative prices, and other useful information, and it made a strong impression on Coleridge (23).

On April 7, 1794, Dr. and Mrs. Priestley boarded the *Samson*, sailed from Gravesend, and arrived in New York City on June 4 (24). On June 27 he wrote (25):

> I think I shall settle in the back part of this state, at Northumberland, near the place where my sons are making their establishment.

In this letter and the one of September 14, quoted above, two points stand out: first, the Doctor's home would be near the settlement, not a part of it; second, he does not consider himself as a partner in the project, which was the province of his sons and Mr. Cooper. On the last page of his autobiography, Dr. Priestley says (26):

> At the time of my leaving England, my son, in conjunction with Mr. Cooper and other emigrants, had a scheme for a large settlement for the friends of liberty in general, near the head of the Susquehanna, . . . I . . . came to Northumberland, the town nearest to the proposed settlement, thinking to reside there until some progress had been made in it.

Here again, the scheme is not his in any way, but he does imply that he would have moved to the settlement if it had gone forward.

Thus, no evidence seems to exist to support claims that Dr. Priestley planned the land project and sent his sons and Cooper to carry out the plan. It is just the opposite; he always refers to it as their plan. Although Joseph might be protecting either his personal interest or his father's reputation, what should be the final word comes from his continuation of his father's memoirs (27):

> He had not, as has been erroneously reported, the least concern in the projected settlement. He was not consulted in the formation of the plan of it, nor had he come to any determination to join it, had it been carried into effect.

Poets and Pantisocracy

Because the poets' story has been told with a range of detail in various biographies, here only the essential parts are included. When Robert Southey, age 18, began his studies at Balliol College, Oxford, in January, 1793, he had been attracted to William Godwin's ideas on rationalism and republicanism, was a supporter of the French Revolution, and was unhappy with the situation in England. Utopian ideas were in his thoughts; in November and

Robert Southey

December, 1793, he was writing about going to France or America, if he were not tied down by family commitments. He wrote of plowing, swinging an ax, grubbing roots, sleeping on rushes, and probably being scalped by an Indian (28).

Samuel Coleridge also was caught up in the fervor over social justice and civil liberty and was very upset by the treatment of Dr. Priestley, as revealed in his sonnet "To Priestley" (December, 1794) (29). In June, 1794, Coleridge, aged 22 and a student at Cambridge University, came to Oxford to visit a friend and was introduced to Southey. The proverbial spark was struck, and an almost instantaneous friendship blossomed as the two explored their common interests: poetry, democratic ideals, despair over the state of affairs in England, and disillusion with the French Revolution. They were, as one author has said, "caught in the stream of Utopian thought which was sweeping Europe in the wake of the French Revolution" (30). Before parting for the summer, they had discussed a settlement in America. Much later, in a letter to Cottle (March 5, 1836), Southey recalled that "the scheme was talked of, but not by any means determined on. It was talked into shape by Burnett and myself," while they were walking to Bath (31). Probably the main contribution of George Burnett, also a student at Balliol, was to offer a receptive ear to his friend (32). Some weeks later, Coleridge joined them in Bristol, and (from the same letter) "Then it was that we resolved upon going to America."

This statement of the origin of the scheme is emphasized because some biographers write as if the concept were developed by Coleridge. One even calls it "Coleridge's Scheme of Pantisocracy" (33). He certainly was the most vigorous proponent, but, to counter any claim that Southey's memory in 1836 was faulty, consider also a letter to his brother (October 19, 1794), written while the events were occurring (34):

> My aunt abuses poor Lovell most unmercifully, and attributes the whole scheme to him; you know that it was concerted between Burnett and me.

Robert Lovell, another Balliol man, was an aspiring poet and the first of the group to marry one of the Fricker sisters, for which his wealthy Quaker family threw him out (35).

Briefly, pantisocracy may be described as a fusion of ideas from Paine, Priestley, Hartley, Godwin, and Dyer concerning human rights, the perfectibility of mankind, civil liberty, religious freedom, benevolence, and similar concepts flowing in that "stream of Utopian thought." Its name comes from the Greek "pan-socratia"(36). Southey defined the two main aspects of the plan for his brother in September, 1794 (37):

> We preached Pantisocracy and Aspheterism every where [*sic*]. There, Tom, are two new words, the first signifying the equal government of all—and the other—the generalization of individual property.

In modern terms, it could be called a democratic, communal society. In a letter of August 22, Southey, revealing his lack of knowledge about life on the frontier, had written that they would establish a system (38):

> …where the common ground was cultivated by common toil, and its produce laid in common granaries, where none are rich because none should be poor, where every motive for vice should be annihilated and every motive for virtue strengthened…When Coleridge and I are sawing down a tree, we shall discuss metaphysics; criticize poetry when hunting a buffalo; and write sonnets whilst following the plough. Our society will be of the most polished order.

Joseph Cottle, the publisher and a benefactor of the young poets, reports that Lovell told him the plan was "to form a Social Colony, in which there was to be a community of property, and where all that was selfish was to be proscribed." The participants would have "tried and incorruptible characters." They would achieve a society free of the "evils and turmoils that then agitated the world" and would "present an example of the eminence to which men might arrive under the unrestrained influence of sound principles." They hope "to regenerate the whole complexion of society" and to set "an example of 'Human Perfectibility'" (39). Such goals were typical Enlightenment concepts, and the poets' nonsectarian plan, although unrealized, can be viewed as a step toward a secular society in the communitive movement in America, which, for over a century, had been sectarian (40).

The unrealistic expectations, especially as to the hard work that would be necessary, can be blamed to a large extent on the misleading promotional writings about America that were popular in England. Cooper and other travel writers exaggerated the good features and minimized or simply omitted the bad. Probably it was the poets' enthusiasm for their vision that led them to disregard warnings about emigration that were appearing in editorials and articles in the press (41). Cottle wrote that they talked constantly about pantisocracy and that they "repel every objection to the practicability of their scheme." He had thought that "their strong good sense would eventually dissipate their delusion" (42).

There is a lack of agreement as to the initial destination of the Pantisocrats. The claim by some writers that the poets were following Dr. Priestley to Pennsylvania is bothersome for two reasons. First, the poets' letters almost never mention Priestley by name. Second, the original idea, at least for Southey, was to go to Kentucky. On July 20, 1794, he wrote of "dwelling in Kentucky" (43), and, in two letters, both dated August 1, 1794, he invites friends: "Come to us in Kentucky," and "I shall hope you will join us in Kentucky" (44). The destination changed, however, within three weeks; on August 22, Southey wrote that, in one year, "the Pantisocratic society of Aspheterists will be settled on the banks of the Susquehannah [*sic*]." Coleridge also wrote, apparently around the same time, "at present our plan is, to settle at a distance, but at a convenient distance, from Cooper's Town, on the banks of the Susquehanna. This, however, will be the object of future investigation." So, in his mind, the location still was not definitely settled. He also said that they intended to leave in March and, again showing his inexperience in such matters, that, during the winter, they would learn "the theory and practice of agriculture and carpentry" (45).

Samuel Coleridge

Trying to establish just where the poets intended to settle, Park analyzed Coleridge's statement and pointed out that, to be near Cooper's Town and also on the river, the settlement would have to be in the vicinity of Asylum, a community of French Girondist refugees (see Figure). She suggests that the land was made available to the French by "Cooper, the Priestleys and their company" and that this settlement may have been an added attraction for Coleridge and Southey, who sympathized with the refugees' cause (46), although no mention of refugees or this town has been found in the poets' writings. Another objection to this suggestion is that only in June, 1795, was it reported in *Gentleman's Magazine* that a group of Girondon emigrants had settled in Frenchtown, near the Susquehanna (47). If this refers to Asylum, it would be too late to have influenced the poets.

The change from Kentucky to Pennsylvania was probably Coleridge's doing. He had read many accounts of travels in America, including Cooper's recently published exuberant presentation of the wonders of the Susquehanna Valley (48), in which he described the pleasing prospects of clearing land easily and living comfortably with only a few hours of work a day. Coleridge wrote to Southey, on September 6, 1794, that, while in London, he had breakfasted with George Dyer, who was enthusiastic about their plans and who claimed to be "intimate with Dr. Priestley, and doubts not that the Doctor will join us" (49). George Dyer was an author interested in social problems and one of the lesser literary lights around London. In the same letter, Coleridge reported meeting several times with "a most intelligent young man" who had spent five years in America and "is lately come from thence as an agent to sell land" and that "He recommends the Susquehanna." It sounds as if Coleridge still was trying to convince himself.

Park concludes that this young man was an agent for the Cooper/Priestley development, because the arguments he used were essentially the same as those in Cooper's book (50). Other writers have suggested he was Cooper himself, but this is impossible for two reasons: Coleridge said he had known the man in school, and Cooper had not lived in America five years.

With the possible exception of this meeting with a land agent, who may have represented Cooper and Joseph, there appears to have been no contact between the poets and the land developers. There is no evidence that anyone reported Coleridge's interest back to Pennsylvania. There is no mention of the poets or of pantisocracy by the Priestleys or Cooper during these years. Ironically, about this time, Dr. Priestley, if not the proprietors, had given up on the project (see his letter of September 14, above, in which he said: "behold that is all over.") So, as the poets continued their planning, they did not know that the large settlement of English expatriates, near which they intended to settle, probably would not exist.

In this same September, in the letter to his brother quoted above, Southey wrote that they were planning to depart in March, 1795. On October 12, he reported to his brother that their number now was 27 (51). Five days later, the first disaster struck: Southey's wealthy aunt, of whom he was to be the heir, learned of his plans to go to America and to marry Edith Fricker. She disinherited him and ejected him from her house into a violent rain storm. Southey, however, did not lose his resolve; he and the others spent the winter trying to earn the necessary funds but were not successful enough. On March 21, he raised the possibility of his and Coleridge's taking wives and living on a farm to begin to learn the skills they would need in America and to begin to practice the ideals of pantisocracy. The situation, however, continued to worsen. Lovell died, and Coleridge heard that Southey had talked of having servants and private ownership of land—except for a small amount to be held communally—and had decided to accept a position offered by an uncle. In November, an angry Coleridge wrote a long critical letter to Southey, condemning him as a traitor to the ideal of pantisocracy and blaming him for the death of their scheme (52).

Southey broke away fairly easily from the doctrine and the enthusiasm that had been a dominating part of his life for over a year, but it was not easy for Coleridge, who continued to dream and write about pantisocracy for several years. Even in 1801, he wrote to Poole that, if he could retain his annuity, "I would go and settle near Priestley in America" (53). This mention of Priestley, five or six years after the project was dead, seems to be only the second one in the early letters of Coleridge, the first, in 1794, being merely the report of Dyer's remarks. The only mention in a Southey letter, in 1797, is similarly indirect: "I have lived much among the friends of Priestley ..." (54).

Conclusion

1. Dr. Priestley did not take an active part in the Pennsylvania land development consortium. He did not contract for land on speculation or buy a lot in that area for his own home. The settlement proposed by his son and Cooper was an attempt to attract liberal minded Englishmen who felt compelled to leave their country, but it was a money making enterprise, and probably no purchaser would have been excluded. It appears that neither Cooper nor the two Priestleys knew about the emigration plans of the poets back in England.

2. In the end, the poets fared better than if they had raised the funds needed to emigrate. Since they were completely unprepared for the hard labor that would be required, it is highly unlikely that they could have survived in Pennsylvania and, even if they somehow had managed, that they would have produced the body of Romantic poetry, which is the basis of their substantial literary reputations. This reason for predicting that the poets' project would fail, if they had managed to get to America, is suggested by Joseph in his insightful analysis in which he admits that it is just as well that his own project did not go any further. He wrote, in 1804 (55):

> Fortunately for the original proposers, the scheme was abandoned.

After saying that it might have worked out financially, he goes on:

> …but the generality of Englishmen come to this country with such erroneous ideas, and, unless previously accustomed to a life of labour, are so ill qualified to commence cultivation in a wilderness, that the projectors would most probably have been subject to still more unfounded abuse than they have been, for their well-meant endeavours to promote the interests of their countrymen.

3. Although the poets shared many of Dr. Priestley's principles and beliefs, as reflected in the various descriptions of pantisocracy, a claim that they were following him to America is difficult to support. He is rarely mentioned in their letters, and the specific details of their plan were based on Cooper's book. The Doctor's significant role in the development of British thought in the later years of the Enlightenment, his calm resolve in the face of abuse and adversity, and his eventual 'exile' (seen as martyrdom) made him, in accord with the metaphor in the title of the ACS symposium (56), an obvious catalyst for the blossoming of the latent social sensibilities of the young poets; but, as is often the case, the reaction proceeded without the presence of the catalyst being obvious.

REFERENCES AND NOTES

1. A version of this paper was presented as part of the symposium "Joseph Priestley, Universal Catalyst" at the 228th National Meeting of the American Chemical Society, Philadelphia, Pa., August 23-24, 2004, HIST 021.
2. E. L. Griggs, Ed., *Unpublished Letters of Samuel Taylor Coleridge*, Constable, London, 1932, 21-22.

3. J. Graham, "Revolutionary in Exile: The Emigration of Joseph Priestley to America, 1794-1804," *Trans. Am. Philos. Soc.*, **1995**, *85*, Part 2, 1-213.
4. M. C. Park, "Joseph Priestley and the Problem of Pantisocracy," *Proc. Delaware Co. Inst. Sci.*, **1947**, *10*, 1-60.
5. R. Ashton, *The Life of Samuel Taylor Coleridge*, Blackwell, Cambridge, MA., 1996, 45.
6. M. Storey, *Robert Southey: a Life*, Oxford University Press, Oxford, 1997, 52.
7. W. Haller, *The Early Life of Robert Southey, 1774-1803*, Columbia University Press, New York, 1917, 141.
8. Anon., "Explanation of the Satyrical Print," *Anti-Jacobin Mag. and Rev.*, **1798**, *1*, 115-16.
9. C. Edmonds, *Poetry of the Anti-Jacobin*, G. Willis, London, 2nd ed., 1854, 247.
10. J. C. C. Mays, Ed., *The Collected Works of Samuel Taylor Coleridge*, Princeton University Press, Princeton, NJ, 2001, Vol. 16: *Poetical Works*: Part 1, *Poems*, 146.
11. R. Holmes, *Coleridge: Early Visions*, Viking, New York, 1990, 82-83.
12. Some authors have stated incorrectly that Cooper left after Dr. Priestley.
13. C. Horner, "The Rise and Fall of Manchester's 'Set of Infernal Miscreants': Radicalism in 1790s Manchester," *Manchester Region History Review*, **1998**, *12*, 18-26.
14. T. Cooper, *Some Information Respecting America*, J. Johnson, London, 1794, 24, n.
15. Ref. 4, pp 52-57.
16. Ref. 4, p 33.
17. Ref. 3, p 178.
18. Ref. 4, p 12.
19. Ref. 3, p 174.
20. Ref. 3, p 33.
21. Ref. 3, p 34.
22. Ref. 14.
23. S. Eugenia, "Coleridge's Scheme of Pantisocracy and American Travel Accounts," *PMLA*, **1930**, *45*, 1069-84, 1073.
24 Ref. 3, p 35.
25. R. E. Schofield, Ed., *A Scientific Autobiography of Joseph Priestley: Selected Scientific Correspondence*, MIT Press, Cambridge, MA, 1966, 281.
26. J. Lindsay, *Autobiography of Joseph Priestley*, Adams & Dart, Bath, 1970, 133.
27. J. Priestley, *Memoirs of the Rev. Dr. Joseph Priestley to the year 1795 with a Continuation by his son, Joseph Priestley*, J. Johnson, London, 1809, 147-148.
28. Ref. 6, p 40.
29. Ref. 10, p 157.
30. R. W. Armour and R. F. Howes, *Coleridge The Talker*, Johnson Reprint, New York, 1969.
31. J. D. Campbell, *Samuel Taylor Coleridge*, Macmillan, London, 1896, 31.
32. Ref. 7, p 131.
33. Ref. 23.
34. J. Dennis, Ed., *Robert Southey. The Story of his Life Written in his Letters*, Bell and Sons, London, 2nd ed., 1894, 91.
35. K. Jones, *A Passionate Sisterhood: The Sisters, Wives, and Daughters of the Lake Poets*, Constable, London, 1997, 10.
36. Ref. 35, p 13.
37. K. Curry, Ed., *New Letters of Robert Southey*, Columbia University Press, New York, 1965, 74.
38. Ref. 37, p 70.
39. J. Cottle, *Reminiscences of Samuel Taylor Coleridge and Robert Southey*, Houlston and Stoneman, London, 2nd ed., 1848, 2.
40. A. E. Bestor, *Backwoods Utopias; The Sectarian Origins and Owenite Phases of Communitarian Socialism in America: 1663-1829*, University of Pennsylvania Press, Philadelphia, PA, 2nd ed., 970, 36-37.
41. Ref. 23, pp1080-1081.
42. Ref. 39, pp 6,11.
43. Ref. 37, p 60.
44. Ref. 37, pp 65, 66.
45. W. G. T. Shedd, Ed., *The Complete Works of Samuel Taylor Coleridge*, Harper & Sons, New York, 1884, 623-624.
46. Ref. 4, p 32, n.
47. Ref. 6, p 51.
48. Ref. 14.
49. Ref. 4, p 38.
50. Ref. 4, p 38.
51. Ref. 37, p 80.
52. Ref. 5, pp 72, 73.
53. Ref. 23, p 1080.
54. C. Ramos, Ed., *The Letters of Robert Southey to John May, 1797 to 1838*, Jenkins, Austin, TX, 1976, 26.
55. Ref. 27, pp 147,148.
56. Ref. 1.

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ESTEEM, REGARD, AND RESPECT FOR RATIONALITY: JOSEPH PRIESTLEY'S FEMALE CONNECTIONS

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Introduction

Throughout the 18th century, the watercolor portrait miniature was held in high esteem as a depiction of intimate human relationships. These 'limnings' (from the Latin luminare, meaning to give light) as they were known were commissioned and painted as documents of introduction between people, cherished personal mementoes, or memorials. This paper will 'limn' the lives of some of those females—students, acquaintances, friends and family—whom Joseph Priestley held in high regard and treated as rational beings, and illuminate their public and personal relationships.

In his letters, books, pamphlets, and memoirs, Joseph Priestley rarely mentioned his female family members, friends, and acquaintances. Nevertheless, if we carefully read Priestley's works and those of his associates, it is possible to compose brief views or sketches of some of these women often invisible in the written historical record.

Although Joseph Priestley is not known for his vocal advocacy of women's rights, his actions as a husband, father, friend, minister, teacher, and scientist, as described in these limnings, will illustrate his personal esteem, regard, and respect for the rationality of women.

Mary Swift Priestley, Mother

In 1732, Mary Swift married cloth dresser Jonas Priestley at Fieldhead in Birstall Parish near Leeds. Mary and Jonas' union produced six children of whom Joseph Priestley, born in 1733, was the eldest. Joseph was sent as a young boy to live with his maternal grandfather and remained on the farm with him until his mother died, when he was six years old. Even though Joseph had spent such a short time in his mother's care, Mary Swift Priestley was remembered by her son who wrote about her in his *Memoirs* (1):

> It is but little that I can recollect of my mother. I remember, however, that she was careful to teach me the Assembly's Catechism, and to give me the best instructions the little time that I was at home. Once in particular, when I was playing with a pin, she asked me where I got it: and on telling her that I found it at my uncle's, who lived very near to my father, and where I had been playing with my cousins, she made me carry it back again; no doubt to impress my mind, as it could not fail to do, with a clear idea of the distinction of property, and of the importance of attending to it.

Sarah Keighley, Aunt

Sarah Keighley's family connection to her nephew Joseph was strengthened when he came to live with Sarah and her husband, John, at their home, the Old Hall in Heckmondwike, in 1742. Sarah's husband was a man of considerable property who died shortly after Joseph's arrival (2). Having no children of her own, Sarah took complete care of her nephew. She saw to his liberal education and introduced him to the world of discussion and debate in the salon-style atmosphere of her home (3), "the resort of all the dissenting ministers in the neighborhood without distinction." According to Priestley (4), "From this time she was truly a parent to me until her death in 1764."

It was Sarah's wish that Priestley study religion in the Calvinist tradition in accordance with her own principles and become a minister instead of continuing in the family tradition of cloth-making. Aunt Sarah promised Joseph that if he became a minister (5), "she would leave me independent of the profession." However, Joseph's professed heterodox Arian beliefs caused controversy within his first congregation at Needham Market and also affected his relationship with his family and Aunt Sarah. In his *Memoirs*, Priestley cited (6), "the ill offices of my orthodox relations ... as partly responsible for the failure of all remittances from my aunt." Priestley named no names of these 'orthodox relations,' though Schofield (7) cites letters from Timothy Priestley, Joseph's brother, to Sarah in which he revealed the degree to which Joseph's beliefs differed from their aunt's. Thus, Aunt Sarah's intimate connection with Joseph was broken.

When Sarah Keighley died, she cut her nephew off with "only a silver tankard as a token of her remembrance." Joseph Priestley apparently took no offence. He respectfully noted that he understood his aunt's decision to leave everything to her deformed niece who depended on Sarah for complete financial support (8).

Hannah Holdsworth Priestley, Stepmother

Jonas Priestley's second wife, Hannah Holdsworth, was connected to her stepson Joseph Priestley only for a short time. Priestley may have hardly known her since he had been sent off to live with his aunt Sarah. He described her as (9) "a woman of good sense, as well as of religion." By 1752 Hannah Priestley was dead.

Mary Wilkinson Priestley, Wife

Mary Wilkinson's life began in the south of Cumbria, England, not far from Morecambe Bay. Her father, Isaac Wilkinson, was a Presbyterian migratory ironworker. With his first wife, Isaac had two boys, John and Henry. He married again sometime before 1742, when his first daughter, Mary, was born. Siblings William, Margaret, and Sarah followed in short succession (10).

By 1753 a more independent and now 'gentleman' Isaac Wilkinson made enough money to become a partner with his son, John, in an ironworks business at Bersham, Clwyd, North Wales. The region was dotted with iron furnaces, paper mills, lime pits and kilns, coal mines, and 'clinker' waste piles, but the family moved there and occupied a fine country house called "Plas Grono," near Wrexham, an area that was home to many Dissenters (11).

In 1756 Mary's brother William was sent to Joseph Priestley's school at Nantwich. Mary was about sixteen years old at the time, and she and her younger sisters may have been among Priestley's female students. Bessie Rayner Belloc described her great-grandfather's school and his educational philosophy toward women (12):

> with a separate room for half a dozen young ladies. Priestley at all times gave his best mind to the teaching of girls, and shows by many incidental words that he held women in as high mental and moral estimation as men.

When Priestley became tutor at Warrington Academy, William moved north and continued as one of Priestley's students. In this manner, the Wilkinsons maintained a connection with Joseph Priestley.

In 1762 Priestley moved into a new house at the Academy and sought ordination, as well as a connection with Mary Wilkinson. Evidently, his happy situation led Joseph to consider marriage, as is evident in this letter to John Sedden (13):

> I am going to have a dearer, more important stake in this world than I have ever yet had in it. I can sincerely say, I never knew what it was to feel a good deal on the account of another person. The hazard of bringing a person into difficulties which she cannot possibly have any idea or prospect of, affects me, at times, very sensibly.

Mary became Joseph Priestley's wife on June 23, 1762 at Wrexham parish. Whether Mary brought a dowry to her marriage is not known, but if one were provided, her elder brother, John, may have been a contributor.

The newly married couple took in students as boarders to supplement Joseph's salary of 100 pounds per annum. Mary supervised the boarders and saw to the running of the household. In 1763 Mary bore her first child, Sarah. The difficulties of childbirth, challenges of caring for her boarders, and the damp environment of Warrington's location on the Mersey River may have contributed to the health problems that plagued Mary for the rest of her life (14).

Mary and Joseph moved several times—first to Leeds, Yorkshire, then to Calne, Wiltshire, and later to Birmingham in the Midlands—always in search of a situation that would afford Joseph professional opportunity and adequate financial support for the growing family that now included sons Joseph, William, and Henry.

Friends, patrons, and subscribers gave money to offset the Priestley's moving expenses and provide income to supplement the salary he received as a minister. Reverend Theophilus Lindsey and his wife, Hannah, introduced Priestley to Mrs. Elizabeth Rayner, one of Lindsey's "hearers and most zealous friends" who became Joseph's greatest benefactress (15). Mrs. Rayner gave Priestley annual gifts of 50 pounds and bequeathed 2,000 pounds to him in her will (16).

Mary's brother, John, found (and probably leased) the country Georgian house called Fair Hill, just outside Birmingham, for Mary and Joseph (17). The property had gardens and outbuildings, and Mary had three servants: Hannah Woodcock, Mary Rawlison, and a servant boy to help with the housework (18). The eleven years Mary and Joseph spent in Birmingham were years of relative peace, contentment, and happiness. They enjoyed spending evenings at the fireside in the parlor talking with the children (19). Daughter Sarah married and gave her parents their first grandchild, and their sons seemed destined for employment with their successful ironmaster uncles.

