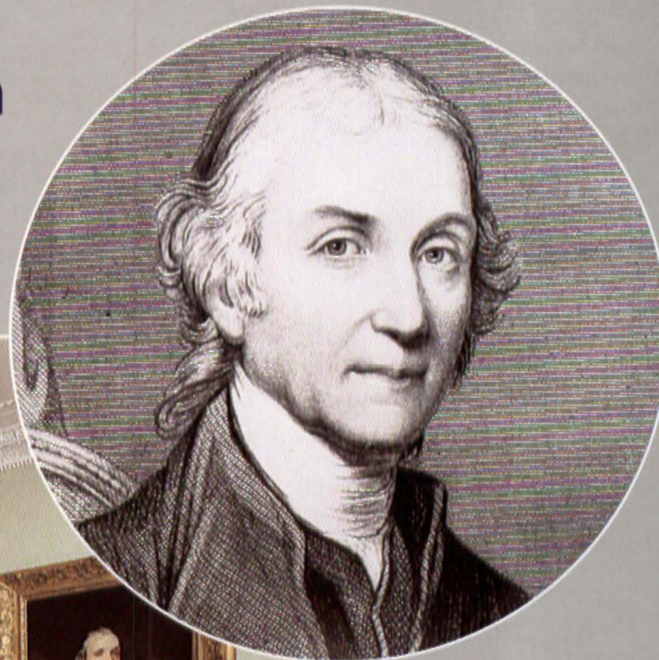
An International Historic Chemical Landmark

Bowood House

The discovery of oxygen by Joseph Priestley



Calne, Wiltshire, UK

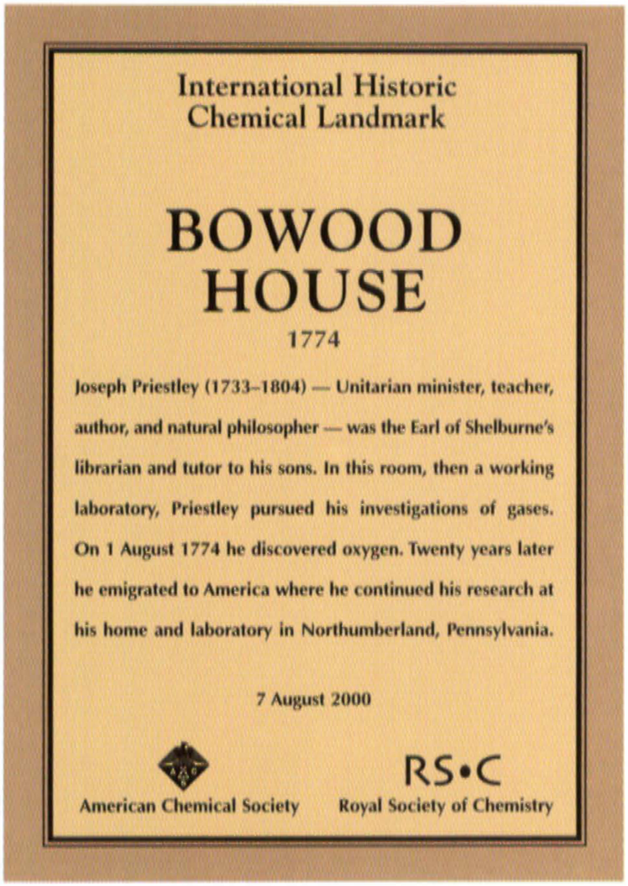
7 August 2000

American Chemical Society

ROYAL SOCIETY OF CHEMISTRY

This booklet commemorates the designation of Bowood House as an International Historic Chemical Landmark. This designation was conferred jointly by the Royal Society of Chemistry and the American Chemical Society, learned societies whose aims are to promote the interests of chemists and chemistry and to serve the public interest.

The commemorative plaque inscription reads:



International Historic Chemical Landmark

BOWOOD HOUSE

1774

Joseph Priestley (1733–1804) — Unitarian minister, teacher, author, and natural philosopher — was the Earl of Shelburne's librarian and tutor to his sons. In this room, then a working laboratory, Priestley pursued his investigations of gases. On 1 August 1774 he discovered oxygen. Twenty years later he emigrated to America where he continued his research at his home and laboratory in Northumberland, Pennsylvania.

7 August 2000

American Chemical Society **Royal Society of Chemistry**

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The text is based on text written for the booklet produced for the designation of Joseph Priestley House in 1994, and includes additional material written by Professor David Knight of the University of Durham. It was designed by Stairway Communications, London.

Photographs courtesy of the Royal Society of Chemistry, Pennsylvania Historical and Museum Commission and Bowood House.

