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

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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

ABOUT THE AUTHOR

Robert E. Schofield is Professor Emeritus of History of Technology and Science, Iowa State University. He has also taught history and history of science at the University of Kansas and Case Institute of Technology (Case-Western Reserve University). He is the author, among other things, of *A Scientific Autobiography of Joseph Priestley: Selected Scientific Correspondence*, MIT Press, Cambridge, MA, 1966; *The Enlightenment of Joseph Priestley,* Pennsylvania State University Press, University Park, PA, 1997; and *The Enlightened Joseph Priestley*, Pennsylvania State University Press, University Park, PA, 2004.