Figure 1. *An older Mary Priestley wearing a shawl. Copy of James Millar (c.1735-1805) after Carl F. von Breda (1759-1818) painting of Mary Priestley by Beverley Conrad, 1995. Courtesy Joseph Priestley House, Pennsylvania Historical and Museum Commission.*

The Church and King riots of 1791 changed Mary's life forever. The drunken mob sacked, looted, and burned Fair Hill. The losses she and Joseph suffered were extreme and the days of mayhem affected Mary's health: her old illness returned and she was spitting blood.

With funds in short supply, John Wilkinson sent the Priestleys 500 pounds, invested 10,000 in French funds with the interest going to his brother-in-law, and provided 200 pounds annually for their support. The increasingly tense political and social atmosphere surrounding the Priestleys between 1791 and 1793 affected their sons, whose prospects for suitable employment in England were substantially reduced. When young Henry learned at school in Hackney that some friends desired to go to America, a plan for the family's emigration began to develop.

Mary was about 51 years old when she sat for a portrait (Fig. 1) by Swedish artist Carl F. von Breda, who painted her wearing a fine muslin cap trimmed with lace over her white hair. Her countenance is thoughtful but lined with distress. Mary is enveloped by a shawl, over the shoulders of her plain black dress, a source of warmth and comfort worn during threatening times. (20).

Tears and disappointment must have overflowed in the Priestley family in the spring of 1794 when Joseph and Mary Priestley set sail for America. They left Sarah and her four children, six years of age and under, in England, with a husband whose difficult and obstinate attitude was of great concern to her parents (21). The sadness of their farewells can only be imagined. After a voyage of much sickness, travel on rough roads from New York to Philadelphia, and thence 120 miles to remote Northumberland, Mary arrived in the village of about 100 houses. As her husband wrote to John Wilkinson from Philadelphia on June 27, 1794, Mary preferred a country home (22): "your sister, as well as myself, dislikes living in such a city as this. We want no more society than we shall have among ourselves at Northumberlan" On August 26, Mary confirmed (23):

> I like America very well . . . and I am happy and thankful to meet with so sweet a situation and so peaceful a retreat as the place I now write from . . .. I am anxious to be settled ourselves, we are not at a time of life to keep rambling about.

Mary and Joseph planned a new home to be built on North Way near the Susquehanna River. From her temporary house nearby, she could see the progress of the home as it rose. Mary's illness became more serious, and she was nursed by her daughters-in-law and a friend, Mrs. Bakewell. She died on September 7, 1796, nine months after the death of her youngest son, Henry, and approximately fifteen months before her new home was ready for occupancy (24). Mary Priestley was fifty-four years old.

Since Mary destroyed most of her correspondence, we can only guess how she might have felt raising her children in so many houses crowded with her husband's books and accumulating collections of scientific apparatus, electrical machines, and bubbling vats where she witnessed the sparks, explosions, and strange smells emanating from his (25) "noxious effluvia." Joseph described his wife as (26):

> a woman of an excellent understanding much improved by reading, of great fortitude and strength of mind, and of a temper in the highest degree affectionate and generous, feeling strongly for others and little for herself. Also excelling in everything relating to household affairs, she entirely relieved me of all concern of that kind, which allowed me to give all my time to the prosecution of my studies.

Martha Priestley Crouch, Sister

Like her brother, Martha Priestley was born in Fieldhead, probably in 1738. She married Zorobabel John Crouch in 1761 (27). From extant correspondence between Joseph and his younger sister, Martha, we can learn something about his affection, generosity, and concern for her situation. Joseph recommended the (28) "agreeable society in Leeds" to Martha in 1786 when she desired to leave Fieldhead, and in December of 1791 and 1792 he reminded Martha to visit his bankers and draw his annual gift to her of 15 pounds (29). Martha also learned about other personal family matters such as the health of her sister-in-law, Mary, and her nephew, Harry. Priestley invited his sister to stay with him in London (30) "whenever it shall be convenient to you to come this way."

After immigrating to America, Joseph continued to write to Martha. He described the eight-week long voyage from England and deplored his (31) "seemingly out of the world" location in Northumberland. In his last will and testament, Joseph bequeathed (32) "the sum of 10 pounds sterling for suits of mourning" each, to his sister Martha Crouch and to his brothers, Timothy and Joshua, all living in England. Martha's special clothing could continue her connection to her brother as a lasting memorial.

Sarah Priestley Finch, Daughter

Sarah Priestley, Joseph's eldest child and only daughter, had a special connection with her father who desired to have her with him always. During her childhood, Sarah learned to play the harpsichord (33), ventured into her father's 'elaboratory,' and cared for her younger brothers.

As a young adult in Birmingham, her social circle included Mary and Martha Russell, Elizabeth and Anne Ryland and their cousins, and Mary Anne Galton, offspring of prominent families who lived in the neighborhood. One of Sarah's friends recalled the occasion when 'Sally,' as she was known, decided to help out by cleaning her father's laboratory. In the process, she very carefully washed out all the bottles for him, necessitating tactful and loving intercession by her mother on Sally's behalf (34).

Faujas de Saint Fond, a French scientist and traveler, described Sarah (35) as Dr. Priestley's "amiable daughter," having "much vivacity of mind and gentleness of manner."

In 1786 Sarah married William Finch, an ironmaster and nail maker who experienced mixed business success in his career. Within sixteen months, Sarah bore her first child, a daughter Ann, who became a 'favorite' with Anna Barbauld, poetess and friend of the Priestley family. By 1797, when Sarah was pregnant with her sixth child, her husband was bankrupt. Joseph Priestley took up his daughter's plight and asked John Wilkinson to cash in funds from Priestley's French investments to aid Sarah (36).

In autumn of 1801 Sarah had her last child, a daughter named Catherine Irene. Although her grandfather never knew of Catherine's success as a schoolmistress, he would have been proud of her for she followed in his footsteps in education (37).

After eighteen years of marriage, Sarah died in June 1803 at Bordesley, England, and was buried at the New Meeting, Birmingham. She was forty years old. Because of slow delivery of the mails, Joseph Priestley, by this time in failing health, never learned of Sally's death before his own occurred. But, with the greatest of understanding and love for his dear Sally and her children, Priestley bequeathed to her an annuity of sixty pounds sterling, or to her children in case of her death, and stipulated through three named trustees, that Mr. Finch was expressly not entitled to any part of the money, nor could he exercise any control over it.

Anna Letitia Aikin Barbauld, Friend

Anna Barbauld (Fig. 2), a poet and writer of children's books and political and religious miscellania, was born on June 20, 1743, to Dr. John Aikin and Jane Jennings Aikin (38). Dr. Aikin and Joseph Priestley were tutors at Warrington Academy from 1761 to 1767. Anna became very close friends with Mary and Joseph Priestley. In his Memoirs, Priestley wrote (39):

> Mrs. Barbauld has told me that it was the perusal of some verses of mine that first induced her to write any thing in verse, so that this country is in some measure indebted to me for one of the best poets it can boast of. Several of her first poems were written when she was in my house, on occasions that occurred while she was there.

In 1767, when the Priestleys moved to Leeds, Anna wrote her first important poem, a farewell, entitled "On Mrs. P[riestley]'s Leaving Warrington." Here are a few lines from the poem (40):

> How oft the well-worn path to her abode
> At early dawn with eager steps I've trod,
> And with unwilling feet retired at eve,
> Loath its approach unheeded to believe.
> Oft have there the social circle joined
> Whose brightening influence raised my pensive mind

According to Turner (41), "An Address to the Deity," "To Mrs. P," and "The Mouse's Petition" were probably written during one of Anna's several visits to the Priestleys in Leeds in the late 1760s. This was the period of some of Joseph Priestley's most famous experiments on gases. "The Mouse's Petition" is a supplication for release from one of Priestley's captured mice intended for experimental testing of his 'suffocating' gases. Turner tells us of its appearance: "Next morning it [the mouse] was brought in after breakfast, with the petition twisted among the wires of its cage." Here are a few lines from the poem (42):

> Oh! Hear a pensive prisoner's prayer,
> For liberty that sighs;
> And never let thine heart be shut
> Against the wretch's cries.
>
> For here forlorn and sad I sit,
> Within the wiry grate;
> And tremble at th' approaching morn,
> Which brings impending fate.

As the story goes, the mouse was freed as a result of its kind friend's petition (43).

In a letter dated June 13, 1769, Joseph Priestley wrote to Anna, encouraging her to publish her poems (44). Thereafter she collected a number of them, including the poems mentioned above, and they were published in 1773 by Joseph Johnson, Priestley's publisher, in St. Paul's Church-Yard, London, in *Poems.* Also during this period, Anna wrote one of her most important poems about Priestley while visiting them in Leeds in 1769 or 1771. "A Character of Joseph Priestley" includes these stirring lines (45):

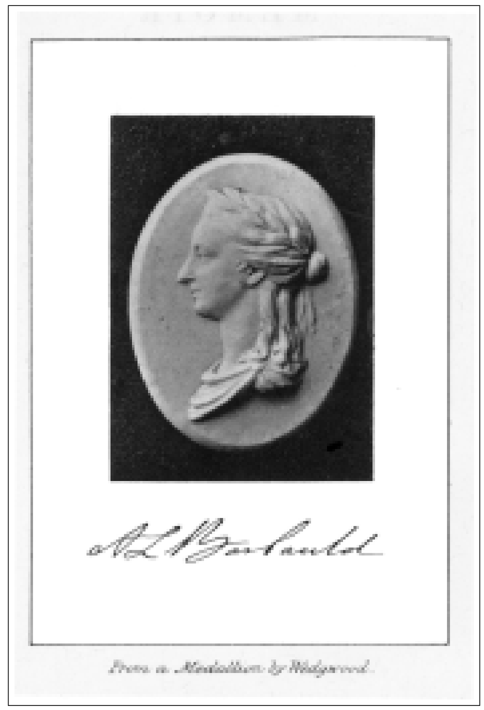

Figure 2. *Anna Letitia Aikin Barbauld from a medallion by Wedgwood. Frontispiece from* Memoir of Mrs. Barbauld, including letters and notices of her family and friends, *by her great niece, Anna Letitia Le Breton, George Bell and Sons, London, 1874.*

> Champion of Truth! Alike thro Nature's field,
> And where in sacred leaves she shines reveal'd,
> Alike in both, eccentric, piercing, bold,
> Like his own lightnings, which no chains can hold,
> Neglecting caution and disdaining art,
> He seeks no armour for a naked heart.
> Pursue the track thy ardent genius shows[,]
> That like the sun, illumines where it goes!
> Travel the various map of science o'er,

Record past wonders and discover more!
Pour thy free spirit o'er the breathing page,
And wake the virtue of a careless age!

"An Inventory of the Furniture in Dr. Priestley's Study" provided a word picture of the room. Schofield said that the description matches the house on Basinghall Street in Leeds (46). The poem alludes to Priestley's *New Chart of History* and *Chart of Biography* hanging on the walls, along with maps of every country. It refers to some of the books he owned, which included the works of the church fathers, books of jurisprudence, and *Metamorphoses*.

In 1774 Anna married Rochemont Barbauld, who had previously attended Warrington Academy, and was a minister of a church in Palgrave, Suffolk. Together they opened a very successful boarding school, which they ran until 1785. *Hymns in Prose for Children* was published in 1781 and was her best work according to the DNB (47). *Hymns* drew a strong connection between the beauties of the natural world and God's love. It remained popular well into the nineteenth century.

In 1785 the Barbaulds closed their school and spent a year touring France. They settled in Hampstead, near London, upon their return. After this Anna began publishing editorials and poems on various social and political issues, including several advocating religious tolerance, women's rights, and abolishment of the slave trade. After the Birmingham riots in 1791, Anna wrote her last poem concerning Priestley in "To Dr. Priestley. Dec. 29, 1792" (48).

Following the Priestleys' move to America, Anna resumed corresponding with Joseph in 1797. Priestley responded by expressing his sadness at (49) "the loss of a folio book [in] which she [his wife, Mary, now deceased] had copied all your unpublished poems, and other small pieces, especially the first poem we ever saw of yours … We also regretted the loss of the little poem you wrote on the birth of Joseph." He mentioned his particular obligations to her for taking under her care a daughter of Sally [Finch]. This might have been Ann Finch, Sally Finch's daughter, for whom Anna wrote an obituary in 1809 in the *Monthly Repository* (50). The remainder of Anna's life passed quietly at Stoke Newington, where she died on March 9, 1825.

Lucy Barclay Galton and her Daughter, Mary Anne Galton Schimmelpenninck, Wife and Daughter of Joseph Priestley's Friend

Lucy Barclay (Fig. 3) was born in 1757 at Bushill. Lucy married Samuel Galton Junior, in October of 1777. Galton was a Quaker, who, in spite of the pacifist tenets of his religion, made a fortune exporting guns as part of the slave trade. He had scientific interests and became a member of the Lunar Society and the Royal Society. Galton was a strong supporter of Joseph Priestley, providing him with financial help for many years. Many of the Lunar Society meetings were held at the Galtons' country home, Great Barr, outside of Birmingham (51).

Mary Anne Galton was born in Birmingham in 1778, the eldest child of Samuel and Lucy Galton. Mary Anne's autobiography (Fig. 4) provides us a window into the life and times of the members of the Lunar Society from a unique perspective, that of a child of one of the members. As Quakers, the Galtons believed that girls should receive the same education as boys. They each took part of the responsibility for educating Mary Anne and their other children. Lucy had high expectations for her children and herself. During one of Lucy's several illnesses, Mrs. Joseph Priestley came to live with the Galton family and was in charge of the invalid (52).

Figure 3. *Lucy Barclay Galton, wife of Samuel Galton Jr., friend of Joseph Priestley. Plate 28 of Vol. 1 of K. Pearson,* The Life, Letters and Labours of Francis Galton, *Cambridge University Press, Cambridge, 1914.*

The Galton and the Priestley families continued to be close friends as their children grew. Even after the Priestleys moved to America, Samuel Galton Junior's records show continued financial support for Priestley in 1798 and 1803. Letters to and from Priestley and Galton continued until Priestley's death in 1804 (53).

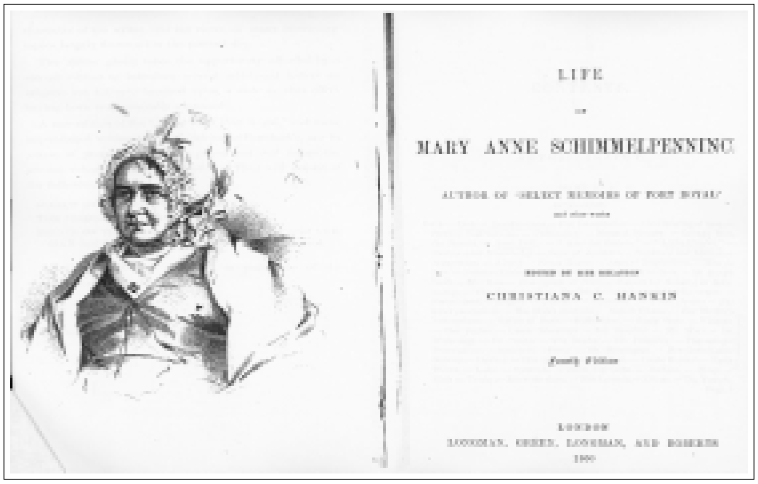

Figure 4. *Frontispiece and title page of the autobiography of Mary Anne Galton Schimmelpennick. M. A. Schimmelpennick,* Life of Mary Anne Schimmelpennick, *edited by her relation, Christiana C. Hankin, Longman, Green, Longman, and Roberts, London, 4th ed., 1860, .*

Mary Anne said that her acquaintance with the Lunar Society members and their friends extended from the time she was eight until she was twenty-four or five. She described her early impression of many of her father's friends, saying of Joseph Priestley (54):

> the father of discoveries on air; a man of admirable simplicity, gentleness, and kindness of heart, united with great acuteness of intellect. I can never forget the impression produced on me by the serene expression of his countenance.

Mary Anne mentions various visits from William Priestley, Joseph Priestley's son (55), "In the evenings when it was rainy, William Priestley would often come and amuse me with tales from the *Arabian Nights*, which was a very favourite book, not only with himself, but also with Dr. Priestley." She relates several occasions when various sons of the Lunar Society men reported at their meetings on visits to France. When Mr. Boulton brought his son to a meeting after a long trip to Paris, she comments (56):

> I noticed, as a remarkable thing, that the company (which consisted of some of the first men in Europe) all with one accord gathered round him, and asked innumerable questions, the drift of which I did not fully understand. They almost hung upon his words; and it was impossible to mistake the indications of deep anxiety, hope, fear, curiosity, ardent zeal, or thoughtful gravity, which alternately marked their countenances, as well as those of my own parents. … All present seemed to give a fearful attention. Why, I did not then well know, … but the rest of the party heard, no doubt, in this young man's narrative, the distant, though as yet faint, rising of the storm which, a year later, was to burst upon France, and, in its course, to desolate Europe.

Mary Anne described first hearing of the French Revolution at a Lunar Society meeting (57):

> the door of the drawing-room opened, and in burst Harry, William Priestley's brother, a youth of sixteen or seventeen, waving his hat, and crying out 'Hurrah! Liberty, Reason, brotherly love for ever! Down with kingcraft and priestcraft. The majesty of the People for ever! France is free, the Bastille is taken: William is there, and helping. I have just got a letter from him. …' We all stood thunderstruck. … I never saw joy comparable in its vivid intensity and universality to that occasioned by the early promise of the French revolution. … I can look back on my surprise at the total change introduced at this time in the subjects of conversation. Even with my father's scientific friends, politics became all-absorbing.

Mary Anne married, but had no children. She became a writer and was active in various causes during her life. In 1825 she was one of the founding members of The Female Society for the Relief of British Negro Slaves, along with several other female descendants of the Lunar Society men: Miss Galton, Mrs. Moilliet, the daughter of James Keir, Mrs. Sneyd Edgeworth, and Miss Wedgwood (58).

Elizabeth Fulhame, Scientific Associate

In 1816 when Thomas Dobson, a Philadelphia bookseller, catalogued the volumes in the library of the late Dr. Joseph Priestley prior to their sale, included in the list (59) was a 1794 London publication entitled "Fulhame on combustion." This unusual book—a serious scientific treatise authored by a woman and properly titled *An Essay on Combustion with a View to a New Art of Dying* [sic] *and Painting wherein the Phlogistic and Antiphlogistic Hypotheses are Proved Erro-*

neous—had been on Priestley's Northumberland library shelf for some time. In fact, he had witnessed her experiments in London (60). In 1800, Priestley published his book *The Doctrine of Phlogiston Established, and That of the Composition of Water Refuted* in which he commented on Fulhame's experiments and conclusions (61):

> I was greatly struck with them; but I do not think that they prove the decomposition of water.

Elizabeth was the wife of Dr. Thomas Fulhame, a physician. She was an intelligent woman who began her scientific work about 1780 when she proposed "the possibility of making cloths of gold, silver, and other metals by chymical processes" to her husband and some friends who decided her ideas were "improbable" (62). She persisted in her efforts and made contributions to photochemical imaging and catalysis. Mrs. Fulhame was the first to be successful with creating photo images on dyed materials and conducted extensive combustion experiments which she interpreted as involving water as a catalyst (63). When she published her essay in 1794, it was widely read and commented on by other scientists and philosophers. Priestley disagreed with Fulhame's interpretations but enjoyed their discussions of phlogiston, airs, and metals (64). In 1810 an American edition of Fulhame's essay was published in Philadelphia and she was reported to be an honorary member of Philadelphia's Chemical Society, possibly at the recommendation of Joseph Priestley (65).

Catherine Hutton, Friend and Member of Joseph Priestley's Congregation

Catherine Hutton (Fig. 5), a writer of novels and miscellania, was born on February 11, 1756, to William Hutton and his wife, Sarah Cock, in Birmingham. William Hutton was most remembered for his histories of Birmingham. Catherine never married and was the constant companion of her father until his death in 1815 (66).

Catherine's early education came mainly from reading, which she loved. Dr. Priestley once observed to William Hutton (67), "A child believes everything to be **real** which is said;" and Catherine **really believed** in the fairy tales she read from the age of five." She grew to love novels, poetry, and plays. According to her cousin, Mrs. Catherine Hutton Beale, who edited Catherine's letters, she was of medium height with a graceful figure and plain features, though lighted up with much intelligence and refinement (68).

In a letter to Mrs. Coltman of Leicester in 1780, Catherine tells of Dr. Priestley, newly come and ministering, in Birmingham (69):

> The celebrated Dr. Priestley has taken up his residence among us for the sake of facilitating his philosophical experiments; and Mr. Hawkes, one of the preachers at the New Meeting, having resigned his place, it has been offered to the Doctor, and it is generally believed he will accept it. If he does so, you may expect to hear of my becoming a convert to his religion, for I am very weary of Calvinistical monotony and nonsense.

And a year later:

> I have much to say to you on the subject of Dr. Priestley. I look upon his character as a preacher to be as amiable as his character as a philosopher is great. In the pulpit he is mild, persuasive, and unaffected, and his sermons are full of sound reasoning and good sense. He is not what is called an orator; he uses no action, no declamation; but his voice and manner are those of one friend speaking to another.

William Hutton was a friend of Joseph Priestley but did not share his political or religious views. Still, Catherine's father's town house was completely destroyed in the Birmingham riots that began on July 14, 1791. The mob was angry about Hutton's decisions in

Figure 5. *Catherine Hutton, member of Joseph Priestley's congregation in Birmingham. From C. H. Beale,* Reminiscences of a Gentlewoman of the last Century: Letters of Catherine Hutton, *edited by her cousin, Cornish Brothers, Birmingham, 1891, frontispiece.*

the city's Court of Requests. In a letter dated July 21, 1791, a week after the riots began, Catherine describes her thoughts about Dr. Priestley and the riots (70):

> A circumstance which particularly rendered Birmingham a likely theatre for mischief was the zeal of Dr. Priestley, fervent though not intemperate. Having fully assured himself of the truth in religion, he conceived it his duty to go abroad into the world and endeavour to persuade all mortals to embrace it, an idea which has done more mischief than any which ever entered the erring mind of man. He sometimes, too, in his sermons, glanced at politics—a subject that should never be mingled with religion; and this treasured up wrath for him against the day of wrath. I look upon Dr. Priestley as a good man, attached to his King and country, and meaning well to every creature; but, though unintentionally, and himself the first sufferer, he was, I think, one of the primary causes of the riots in Birmingham, by rousing the spirit of bigotry and all uncharitableness in others. He was himself so unconscious of having done wrong, nay, he was so certain of having done only right, that his friends took him almost by force from his house and saved him from the vengeance of a mob who would have torn him to pieces.

Catherine Hutton's connection with Joseph Priestley seems to have ended after his move to London, but she leaves us with an excellent example of how one gentlewoman of many must have felt about Priestley as a minister. She also leaves us with a unique and emotional explanation of her mixed feelings about Priestley, just after the Birmingham riots, which affected her and her family so greatly.

Elizabeth Ryland Priestley and Margaret Foulke Priestley, Daughters-in-law

Elizabeth Ryland was born October 25, 1769 in Birmingham to Samuel and Hannah Jeffreys Ryland (71). The Rylands were a well known Dissenting family involved in the wire drawing and pin making business. They were members of New Meeting Congregation where Joseph Priestley preached (72). Elizabeth married Joseph Priestley Junior in 1792, less than a year after the Church and King riots laid waste to both their parents' estates. Their first child, Joseph Rayner Priestley, was born in 1793, and the young family of three traveled to America shortly thereafter. They settled in the village of Northumberland, Pennsylvania, where they lived in a small brick house. For a time, Elizabeth's mother- and father-in-law also crowded into the brick house while their own home was being built (73). Elizabeth dutifully cared for her mother-in-law in these cramped circumstances during Mary's illnesses. For a time, Elizabeth's sister-in-law, Margaret, also helped care for Mary (74).

Elizabeth's family began to grow. Her first daughter, Elizabeth Rayner Priestley, was born in 1797. Called 'Eliza,' this favorite granddaughter of Joseph Priestley, who lived in her grandfather's house with her family beginning in 1798, later learned to read at his knee. Between 1801 and 1807, Elizabeth had three more children: Lindsey, Marianne, and Sarah. Elizabeth managed all the household affairs and supervised the three servants in Joseph Priestley's home. She accompanied her father-in-law on trips to Philadelphia and was a great comfort to him at all times.

Aspiring to Priestley's zeal for debate as the path to knowledge, Elizabeth boldly wrote two political essays: the first in response to Thomas Cooper's opinion about the power of the U.S. President to declare a day of fasting and prayer, and the second in support of unlimited enquiry as the means for governments to secure the greatest good for society. These articles were published under her initials 'E.P.' in Cooper's *Political Essays* in 1800 (75).

In 1812 Elizabeth and her husband returned to England with four of their children. Eldest son, Joseph Rayner Priestley, remained in America and acted as his father's legal agent. Elizabeth died in England in 1816 after a relatively short but severe illness (76).

While it is not known how they became acquainted, Margaret Foulke, born near Harrisburg, Pennsylvania in 1771, married William Priestley in 1796. They moved onto a farm near Northumberland (77). Joseph Priestley described Margaret and her situation (78), "He [William] has got a very suitable wife, tho rather too tender, and the life they lead, quite solitary in the woods, is such as you cannot easily form an idea of. We see him sometimes, but her seldom indeed, and yet she seems very happy ."

Despite the appearances of contentment, Margaret's husband was deep in debt by 1800 and under suspicion of having attempted to poison members of his father's household. After Joseph Priestley paid off William's debts, the couple left Northumberland. They lived for a time in the Harrisburg area, where Margaret's first child, Lucy, was born in 1800 (79). The family later moved on to Louisiana and took up residence in St. James Parish at Priestley Point, a plantation along the Mississippi River, where three more children were born.

As he had done for his daughter Sarah, Joseph Priestley provided for Margaret in his will. He left her an annuity of sixty pounds sterling and stipulated that William was to have no part of or control over his wife's inheritance (80). In 1840 the then-widowed Margaret returned to Northumberland where she paid a visit to her nephew, Joseph Rayner Priestley. She died some years later in New Orleans (81).

Sarah Bull Haines Young and Mrs. William Bakewell, Friends

Sarah Bull was the youngest daughter of John and Mary Phillips Bull of Philadelphia. Sarah was educated in the city's better schools. Genealogist H. L. Dufour Woolfley describes her as (82) "a cultivated and highly literate woman with broad interests, political acuity, awareness of history, at least a smattering of French, and more than passing curiosity in matters scientific." Sarah married Josiah Haines, a wealthy Philadelphia Quaker with property in Northumberland. They built a large and imposing house with gardens there that occupied an entire town square near the river (83).

Mr. and Mrs. William Bakewell, an English couple who worked for Josiah Haines as house stewards, came to Northumberland in the spring of 1795 and (84) "found on our arrival there that Dr. Priestley was a resident in Mr. [and Mrs.] Haines' house, while his own was fitting up for his reception." When their year of employment with the Haines family was completed, the Bakewells took a house in Northumberland; and finding themselves more "at liberty," they spent a great deal of time with Joseph and Mary Priestley. Bakewell wrote (85):

> Our frequent intercourse with the Doctor and his family occasioned Mrs. Priestley to contract a great partiality for my wife, which led her to seek her help whenever it was possible. . . we were both of us so often with them as to occasion an entire neglect of our own affairs at home. . .the old lady wished to buy all our incumbrances, and have us altogether. . . .

Josiah Haines died in May of 1795 and was buried in Northumberland's Quaker Green, a plot in the center of town set aside for a Meeting House and cemetery for those of Quaker faith (86). Sarah was "a gentlewoman of kind and liberal heart," whose connection with Joseph Priestley was so compassionate that when his son, Henry, died a few months later, she (87):

> dispatched me [William Bakewell] with a note to Dr. Priestley, generously offering him the privilege of their family ground, if he chose to accept it; which he did with thankfulness, returning an answer by me, in which he expressed a hope that he and all his would manifest a due degree of gratitude for her kindness.

In September of 1796, when Mary Priestley was taken ill and Mrs. Bakewell "was wholly taken up in attending upon her," William Bakewell (88) decided to pay a short visit to Philadelphia. While there, he received a letter announcing Mary Priestley's death. On his return to Northumberland, Bakewell "found that the Doctor had broken up housekeeping and was gone to live with his son Joseph." Mr. and Mrs. Bakewell did the same and "went to live in the [Priestley Junior] family during the winter."

When Joseph Priestley went to Philadelphia for the winter of 1797, he desired Mr. and Mrs. Bakewell, his trusted friends (89), "to sleep in his bed, in a comfortable room, well stored with books. . . to be sure to read to the servants at night in the kitchen, and endeavour to keep them cheerful and happy." This most intimate of connections was disrupted as Mr. and Mrs. Bakewell never saw Joseph Priestley again. They left Northumberland in April of 1797 and returned to England.

Sarah Haines, remarried in 1798 to Dr. Benjamin Young, was widowed again in 1803. In 1814 she married once more. It is believed Sarah was interred in Northumberland's Quaker Green alongside her parents, two husbands, and several children (90).

Ellen Sharples, Portrait Painter

Ellen Wallace Sharples, the only female artist known to have painted Joseph Priestley's portrait, was born in 1769 in Birmingham (91). She came from a well-to-do English Quaker family and was a student of James Sharples (1751-1811), a portrait painter who worked primarily in pastels, whom she later married. Ellen taught herself to paint miniatures and became a noted portrait painter in her own right, as well as a fine stitchery artist.

Biographer Charlotte Streifer Rubinstein, in her survey of American women artists, chronicled the Sharples family history. Ellen visited America twice, 1793-1801 and 1809-1811, with her husband and three children, traveling in an oversized horse-drawn caravan that housed the family and all their art supplies. James earned an uncertain living as an itinerant painter in New England prior to settling for a time in Philadelphia, where Ellen decided to use her drawing skills to supplement the family income (92).

Ellen assisted her husband by making copies of his paintings to order and was swamped with commissions for images of Alexander Hamilton, George and Martha Washington, and Lafayette, among other notable personages who visited the city. In her diary, Ellen wrote about her work in Philadelphia (93, 94), "they [her paintings] were thought equal to the originals, price the same; we lived in good style associating in the first society." Rubinstein describes the Sharples portraits as straightforward renderings that were much admired in their day—so accurate that dust from powdered wigs could often be seen on the subject's shoulders. Many years earlier, in 1864, Mr. G. Scharf, the Secretary and Keeper of the National Portrait Gallery, related in a letter how (95) "Sir Charles Eastlake, one of the Board of Trustees, admired the honest and sophisticated manner in which the countenance of Priestley had been expressed by Mrs. Sharples."

A number of images of Priestley painted by the Sharples are extant (96), but determining which of the Sharples painted which portrait can be complex because of Ellen's prolific work as a commissioned copyist as well as a painter in her own right.

In his book *Joseph Priestley, Man of Science 1733-1804: An Iconography of a Great Yorkshireman,* John McLachlan discusses two portraits of Joseph Priestley in England's National Portrait Gallery that are attributed to Ellen and believed to have been painted shortly after Priestley arrived in Philadelphia in 1794 (97). McLachlan describes the delicately drawn, rectangular and oval pastel representations as (98) "pleasing, and notable for the fact that we see a Priestley not depicted before. After he left England, Priestley ceased wearing a wig. Hence these are the first portraits in which he is seen with his own hair."

In an intriguing (but confusing) note, McLachlan refers to the existence of a copy of a portrait of Priestley by James Sharples of similar description to that of Priestley by his wife that was said to be in the collection of James Walter, Esq., Stratford Lodge, Kingston-on-Thames. McLachlan goes on to state (99) "the National Portrait Gallery Archives contain a photograph of this, but record that the whereabouts of the original are not known." Not having located any original painting of Priestley by James Sharples with which he might compare Ellen's work, McLachlan limits his discussion to those attributed to Ellen which have survived to inform us and record Joseph Priestley's image in particular detail.

Yet another image of Priestley attributed to Ellen is a profile in pastel painted in Philadelphia in 1796 or 1797 and owned by the Clements Library Associates, University of Michigan. The painting depicts (100) "the eminent doctor well into middle age – delicate features, aging skin, and faint smile," and is said to have been the inspiration for the engraving that appears at the frontispiece of Priestley's *Notes on all the Books of Scripture*, published in Northumberland in 1803-1804.

Did Joseph Priestley in fact 'sit' for Mrs. Sharples to have his portrait taken by this female artist? The biographical information emphasizing Ellen's role as a commissioned copyist suggests that probably he did not. However, this pair of artists obviously worked so closely together that Ellen must have met Dr. Priestley in their Philadelphia studio.

Caty Gable and Jane (Jenny) Moor, Family Servants

Caty and Jane served the Priestley Senior and Priestley Junior families. They transported a variety of foodstuffs and other goods from Robert Irwin's general store during 1796 and 1797 for the Priestleys (101). They may have been of Dutch and Irish descent according to William Bakewell, who read to them while Joseph Priestley was away from home (102). Perhaps Caty and Jane were the unnamed 'hired girl' and 'little bound girl' referred to in newspaper articles published by the *Reading Advertiser* and the *Philadelphia Gazette* that reported the attempted poisoning of members of the Priestley household (103). We do not know with certainty who these young women were, but their intimacy and connection with the Joseph Priestley households can not be denied.

Elizabeth Darch, Entrepreneur and Friend

Elizabeth Darch was connected with Joseph Priestley and his eldest son through a number of cash transactions that were conducted and recorded at Robert Irwin's general store throughout 1796. In July, she paid $50 to Joseph Priestly [*sic*], and one month later, paid $50 to Joseph Prestley Jur [sic]. Irwin's ledger indicates that Elizabeth made regularly scheduled payments to the Priestleys, but there is no indication as to the nature of her debts (104).

Mrs. Darch, said to be a woman of great spirit and enterprise, was the wife of an English banker who failed in business. While he remained in England to settle his affairs, Elizabeth came to America in 1794 with her daughters. The family purchased 100 acres of land near Northumberland on which was first erected a log cabin. Twenty acres was sown in wheat that was sold through Irwin's store (105, 106). A "Miss Darch," certainly one of Mrs. Darch's daughters, painted a watercolor view of the Susquehanna River from Northumberland that caught Joseph Priestley's attention (107). He wrote to Mrs. Barbauld (108):

> It is a pleasure to be in a place that is continually and visibly improving, and this is the case here to an astonishing degree. ... Nature has done everything that can be done for any place. Perhaps you have seen the views of it taken by Miss Daich [sic]. They are not by any means too flattering.

Conclusion

In Joseph Priestley's roles as husband, father, friend, minister, teacher, and scientist he had occasion to interact with and influence many women in a variety of ways. The women in his family and households, wives and daughters of his friends, the women who attended his churches, and the women who were involved with the intellectual life of Birmingham and London were directly impacted. Later women of this period were able to read Priestley's writings, scientific, educational and religious, and use them to further their own efforts. Joseph Priestley's legacy of esteem, regard, and respect for the rationality of women lives on as inspiration to those of us today.

REFERENCES AND NOTES

1. J. 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.* J. Johnson, London, 1806, 2-3.
2. Ref. 1, p 3.
3. Ref. 1, p 6.
4. Ref. 1, p 3.
5. R. Schofield, *The Enlightenment of Joseph Priestley, a Study of His Life and Work from 1733 to 1773,* Pennsylvania State University Press, University Park, PA,1997, 67.
6. Ref. 1, p 27.
7. Ref. 5, pp 66-67.
8. Ref. 1, p 27.
9. Ref. 5, p 5.
10. J. and J. Carlisle, Website: The Wilkinson Family, Ironmasters: A Series of Historical Essays. http://www.iron.oakengates.com, 2001.
11. Ref. 10.
12. B. R. Belloc, "Joseph Priestley in Domestic Life," *Contemporary Review*, **1894**, *66*, 572.
13. Ref. 5, p 91.
14. Ref. 1, p 55.
15. Ref. 1, pp 87-88.
16. Ref. 1, p 204.
17. F. W. Gibbs, *Joseph Priestley: Revolutions of the Eighteenth Century,* Doubleday & Company, Inc., New York, 1967, 135.
18. Anon., "Inventory of the House and Goods of Dr. Joseph Priestley which were destroyed during the riots at Birmingham in 1791," Birmingham Reference Library, Birmingham, England, circa 1792.
19. Ref. 1, p 109.
20. J. McLachlan, *Joseph Priestley, Man of Science 1733-1804: An Iconography of a Great Yorkshireman,* Merlin Books Ltd., Devon, England, 1983, 26.
21. S. Haas, "Docent Guide Appendix I: Biographical Sketches of Sarah, Joseph, William, and Henry Priestley and Thomas Cooper," Joseph Priestley House, Degenstein Intern Project, Northumberland, PA, June 2004, 2.
22. J. Priestley, Letter to John Wilkinson, June 27, 1794, Collection of the University of Pennsylvania. Photocopy of letter in site research files, Joseph Priestley House.
23. M. Priestley, Transcription of letter to Wm. Vaughan Esq., London from Northumberland, August 26, 1794.
24. M. A. Bashore, "Joseph Priestley House: Private Home to Public History Museum," unpublished manuscript, Northumberland, PA, 2004, 3-4.
25. Ref. 5, p 265.
26. Ref. 12, p 573.
27. M. E. Ware, "Descendants of William Priestley of Hartshead," Self-published, 2003.
28. H. C. Bolton, *Scientific Correspondence of Joseph Priestley,* Kraus Reprint Co., New York, 1969, 80-81.
29. Ref. 28, pp121-123.
30. Ref. 28, pp 132-133.
31. J. Priestley, "Dear Sister": Transcribed letter from archives of the Wiltshire Archaeological and Natural History Society Museum and Library, Devises, Wiltshire, England (original manuscript given by William C. Priestley to Royal Society of Chemistry, London).
32. J. Priestley, Last Will and Testament, manuscript written January 1802 (Copy). Research files at Joseph Priestley House, Northumberland, PA.
33. Ref. 21, p 1.
34. Ref. 17, p 140.
35. E. G. Rose, "Mary Priestley: Life with a Famous Scientist," paper presented at Middle Atlantic Regional Meeting of the American Chemical Society, 1996, p 5.
36. Ref. 21, p 2.
37. P. Toulmin, "The Descendents of Joseph Priestley, LL.D., F.R.S.", *Proceedings of the Northumberland County Historical Society,* **1994,** *32,* 14.

38. Anna Letitia Barbauld, (1743-1825), Dictionary of National Biography (DNB), *1*, 1064.
39. Ref. 1, p 49.
40. W. McCarthy and E. Kraft, *The Poems of Anna Letitia Barbauld*, The University of Georgia Press, Athens, GA.and London, 1994, 1-3.
41. W. Turner, "Mrs. Barbauld," *Newcastle Magazine*, **1825**, *n.s.*, *4*, 183-186.
42. Ref. 40, pp 36-37.
43. Ref. 41.
44. Ref. 40, p 233.
45. Ref. 40, pp 37-38.
46. Ref. 5, p 162.
47. Ref. 38, p 1065.
48. Ref. 40, p 125.
49. A. L. Le Breton, *Memoir of Mrs. Barbauld, including letters and notices of her family and friends, by her great niece*, George Bell and Sons, London, 1874, 78-79.
50. A. L. Barbauld, "Miss Anne Finch," *Monthly Repository*, **1809**, *4*, 171-172.
51. K. Pearson, *The Life, Letters and Labours of Frances Galton*, Cambridge University Press, Cambridge, 1914, Vol. 1, 45-46.
52. M. Wilson, *Jane Austen, and Some Contemporaries*, Cresset Press, London, 1938, 153-155.
53. R. E. Schofield, *The Lunar Society of Birmingham, a Social History of Provincial Science and Industry in Eighteenth-Century England*, Clarendon Press, Oxford, 1963, 360-366.
54. M. A. Schimmelpenninck, *Life of Mary Anne Schimmelpenninck*, edited by her relation, Christiana C. Hankin, Longman, Green, Longman, and Roberts, London, 4th ed., 1860, 31-33.
55. Ref. 54, pp 110-114.
56. Ref. 54, pp 125-126.
57. Ref. 54, pp 181-186.
58. M. Dick, *The Lunar Society and the Anti-slavery Debate*, Internet site, http://www.search.revolutionaryplayers.org.uk/engine/resource/exhibition/standard/default.asp?resource=670 p12.
59. T. Dobson, *Catalogue of the Library of the late Dr. Joseph Priestley containing many very scarce and valuable books*, T. Dobson, Philadelphia, PA, 1816, 45.
60. J. Priestley, *The Doctrine of Phlogiston Established and that of the Composition of Water Refuted*, A. Kennedy for the author, Northumberland, PA, 1800, 59.
61. Ref. 60, p 59.
62. D. A. Davenport and K. M. Ireland, "The Ingenious, Lively and Celebrated Mrs. Fulhame and the Dyer's Hand," *Bull. Hist. Chem.*, **1989**, *5*, 37.
63. K. J. Laidler, *The World of Physical Chemistry*, Oxford University Press, Oxford, 1993, 249-253, 277-279.
64. Ref. 62, p 37.
65. Ref. 63, pp 250-251.
66. Catherine Hutton (1756-1846), Dictionary of National Biography (DNB), *10*, 351.
67. C. H. Beale, *Reminiscences of a Gentlewoman of the last Century: Letters of Catherine Hutton Beale*, edited by her cousin, Cornish Brothers, Birmingham, 1891, 2.
68. Ref. 67, p 9.
69. Ref. 67, pp28-29.
70. Ref. 67, p 88.
71. S. Dixon and A. M. Ronald, Introduction and Appended Notes to "Recollections of Dr. Priestley by John Ryland," *Transactions of the Unitarian Historical Society*, **1927-1930**, *4*, 428.
72. Ref. 71, pp 418-419.
73. Ref. 21, p 3.
74. W. J. Weston, *Priestley Chronicles: Essays on Joseph Priestley, LL.D., F.R.S., and His Northumberland Legacy*, The Unitarian Universalist Congregation of the Susquehanna Valley, Northumberland, PA, 1998, 27.
75. T. Cooper, *Political Essays*, Robert Campbell, Philadelphia, PA, 2nd ed., 1800, 3-7, 62-88.
76. J. Priestley Jr. Transcription of Letter to J. R. Priestley, May 18, 1816. Box 3-6, Dickinson College Library, Carlisle, PA.
77. Ref. 37, pp 16-23.
78. Ref. 21, p 6.
79. Ref. 37, p 16.
80. Ref. 32.
81. Ref. 37, pp 29-30.
82. H. L. D. Woolfley, *The Story of William Lloyd.* Unpublished draft manuscript, 2003, pp 14-18.
83. Ref. 82, pp 17-19.
84. W. Bakewell, "Some Particulars of Dr. Priestley's Residence at Northumberland, America," *Monthly Repository* , **1806**, *1*, 394.
85. Ref. 84, pp 505-506.
86. Ref. 82, p 19.
87. Ref. 84, p 396.
88. Ref. 84, pp 565-567.
89. Ref. 84, p 622.
90. Ref. 82, pp 20-49.
91. J. L. Collins, *Women Artists in America: 18th Century to the Present*, University of Tennessee, Chattanooga, 1973, not paginated.
92. C. S. Rubinstein, *American Women Artists from Early Indian Times to the Present.* G.K. Hall & Co., Boston, MA, 1982, pp 40-42.
93. Ref. 84.
94. K. M. Knox, *The Sharples: Their Portraits of George Washington and his Contemporaries*, Yale University Press, New Haven, 1930, p 13.
95. Ref. 20, p 30.
96. Email message from M. Sofer-Frankel, doctoral student, University of Anglia to A. Bashore, Joseph Priestley House, July 24, 1999. Sofer-Frankel cites tow portraits of Priestley by Ellen Sharples in the National Portrait Gallery, London, and portraits of Priestley by james Sharples—one in Bristol City Museum, England, and one in the National Portrait Gallery, Washington, DC.
97. Ref. 20, pp 28-30.

98. Ref. 20.
99. Ref. 20, p 30.
100. A. Shy, "A Portrait of Joseph Priestley in America by Ellen Sharples, Philadelphia circa 1796-1801," *The Quarto: University of Michigan*, **1996,** 11.
101. Priestley House Staff. Database of Priestley Entries from selected volumes of the Robert Irwin Store Daybooks and Ledgers 1791-1812, courtesy Dr. Jack Fairweather, 2004, not paginated.
102. Ref. 84, p 622.
103. L. Patrick. "Priestley and the Inhabitants of Northumberland: Slaves and Servants, Friends and Acquaintances." Final Report for Raising Our Sites: Community Histories of Pennsylvania, 2000, 37.
104. Ref. 91.
105. J. F. Meginness, *Otzinachson: A History of the West Branch of the Susquehanna,* Gazette and Bulletin Printing House, Williamsport, PA, Vol. I, 1889, 689.
106. Ref. 91.
107. Photocopy of photograph of 1797 watercolor painting by Elizabeth Darch, courtesy Clifford Lewis 3rd, 1988. Darch research file at Joseph Priestley House, Northumberland.
108. T. E. Thorpe, *Joseph Priestley,* J. M. Dent & Co., London and E.P. Dutton & Co., New York, 1906, 160-161.

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PRIESTLEY, JEFFERSON, AND ADAMS: THE ÉMIGRE AND AMERICAN POLITICS*

Judah B. Ginsberg, American Chemical Society

Shortly after his arrival in America, Joseph Priestley wrote that he "made it a rule to take no part whatever in the politics of a country in which I am a stranger" (1). Priestley added that "I only wish to be quiet, and pursue my studies without interruption, with the few advantages that I can expect in this country" (2). Famous as the discoverer of oxygen, Priestley intended to conduct further chemical experiments in America and to submit scientific papers to the American Philosophical Society. And as one of England's leading Unitarians, he anticipated further theological study and publication. Given these pursuits, there is no reason to doubt Priestley's intention to avoid political activity. After his triumphant arrival in the summer of 1794 in New York, where he received many laudatory welcoming addresses, and a stay in Philadelphia, Priestley settled in Northumberland, Pennsylvania, far from the hurly-burly of American politics.

Despite his earnest wish to avoid controversy, two forces worked to draw Priestley into the vortex of American politics. One was Priestley's own decidedly radical political philosophy. The other was the deepening divisions within the Revolutionary generation and the emergence of political parties, or factions, to use a term more congenial to the founders. This development was symbolized by the rift in the 1790s between John Adams and Thomas Jefferson, both of whom Priestley knew. Priestley's view of Jefferson and Adams, their attitudes towards him, and his relationship with each changed dramatically during his decade in America. To put it succinctly, Adams and Priestley drifted apart in the years of the Adams presidency, most notably over the issue of the Alien and Sedition Acts, while Jefferson and Priestley drew closer as Priestley came to view Jefferson's election in 1800 as necessary to put the United States on a proper political and philosophical course. Indeed, Adams concluded that Priestley's role in 1800 contributed to his defeat. It is in the complicated interrelations among Adams, Jefferson, and Priestley that the scientist can be viewed as a lightning rod for the schism between the two American revolutionary leaders and a symbol of their differences and of the emerging political parties.

Priestley's location made it possible for him to stay out of partisan politics, for a time. In the late 18th century Northumberland, Pennsylvania, was isolated. It is about one hundred and thirty miles from Northumberland to Philadelphia, a goodly distance in the era before steam engines. Roads were horrible and bridges largely non-existent. It took roughly five days to make the journey under the best circumstances. The first time Priestley and his wife made the trip from Philadelphia to Northumberland was that first summer in America, and it was a particularly difficult journey. The Priestleys expected hardships, but the summer rains had swollen creeks and rivers, making fording hazardous. Accommodations in the 1790s for travelers were so dreadful that the Priestleys slept the last two nights of that first trip in "a common wagon" (3).

It is not entirely clear why Priestley settled in Northumberland. It is true his sons and his friend Thomas Cooper attempted to build in that region of Pennsylvania a community of English liberal dissenters which was to include the good doctor. It is also true that Mrs. Priestley instantly took a dislike to Philadelphia, finding it expensive and dirty, and she was anxious to move to the country. Priestley did not disagree with his wife's view: "There is a great drawback in the expence [sic] of living here [in Philadelphia], which is higher than in London, the price of every thing having been doubled in the last two years. On this account and with a view to having more leisure, I think I shall settle in the back part of this state, at Northumberland" (4).

"More leisure…" is the key to understanding Priestley's motivations in settling in rural Pennsylvania. To have leisure, Priestley had to live economically. As he explained to Josiah Wedgwood, he turned down a professorship at the University of Pennsylvania "for the sake of living in a much more agreeable, and healthy situation, at one-third of the expence, and where I can have more leisure for my pursuits" (5). Leisure did not, of course, mean living the life of a gentleman farmer; rather, it meant time to pursue scientific experiments and to write, mostly about theology. During his decade in Northumberland Priestley wrote some of his most important theological works, including the last four volumes of the *General History of the Christian Church*, *Notes on all the Books of Scriptures, Index to the Bible*, and many others.

Priestley returned to Philadelphia only four times before he died in 1804, and while he undoubtedly missed the delights of urban life, he appears to have easily and comfortably settled into a routine in Northumberland not unlike that of his earlier life in Birmingham, England (6). To be sure, there were problems being so isolated. "This place is inconveniently situated for carrying out my experiments," he wrote in January 1795, but quickly added, "living here is cheap, and the climate, &c., uncommonly fine, and my sons are settling in farms around me" (7).

Priestley may have been isolated, but he appears to have stayed well informed about the emerging political divisions of the 1790s. The schism among the "Band of Brothers" of 1776 can be seen in the rupture between Jefferson and Adams, revolutionaries who had worked intimately together on the Declaration of Independence and who had remained close during their years in Europe in the 1780s. While it is true that Jefferson came to speak for and lead the anti-Federalists, or Republicans as they eventually would be called, Adams' relationship to the Federalists was murkier. Still, the differences between Jefferson and Adams encapsulated different views of society, economics, and politics in the new nation; and those differences were serious enough to result in a breach in their friendship that would last until the two old friends were able to forget the personal bitterness of the 1790s and renew their correspondence while in retirement, a correspondence in which the two aging revolutionaries not only "explained ourselves to each other" but in which they reflected on many of the issues that had divided them in the first place (8).

Priestley corresponded with both Adams and Jefferson. Both men urged Priestley to settle in their region of the country, with Adams singing the praises of New England, Jefferson those of Virginia (9). Both men met Priestley in Philadelphia, and both attended services in the Unitarian Church where Priestley occasionally preached. All three were members of the American Philosophical Society. The affection that the two aging revolutionaries felt for Priestley never waned. In 1813 Adams wrote "I never recollect Dr. Priestley, but with tender-

Photograph by James J. Bohning

ness of Sentiment. Certainly one of the greatest Men in the World." But the New Englander added, "certainly one of the weakest" (10). To Jefferson, Adams wrote that same year, "Oh! That Priestley could live again! and have leisure and means." And a few weeks later, Adams exclaimed, "Will it not follow, that I ought to rejoice and be thankful that Priestley has lived?" (11). Jefferson, whose intellectual debt to Priestley was great, once simply told the scientist, "Yours is one of the few lives precious to mankind for the continuance of which every thinking man is solicitous" (12).

It was the French Revolution that revealed the early differences between Priestley and Adams. It is true that in 1792 Priestley wrote a letter to Adams expressing some reservations about events in France, but Priestley's mostly enthusiastic support of the French Revolution stands in stark contrast to Adams' early opposition, long before the Terror (13). In his *Discourses on Davila,* Adams voiced disapproval of the philosophical and political direction of revolutionary France. He also mocked the French experiment with a unicameral legislature, an experiment that appealed to Priestley and like-minded radicals such as Tom Paine. In the *Discourses,* as in his earlier A *Defence of the Constitutions of Government of the United States of America,* Adams stressed the need for a balanced government which recognizes distinctions within society. These arguments always sounded to his more egalitarian contemporaries like a defense of hereditary government and as a wish to impose a British-style government on the United States. In this connection, it should be noted that the *Davila* essays caused the beginning of the rift between Adams and Jefferson (14).

By 1794, when Priestley landed in the United States, Treasury Secretary Alexander Hamilton had succeeded in establishing most of his nationalizing economic system. The disagreements over Hamilton's program had led to divisions within George Washington's cabinet and to the retirement of Hamilton's chief adversary, Secretary of State Jefferson. By that date partisan divisions over the French Revolution were dominating politics and party development. Democratic-Republican Societies had begun to appear in considerable numbers in the more populated areas of the nation. These organizations toasted French victories against Britain and condemned the policies of the Washington administration; as such, they were symptomatic of the bitter discourse that was beginning to enter American politics. In 1794 an insurrection erupted in western Pennsylvania over Hamilton's imposition of an excise tax on whiskey, which hit western farmers hard because the cheapest way for them to get their produce to market was as distilled whiskey. Federal troops were raised in a show of strength to suppress the Whiskey Rebellion, and Washington issued a condemnation of the Democratic Societies, which he believed encouraged rebellion (15).

Into this increasingly bitter and partisan political climate landed Dr. Priestley, with his intellectual baggage, which included his dissenting religious beliefs and his radical politics. Priestley's Unitarianism differentiated him from Americans of the time; and his pro-French views, which drove him from Britain, put him in the middle of partisan strife. But Priestley's radicalism went deeper than support of the French Revolution, for it drew on a long-standing tradition in English social thought. Moreover, his radicalism defined his position in the political wars of the late 1790s and his relations to two of the poles in those wars: Adams and Jefferson.

Priestley's politics grew out of his contact with radical intellectuals during his years in Britain (16). His political outlook drew heavily on John Locke, especially on the right of rebellion against tyranny, which had made him an early supporter of the American Revolution. Two principles underlay Priestley's radicalism: belief in the inherent equality of all men and an unshakeable faith in mankind's capacity for self-improvement, indeed in the perfectibility of man.

As the influence of Locke would indicate, Priestley was a vigorous advocate of a balanced constitution, and his political views fell into mainstream Whig tradition. For the most part, Priestley followed Lockean principles in rejecting Divine Right and arguing for a secular basis for political authority. Priestley also accepted Lockean notions of inalienable natural rights and of the social compact as the basis for political society. Related to this was Priestley's devotion to limited government and separation of powers. But Priestley went beyond Locke in his political thought and writing. Priestley wrote in the preface to his *Essay on First Principles*, "…I had placed the foundation of some of the most valuable interests of mankind on a broader and firmer basis, than Mr. Locke, and others who had formerly written upon this subject" (17). And for Priestley that "broader and firmer basis" meant the adoption of a liberalism that merged, as D. O. Thomas has suggested, "the concept of a continuous progress to be achieved by a hardheaded appeal to the criterion of utility" (18).

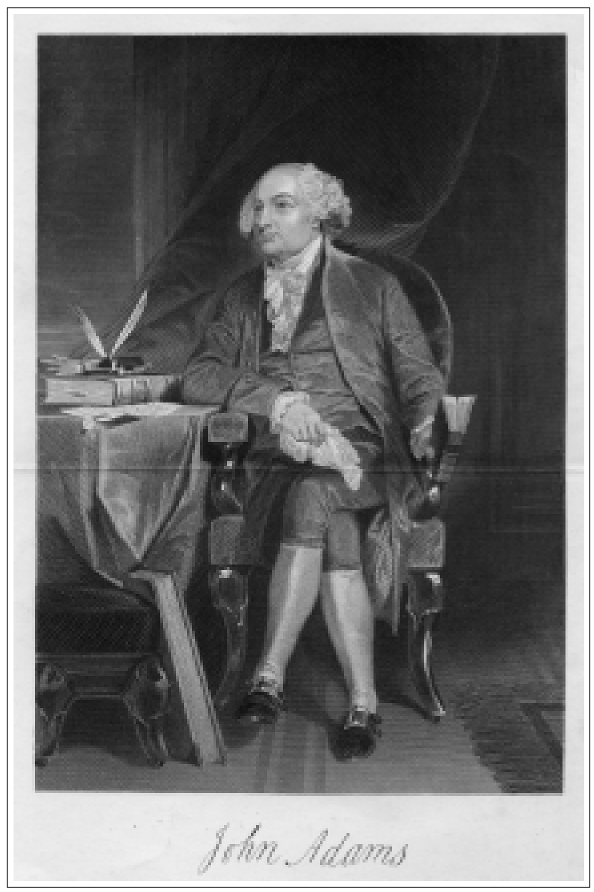
One should never forget that Priestley's science informed his other passions: whether it be theology or politics or any other field upon which his curious and roving mind alit. Priestley, dedicated to the discovery of truth, believed that the application of scientific methods could yield results in any area of intellectual investigation. This underpinned his belief in progress, which of course ultimately led to a belief in human perfectibility. "…The human species itself," Priestley wrote, "is capable of a similar and unbounded improvement; whereby mankind in a later age are greatly superior to mankind in a former age…" (19). At the same time, Priestley believed, in the realm of civil government at least, that the principle of utility should be applied. Long before Jeremy Bentham, Priestley wrote (20):

> 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 every thing relating to that state must finally be determined. And though it may be supposed, that a body of people may be bound by a voluntary resignation of all their interests to a single person, or to a few, it can never be supposed that the resignation is obligatory on their posterity; because it is manifestly *contrary to the good of the whole that it should be so*.

This is very close to Jefferson's famous statement to James Madison: "I set out on this ground, which I suppose to be self-evident, 'that the earth belongs in usufruct to the living'" (21). It is just one instance where Priestley and Jefferson shared beliefs. Starting in 1800, Jefferson and Priestley had a long-running correspondence on educational theory (22). Priestley's ideas on education influenced Jefferson's planning of the University of Virginia. Jefferson no doubt was familiar with Priestley's opinions on the disestablishment of the Anglican Church when he, with the help of Madison, drafted the statute on religious freedom in Virginia in 1786 (23). Jefferson also frequently praised Priestley's writings on religion and the two shared similar views on Unitarianism and Jesus Christ. Jefferson possessed Priestley's faith in human perfectibility and progress. Moreover, Jefferson's famous alteration of the Lockean formula of "Life, Liberty, and Property" in the Declaration of Independence to "Life, Liberty, and the Pursuit of Happiness" may well have owed something to his reading of Priestley's early political works.

The evidence suggests Priestley met Jefferson in Philadelphia; but their strong philosophical and intellectual ties were forged long before they met. Priestley and Adams, on the other hand, had a personal acquaintance that was about a decade longer, having met in London when Adams was the first U.S. ambassador to Britain. The two men remained on cordial terms after Adams returned to the United States. In 1792 Adams wrote Priestley to express his condolences over Priestley's "Sufferings in the cause of Liberty" during the Birmingham Riots of 1791. Priestley replied that more than a year after the riots there still had been no indemnification for the destruction and that he was considering emigrating (24). Yet Adams and Priestley were far apart politically and in their views of man and society. The only exception came in the realm of religion: Adams shared Priestley's Unitarian views, and the vice president appears to have attended Priestley sermons on the "Discourses on the Evidences of Divine Revelation" delivered at the Universalist Church in Philadelphia in the spring of 1796. (25).

Adams did not attend a second set of "Discourses" the following year, although the two breakfasted during Priestley's visit to Philadelphia. "I asked him," Adams wrote his wife after Priestley and he breakfasted, "whether it was his Opinion that the French would ultimately establish a Republican Government. He said it



William L. Clements Library, University of Michigan was…" (26). More than twenty-five years later, Adams wrote Jefferson about this meeting, saying Priestley "was very sociable, very learned and eloquent on the subject of the French revolution" (27). This breakfast appears to have been the last friendly encounter between the two men, and it shows that for Adams differences over the French Revolution proved critical. But in truth, the crusty New Englander viewed man and society through a much different prism from that of Priestley. To Adams, human nature in the 18th century was the same as it had been in ancient times. Inequality in society was inevitable; and human beings were just as likely to commit evil as good. Even in America, where centuries of hereditary inequality did not exist, there were inequalities tied to family, wealth, and education. This rather dour view of human nature stands in stark contrast to Priestley's almost sunny optimism (28).

It took less than three years' residence in the United States for the disagreements between Priestley and Adams to become so serious as to cause a breach between the two old correspondents. It was perhaps inevitable that this would happen, despite Priestley's initial protestations "to take no part whatever in the politics of a country in which I am a stranger" (29). He may have intended not to take part, but he surely never meant to be oblivious to American politics. Shortly after settling in Northumberland Priestley wrote Benjamin Vaughn (30):

> I have seen all the principal people and also persons who may be said to be the opposition… I perceive that the opposition is very considerable, and I am persuaded does not consist, as your brother will have it, of ill-intentioned men. They are called *Anti-federalists*, and object principally to the *excise laws*, and the *funding-system* founded on a *national debt*, which they wish to have discharged, while others avow a liking of it, as a means of creating a dependence on the governing powers, which they think is wanting in this country tho it has grown to dangerous excess in England.

This may have been a simplistic analysis of American politics in 1794, but it was an analysis Priestley shared with Jefferson and the Democratic-Republican Societies. Events in the period between Priestley's arrival in Northumberland and the election of Adams as president only served to show how close the Englishman's views were to what he called the "Anti-federalists." The most significant of these for party development was the bitter debate over Jay's Treaty, negotiated in 1795 with Great Britain. Priestley wrote at the time that "Mr. Jay's Treaty is almost universally condemned" (31), and in fact large sections of public opinion viewed the treaty as one-sided in favor of Britain and as a repudiation of the Franco-American alliance of 1778, so instrumental in securing American independence. Priestley later noted that the treaty "could not fail to give umbrage to France" (32). Popular wrath against the treaty ran so strong that Jay later claimed his burning effigy lit the entire eastern seaboard every evening. Priestley, "having much leisure" in the spring of 1796, attended the debates on it in the House of Representative (33).

The Jay Treaty was crucial for party development, but Priestley noted that despite growing partisanship, the two parties "do not avoid one another… and once anything is decided by fair voting, all contention ceases" (34). This benign view of American politics extended to the upcoming presidential election, of which he noted: "Tho the contest will be a very warm one, it will be attended with no serious inconvenience" (35). While it was true that there was no serious inconvenience during the election, the result was a rather inconvenient one, putting Adams in the presidency and Jefferson in the vice-presidency.

In the first summer of Adams' presidency Priestley wrote Adams in what would prove to be one last overture to his old friend. Priestley evidently believed that Adams would not allow partisanship to interfere with friendship, but his naiveté revealed how little he understood the New Englander. The purpose of the letter was to seek a government position for his old friend Thomas Cooper, a request Adams ignored, in part probably because Priestley was not a particularly good salesman (36):

> It is true that both, Mr. Cooper and myself fall, in the language of calumny, under the appellation of *democrats,* who are represented as enemies of what is called *government* both in England, and here. What I have done to deserve this character you well know, and Mr. Cooper has done very little more. In fact, we have both been persecuted for being the friends of liberty, and our preference of the government of this country has brought us both hither.

"Persecuted for being friends of liberty…" was no doubt a reference to his earlier treatment in England for his nonconformist religious views and his pro-French activities. But that persecution was beginning to have echoes in America, as Priestley increasingly found himself under attack, especially from William Cobbett in the columns of *Porcupine's Gazette*. Cobbett took Priestley to task for supporting the French Revolution and even for emigrating from Britain to America. Cobbett had first put Priestley in his sights in 1794, when the Englishman's arrival in America had been the occasion of complimentary addresses to him by a host of Democratic Societies, to which Priestley had replied in kind. Angered by the addresses and replies, Cobbett issued a pamphlet entitled *Observations on the Emigration of Dr. Joseph Priestley.* Cobbett professed indifference to Priestley's coming to America, but "the fulsome and consequential addresses sent him by the pretended patriots, and his canting replies, at once calculated to flatter the people here, and to degrade his country, and mine, was something to me" (37). By the spring of 1797 Priestley, stung by Cobbett's constant barrage, saw fit to complain (38):

> The writer of that scurrilous pamphlet on my emigration now publishes a daily paper, in which he frequently introduces my name in the most opprobrious manner, though I never took the least notice of him; and have nothing to do with the politics of the country; and he has more encouragement than any other writer in this country. He, every day, advertises his pamphlet against me, and after my name adds, "commonly known by the name of the fire-brand philosopher."

Of course, Cobbett was not the only scandal-monger writing in the late 1790s. Adams was to become the butt of many vitriolic attacks, some coming from James Callender, who Adams and his wife believed was in Jefferson's employ. Nor did Cobbett create the anti-French mania that gripped the United States during Adams' presidency; he merely stoked it. The actions of the French government fanned the flames as well, when it was revealed in the XYZ Affair that French Foreign Minister Talleyrand would not deal with an American delegation sent by Adams to negotiate differences unless a substantial bribe was paid. The Americans had gone to France to resolve issues arising from the Jay Treaty and to try to stop the Franco-American drift toward war caused by the depredations of French privateers against American shipping. By 1798 the United States and France were engaged in a quasi-Naval War and the government had begun to raise an army in case of war with France (39).

In the midst of this crisis atmosphere, the Federalist dominated Congress passed the Alien and Sedition Laws. The biggest blunder of Adams' blunder-prone administration, these laws were intended to deport or silence foreign-born residents, especially those who were pro-French and likely to support the Jeffersonian Republicans. The laws also made it a crime to publish "any false, scandalous and malicious writing or writings against the government of the United States, or either house of the Congress of the United States, or the President of the United States, with intent to defame the said government, or either house of the said Congress, or the said President, or to bring them, or either of them, into contempt or disrepute." Adams went to his grave insisting he never supported these infamous statutes, but he signed them into law and they became a burning issue in the election of 1800 (40).

Since Priestley never became a U.S. citizen, he could have been prosecuted under the Alien Laws. Cooper did become a citizen, so he was successfully prosecuted under the Sedition Law for an attack on President Adams. Secretary of State Timothy Pickering wrote Adams, "Cooper has taken care to get himself admitted to citizenship. I am sorry for it; for those who are desirous of maintaining our internal tranquility must wish them both [Priestly and Cooper] removed from the United States" (41). Adams replied, "I do not think it wise to execute the alien law against poor Priestley at present. He is as weak as water, as unstable as Reuben, or the wind. His influence is not an atom in the world" (42).

Adams, apparently under some pressure to have Priestley deported, quietly urged his old friend to keep silent (43). This, of course, Priestley could not do. Priestley and Cooper attended meetings in Northumberland in the summer of 1799 at which "democratic" toasts were drunk and the administration castigated. The year before, Priestley published under the pseudonym "A Quaker in Politics" the *Maxims of Political Arithmetic*, which criticized the Adams administration and lent support to Jeffersonian programs and philosophy. But most damaging to Priestley was the publication in 1798 by Cobbett of a cache of letters from John Hurford Stone in Paris to Priestley that had been captured aboard a Danish ship and previously published in London. Stone was a partisan of the French Revolution and Cobbett was able to use the letters to portray Priestley as an agent and spy for France (44).

Priestley, believing he might be deported, defended himself by publishing *Letters to the Inhabitants of Northumberland* in November 1799 (45). The *Letters* were more than just an answer to the Adams administration. They were also written to spell out Priestley's support for the opposition, as shown by his sending copies to Jefferson. In the *Letters* Priestley defended the French Revolution, while deploring its atrocities. He concluded that both the French and American revolutions were democratic and insisted that America had nothing to fear from France.

Priestley then turned his attention to the American Constitution, which he labeled "the best that has ever been." He expressed Jeffersonian views on states' rights as opposed to what he saw as the centralizing actions of the Adams administration, and he went to lengths to deplore the Alien and Sedition Laws (46):

> Laws calculated to restrain the freedom of speech and of the press, which have always been made on the pretence of the abuse of them, are of so suspicious a nature in themselves, and have been so constantly the resort of arbitrary governments, that I was beyond measure astonished to find them introduced here; and yet in some respects the laws that have lately been made by Congress are more severe than those of England.

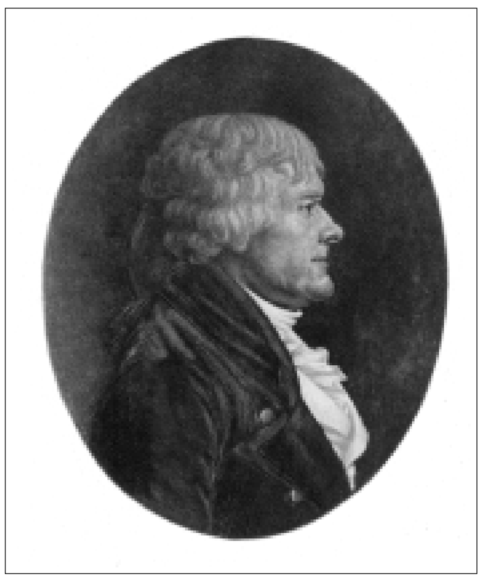
But silencing the press was counter-productive: "The cause of *monarchy* in England and *federalism* in this country" will not be advanced, he wrote, by such laws against sedition. As for the Alien Laws, they were designed to keep out of the United States "the friends of liberty (opprobriously called *Jacobins, Democrats, &c*.) emigrating from Europe, a description of men in which I am proud to rank myself" (46).

Jefferson expressed to Priestley, before the election of 1800, his pleasure with the *Letters* and encouraged their further dissemination (47):

> You will know what I thought of them by my having before sent a dozen sets to Virginia to distribute among my friends. Yet I thank you not the less for these, which I value the more as they came from yourself... The papers of Political arithmetic, both in your's [sic] and Mr. Cooper's pamphlets are the most precious gifts that can be made us; for we are running navigation-mad and commerce-mad, and navy-mad, which is worst of all. How desirable is it that you could pursue that subject for us. From the Porcupines of our country you will receive no thanks; but the great mass of our nation will edify & thank you.

Jefferson went on to sympathize with Priestley (47):

> How deeply have I been chagrined & mortified at the persecutions which fanaticism & monarchy have excited against you, even here… You have sinned against church & king, & can never be forgiven.



Thomas Jefferson
William L. Clements Library, University of Michigan

In a second letter Jefferson urged Priestley to withstand the abuse hurled at him and expressed a belief in human progress normally so congenial to both correspondents (48):

> Pardon, I pray you, the temporary delirium which has been excited here, but which is fast passing away. The Gothic idea that we are to look backwards instead of forwards for the improvement of the human mind… is not an idea which this country will endure; and the moment of their showing it is fast ripening; and the signs of it will be their respect for you, & growing detestation of those who have dishonored our country be endeavors to disturb your tranquility in it.

Priestley responded, somewhat pessimistically for him, that he wished he "could see the effects… of the increasing spread of republican principles in the country." He added "… if I be rightly informed, my *Letters* have done more harm than good. I can only say that I am a sincere well wisher to the country, and the purity and stability of its constitution." Jefferson replied "the mind of this country is daily settling at the point from which it has been led astray… and I trust the day is not distant when America will be proud of your presence." Jefferson's friendly words encouraged Priestley to bring out a second edition of the *Letters*, in 1801, in which Priestley wrote in the preface that he had been told his pamphlet "contributed something" to the victory of Jefferson over Adams in 1800 (49).

Jefferson was right: his victory in 1800 meant an end, for the most part, of the attacks on Priestley. Beyond that, Jefferson's election had a calming influence on national discourse. Priestley recognized this when he wrote before the inauguration that "Mr. Jefferson will do nothing rashly." In another letter, Priestley said "party-spirit is not so high as it was, owing to the moderation and prudence of Mr. Jefferson" (50). In his inaugural Jefferson went to lengths to demonstrate that moderation: "We are all republicans; we are all federalists," he said, adding, "if there by any among us who wish to dissolve this union, or to change its republican form, let them stand undisturbed, as monuments of the safety with which error of opinion may be tolerated where reason is left free to combat it" (51).

To Priestley, Jefferson wrote just a few weeks after assuming office that "in the first moments of my public action, I can hail you with welcome to our land, tender to you the homage of it's [sic] respect & esteem, cover you under those laws which were made for the wise and good like you." Jefferson then spoke of the limitless possibilities for the new land (52):

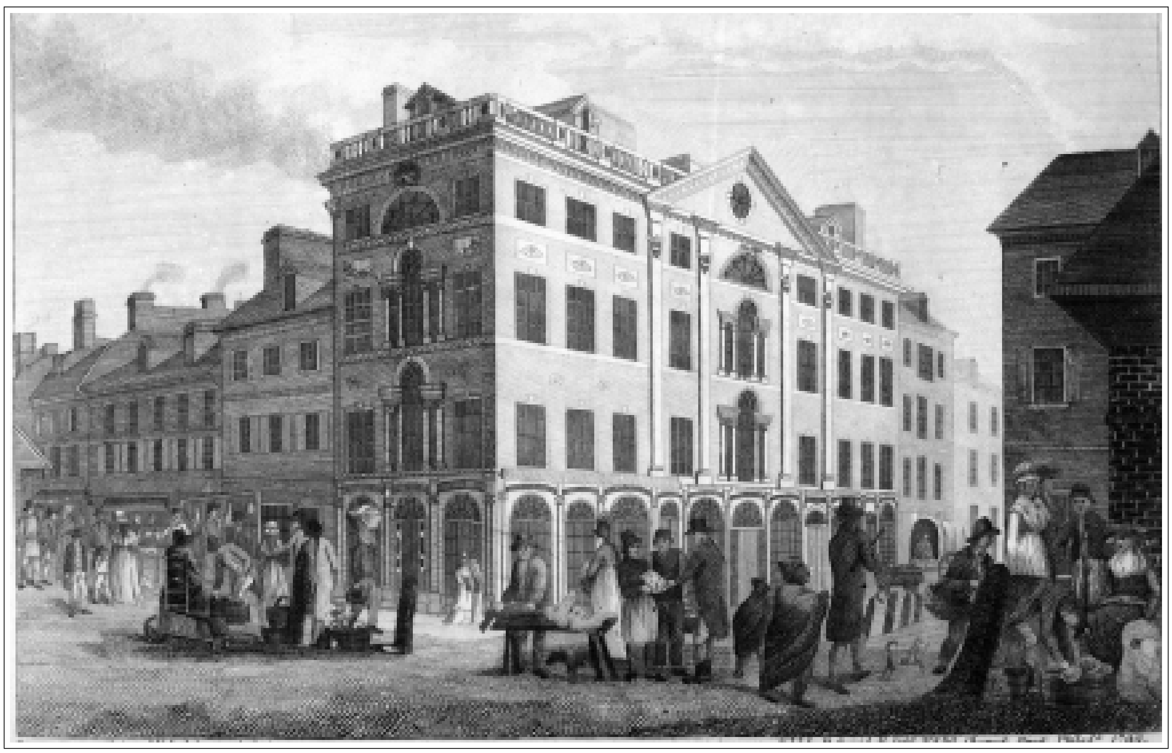
> As the storm is now subsiding & the horizon becoming serene, it is pleasant to consider the phenomenon with attention. We can no longer say there is nothing new under the sun. For this whole chapter in the history of man is new. The great extent of our republic is new… The order & good sense displayed in this recovery from delusion, and in the momentous crisis which lately arose, really bespeak a strength of character in our nation which augurs well for the duration of our Republic: & I am much better satisfied of it's [sic] stability than I was before it was tried.

The "momentous crisis" occurred in the Electoral College where there was no constitutionally-mandated way to choose between president and vice president. But it was resolved peacefully: "There was no idea of force, nor of any occasion for it" (52).

Priestley responded, expressing his pleasure on living in a country led by a President with whom he shared a political philosophy and an optimistic view of human progress (53):

> I rejoice more than I can express in the glorious reverse that has taken place, and which has secured your election. This I flatter myself will be the permanent establishment of truly republican principles in this country, and also contribute to the same desirable event in more distant ones

By the time Jefferson assumed the presidency Priestley was in the last years of his life, and the combination of old age and a more favorable political climate meant that Priestley became less active politically and more content with life in America. In a letter to Samuel Mitchill, a Professor of Chemistry at Columbia University serving in the House of Representatives, Priestley declared: "In all respects I think the climate of this country greatly preferable to that of England; and its government still more so. Here we have *peace* and *plenty*, and in England they have neither…" (54). To Jefferson, Priestley wrote that he wished to dedicate the second part of his *Church History* to the Virginian because he was a friend of religious toleration and political liberty. Priestley wrote of Jefferson with some exaggeration (55):



Southeast corner of Third and Market Streets, Philadelphia, William Burch & Son, 1799.
Free Library of Philadelphia

> It is the boast of this country to have a constitution the most favourable to political liberty, and private happiness of any in the world, and all say that it was yourself, more than any other individual, that planned and established it; and to this your conduct in various public offices, and now the highest, gives clearest attestation.

Priestley praised Jefferson for the constancy of his dedication to "the rights of man," claiming that many are the friends of liberty when out of office, "but I do not recollect one besides yourself who retained the same principles, and acted upon them, in a station of real power." In a reflection of the fear of authority that Priestley had felt both in England and perhaps under the Adams administration, he told Jefferson that "It is only now that I can say I see nothing to fear from the hand of power, the government under which I live being for the first time truly favourable to me" (55).

In late 1801 Priestley told a confidant that "To me, the administration of Mr. Jefferson is the cause of peculiar satisfaction, as I now, for the first time in my life (and I shall soon enter my 70^{th} year) find myself in any degree of favour with the governor of the country in which I have lived, and I hope I shall die in the same pleasing situation" (56). He was to get his wish, dying on February 6, 1804 at his home in Northumberland during Jefferson's first term as president. The émigré, who spent the last decade of his life in the United States professing to want only to live quietly and peacefully, found himself not only enmeshed in the politics of his new land but also a symbol of the partisanship of the 1790s. Priestley's intention to stay out of American politics proved impossible as did any attempt to stay neutral in the disputes between Jefferson and Adams. As an 18^{th}-century English radical, Priestley was most definitely a Jeffersonian in the context of American politics. That radicalism, of course, had made it difficult for Priestley to maintain silence in the United States. Priestley was a political as well as a scientific and religious man. After all, it was politics, along with his dissenting views, that provoked his emigration to the United States in the first place.

Epilogue

Nearly a decade after his death, Priestley served as the focus of debate between Adams and Jefferson. The occasion was the publication in 1812 of the *Memoirs of the Late Reverend Theophilus Lindsey,* a prominent English Unitarian. Priestley had sent Lindsey copies of some of his letters, and these wound up in the *Memoirs.* One of those letters was from Jefferson, written shortly after his inauguration, which included some sharp criticisms of Adams as well as Jefferson's famous comment telling Priestley that his was "one of the few lives precious to mankind" (57).

Two points by Jefferson particularly irked Adams, who shortly after Lindsey's book appeared, wrote Jefferson for an explanation (58). One point was a criticism of the Federalist regime for its "'bigotry'" and for looking to "'the education of our ancestors; We were to look backwards, not forwards, for improvement: *the President* [Adams] *himself* declaring, in one of his Answers to addressees, that we were never to expect to go behind them in real Science.'" To Jefferson, Adams said he had "no recollection of any such Sentiment ever issued from my Pen, or my tongue, or of any such thought in my heart…," though he conceded he could not recall every public statement he made as president. "The Sentiment," Adams challenged his old friend, "that you have attributed to me in your letter to Dr. Priestley I totally disclaim and demand… of you the proof" (59).

The second bothersome point to Adams concerned politics. This was a condemnation by Jefferson of the Alien Act as a "Libel on legislation." Adams' answer to this accusation was to try to spread the blame while denying culpability (60):

> As your name is subscribed to that law, as Vice President, and mine as President, I know not why you are not as responsible for it as I am. Neither of Us were concerned in the formation of it. We were then at War with France: French Spies then swarmed in our Cities and in the Country. Some of them were, intollerably [sic], turbulent, impudent and seditious. To check these was the design of this law. Was there ever a government, which had not Authority to defend itself against Spies in its own Bosom? Spies of an enemy at War? This Law was never executed by me, in any Instance.

Adams was accusing Jefferson of supporting legislation that neither of them favored but that was necessary because of French spying but which was not enforced.

Jefferson replied to Adams' accusation, urging his friend to ignore the controversy. "The renewal of these old discussions," he wrote, "would be equally useless and irksome" (61). But in truth Jefferson was embarrassed that his private correspondence had been published: "It was a confidential communication… from one friend to another… Whether the character of the times is justly portrayed or not, posterity will decide" (62). Jefferson rather adroitly attempted to deflect the accusation that Adams looked backwards: "You possess, yourself, too much science, not to see how much is still ahead of you, unexplained and unexplored." At the same time, Jefferson tried to separate Adams from the Federalist Party: "In truth, my dear Sir, we were far from considering you as the author of all measures we blamed. They were placed under the protection of your name, but we were satisfied they wanted much of your approbation" (63). Adams responded to this letter, saying "Be not surprised or alarmed. Lindsays [sic] Memoirs will do no harm to you or me" (64).

In one sense, the contretemps over the publication of Jefferson's letter to Priestley was a tempest in a teapot and ultimately part of the ongoing attempt of Jefferson and Adams both to patch up their differences and understand each other. But the flurry of letters in 1813 also sums up how Priestley symbolized those differences, differences which were reflected in the party development of the late 1790s.

REFERENCES AND NOTES

***** This paper is based on the presentation at the symposium at the Philadelphia ACS Meeting, Philadelphia, 2005, HIST 017.

1. Joseph Priestley to John Adams, 13 November 1794, Adams Papers, Massachusetts Historical Society, Reel 378.
2. Ibid.
3. A. Holt, *A Life of Joseph Priestley,* Oxford University Press, London, 1931, 186.
4. Priestley to Samuel Parker, 27 June 1794, Robert Schofield, Ed., *A Scientific Autobiography of Joseph Priestley (1733-1804): Selected Scientific Correspondence Edited with Comentary,* MIT Press, Cambridge, MA, 1966, 280-81.
5. Priestley to Josiah Wedgwood, 17 March 1795, Ibid., p 285. See also Priestley to Benjamin Rush, 11 November 1794, Ibid., p 283.
6. On Priestley's decision to settle in Northumberland and on his life once there, see C. Robbins, "Honest Heretic: Joseph Priestley in America, 1794-1804," *Proc. Am. Philos. Soc.*, **1962**, *106:I*, 65ff. Also see E. F. Smith, *Priestley in America 1794-1804*, 1920. Reprint, Arno Press, New York, 1980.
7. Priestley to Parker, 20 January 1795, Schofield, Ed., *Scientific Autobiography*, 284-85.
8. Adams to Jefferson, 15 July 1813, L. J. Cappon, Ed., *The Adams-Jefferson Letters: The Complete Correspondence between Thomas Jefferson and Abigail and John Adams*, University of North Carolina Press, Chapel Hill, NC, 1959, Vol. II, 358. The complete quotation: "You and I ought not to die, before We have explained ourselves to each other." Joseph Ellis has written sensitively about the Adams-Jefferson friendship, especially in chapter eight of *Founding Brothers: The Revolutionary Generation,* Alfred Knopf, New York, 2001.
9. J. Graham, *Revolutionary in Exile: The Emigration of Joseph Priestley to America, 1794-1894, Trans. Am. Philos. Soc.*, **1995**, *85 (2)*, 28, 33, 48. See also Robbins, "Honest Heretic," p 63.
10. Adams to J. Vaughn, 23 November 1813, quoted in Graham, *Revolutionary in Exile,* p 165.
11. Adams to Jefferson, 3, 25 December 1813, Cappon, Ref. 8, II:405, 409-10.
12. Jefferson to Priestley, 21 March 1801, Jefferson Papers, Library of Congress (online). On the importance of Priestley in "The Jeffersonian Circle," see D. Boorstin, *The Lost World of Thomas Jefferson,* Beacon Press, Boston, MA, 1960, 17-19.
13. Priestley to Adams, 20 December 1792, Adams papers, Reel 375.
14. See John Adams, *Discourses on Davila* and *A Defence of the Constitutions of Government of the United States of America.* Both of these can be found in C. F. Adams, Ed., *The Works of John Adams,* 10 vol. Little, Brown, Boston, MA, 1856. For more on Adams, see D. McCullough, *John Adams,* Simon & Schuster, New York, 2001. For an analysis of these writings, see J. Ellis, *Passionate Sage: The Character and Legacy of John Adams,* Norton & Company, New York, 1993, Ch. 5. The Republicans were fond of labeling Adams, as well as Alexander Hamilton, as a "monarchist." The validity of the charge is irrelevant here: it is political perception that contributed to party development.
15. On the Democratic-Republican Societies and the Whiskey Rebellion, see the following: S. Elkins and E. McKitrick, *The Age of Federalism: The Early American Republic, 1788-1800,* Oxford University Press, New York, 1993; G. Chinard, *Thomas Jefferson, The Apostle of Americanism,* University of Michigan Press, Ann Arbor, MI, 2nd ed. rev., 1957; R. Chernow, *Alexander Hamilton,* The Penguin Press, New York, 2004. These are just a few of the many secondary works covering these events.
16. On the origins of Priestley's political philosophy, see the following: I. Kramnick, "Eighteenth-Century Science and Radical Social Theory: The Case of Joseph Priestley's Scientific Liberalism," in A. T. Schwartz and J. G. McEvoy, Ed., *Motion Toward Perfection: The Achievement of Joseph Priestley,* Skinner House Books, Boston, MA, 1990, 57-92. This collection contains a number of other essays useful to understanding Priestley's political philosophy and Priestley in America. See, for example, D. Davenport, "Joseph Priestley in America, 1794-1804," pp 219-235, and D. D'Elia, "Joseph Priestley and His American Contemporaries," pp 237-50. See also D. O. Thomas, "Progress, Liberty and Utility: The Political Philosophy of Joseph Priestley,"

in R. G. W. Anderson and C. Lawrence, Ed., *Science, Medicine and Dissent: Joseph Priestley (1733-1804)*, Wellcome Trust/Science Museum, London, 1987, as well as Robbins, "Honest Heretic" and J. Graham, "Revolutionary Philosopher: The Political Ideas of Joseph Priestley (1733-1804), Part One," *Enlightenment and Dissent*, **1989**, *8***,** 43-68, and "Part Two," Ibid., **1990**, *9*, 14-46; The best modern biography of Priestley, which goes over much of this ground, is the two-volume work of R. Schofield, *The Enlightenment of Joseph Priestley: A Study of His Life and Work*, Pennsylvania State University Press, University Park, PA, 1997, 2004. On the importance of politics in Priestley's philosophy, see, C. Bonwick, "Joseph Priestley: Emigrant and Jeffersonian," *Enlightenment and Dissent,* **1983**, *2,* 9: "He was much concerned with political behaviour as an integral component of his philosophy, and his cosmology embraced secular as well as theological affairs." Finally, for a careful analysis of dissenting thought in England in the 18th century, see C. Robbins, *The Eighteenth-Century Commonwealthmen,* Harvard University Press, Cambridge, MA, 1959.

17. J. Priestley, *Essay on the First Principles of Government, and on the Nature of Political, Civil, and Religious Liberty,* printed for J. Johnson, London, 1771, in J. Priestley, *Political Writings,* Peter Miller, Ed., Cambridge University Press, Cambridge, 1993, 3.
18. D. O. Thomas, Ref. 16, p 73.
19. Ref. 17, p 9.
20. Ref. 17, pp 13-14. Italics are in the original text.
21. Jefferson to Madison, 6 September 1789, Jefferson Papers.
22. See, e.g, Jefferson to Priestley, 18 January 1800 and Priestley's "Hints Concerning Public Education," Priestley to Jefferson, 8 May 1800, Jefferson Papers.
23. On Jefferson's debt to Priestley, see Kramnick, Ref. 16, note 3, p 87.
24. Adams to Priestley, 19 February 1792, Adams Papers, Reel 115; Priestley to Adams, 20 December 1792, Adams Papers, Reel 375.
25. Adams to Abigail Adams, 13 March 1796, Adams Papers (online).
26. Adams to Abigail Adams, 26 January 1797, Adams Papers (online).
27. Adams to Jefferson, 15 August 1823, Cappon, Ref. 8, II:594-95.
28. For Adams' opinions on human nature, see McCulloch, Ref. 14, and Ellis, Ref. 14.
29. See Ref. 1.
30. Priestley to Benjamin Vaughan, 30 July 1794, quoted in Graham, Ref. 9, p 62.
31. Priestley to Lindsey, 12 August 1795, in J. T. Rutt, Ed.., *The Theological and Miscellaneous Works of Joseph Priestley,* London, 1817-1832, I.2.315. Cited as *Works* below.
32. J. Priestley, *Letters to the Inhabitants of Northumberland,* 2nd ed., *Works,* XXV.168.
33. Priestley to Lindsey, 3 May 1796, Priestley, *Works*, I.2.340.
34. Ref. 33.
35. Priestley to William Vaughan, 4 November 1796, quoted in Graham, Ref. 9, p 91.
36. Priestly to Adams, 11 August 1797, Adams Papers, Reel 385.
37. W. Cobbett, *The Life and Adventures of Peter Porcupine,* in G. D. H. Cole, Ed., *The Life and Adventures of Peter Porcupine, with Other Records of his Early Career in England & America*, Kennikat Press, Port Washington, NY, 1970, 43. For the attacks on Priestley, see W. Cobbett, *Observations on the Emigration of Dr. Joseph Priestley, and on the Several Addresses delivered to him on his Arrival at New York*, Philadelphia, PA, 1794. See D. Davenport. Ref. 16, pp 226ff.
38. Priestley to Lindsey, 30 April 1797, *Works*, I.2.377-78.
39. See Elkins and McKitrick, Ref. 15, pp 549-662, on the tumultuous events of these years. See also McCullough, Ref. 14, and Chernow, Ref. 15.
40. The standard work on the Alien and Sedition Laws is J. M. Smith, *Freedom's Fetters: The Alien and Sedition Laws and American Civil Liberties*, Cornell University Press, Ithaca, NY, 1956.
41. Timothy Pickering to Adams, 1 August 1799, C. F. Adams, Ref. 14, IX:5-6. On Cooper, See D. Malone, *The Public Life of Thomas Cooper, 1783-1839,* Yale University Press, New Haven, CT, 1926.
42. Adams to Pickering, 13 August 1799, C. F. Adams, Ref. 14, IX:14.
43. Smith, Ref. 40, pp173-74; Graham, Ref. 9, pp 125-26.
44. Graham, Ref. 9, pp 110-14, contains a detailed account of this convoluted tale.
45. J. Priestley, *Works,* XXV:114-15.
46. J. Priestley, *Works*, XXV:163-65.
47. Jefferson to Priestley, 18 January 1800, Jefferson Papers. See Priestley to Robert Livingston, 17 April 1800 [in Schofield, Ref. 4, p 303] for a reference to further editions and Priestley's comment: "These Letters, I find, have given great offence to the Federalists."
48. Jefferson to Priestley, 27 January 1800, Jefferson Papers.
49. Priestley to Jefferson, 8 May 1800, Jefferson to Priestley, 11 August 1800, Priestley to Jefferson, 10 April 1801, Jefferson Papers.
50. Priestley to Lindsey, 25 December 1800, Priestley to Thomas Belsham, 2 March 1801, *Works*, 1.2:451, 454-55.
51. Scholars have debated just what Jefferson meant by these famous words. But it seems clear that he meant, as he himself said, that not every difference of opinion is a difference of principle. And yet, Jefferson's view of "the revolution of 1800," at least as he wrote about it in later years, contrasts with the "we are all republicans; we are all federalists" formula of his first inaugural. In 1819, Jefferson said "the revolution of 1800… was as real a

revolution in the principles of our government as that of 1776 was in its form; not effected by the sword, as that, but by the rational and peaceable instrument of reform, the suffrage of the people." Jefferson to Spencer Roane, 6 September 1819, Jefferson Papers. Part of the problem in parsing this phrase is grammatical: in the printed versions of the speech Federalists and Republicans were capitalized, indicating that Jefferson was referring to political parties; but in Jefferson's hand-written draft, the words are lower case, indicating not a reference to parties, but rather an observation that all Americans were united by a belief in a republican form of government bound by a federal structure. These are two significantly different meanings. See J. Ellis, *American Sphinx: The Character of Thomas Jefferson,* Vintage Books, New York, 1996, 216.

52. Jefferson to Priestley, 21 March 1801. The importance of the peaceful transfer of power as demonstrated in this election cannot be underestimated. In 1796 power was transferred peacefully, but within the Federalist Party. In 1800, power was transferred peacefully from one party to the other, by, as Jefferson himself said, "the suffrage of the people." See Ref. 51. On the election, see J. Ferling, *Adams vs. Jefferson: The Tumultuous Election of 1800*, Oxford University Press, New York, 2004.
53. Priestley to Jefferson, 10 April 1801, Jefferson Papers.
54. Priestley to Samuel Mitchill, 16 July 1801, Schofield, Ref. 4, p 309.
55. Priestley to Jefferson, 17 June 1802, Jefferson Papers.
56. Priestley to George Logan, 26 December 1801, cited in Graham, Ref. 9, pp 153-154.
57. Jefferson to Priestley, 21 March 1801, Jefferson Papers.
58. Adams wrote on 29 May 1813, asking Jefferson "if you have seen this Book." Cappon, Ref. 8, II:326.
59. Adams to Jefferson, 10 June 1813, Cappon, Ref. 8, II:326-27. Note that the first quotation in this paragraph is Adams quoting what Jefferson wrote, where the punctuation is slightly different from that in the original letter to Priestley in the Jefferson papers. Since the issue here is the lingering dispute between Adams and Jefferson, I have quoted the Adams version of the letter.
60. Adams to Jefferson, 14 June 1813, Cappon, Ref. 8, II:329.
61. Jefferson to Adams, 27 June 1813, Cappon, Ref. 8, II:337.
62. Jefferson to Adams, 15 June 1813, Cappon, Ref. 8, II:331. This is a reply to Adams' letter of 29 May 1813 which raises the issue for the first time but does not include specific allegations. Adams to Jefferson, 29 May 1813, Cappon, Ref. 8, II:325-326.
63. Jefferson to Adams, 15 June 1813, Cappon, Ref. 8, II:332.
64. Adams to Jefferson, 25 June 1813, Cappon, Ref. 8, II:333.

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BERNARD COURTOIS (1777-1838), FAMED FOR DISCOVERING IODINE (1811), AND HIS LIFE IN PARIS FROM 1798

Patricia A. Swain

The Family in Dijon (1)

Bernard Courtois was born in 1777 in Dijon, the handsome provincial capital of Burgundy, France with a population of about 20,000. He grew up there and learned about the saltpeter industry from his father's work but he had no formal schooling. His father Jean-Baptiste Courtois came from a family of cobblers in that region, and his mother Marie Blé was the daughter of a village laborer. When they married in 1771, Jean-Baptiste was a valet to M. Bouchin de Grandmont aged 82, the first president of Dijon's Chamber of commerce and the owner of a grand hotel in the town. After their first son died in 1772 Marie and Jean-Baptiste had six children, a daughter Catherine followed by sons Pierre, Bernard, Jean-Baptiste, then in 1780 the twins Anne-Marie and Pierre (second of the name). Thus Jean-Baptiste, who was skilful and adaptable, had to support his young family during the final years of the *ancien régime* and the French Revolution (1789-1794). He became a wine merchant after M. Bouchin de Grandmont's death in 1772 when the hotel was sold to the Dijon Academy for scientific activities. That was at the time Guyton de Morveau, the well-known chemist and Dijon lawyer, successfully appealed to the provincial government for financial support to provide a free chemistry course at the Academy (2). Soon a new chemistry laboratory opened in the former hotel, situated directly opposite Bernard's birthplace, and in 1775 Jean-Baptiste became a laboratory assistant (3).

In January 1776 Bernard's father became a full-time demonstrator to Guyton, whose annual chemistry course was formally opened on April 28 (3, 4). Three years later he was fortunate to be able to rent accommodation in the Academy buildings, where the family lived for the next ten years. Thus the infant Bernard was raised in the prestigious surroundings close to his father's work, at a time when the Dijon Academy chemistry department was well-known largely due to Guyton's distinguished reputation. The well-equipped laboratory needed for the practical science demonstrations was also used for other purposes, as Guyton had predicted. It served as a small pharmacy from 1778, managed by Jean-Baptiste who was even called the '*pharmacien de l'Académie*' by his family (3). As well as keeping the accounts he purchased small quantities of chemicals to make medicines, wine vinegars, and inks which he sold to surgeons, apothecaries, retailers, other academy departments, and private individuals (5). He also developed an improved white paint for buildings, replacing the usual lead carbonate with zinc oxide (6).

The French authorities at that time were urgently seeking ways to increase the country's saltpeter production for gunpowder. In Dijon, as a result of a partnership which included Guyton and the Burgundy powders commissioner Champy, work began in 1778 to build an experimental plant to make saltpeter artificially. It was on ten acres of unused land near an old saltpeter refinery outside the town gates, just over a mile from the

Academy. When this nitrary opened in 1780 it was named the *Saint-Médard Nitrary* and Jean-Baptiste was the manager, on Guyton's recommendation. However he still kept his post at the chemistry laboratory and the family lived at the Academy until three months after the outbreak of the Revolution.

Jean-Baptiste and his wife bought the *Saint-Médard Nitrary* on June 25, 1788 from Guyton and Champy (7). The following year, when Bernard was twelve years old, they moved to the residence after leaving their Academy accommodation on October 31 (8). Bernard with his elder brother Pierre began to learn about the saltpeter industry and in due course were able to assist their father. Pierre eventually remained in that trade in the region, whereas chemistry was to influence Bernard's choice of career. Meanwhile the violence and terror of the Revolution raged until July 1794 when the worst excesses ended after the execution of Robespierre in Paris. Dijon became the principal town of the *département* of the Côte d'Or when the National Assembly reorganised local government in l789, and in 1793 the former provincial Academies were suppressed by the National Convention which led to the closure of Dijon's Academy. Jean-Baptiste's laboratory position ended when Guyton left for Paris on being elected to the Legislative assembly in 1791. He then concentrated on his saltpeter industry and later profited from events by buying some national land made available by new legislation (7, 8).

Bernard lived at the *Saint-Médard Nitrary* until he was eighteen, and it seems likely he had an untroubled boyhood despite the difficult times. He would have been welcomed on visits to his parents' relatives and there was much to enjoy in the lovely surrounding countryside, including bathing and fishing in the rivers Suzon and Ouche. His father's brother Zacharie lived in nearby Plombières, where Bernard sometimes stayed during holidays from his pharmacy apprenticeship (3). It was about 1795 that he left home to begin this apprenticeship in the town of Auxerre 80 miles north of Dijon, under M. Frémy who was the future grandfather of the distinguished chemist Edmund Frémy (1814-1894). Bernard spent three years at the Frémy pharmacy and also became interested in practical chemistry during this period. Thus on completing his apprenticeship about 1798 he was pleased to obtain a position in the chemistry laboratory of Antoine François de Fourcroy (1755-1809) at the *École Polytechnique* in Paris (9). This was achieved with the help of his godfather Bernard Maret who had gone to Paris as a journalist in 1788 and was destined for a brilliant career as a diplomat and statesman. He was the son of Jean-Baptiste's friend Dr Hugues Maret, former permanent secretary and lecturer in applied science at the Dijon Academy before his death in 1786 (8).

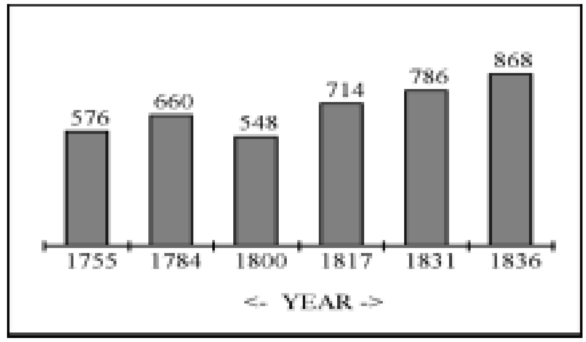

Figure 1. *Chart showing Paris populations to the nearest thousand, before and after the 1789 Revolution (10)*

At the École Polytechnique

The capital was the city of opportunities and its population was increasing rapidly again after a fall during the Revolution (Fig.1). In December 1794 the *École Centrale des Travaux Publics* opened (renamed the *École Polytechnique* in September 1795) in the former Palais-Bourbon, to provide the republic with skilled engineers. Students studied the necessary basic sciences and mathematics for three years before going on to graduate from a specialist school of engineering. The chemistry courses were taught by three distinguished full professors of chemistry, Fourcroy, Guyton de Morveau, and Berthollet (11), who also had their own laboratories for research (12). Among *Dijonnais* who left for Paris were two of Bernard's contemporaries, Charles-Bernard Désormes (1777-1862) and Nicolas Clément (1779-1841). Désormes was a student admitted to *the École Centrale des Travaux Publics* when it opened. He remained there on completing his course, becoming a demonstrator for Guyton de Morveau. Clément had a modest library post near Dijon which he left when a wealthy relation offered an opportunity to work and study in the capital. After winning a lottery he became a scientist and began industrial chemistry research at the *École Polytechnique* in 1801, collaborating with Désormes (13).

Two years before Bernard entered the *École Polytechnique* it was reorganized, with considerable economies adversely affecting the staff employment, student numbers, and laboratory provision. By 1799 the students were following a two-year course of study instead of three, although the chemistry courses continued as before (11). Nicolas-Louis Vauquelin (1763-1829) the assistant professor of chemistry, who often substituted when Fourcroy was busy with appointments outside the college (14), was not replaced when he left in 1797. A year later about the time Bernard arrived, Louis-Jacques Thénard (1777-1857), previously a laboratory assistant, was appointed *préparateur de chimie* (15). Thénard formed a friendship with Bernard and soon recognized his abilities before both men were required for military service in 1799, under a new conscription law. Thénard was posted to the mining corps at the military engineering school at Metz (16). Bernard served as a pharmacist in military hospitals and then returned to the *École Polytechnique* in 1801 to work in Thénard's laboratory (9). About that time Armand Séguin (1767-1835) (17), former aide to Lavoisier, opened a research laboratory at the college (18). As director of a tanning industry at Sèvres which supplied boot leather for Napoleon's armies, Séguin was a wealthy man and able to pursue his scientific interests (19). One of his several research projects was a study of opium, which became Bernard's work in 1802 when he moved to Séguin's laboratory (20).

Bernard must have been a useful chemistry assistant although there are no *École Polytechnique* documents mentioning his name. As a young man from the provinces with no previous experience it seems likely he was given a low-grade position, undoubtedly obtained due to Guyton de Morveau's influence. The latter, who was director of the *École Polytechnique* in 1798 and 1800-1804 (21), could recommend the son of his former assistant at the Dijon academy, Jean-Baptiste Courtois, despite the economies and redundancies of 1797 (22). Guyton, Fourcroy, Berthollet and others had provided revolutionary courses on saltpeter, powder, and cannon manufacture (23), and they were consulted about the use of chlorine bleaching to manufacture paper for the *assignats* currency. Guyton became particularly interested in the value of chlorine as a disinfectant and his *Traité sur les moyens de désinfecteur l'air* appeared in 1801. His successful investigations led to new methods of fumigation which were taken up by the medical authorities (24). However, Bernard was probably not directly involved with laboratory work on chlorine since Fourcroy and Thénard had other research interests.

Fourcroy was particularly interested in plant and animal chemistry. His research at this period was mostly with his collaborator Vauquelin and included some inorganic chemistry on reactions of sulphites and phosphites. The two analyzed many animal and vegetable substances and investigated urine, urea, and urinary calculi. They found that sulfuric acid can remove the elements of water from vegetable substances and they also studied its reaction with alcohol to form ether. Thénard was influenced by the work of Fourcroy and Vauquelin since he was their laboratory assistant before his appointment as *préparateur de chimie*. He therefore began his own research with an interest in organic chemistry, which led to the discovery of sebacic acid in 1801. He was also gaining a reputation as a skilful analytical chemist at the period when Bernard was with him. Thénard was interested in the proportions in which elements combine in compounds, particularly in the metal oxides. He examined oxides of nickel, cobalt, antimony, iron, as well as other compounds and showed that two series of mercury compounds exist. Soon he was to achieve fame following his discovery in 1804 of the cobalt aluminate pigment ($CoAl_2O_4$) named *Thénard's Blue*, a substitute for ultramarine and a colorant for porcelain (25).

Thus, in the laboratories of Fourcroy and Thénard, Bernard acquired a good knowledge of the practical techniques used for research in organic and analytical chemistry. He was intelligent, enthusiastic, and a competent laboratory worker; hence as well as performing routine chemical tasks he could assist with some of the research (9). In this way Bernard gained valuable experience, enabling Armand Séguin to entrust his research on opium to him in 1802. Séguin presented his *first* memoir on opium to the French Institute on December 24, 1804, but it was not published until 1814 (26). One of the *principles* isolated in this research was morphine; thus in 1816 it became of particular interest to French chemists when Vauquelin tried to claim priority for Séguin, over Sertürner, for the discovery of this alkaloid (9). As Bernard's name is not mentioned in Séguin's memoir it is from biographical sources that his contribution is known. P. A. Cap wrote in 1850 (19):

> Dans la répartition des travaux que Séguin voulait entreprendre, Courtois fut désigné pour l'étude de l'opium. Il se consacre avec dévouement à ces recherches et il parvint à isoler de l'opium un corps crystallisé, doué de réactions alcalines, et susceptibles de se combiner avec les bases. Cependant, comme il obtenait cette substance par l'intermède de l'ammoniaque, il n'osa pas affirmer que celle-ci fût étrangère aux propriétés alcalines qu'il accusait. Plus hardi que lui, Sertuerner donna le nom d'alcali végétal à la substance cristalline que Courtois avait

> découverte, que n'était autre chose que la morphine, et il eut l'honneur de mettre la science sur une voie nouvelle, en révélant l'existence d'une série de corps, aujourd'hui désignée sous le nom d'alcaloïdes.

L. G. Toraude adds an informative *Note* at the end of his biography (27). A translation :

> There is one point, I am afraid, which seems to me has not been extended or explained sufficiently in the course of this study. It is about the participation of Courtois in the discovery of morphine. Although Courtois had been, on this occasion, his direct collaborator, Séguin nevertheless did not name him **...** Yet, two testimonies of totally different character seem right to confirm it: one, a testimony from the scientist Frémy who relates in one of his letters, *that he has seen Courtois trying to produce the organic alkalis artificially;* the other, a testimony of an illiterate person, who is none other than the widow of Courtois and who writes twenty years after the death of her husband : *He was a saltpêtrier under the reign of Napoléon. For a long time, he gave himself up to serious work on morphine.* These are two testimonies of great significance in our eyes and not to be disregarded.

Séguin's promising opium research nevertheless came to an end, at a time when the *École Polytechnique* was undergoing many changes. Emperor Napoleon issued a decree in July 1804 for the militarization of the school, then another in March 1805 for its transfer to a new building, the former College de Navarre in the Latin Quarter of Paris (28). Séguin, it appears, was in trouble with Napoleon and was forced to return much of his massive fortune. For Bernard, too, 1804 was a turning point because he left the college to assist in a saltpeter business his father had recently set up in Paris (9).

Jean-Baptiste Courtois moves to Paris

It was towards the beginning of 1802 that Bernard's 54-year-old father journeyed from Dijon to Paris and took lodgings with M. Lamy, a courier, at 5 rue Montorgueil. Since he wanted to start a saltpeter business in the capital he proceeded to buy a house at 29 rue Sainte-Marguerite in the east-end suburb of Saint-Antoine, a busy working class district. By June 15 he had signed the legal documents for purchasing the property for 12,236 francs, jointly with his wife. This contract was despatched to Mme Courtois in Dijon, who unreservedly ratified it on June 20 and the conveyance was recorded in Paris on July 4, 1802 (29). Jean-Baptiste had agreed to settle the purchase eleven months later, so with this in mind he travelled back to Dijon to sell some of his national property (9). When he returned to the capital to commence trading, his wife Marie, then aged 60, remained with the family in Dijon.

Rue Sainte-Marguerite (renamed rue Trousseau in 1894) came within the city boundary towards the western side of the suburb, in a populated area near the parish church of Sainte-Marguerite. The road, extending from rue du Faubourg Saint-Antoine to rue de Charonne, had opened in 1622 when a chapel dedicated to Sainte-Marguerite was built. This chapel became the church in 1721 and by the 19th century its parish had about 90,000 inhabitants, one reason why the church cemetery had to close in 1804. Skilled craftsmen had dwelt and traded in the locality since the reign of Louis XIV (1643-1715), many of whom were trade guild dissenters tolerated within the confines of the Royal Abbey of Saint- Antoine. The district, which extended from the place du Trône (named place de la Nation in 1880) to place de la Bastille, had always been quick to rise in support of any rebellion, as it did when a revolutionary mob stormed the Bastille prison on July 14, 1789.

Place du Trône, covering an area of about 12 acres, was designed to commemorate the grand occasion when Louis XIV and Marie-Thérèse passed through to enter Paris after their marriage in 1660. In the 1770s it became one of about 60 entrances at the wall of the *fermiers généraux*, the unpopular administrative boundary built to facilitate tax collection on goods entering the city. However in 1789, renamed place du Trône-Renversé (until 1805), it resembled a field after the revolutionary National Assembly reorganised local administration and the city *département* extended along rue du Faubourg Saint-Antoine no further than the abbey. A guillotine was placed there in July 1794, which claimed 1306 victims in just six weeks. Also another guillotine was put up at place de la Bastille, although it was only allowed to remain for three days because residents protested (30). Three hundred of those executed were buried at the cemetery at the church of Sainte-Marguerite (31).

The violent history of the locality had not deterred *Dijonnais* Jean-Baptiste in 1802 when he purchased the house in rue Sainte-Marguerite for his saltpeter business. At that time, although only until August 1803, Europe was at peace after the signing of the Treaty of Amiens on March 27, 1802. The capital of France was now calm and the regime's authoritarian First Consul Napoléon Bonaparte was made a Consul for life. Also that same year, following a concordat with Pope Pius VII in 1801 the Roman Catholic church was restored to a place in French society again after its banishment during the revolution.

A detailed plan of Paris (32), although made some sixty years before Bernard's father arrived, nevertheless indicates what rue Sainte-Marguerite was like when he started his saltpeter business (Fig.2). His premises had a front opening onto rue Sainte-Marguerite which provided access for horse-drawn transport of materials for the factory. It had once been two separate houses and consisted of a courtyard, several buildings, cellars, sheds and stables, with entrances into the three adjacent properties at the rear and both sides (29). In 1804 information on the saltpeter factory belonging to Jean-Baptiste Courtois was shown in de la Tynna's *Almanach du commerce de Paris*, and it was there again in 1805 and 1806 although the business was failing (9). Indeed it was a sad state of affairs, for in 1805 Jean-Baptiste was bankrupt and it appears that he spent 26 months detained in the *Sainte-Pélargie* debtors' prison, from about November 1805 until his release in December 1807 (33). For Bernard, too, who had to manage the situation of the saltpeter business at rue Sainte-Marguerite, this was a very difficult time.

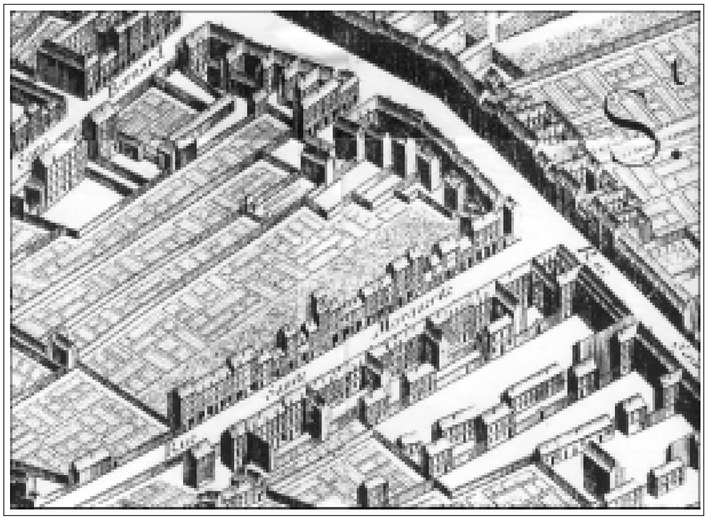

Figure 2. *Houses in Rue Sainte Marguerite from Turgot's plan of Paris (1734-39).*

Bernard Courtois in the Saltpeter Industry

Bernard's life and work were greatly affected by Jean-Baptiste's business affairs once he left the *École Polytechnique* in 1804. It was presumably for the saltpeter business that, towards the end of that year, he borrowed 32,528 francs in solidarity with his father to be paid back over a period extending to 1816. Their four creditors were MM. Desgouges, a salpêtrier; Lamy, a merchandise courier; Bourlier, a chemicals manufacturer; and Guyton de Morveau who loaned 4,000 francs (34, 35). Bernard may have been unaware of his father's precarious financial circumstances when he entered into these agreements. In fact it seems that Jean-Baptiste owed creditors for his purchase of 29 rue Sainte-Marguerite, which he had originally agreed to settle by 1803 (36). In Dijon also, although his ownership of the *Saint-Médard Nitrary* was completed in 1794 he still had other debts on the property. These debts were taken over by the purchaser when Bernard's elder brother Pierre, as his father's proxy in Dijon, sold the nitrary for 24,000 francs on October 12, 1805 (37). Unfortunately the proceeds from this sale did not prevent Jean-Baptiste's insolvency.

Thus it came about that the first official record for Bernard Courtois as a Paris businessman was a financial statement deposited with the Seine Tribunal of Commerce on February 26, 1806. It was for a factory at 39 rue Sainte-Marguerite belonging to Bernard Courtois Fils, *salpêtrier* (34). This indicated that Bernard was in charge under the unfortunate circumstances, shortly before his father's legal representative sold the property on May 28 (36). Some nineteen months later Jean-Baptiste's bankruptcy discharge document recorded his address as 9 rue Saint-Ambroise (33), a road just less than a mile north of rue Sainte-Marguerite, in the Popincourt district. *L'Almanach du commerce de Paris* showed that a M. Lamirau managed a saltpeter works there in 1807 and 1808 (38). Nevertheless no details are known about the life of Jean-Baptiste after his discharge.

In 1808 Bernard married Madeleine Morand the daughter of a Paris hairdresser, but his address and occupation from 1807 to 1809 are not known (9). However, except for the three years 1815 to 1817, details of his saltpeter factory at 9 rue Saint-Ambroise appeared in *L'Almanach du commerce de Paris* from 1810 until 1821 (38). This road had opened in 1783 on land belonging to the former convent *des Annonciades de Popincourt.* The convent's chapel of *Notre-Dame de Protection*, at the west end of the road near rue Popincourt, was the parish church from 1791 until the new Saint-Ambroise church was built in the 1860s (39). Rue Saint-Ambroise was still relatively undeveloped in 1810 when Bernard commenced trading, with just a few houses on the side opposite the church. This was soon to change, since land adjacent to the church buildings was earmarked for one of five large abattoirs to be built in Paris according to the Emperor's decree of 1810. However, the project was delayed, so for a few years Bernard was spared the inconvenience of a major development near his property; but eventually the large, attractively designed abattoir *Ménilmontant* opened in September 1818. It occupied the rectangular area bounded by the rues Saint-Maur, Saint-Ambroise, de Chemin-Vert. and a new road linking the two latter—part of Avenue Parmentier (40). Some years later when the Paris land registry plans were produced (Fig.3), the house at 9 rue Saint-Ambroise was shown to occupy about 0.25 acres, with a good sized courtyard surrounded by outbuildings (41).

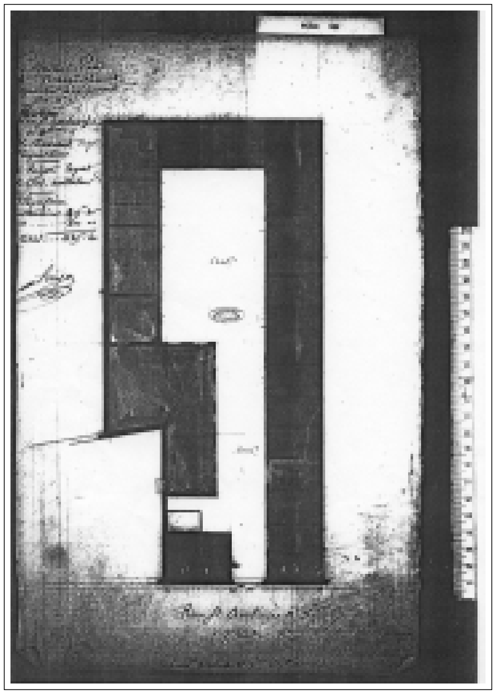

Figure 3. *Plan from the Paris Land Registry for the house at 9 Rue Saint-Ambroise in the Popincourt district (about 1840).*

Iodine

Meanwhile, with France at war until 1815 and the saltpeter trade largely government controlled, there was a shortage of wood ashes for obtaining potassium nitrate from nitre-bed mother-liquors. As an alternative source of potassium salts the manufacturers turned to cheap soda kelp made from ashes of Normandy and Brittany seaweeds. This raw material also contained another very important chemical, as yet undiscovered, which was to make Bernard famous soon after he began using the kelp in his manufacturing process. It all began one day towards the end of 1811 when he was investigating corrosion of his copper vessels and noticed an unusual purple vapor given off, an event later recorded by Humphry Davy (42) :

> ... This substance was discovered accidentally, 2 years ago by M. Courtois, a Paris manufacturer. In the course of the procedure by which he obtained soda from seaweed ash, he found that the metal vessels he used were corroded and he looked for the cause, when he discovered the new substance. It appeared when a little sulfuric acid was added to the ash after extracting carbonate of soda. When the acid is concentrated enough to produce a strong heat the new substance appears as a beautiful violet vapour and condenses in crystals which are the colour and lustre of graphite.

L.G. Toraude notes that Davy does not actually state that Courtois was using sulfuric acid to remove this corrosion product in his metal vessels. He considers that Bernard may have noticed the violet vapor for the first time, as a result of the reaction of the acid on this *calfatage*, and it then appeared again when he added sulfuric acid to his seaweed ash (27). Davy's record of the discovery can be interpreted this way.

Bernard investigated this interesting substance in his laboratory for a few months although busy running his business. He determined many of its properties including its reaction with ammonia to form a fulminating powder (43). The French chemists knew nothing of the discovery until he informed his former colleagues Nicolas Clément and Charles-Bernard Désormes about May 1812, and asked them to continue his research. They too had other commitments so it was not until November 29, 1813 that Clément, the professor of chemistry at the Conservatoire des Arts et Métiers, was able to announce it to the Institute. Clément presented the paper a week later on December 6, with Bernard as author, and the name *Iodine* proposed by Gay-Lussac was used. Gay-Lussac's on-going research on iodine and his opinion that it was a simple substance analogous to chlorine were also mentioned (44, 45).

Prior to the announcement of Bernard's discovery, Clément had invited Gay-Lussac to do some research on the new substance which he also showed to the scientists Chaptal and Ampère (43). Thus it came about that when the distinguished chemist Humphry Davy arrived in Paris he received a sample from the physicist Ampère. Davy, who in 1813 was "...going to the Continent upon a journey of scientific inquiry," was only in the capital from October 15 until December 23 (45). Nevertheless, during this short visit he did many experiments on his sample, concluding that it was a new undecomposable substance with similar chemical properties to chlorine and it formed a new acid with hydrogen (46). In fact Davy's results were published in December 1813, at almost the same time as Gay-Lussac's first two papers on iodine (47, 48) before his lengthy memoir of 1814 (43).

Bernard was clearly acknowledged as the discoverer of iodine by these distinguished chemists, two years after the important event. Meanwhile he had generously provided samples and discussed the substance with pharmacist friends, and articles began to appear in the journals of pharmacy (49). He was rewarded for this loyalty some years later about 1820 when German doctors visiting Paris told him about the numerous valuable medicinal properties that iodine possessed (50). This was known from medical research by the Swiss doctor Jean-Francois Coindet (1774-1834), who found that iodine was an effective remedy for goitre and several other ailments (51). Soon afterwards, hoping to profit from his discovery, Bernard decided to change his business and manufacture iodine and its salts. However he was still a *salpêtrier* when his son Louis was born in 1816, for although his business at 9 rue Saint-Ambroise was not in *L'Almanach du commerce de Paris* from 1815-1817, it appeared from 1818-1821.

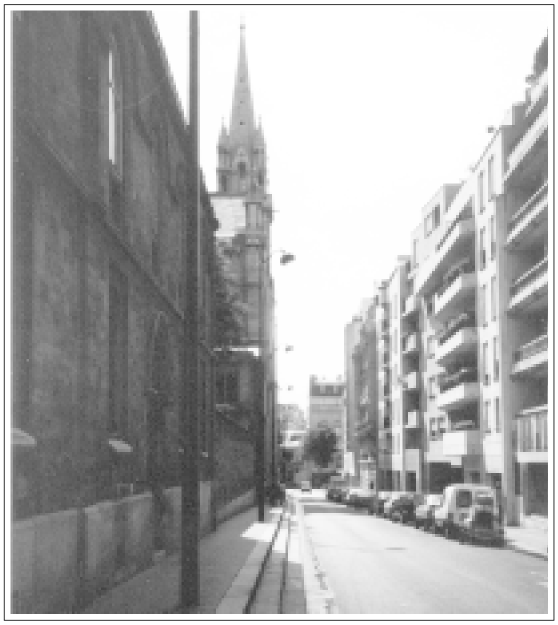

Figure 4. *View along Rue Saint-Ambroise near the church. The white van is parked near number 9. (photo by the author, 1997)*

The Napoleonic wars were over, and importation of cheap Indian saltpeter began in 1815, making manufacturing less profitable. Bernard realized there would be a demand for iodine so, helped by Clément and Désormes, he developed an industrial process using chlorine to extract iodine from mother liquors of seaweed ashes (52). He first appeared as a manufacturer of high quality iodine and its salts in 1822, at a new address in the old historic center of Paris, 3 Quai de la Cité (now part of Quai la Corse). However the next year he was back in the district of Popincourt, a short distance north of rue Saint-Ambroise, at 36 rue des Trois-Couronnes from 1823-1824, then at number 26 from 1825-1833 (38). This district became inconveniently isolated from the city center when the nearby canal Saint-Martin was completed in 1825. However, from 1814, he also sold his products from depots at addresses in other districts, shown in the Table.

Bernard's business remained small although inevitably, demand increased as more was known about the medicinal properties of iodine. As early as 1824 another factory opened producing relatively large quantities, managed by M. Tissier for Baron d'Aigremont. Then Tissier joined Couturier's Cherbourg soda manufacturing company to set up a factory for the manufacture of iodine and salts from seaweed ashes. This was soon producing 400 kg of iodine a year at a price of 100 francs a kilogram (Bernard charged 600 francs). In 1830 Tissier was a co-founder of a factory at Conquet, Finistère, which became well-known for its iodide of potassium. Nevertheless Bernard's modest business survived until it was taken over by Couturier & Company in 1835. He then went to live in lodgings at number 12 l'Impasse des Récollets (38).

Although trading on his reputation as the discoverer of iodine, Bernard found it difficult to make a living as a manufacturer and salesman; but he persevered for many years. He received recognition for his valuable contribution to medicine in 1831, when *l'Académie royale des sciences* awarded him 6,000 francs as part of its Montyon prize, on the recommendation of his friend the distinguished chemist Louis-Jacques Thénard (19). Nevertheless when he died at his lodgings on September 27, 1838 at the age of 62, he left no assets for his widow and son. He was buried in a temporary grave for five years at the cemetery of the North, but what finally happened to his remains is not known. Madeleine, his widow, struggled against the misfortunes of poverty and ill-health for many years. At the time of her death in 1859 aged 70, she had a few possessions and a small pension (38). As the widow of Bernard Courtois, discoverer of iodine, she had received financial help, somewhat belated, from the Society for the Encouragement of National Industry and the Society of Pharmacy.

REFERENCES AND NOTES

1. L. G. Toraude, *Bernard Courtois (1777-1838) et la découverte de l'iode (1811)*, Vigot Frères, Paris, 1921.
2. W. A. Smeaton, "Guyton de Morveau's Course of Chemistry in the Dijon Academy," *Ambix*, **1961**, *9*, 53-69.
3. Ref. 1, Ch. 1.

Table 1 *Depots for Iodine and Salts produced by Bernard Courtois*

Year	Address	Reference
1814	rue de Vieille-du-Temple (with pharmacists MM Vallee & Baget)	(49)
1814	rue Saint-Victor	(49)
1827-1829	15 rue Jacob	(38
1830-1832	17 rue Jean-de-l'Epine	(38); the road is now part of rue de la Coutellerie (30)
1833-1834	6 rue des Enfants-Rouges (chez Lecreux)	(38); this road, now part of rue des Archives, was near l'hopital des Enfants-Rouges (30)

4. W. A. Smeaton, "Science and the Arts in a French Provincial City. The Dijon Academy from the Eighteenth to the Twentieth Century," *Proc. Manchester Lit. Philos. Soc.*, **1993-94**, *132*, 81-91.
5. A. Baudot, "Etudes historiques sur la pharmacie en Bourgogne avant 1803," *Mém. Acad. Dijon,* **1905,** 497-499.
6. Cited in Ref. 3: Guyton de Morveau, "Recherches pour perfectionner la préparation des couleurs employées dans la peinture," *Nouveau Mémoires de l'Académie de Dijon, premier semestre*, **1782**, 23.
7. Ref. 1, Annexes Pièce 1.
8. Ref. 1, Ch. 2.
9. Ref. 1, Ch. 3.
10. *Encyclopaedia Britannica*, Adam and Charles Black, Edinburgh 1885, *9th ed.,* Vol. 8, 227.
11. W. A. Smeaton, "The Early History of Laboratory Instruction in Chemistry at the Ecole Polytechnique, Paris, and Elsewhere," *Annals Sci.* **1954**, *10*, 224-233.
12. J. Langins, "The Decline of Chemistry at the Ecole Polytechnique (1794-1805)," *Ambix*, **1981**, *28*, 1-19.
13. Ref. 1, Ch. 6.
14. W. A. Smeaton, "Fourcroy, Antoine François de," in C. C Gillispie, Ed., *Dictionary of Scientific Biography*, Charles Scribner's Sons, New York, 1970-1979, Vol. 5, 89-93.
15. A collection of documents in a folder headed "Thénard - Préparateur de Chimie: 1798. Professeur de Chimie: 1810 -1836," is available at the École Polytechnique Bibliothèque Centrale Archives, Palaisseau, Paris.
16. Ref. 15, Thénard's posting is known from a letter dated, "25 August 1799 (*le 8 fructidor an 7*)," from "Le Ministre de la Guerre au C[en] Thénard préparateur de Chimie, à l'Ecole Polytechnique à Paris."
17. S. Pierson, "Séguin, Armand," in Ref. 14, Vol.12, 286-287.
18. There are no documents on Séguin at the École Polytechnique Bibliothèque Centrale Archives, Palaisseau, Paris. However, his name does appear in one of the many documents in the folder headed, "Fourcroy – Professeur de Chimie : 1794 – 1808." This contains a long handwritten inventory concerning, "effets et matières" held in "Ecole Polytechnique ... Magasin de Chymie." It is dated "1[er] Messidor an 5. 19 juin 1797," but there are later additions, e.g. "fer en fonte" in 1799. Séguin's name is near the end under "Objects déposés et non appartenant au Magasin: 3 Barile contenant des terres dont un grand et deux petits provenant du C[n] Guyton 1 Paquet de Cuir tanné ...1 Baril contenant du Tan, appartenant au C[n] Seguin." (As an industrialist Séguin may have assisted with the courses for students on industrial processes and applications. See Ref. 12, p 5.)
19. P. A. Cap, "Notes historiques sur Bernard Courtois et sur la découverte de l'iode," *J. Pharm. Chim.*, **1851**, *20*, 131-138.
20. St. Le Tourneur, "Courtois, Bernard," in Roman d'Amat, Ed., *Dictionnaire de Biographie Française*, Librairie Letouzey et Ané, Paris-VI, 1961, Tome Neuvième, 1038.
21. W. A. Smeaton, "Guyton De Morveau, Louis Bernard," in Ref. 14, Vol. 5, 600-604.
22. M. Bradley, "The Facilities for Practical Instruction in Science during the Early Years of the Ecole Polytechnique," *Annals Sci.*, **1976**, *33*, 425-446.
23. Details from a document in the Ecole Polytechnique Bibliotheque catalogue: "Author Guyton de Morveau, Louis Bernard, *Programmes des cours* révolutionnaires *sur la fabrication du salpêtre, des poudres et des canons faits à Paris dans l'amphithéatre du Muséum d'histoire naturelle et dans la salle des électeurs, maison du ci-devant Évêché les 1, 11, 21 Ventôse et 5 Germinal, deuxième année de la République française une et indivisible/ par les citoyens Guyton, Fourcroy, Dufourny, Berthollet, Carny, Pluvinet, Monge, Hassenfratz et Perrier*. Paris, 1794, Imprimerie du Comité de salut public."

24. J. G. Smith, *The Origins and Early Development of the Heavy Chemical Industry in France*, Clarendon Press, Oxford, 1979, 179, 182.
25. M. P. Crosland, "Thenard, Louis Jacques," in Ref. 14, Vol. 13, 309-314.
26. A. Séguin, "Premier Mémoire sur l'Opium," *Ann. Chim*., **1814**, *92*, 224-247.
27. Ref. 1, Annexes Notes.
28. M. Bradley, "Science Education versus Military Training: The Influence of Napoleon Bonaparte on the Ecole Polytechnique," *Annals Sci.*, **1975**, *32*, 415-449.
29. Ref. 1, Annexes Pièce 2.
30. J. Hillairet, *Dictionnaire Historique Des Rues De Paris*, Les Editions de Minuit, Paris, 1963; see details for *Nation* (*place de la*).
31. Historical details from two wall plaques in Paris: "Eglise et cimetière Sainte-Marguerite," on the wall inside the church of Sainte-Marguerite near the rue St. Bernard entrance, and "La paroisse du Faubourg," *in* rue St. Bernard on the wall outside the church.
32. Plan of Paris 1734-1739, commissioned by Michel Etienne Turgot.
33. Ref. 1, Annexes Pièce 9.
34. Ref. 1, Annexes Pièce 5.
35. Ref. 1, Annexes Pièce 6.
36. Ref. 1, Annexes Pièce 8.
37. Ref. 1, Annexes Pièce 7.
38. Ref. 1, Ch. 8.
39. "Cronistoria Della Chiesa Di Saint-Ambroise" is a document about the history available at the church.
40. Ref. 30, see details for *Guilhem* (*rue*).
41. Cadastre de Paris Microfilm Document F/31/61, "Pièce 144 Quartier Popincourt Maison Rue S[t.] Ambroise N[o] 9," *Centre d'accueil et de recherche des Archives nationales (CARAN) Paris*. "En face de l'abattoir" is handwritten on Pièce 159 Maison Rue S[t.] Ambroise N[o] 11.
42. H. Davy, "Some Experiments and Observations on a New Substance which becomes a Violet-coloured Gas by Heat," *Philos. Trans. R. Soc. London*, **1814,** *Part 1*, 74-93; also a translation by professeur de la Rive in "Mémoire sur l'iode," *Ann. Chim*., **1814,** *92*, 74.
43. J. Gay-Lussac, "Mémoire Sur l'iode," *Ann. Chim*. **1814**, *91*, 5-160; see his "Note historique sur la découverte de l'iode," pp 118-119.
44. B. Courtois, "Découverte d'une substance nouvelle dans le Vareck," *Ann. Chim*., **1813**, *88*, 304-310.
45. J. Davy, *Memoirs of the Life of Sir Humphry Davy*, Smith, Elder and Co, Cornhill, London, 1839, 163-164.
46. H. Davy, "Sur la nouvelle substance découverte par M. Courtois, dans le sel de Vareck," *Ann. Chim*., **1813**, *88*, 322-329.
47. J. Gay-Lussac, "Sur un nouvel acide formé avec la substance découverte par M. Courtois," *Ann. Chim*., **1813**, *88*, 311-318.
48. J. Gay-Lussac, "Sur la combinaison de l'iode avec l'oxigène," *Ann. Chim*., **1813**, *88*, 319-321.
49. Ref. 1, Ch. 7.
50. Ref. 38, Letter written by the widow of Bernard Courtois in 1849 to the secretary of the School of Pharmacy in Paris.
51. B. Reber, "Le Docteur Coindet," *Aesculape*, **1913**, *3*, 93-96.
52. Ref. 1, Ch. 4.

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ABOUT THE AUTHOR

Patricia A. Swain received her Ph.D. in physical chemistry at Imperial College, London in 1958, for research on reactions of alkaline iodine solutions with aliphatic aldehydes. From 1958-1960 she was an investigator with The British Non-Ferrous Metals Research Association and since then has mainly combined school teaching with raising a family. She was employed as a chemist with Scott Bader Company from 1968-1969 and in 1977 received a P.G.C.E. at the London Institute of Education. A teacher's study period at St. John's College, Oxford in the summer of 1992 enabled her to further an interest in the history of chemistry. Her address is 122 Juniper, Bracknell, Berkshire, RG12 7ZE, UK. E-mail: Pswain5050@aol.com.

CALL FOR NOMINATIONS FOR THE 2006 EDELSTEIN AWARD

The Division of History of Chemistry (HIST) of the American Chemical Society (ACS) solicits nominations for the 2006 Sidney M. Edelstein Award for Outstanding Achievement in the History of Chemistry. This award, first given in 2002, honors the memory of the late Sidney M. Edelstein, who established the Dexter Award in 1956, and continues the tradition of the Dexter Award for Outstanding Achievements in the History of Chemistry, which was discontinued after 2001. Lists of previous recipients of the Edelstein Award and its predecessor Dexter Award are available at the HIST webpage (http://www.scs.uiuc.edu/~mainzv/HIST/).

The Edelstein Award is sponsored by Ruth Edelstein Barish and family and is administered by HIST. The recipient chosen to receive the Edelstein Award is presented with an engraved plaque and the sum of $3500, usually at a symposium honoring the recipient at the Fall National Meeting of the ACS, which in 2006 will be held in San Francisco, CA, September 10-14. The award is international in scope, and nominations are welcome from anywhere in the world. Previous winners of the Dexter and Edelstein Awards include chemists and historians from the United States, Canada, Germany, France, the Netherlands, Hungary, and the United Kingdom.

A complete nomination consists of

- a complete curriculum vitae for the nominee, including biographical data, educational background, awards, honors, list of publications, and other service to the profession;
- a letter of nomination summarizing the nominee's achievements in the field of the history of chemistry and citing unique contributions that merit a major award; and
- at least two seconding letters.

Copies of no more than three publications may also be included. Only complete nominations will be considered for the award.

All nomination materials should be submitted in triplicate to James G. Traynham, Chair of the Edelstein Award Committee for 2006, 122 Highland Trace Drive, Baton Rouge, Louisiana 70810-5061 U.S.A. (e-mail: jimtraynham@msn.com) for arrival no later than December 31, 2005.

THE DECOMPOSITION OF HYDROGEN PEROXIDE BY BLOOD. GEORGE SENTER'S DISCOVERY OF THE ENZYME INVOLVED

John T. Stock† and James D. Stuart,* University of Connecticut

Discovery of Hydrogen Peroxide and its Catalytic Decomposition

Figure 1. *Jacques Thénard (1777-1857)*

Hydrogen peroxide was discovered in 1818 by Louis Jacques Thénard (Fig. 1), professor at the Collège de France (1). He was examining the action of various acids on barium peroxide and at first thought that he had made modified forms of the acids. Eventually he concluded that the "eau oxygènée" was a new compound that contained more oxygen than water. The addition of various substances, including blood, caused the new compound to decompose, with evolution of oxygen.

The term *catalysis* was coined in 1835 by Jöns Jakob Berzelius to characterize the promotion of chemical reactions by a substance that appears to remain unchanged (2). As an example, he mentioned the decomposition of hydrogen peroxide. Since then, catalysis has been studied by many others, especially Wilhelm Ostwald, whose nomination for the 1909 Nobel Prize for Chemistry was largely based on his work in this field.

In 1863 Christian Friedrich Schönbein (Fig. 2), professor at Basel, found that various other animal and plant extracts, as well as blood, also cause the decomposition of hydrogen peroxide (3). He concluded that *enzymes*, the natural catalysts contained in the additives, were responsible for this effect. Unlike metallic catalysts, enzymes could be deactivated by heating. Certain substances, now commonly termed "catalyst poisons," were found to interfere with enzyme activity.

George Senter

While Ostwald was Professor of Physical Chemistry at the University of Leipzig, he assigned studies that involved catalysis to a number of his English-speaking students. One such recipient was the Scotsman George Senter, who was born in Kildrummy on January 25, 1874. Following primary education, he studied pharmacy in London and graduated from the University of London in 1900. He then entered Ostwald's laboratory, aiming to bring order to a topic with a long history: the decomposition of hydrogen peroxide by blood. Obviously, Senter had to review the numerous studies that had been carried out during the long time interval since the discovery of the decomposition. He devoted more than one quarter of his very long paper to a survey of catalysis, especially of the catalytic decomposition of hydrogen peroxide by blood and by other substance (4).

Enzyme Action

Other workers had noted that the action of an enzyme is often limited to one or one type of reaction and that the temperature of deactivation varies with the particular enzyme (5, 6). The demonstration that an extract from a living cell can possess enzyme activity dismissed the earlier view that enzyme action required living cells themselves. An example is the extraction of the sugar-fermenting enzyme, zymase, from yeast cells (7). Nevertheless, Senter commented that, owing to the chemical nature of enzymes and the difficulties of their extraction, not one enzyme had been obtained in approximately pure state.

Figure 2. *Christian Friedrich Schönbein (1799-1868)*

Senter viewed the enzymes as belonging to two main classes, the first being hydrolyzing enzymes such as emulsin which, for example, breaks down the glucoside amygdalin. He pointed out that, although these enzymes had been extensively studied, enzymes of the second class, the *oxidases*, had not received much attention. Enzymes in substances that caused the decomposition of hydrogen peroxide were provisionally termed *superoxidases.*

As Berzelius had noted, inorganic substances such as metals can cause the decomposition of hydrogen peroxide. Senter termed such substances *general catalysts*. The utility of platinum as a catalyst was greatly enhanced by the introduction of colloidal platinum by Georg Bredig in 1898 (8). Bredig was a member of Ostwald's staff, so Senter naturally studied the catalysis of hydrogen peroxide both by enzyme preparations and by platinum sol.

Preliminary Experiments

Preliminary experiments on the decomposition of hydrogen peroxide were made, with either defibrinated ox blood or commercial hemoglobin as the catalyst. The results confirmed many of the observations of earlier workers, who had followed the progress of the reactions by measurement of the evolution of oxygen. Because of sources of error such as possible supersaturation, Senter decided to measure the amount of hydrogen peroxide present at any time by titrating it at ice temperature with potassium permanganate solution. Dilute solutions and a low temperature minimized the destruction of hemoglobin by the peroxide.

In a typical experiment, 100 mL each of 0.1 percent hemoglobin solution and 0.01 M hydrogen peroxide were mixed. Samples for titration were withdrawn at timed intervals. Even after 12 hours, only about 3% of the peroxide had been decomposed. When blood solution, corresponding to approximately 1 part in 7,000 with respect to hemoglobin, replaced the hemoglobin solution, all of the hydrogen peroxide had decomposed in about 5 minutes. These results, which showed that hemoglobin itself possesses less than one ten-thousandth of the activity of blood, led Senter to seek the active enzyme in blood.

Isolation of the Enzyme

Various attempts at isolation, including fractional precipitation by sodium chloride or other salts, were unsuccessful. Senter then tried precipitation by ethanol. He had found that the precipitation of hemoglobin from 50% ethanol was negligible. Therefore hemoglobin should stay in solution when equal volumes of blood solution and of 99% ethanol were mixed. The red-brown precipitate that formed was washed with dilute ethanol to remove traces of hemoglobin, then the solid was dried in vacuum. The powdered solid was mixed with water and left in an ice chest for 1-2 days to extract the enzyme. Filtration gave a slightly yellowish solution that had strong catalytic properties and was stable for weeks at 0° C. At Ostwald's suggestion, the enzyme in the solution was named "Hämase" (I believe that the modern name is *catalase*). Because the ash obtained from a few cc of solution did not give a red color with acidified thiocyanate solution, Senter concluded that the enzyme did not contain iron. This metal was certainly present, but at a concentration too low for detection by his method.

Dynamics of the Hämase-catalyzed Decomposition of Hydrogen Peroxide

Preliminary experiments on the rate of decomposition, carried out with diluted blood, implied that the rate of reaction was of first order with respect to the concentration of hydrogen peroxide. Senter made some measurements at temperatures up to 30° C but, having found that catalysis proceeded satisfactorily at 0° C, he carried out almost all of his subsequent experiments at this temperature.

Having demonstrated that no oxidation of Hämase occurred when the initial concentration of hydrogen peroxide was 1/80 M, he made extensive measurements with fixed amounts of Hämase and various lower concentrations of hydrogen peroxide. Consistent values for the velocity constant, K, were obtained for each of the concentration levels. However, these values depended upon the level chosen. This is indicated in Table 1, which gives the average value of K for each hydrogen peroxide (H_2O_2) concentration.

Table 1. Effect of H_2O_2 concentration on the velocity constant with fixed enzyme concentration

H_2O_2 (M)	1/106	1/126	1/290	1/440	1/460	1/1100
Constant, K	0.0192	0.0175	0.0120	0.0225	0.0188	0.0122

Senter then conducted experiments with a constant initial concentration of peroxide but with variable amounts of Hämase. For purposes of comparison, Senter used velocity constant values that were calculated for an interval in which the H_2O_2 titer fell to approximately one half. Table 2 summarizes the results applicable to the series in which the H_2O_2 concentration was approximately 1/480 M.

Table 2. Effect of relative Hämase concentration with fixed H_2O_2 concentration

Relative Hämase conc.	3:	6:	8:	24
Constant, K	0.0028	0.0058	0.0072	0.0230
Velocity/Hämase conc.	9.33	9.66	9.00	9.6

Obviously, the velocity constant increases with increasing Hämase concentration. However, within experimental error, the velocity of reaction is proportional to the concentration of enzyme. Senter concluded that, in dilute solutions, the rate of decomposition of hydrogen peroxide was proportional to the product of the respective concentrations of peroxide and of Hämase. However, this relationship did not hold for more concentrated solutions. Senter assumed that hydrogen peroxide itself exerted a retarding effect on the reaction. He introduced a correction term to allow for the retardation but could not check this quantitatively. Quoting available results that had been obtained with colloidal platinum as a catalyst (9), Senter noted that, in some respects, the phenomena observed were paralleled by those found with Hämase. In the end Robert Luther, who almost certainly supervised Senter's work, developed a more complicated relationship that satisfactorily accounted for the experimental data.

Effect of Heat and of Various Additives on the Catalytic Decomposition of Hydrogen Peroxide

Parallel experiments with Hämase, carried out at 0° C and 10° C, indicated that the temperature coefficient of the rate of decomposition was +1.50 for this 10-degree interval. Although this coefficient is smaller than in many other reactions, it is in line with +1.7, quoted for the platinum-catalyzed decomposition of hydrogen peroxide.

Senter found that, in decomposition experiments made at 65° C, the activity of blood or Hämase was completely lost in 15 minutes. In experiments at 55° C, only 5% of the original activity remained after 2 hours, while about 60% remained after a heating period of 3 hours at 45° C.

Jacobson had found that small amounts of acids hindered the catalytic decomposition of H_2O_2 (5). Senter extensively examined the very marked hindering effect of submillimolar concentrations of hydrochloric and nitric acids on the Hämase-catalyzed decomposition of hydrogen peroxide. Results with acetic acid were similar when allowance was made for the incomplete ionization of this weak acid. Senter concluded that the hydrogen ion caused the hindrance, even though hydrogen-ion concentration had no effect in the platinum-catalyzed decomposition of peroxide (9). Following an experiment involving a slightly acidified solution of hydrogen peroxide and Hämase, Senter added sodium hydroxide to neutralize the acid and then added more hydrogen peroxide. A second decomposition could then be performed, thus demonstrating that acidification did not permanently decrease the activity of the enzyme.

Unlike the rapid response to acidification, Hämase deactivation by sodium hydroxide took several hours. However, as with acids, the activity was restored on neutralization. Compound formation between hydrogen peroxide and sodium hydroxide had been reported in 1901 (10), so that hindrance by the alkali might be modified by such formation.

Having shown that salts such as sodium chloride or potassium nitrate also caused hindrance, Senter turned to the well-known general "catalyst poisons," cyanide and aniline. Even at micromolar levels, hydrocyanic acid exerted a hindering effect on the catalysis by Hämase. Senter attributed the smaller effect, when blood was the catalyst, to the binding of the cyanide by hemoglobin. He pointed out that the effect of HCN in catalysis by platinum was about 20 times greater than in catalysis by Hämase. Senter found that aniline has a much weaker poisoning effect than hydrocyanic acid. In experiments with blood solutions that were 2.5 millimolar with respect to aniline, half of the original peroxide remained after 16 minutes.

Senter's paper included a survey of the then prevailing views of enzyme action (4). Concerning living organisms, his provisional theory was that oxygen from the air was carried over to oxidizable substances, whereby oxides and hydrogen peroxide were formed. A reaction scheme for this had been proposed by Fritz Haber in 1900 (11). Senter concluded by summarizing the analogies that exist between catalysis by colloidal platinum and by Hämase. Both substances are colloidal in solution and catalyze the decomposition of hydrogen peroxide at comparable rates. The catalyses have small temperature coefficients and are both poisoned by HCN and aniline. A major difference is sensitivity to temperature. The activity of the enzyme is destroyed by moderate heating.

Senter's Career

Senter received his D. Phil. at Leipzig in 1903 and was appointed lecturer in chemistry at St. Mary's Hospital Medical School in London. Here he continued the work begun in Leipzig, including the study of the hindering effects on catalysis of other compounds (12). He showed that these effects agreed with those expected from the ionic theory and reiterated his belief that enzyme action was most simply explained by the theory proposed by Nernst (11). However, he gave reasons for supposing that this theory was not of general application in heterogeneous systems (13, 14).

Figure 3. *George Senter (1874-1942) photo provided by B. Hudson of the Royal Pharmaceutical Society of Great Britain.*

Since Senter's pioneering studies, interest in enzymes and enzyme action has grown enormously. By 1992, when the 12th Collective Index of *Chemical Abstracts* appeared, about one hundred pages were devoted to these topics.

Senter's interests eventually turned to areas such as the reactivity of halogens in organic compounds and the Walden inversion. His texts on inorganic and physical chemistry ran through numerous editions. In 1913 Senter became head of the chemistry department of Birkbeck College, which later became part of the University of London. He was appointed Principal of the College in 1918 and became an active member of the University Senate (15). A tribute to his distinguished service both to the College and to the University marked his retirement in 1939 (16). He died in Pinner, Middlesex, England, on March 14, 1942.

REFERENCES AND NOTES

† Deceased February 6, 2005. This paper was fully prepared by Prof. J. T. Stock.

* J. D. Stuart as the corresponding author provided only formatting and certain editorial changes in preparing the manuscript for publication. This paper was read at the 229th ACS National Meeting, in the Division of the History of Chemistry Session, San Diego, CA, March 13, 2005, HIST 004.

1. J. W. Mellor, *A Comprehensive Treatise on Inorganic and Theoretical Chemistry*, Longmans Green, London, 1924, Vol. 1, 878.
2. J. E. Jorpen, (trans. B. Steele), *Jac. Berzelius, His Life and Work*, Almqvist & Wiksell, Stockholm, 1966, 109-112.
3. C. F. Schönbein, "Ueber die katalytische Wirksamkeit organischer Materien," *J. Prakt. Chem.*, **1863**, *89*, 323-344.
4. G. Senter, "Das Wasserstoffsuperoxyd-zersetzende Enzym des Blutes. I," *Z. Phys. Chem.*, **1903**, *44*, 257-318.
5. J. Jacobson, "Untersuchungen über lösliche Fermente," *Z. Physiol. Chem.*, **1892**, *16*, 340-369.
6. G. Tammann, "Zur Wirkung ungeformte Fermente," *Z. Phys. Chem.*, **1895**, *18*, 426-442.
7. E. Buchner, "Alkoholische Gährung ohne Hefezellen," *Ber. Dtsch. Chem. Ges.*, **1897**, *30*, 117-124.
8. G. Bredig, "Darstellung colloidaler Metallösung durch elektrische Zerstäubung," *Z. Angew. Chem.*, **1898**, *11*, 951-9
9. G. Bredig and K. Ikeda, "Ueber anorganische Fermente. II. Die Lähmung der Platinkatalyse durch Gifte," *Z. Phys. Chem.*, **1901**, *37*, 1-68.
10. H. T. Calvert, "Ueber die Alkalisalze des Hydroperoxides in wässeriger Lösungen," *Z Phys. Chem.*, **1901**, *38*, 513-542.
11. F. Haber, "Ueber die Autoxydation und ihren Zusammenhang mit der Theorie der Ionen und der galvanischen Elemente," *Z. Elektrochem.*, **1900-1901**, *7*, 441-448.
12. G. Senter, "Das Wasserstoffsuperoxyd zersetzende Enzym des Blutes. II., Z. *Phys. Chem.*, **1905**, *51*, 673-705.
13. G. Senter, "Reaction-velocities in Heterogeneous Systems: with Particular Reference to Enzyme Actions," *J. Phys. Chem.*, **1905**, *9*, 311-319.
14. G. Senter, "The Role of Diffusion in the Catalysis of Hydrogen Peroxide by Colloidal Platinum," *Proc. R. Soc., London*, **1905**, *74*, 566-574.
15. W. Wardlaw, "Dr. George Senter," *Nature*, **1942**, *149*, 405-406.
16. Anon, "Dr. George Senter," *Nature*, **1939**, *143*, 1014.

ABOUT THE AUTHORS

The late John T. Stock and James D. Stuart, both Professor Emeriti, were colleagues for many years at the Department of Chemistry, University of Connecticut, Storrs, CT 06269-3060.

John T. Stock, born in Margate, England in 1911, died on February 6, 2005, in Storrs, CT. Professor Emeritus of Chemistry at the University of Connecticut, Dr. Stock held baccalaureate, M.Sc., Ph.D., and D.Sc. degrees from University of London. After an active career in analytical chemistry, Professor Stock turned his efforts in retirement toward the history of chemistry, with particular attention to instrumentation and the legacy of students of Wilhelm Ostwald. He made oral presentations at virtually every national American Chemical Society meeting over a 20-year period and published numerous articles in this field, many in the *Bulletin*. His last paper appears in this issue. The recipient of the Dexter Award of the History of Chemistry Division in 1992, Dr. Stock was a life member of the Royal Society of Chemistry, the Society of Chemical Industry, the Royal Institution, and a 50-year member of the American Chemical Society.

BOOK REVIEWS

The Enlightenment of Joseph Priestley: A Study of His Life and Work from 1733-1773 (1997); The Enlightened Joseph Priestley: A Study of His Life and Work from 1773-1804 (2004). Robert E. Schofield, The Pennsylvania State University Press, University Park, PA.

In the Preface to the first volume of this superb biography the author noted:

> I now present the first fruit of an attempted solution to the Priestley manifold. It is only one of the two volumes I had planned for the complete story of Priestley's life. But volume 2 is not completed and retirement and two bypass operations have forced me to accept temporal realities. I can no longer choose to delay publication of half my work in anticipation of completing the whole.

It was then a marvelous moment when, on August 24, 2004, Robert Schofield, in seeming good health and powerful voice, burst into the final session of the two-day symposium, "Joseph Priestley, Universal Catalyst," waving a copy of the second volume of his *magnum opus*. "It's done;" he roared, "it's finished. No wonder that the opening words in the preface to the new work are *nunc dimittis.*

In the first volume Schofield outlined Priestley's youth and education and his precocious and productive early maturity. Priestley's first publications were products of his pedagogic experiences and his theological reading but their variety still astonishes: language, grammar, rhetoric, history, liberal education, and even perspective. However, as was true throughout his life, theology and religious polemics dominated all else. Priestley's religious beliefs evolved from the Calvinism of his upbringing through gradations that only a theologian can comprehend to end in Unitarianism. Since in late 18th-century England such apostasy from the tenets of the established church by a prominent (and vocal) dissenter inevitably led to political controversy, Priestley was soon drawn into the political/religious maelstrom. His association with Lord Shelburne accelerated his transformation from provincial scold to national rebel.

Priestley came late to science and his first endeavors were in the realm of physics. His "A History and Present State of Electricity with Original Experiments," first published in 1767, was to remain in print for more than a century and was to influence Davy, Faraday, and even Maxwell. The subsequent "The History and Present State of Discoveries Relating to Vision, Light and Colours" was less original and also less successful.

Chemistry features only briefly in Schofield's first volume, but it is dealt with in detail in the second. This is divided into four periods: Calne, 1773-1780; Birmingham, 1780-1791; Clapton/Hackney, 1791-1794; and Northumberland, Pennsylvania, 1794-1804. Most of Priestley's immortalizing discoveries came in the first of these periods. However, before the reader gets to the heart of Priestley's chemistry he must make his way through chapters entitled: "Shelburne and Politics," "Religion and Theology," "Common Sense and Associationism," "Matter and Spirit," and "Philosophical Necessity." For a mere chemist unblessed by a philosophical education (though sometimes blessed with a Ph.D.) these chapters are hard going; but if one wishes truly to understand Priestley, the attempt must be made.

Not only did these matters occupy much of Priestley's life but his scientific studies were, in his mind at least, intimately connected with them.

It is with a sense of relief that one reaches Chapters VI and VII where Schofield gives a masterly account of Priestley's experimental chemistry and theoretical musings. All chemists know that Priestley was a great discoverer but no one before Schofield has made it so clear that such discoveries were based on remarkable, if at times naïve, experimentation and on preternatural powers of observation. Priestley's apparatus was crude. Schofield graphically describes the fetid, black, effluvial water in the large pneumatic trough in which many of his greatest discoveries were made. The presence of adventitious gases is no doubt partly the reason for the variability in some of Priestley's findings. Priestley eagerly notes the flash of light when a candle is snuffed in gaseous ammonia; he ponders the occurrence of an inflammable gas where none is to be expected; and most miraculously of all he discovers the basic process of photosynthesis before he has isolated dephlogisticated air. Furthermore, he immediately places this last finding in its ecological framework ("I have discovered what I long have been in quest of, *viz*, that process in nature by which air, made noxious by breathing, is restored to its former salubrious condition").

Joseph Priestley was sixty years old when he immigrated to the United States and settled in the semi-frontier town of Northumberland, Pennsylvania. His intellectual powers were still high and his combative spirit undimmed ("even a dying hand has sometimes done execution"); but his philosophically abrasive mind needed something to rub up against. He chose to recognize that the young United States was not in as much need of his restless questioning as the England that he had reluctantly left. His theological writings continued virtually unabated; but, though he established a well-equipped laboratory, nothing of great moment came forth. His last ditch opposition to the new French chemistry, "Doctrine of Phlogiston established and that of the Composition of Water refuted," did nothing to stem the tide of its acceptance.

Robert Schofield has done this remarkable man proud. Others may write shorter and perhaps more popular biographies of Joseph Priestley, but they will do so in the shadow of this magisterial work. *Derek A Davenport, Purdue University*.

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*Ladies in the Laboratory II – West European Women in Science, 1800 – 1900: A Survey of Their Contributions to Research***.** Mary R. S. Creese with contributions by Thomas M. Creese, The Scarecrow Press, Inc. Lanham, MD and London, 2004, xii + 285 pp, $69.95.

This book is a continued survey of women scientists who began their work in the nineteenth century as women were just beginning to emerge significantly within science communities. Like the earlier work by Mary Creese, *Ladies in the Laboratory? American and British Women in Science, 1800 -1900* [*Bull. Hist. Chem*., **1998,** *25*, 132-133], it continues studies based on a bibliography of scientific journal articles from the London Royal Society's *Catalogue of Scientific Papers,* 1800 to 1900. The focus of this second book is the work of women in twelve Western European countries: Austria-Hungary, Belgium, Denmark, Finland, France, Germany, Ireland, Italy, the Netherlands, Norway, Sweden, and Switzerland. The 177 women discussed in the book were responsible for about 20 percent of the papers referenced in the *Catalogue*. They worked in various areas of activity, biological and medical sciences, mathematical and physical sciences, and social sciences. The book also includes an appendix on British and American women either omitted from the first volume or for whom additional information has been obtained.

Ladies in the Laboratory II is both a valuable compendium of work done by women scientists in the nineteenth and early twentieth centuries and a fascinating recounting of their personal journeys as women and scientists. Each chapter covers a specific region and is organized by field of science. Chapters are headed with a useful abstract and end with a summary describing the place of that region's women within the scientific community. When chapters cover more than one country, e.g., Scandinavia, they are subdivided into countries. An overview of the societal trends and geopolitical situations in each country is given, and statistics showing distributions of authors and papers by decade and field are presented graphically. Creese then presents biographical information on the women, many of whom are little known outside their countries. Her intent is "….to offer a selected and ordered series of pictures of the lives and careers of many of the most notable nineteenth-century women of science in Western Europe."

Since universities in Western Europe began to open to women late in the nineteenth century, many of the women discussed began scientific careers in the 1880s and 1890s. Certain universities, especially those in Switzerland, were early in their education of women, and many formed lasting friendships while studying there. Creese describes contributions throughout a lifetime and hence a picture of both late nineteenth- and early twentieth-century women emerges. Several of the women were productive well into their seventies and eighties, serving as role models not only to young women but to those of all ages.

By telling their "stories" Creese brings these early scientists to life and makes them accessible to the reader. One gets a fascinating journey into the lives of exceptional women who overcame serious social and political constraints to lead productive lives as scientists and women. Their love for science and their persistence in continuing their studies inspire awe. Many worked in obscurity and others had to leave their countries to continue their studies. Political events interrupted their work, but they continued to contribute in their fields. They frequently had a strong social conscience and several were responsible for positive changes in health and education policies in their respective countries, and two at least had influence well beyond their regions: Marie Baum of Germany in industrial health and welfare and Maria Montessori of Italy in education. In addition, these women were aware of their unique positions in society and used these positions to advance the roles of women either by direct political action, mentoring, expanding opportunities, or serving as exceptional models of accomplishment.

These early women scientists were involved in numerous scientific fields, with contributions in botany particularly noteworthy. One of the enjoyable features of the book is learning of the interesting botanical work done at the turn of the century and the excitement of field exploration and discovery of new species. Work in other biological sciences, especially zoology, and in medicine and chemistry was also notable though less extensive. Again, it is a pleasure to read of early work in these fields. Several chemists and physicists-chemists are profiled including Naima Sahlbom (Sweden), Marie Curie (France), Marie Baum (Germany), Clara Immerwahr Haber (Germany), and Ida Welt (Austria). Agnes Pockels (Germany), whose work in surface properties is often claimed by the chemical community, is also described in depth but as a physicist.

Ladies in the Laboratory II includes extensive bibliographic references and the work is well documented. The book is useful for the scholar wishing to study activities in a particular field or country. For the more casual reader, the profiles are the most fascinating part of the work and one can return again and again to read of interesting science and to study intriguing lives. Marie Creese succeeds splendidly in casting a light on the lives of an important group of early women scientists. *Maureen Gillen Chan, Bell Laboratories, Lucent Technologies (retired).*

The Life and Work of Friedrich Wöhler (1800-1882). Robin Keen, J. Büttner, Ed., Verlag Traugott Bautz GmbH, Nordhausen, 2005; hardcover, 493 pp, 0, ISBN 3-99309-224-X, E 120.

This biography of the famous Friedrich Wöhler is based upon the Ph.D. dissertation written by Robin Keen at University College, London, in the 1970s. The author was directed in his historical research by the late William A. Smeaton. Having lain dormant for a quarter century, the richly informative treatise has now been transformed into a book after meticulous revision by William Brock (who served on Keen's oral doctoral examination in 1976) and final editing by Johannes Büttner, cofounder with the late Wilhelm Lewicki in 2000 of Edition Lewicki-Büttner. This Wöhler biography constitutes Volume 2 in the Lewicki- Büttner series, Volume 1 being *Stoffwechsel im tierischen Organisumus: Historische Studien zu Liebigs 'Thier-Chemie' (1842).*

Source materials are extensive: besides over 300 books and articles cited, Keen took advantage of the myriad letters exchanged between Wöhler and Liebig and between Wöhler and his cherished mentor and friend Berzelius. According to the editor, Keen's collection of correspondence includes several omitted from A. W. Hofmann's "Briefwechsel" published in 1888. Citations are carefully footnoted; even though many are necessarily repeated, the number of footnotes reached an impressive1,378.

Organization of the 23 chapters is chronological to a degree, in that Wöhler's life is traced from early days through his education and the year spent with Berzelius in Stockholm, followed by his positions in Berlin, Kassel, and finally Göttingen. Interspersed between these moves, however, are descriptions of Wöhler's varied research activities at each location, spanning his early work with aluminum in 1828 to his fascination with meteorites and minerals up to the end of his career. Because he frequently dropped one area of investigation to take up another, only to return to an earlier interest later, the author's treatment of each research area often spans decades or sometimes nearly his entire professional career. Wöhler had unusually broad interests. As Brock has stated in his foreward, "Wöhler refuses to be categorized as an inorganic, organic, or physical chemist." His early work in Berlin on urea earned lasting fame, as is well known, but his claim for the first isolation of aluminum also dates from the Berlin days, as does work on beryllium, yttrium, and vanadium (clearly inspired from his year with Berzelius). At Göttingen alone he investigated 23 elements, all described in some detail, while concurrently delving into organic chemistry. He published scientific articles numbering more than 500 over a period of 59 years, many coauthored with Liebig and some written in Swedish.

Although much of the work and probably all of the publications were done by Wöhler himself, he directed the research of many doctoral students in Göttingen over a time span of 30 years, beginning in 1841. Some but not all of these students can be found in appendices, either as assistants under Wöhler or professors who were his pupils. A full bibliography of Göttingen chemistry doctoral students was published in 1998 (G. Beer, *Die Chemischen Dissertationen der Universität Göttingen, 1734-1900*, Verlag Museum der Chemie, Göttingen).

What about Wöhler the man? The reader gains considerable insight into the individual: well educated, with knowledge of Latin, Swedish, and apparently Russian as foreign languages; possessed a keen interest in science from an early age; industrious and adventurous in his explorations; a prodigious reader, author, and correspondent. He made Berzelius' *Lehrbuch der Chemie* and *Jahresbericht* available to European readers by translating the many volumes into German from the original Swedish. This labor of dedication deprived Wöhler of untold weeks of time he might have devoted to his own investigations. Benefiting from a pleasing disposition, he was even tempered, abhorred confrontations and conflicts, and served effectively as a diplomat in controversies between Liebig and Mitscherlich and Liebig and Berzelius. Wöhler, charismatic and a genuine friend to many, frequently used his sense of humor in correspondence. In writing to Liebig in 1843 concerning Liebig's annoyance with Marchand, he reminded his colleague that by 1900 they all would have become ammonia, carbon dioxide, and water! The fact he was successful in collaborating with Liebig in research and editing is a measure of his good disposition.

The text is highly readable, although the treatment of individual research areas is sometimes difficult to follow because of the time spans covered. The many appendices enhance the book considerably. While the "Index of Personal Names" appears to be fairly extensive, the subject index is scant. Typographical errors, inevitable in view of the final preparation by individuals with different native languages, do not usually distract from the meaning. English-speaking readers may well be confused, however, to learn about a "3.000-word letter" written by Berzelius to Liebig. This welcome biography of one of the giants of 19th-century chemistry, in English, will serve historians of chemistry most effectively. We owe an immense debt of gratitude to the original author and those who had the persistence to realize its evolution into a full-length book. *Paul R. Jones, University of Michigan.*

A Well-Ordered Thing. Dmitrii Mendeleev and the Shadow of the Periodic Table. Michael D. Gordin, Basic Books, New York, 2004; hardover, xx + 256 pp, $30.

This book is by no means a classical biography, as the author himself warns in the preface: "What follows is not a traditional biography. Here is no comprehensive account of every aspect of the adult Mendeleev's life, and we encounter precious little of his childhood." The promise is kept. Overall, Gordin provides an assessment of Mendeleev that is consistent, although I am not certain that I agree with all his conclusions. Nevertheless, I am comfortable recommending the book to those with an interest in Mendeleev and Russian chemistry in the last half-century of Tsarist Russia.

Dmitrii Ivanovich Mendeleev, the subject of this book, is perhaps the most identifiable Russian chemist of the last two centuries. A major part of the familiarity of western chemists with Mendeleev is actually an acquaintance with his first major discovery: the Periodic Table of the Elements and the Periodic Law. I was fascinated to find out that I was nowhere near as familiar with Mendeleev, the man, as I thought I was; and this book has substantially altered my perspective on the man behind the science. What emerges from Gordin's narrative is a complex man living in some of the most interesting times of recent Russian history: the reigns of Alexander II, the great reformer, assassinated in 1881, and his son, Alexander III, whose reign was characterized by the roll-back of many of those same reforms.

As Gordin views it, Mendeleev's career was really two rather disparate careers, with a dividing point in time of the defeat of his nomination to the Imperial Academy of Sciences in St. Petersburg. Prior to this seminal event in Mendeleev's life, Gordin views him as predominantly the scientist, for whom organizing science was a major thrust of his efforts, while afterward, his vision became much more imperial (rather than local), and his efforts became much more involved with using the imperial bureaucracy to effect change.

The book is organized in roughly chronological order of the topics discussed, although the various chapters obviously overlap in time. The first half of the book (roughly) deals with many of the facets of Mendeleev's scientific life as a professor in St. Petersburg, as he built his reputation in the scientific community, while the second half of the book concentrates on the more bureaucratic work of the established scientist.

The first chapters of the book deal with the development of Mendeleev, the fully mature scientist. It begins with a discussion of a seminal event in chemistry, the Karlsruhe Conference of 1860, where Stanislao Cannizzarro proposed his atomic weights for the elements, based on the earlier work of Amedeo Avogadro. Mendeleev himself saw his attendance at this meeting as a watershed in his early career, and Gordin makes some interesting points about the way in which Mendeleev used his attendance at this meeting to further his own career and raise his visibility in Russia.

This is followed by a discussion of the development of the Periodic System of Elements and its evolution into the Periodic law, an excellent chapter, where Gordin gives a lucid account of this advance, and where he debunks some long-held myths about how Mendeleev developed his periodic system. He also raises some interesting questions for the reader, among which is the question of how Mendeleev himself, who (like many of his contemporaries) did not embrace the concept of atomism as a physical reality, but who adhered to the concept of "chemical atomism," viewed the periodic system of elements that he had developed as a teaching tool. The beginnings of the Periodic System as a pedagogical problem, rather than as a fundamental research problem, and the evolution of the system as a problem from the realm of teaching to that of "pure science," are most revealing.

Although known best for his development of the periodic system of elements, Mendeleev actually finished his work on this topic fairly early and by 1872 had ended his own original work in the area, although he did continue to follow the work of others as they confirmed his predictions over the next decade and a half. His next great opus was work with gases. Mendeleev's work with gases had, as its ultimate goal, finding experimental evidence for the existence of the luminiferous ether by observing the behavior of gases at low pressures. The tale told is how Mendeleev sought out funding for his *low-pressure* gas experiments—based on *high-pressure* experiments to be carried out—and how he organized his laboratory assistants to accomplish the goals of what was a "big science" program. In many ways, this chapter best illustrates Mendeleev, the man. It begins with a somewhat scathing assessment of Mendeleev himself by his contemporary, organic chemist Fedor Fedorevich (Friedrich Konrad) Beilstein, who apparently harbored a healthy skepticism of Mendeleev's periodic law.

The next two chapters were, for me, the most enjoyable of the book. They describe the two great battles of Mendeleev's professional and personal life: his work against spiritualism and his battle to be elected to the Imperial (Petersburg) Academy of Sciences. In these two chapters the life of the chemistry and broader science establishments of St. Petersburg are laid out. Gordin's well written discussions of the political undertones of these two seminal events in Mendeleev's life contain a view of the major protagonists that are sometimes at odds with the traditional views of the great Russian chemists of the nineteenth century.

Spiritualism had become a major force in Europe during the nineteenth century, counting many reputable scientists among its adherents. Indeed, Gordin's account of Butlerov's gradual alignment with the spiritualists was particularly illuminating for me. Mendeleev saw it as his job to help discredit it, believing that these reputable scientists gave it a "scientific" status that it did not deserve (much like Kolbe saw Wislicenus giving stereochemistry a status it did not merit). The debates over spiritualism as described by Gordin work to overcome the popular mythology that has grown up around this topic, but it is at the expense of the "noble" Mendeleev, who occasionally appears to be more ideologue than dispassionate seeker after truth.

The battle over Mendeleev's candidacy for election to the Imperial Academy of Sciences was a turning point in his life, but it was also a seminal event of the development of a "Russian" identity of science in Russia. Like many, I was somewhat acquainted with this story, but I did not know the details. Gordin has done an excellent job of discussing this event and its wider implications; again, not all the protagonists emerge with their reputations unsullied. Butlerov, in particular, emerges as a man who allowed his national pride to overcome his better judgment, and who was willing to sacrifice friendship for nationalistic principle.

I found the second half of the book much more difficult to read, perhaps because of a lack of social sciences in my own background. It begins with Gordin's assessment of Mendeleev's reaction to being denied election to the Academy of Sciences. There is little doubt that the losing fight over Academy membership took its toll, and in the first chapter of the second half of the book, we see the evolution of his views on scientific societies, among others, in response to his rejection. Following his rejection by the Academy, Mendeleev's emphasis shifted, becoming increasingly bureaucratic (in the sense of organizing and standardizing the various functions of government). He used his closeness with Tsar Alexander III and his position in the Chief Bureau of Weights and Measures to make imperial Russia a laboratory for his economic theories, as he led the modernization effort, including his attempts to introduce the metric system and his introduction of tariffs to encourage domestic economic growth in the face of international competition. His views on the use of tariffs are remarkably modern; similar views are being espoused today.

This chapter is followed by an assessment of the development of Mendeleev's persona and a critical examination of the legends that surround him (e.g., his "Siberian-ness," which is compared with the romance of the "wild west" in American folk-lore), and Mendeleev's own role in developing his public image. The chapter concludes with the transformation of the image of Mendeleev, a life-long conservative and supporter of the Tsar, into a "radical" romantic and his dismissal from his post at St. Petersburg University (a similar fate awaited Markovnikov a few years later). Gordin makes the point that this transformation of Mendeleev's image was not coupled to a transformation of the man. I found Gordin's arguments about Mendeleev's probable motives to be persuasive; the image of Mendeleev as a radical liberal is inconsistent with the bureaucrat who emerges during the preceding chapters.

This dismissal from St. Petersburg University provides the introduction to the penultimate chapter, which deals with the last years of Mendeleev's life and with the collapses that led to the revolution of 1905 and his withdrawal from public life. To the end, Mendeleev is portrayed as being a staunchly loyal Tsarist, who did not believe that a republic was a viable form of government for Russia.

In the final chapter of the book, "Conclusion: The Many Mendeleevs," what emerges is a well-rounded portrait of a man who, Gordin implies, may serve as a model for both his times and his country. The Mendeleev who emerges from Gordin's treatment is not the mildly eccentric Mendeleev of popular chemistry folk-lore, but a complex individual: an ambitious man who played a central role in the development of Russian science after passage of the Great Reforms, accumulated significant influence over Russian science, and saw his own role in the Russia emerging from the Great Reforms as central to the modernization of Russian society, politics, and economics.

The narrative is extensively annotated and supported by nearly 60 pages of notes and a 40-page bibliography; the level of scholarship is impressive. However, I was disappointed with the index, which occupies a scant seven pages in three-column format, is quite sparse compared to the notes and bibliography, and which is not as useful as it should be.

The clear strength of this book is in the study of the man, Mendeleev. However, the author's insight into the chemistry underlying that man's work is not one of its strengths. There are occasional places where Gordin's commentary is somewhat confused, betraying a less-than-commanding grasp of the underlying chemistry, especially when he addresses more modern concepts, and this will temper the enjoyment of the book by the chemist reader. From my own perspective, one of the best facets of this book is that it lays out—albeit somewhat indirectly—the effects of the Great Reforms of Alexander II and the effects of the University Statute of 1863 on the development of Russian chemistry during the second half of the nineteenth century. *David E. Lewis, Department of Chemistry, University of Wisconsin-Eau Claire, Eau Claire, WI 54702-4004*.

AUTHOR INDEX, *1-30*

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