Front cover: Portrait of Priestley reproduced courtesy of the Library and Information Centre, Royal Society of Chemistry.
Laboratory photograph reproduced courtesy of the Trustees of the Bowood Collection.

US National Historic Chemical Landmark

The ACS designation of the Joseph Priestley House, Northumberland, Pennsylvania as a National Historic Chemical Landmark in the USA was marked with a plaque presented to the Pennsylvania Historical and Museum Commission on 1 August 1994. Joseph Priestley supervised the construction of the house and laboratory from 1794 to 1798, then lived and worked there until his death in 1804. His library of some 1,600 volumes and his chemical laboratory, where he first isolated carbon monoxide, were probably the best in the country at that time.

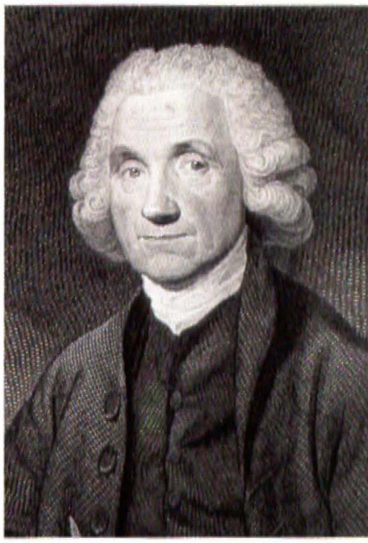
The formation of the American Chemical Society

In 1874, one hundred years after the discovery of oxygen at Bowood House, Joseph Priestley was honoured by a meeting of chemists in the USA. This meeting led to the founding of the American Chemical Society in 1876. The American Chemical Society has since grown to be the largest scientific society in the world with more than 161,000 members.

Bowood from the Lake, Graham Rust, 1976

Reproduced courtesy of the Trustees of the Bowood Collection

Joseph Priestley (1733–1804)



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Joseph Priestley was born on 13 March 1733 in Yorkshire, England, the eldest of nine children. His mother died when he was six and his father, who made wool cloth, remarried when Joseph was twelve. He was raised by an aunt who encouraged his education. His early studies included Latin, Greek, French, Italian and German.

His aunt was a pious woman of Calvanistic principles. It was in her home that Joseph Priestley met and studied with Dissenting ministers, whose convictions differed from those of the established Church of England. At the Academy at Daventry from 1752 to 1755, his studies included a focus on his future duties as a Christian minister.

In 1762 Joseph Priestley married Mary Wilkinson, the sister of one of his students at Nantwich, and the daughter of the ironmaster Isaac Wilkinson. He wrote that she was a woman "… of great fortitude and strength of mind, and of temper in the highest degree of 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." Bessie Parkes, Priestley's great-granddaughter is quoted as saying: "It is a tradition in the family that Mrs Priestley once sent her famous husband to market with a large basket and that he so acquitted himself that she never sent him again!"

Joseph Priestley supported himself, and then his family, by a succession of positions as pastor or school teacher. In 1773 he became librarian to the Earl of Shelburne, and tutor for the Earl's children. This position allowed him to travel, and gave him leisure to pursue his investigations in "pneumatic" chemistry as the study of gases was then known, and to write prolifically on science and philosophy. In 1780 he moved to Birmingham. There he continued both his theological investigations and his scientific experiments, receiving financial support from a number of benefactors.

It was on 1 August 1774 that Priestley made his discovery of oxygen, but he investigated many other gases and is credited with the discovery of sulphur dioxide, sulphur trioxide, hydrogen sulphide, silicon tetrafluoride, nitric oxide, nitrous oxide, nitrogen dioxide, ammonia, hydrogen chloride, and carbon monoxide. He was also the first to discover how to make carbonated water, for which he received the Copley Medal from the Royal Society of London in 1773.

Joseph Priestley's religious views, and his sympathy for both the French and American Revolutions, made him an unpopular figure in England. On 14 July 1791, the second anniversary of the French Revolution, a mob began burning the homes and meeting places of suspected anti-royalists in Birmingham. Warned of impending danger, Priestley and his family barely escaped before the mob attacked, destroying the house and its contents. The family found temporary refuge in London, a city more tolerant of divergent views. But the Priestleys could not maintain their lifestyle in that expensive city, nor could Priestley expect to find religious and political freedom there. On 8 April 1794, Joseph and Mary set sail for America in search of a peaceful haven.

They stayed for a time in Philadelphia but Mary's aversion to city life prompted them to move to Northumberland, Pennsylvania, then a village of 100 homes at the junction of the branches of the Susquehanna River, a five-day trip from Philadelphia. Two of Priestley's sons had already settled there, planning to establish a community for dissident Englishmen.

On 3 February 1804, Priestley began an experiment in his laboratory, but became too weak to continue it. On 6 February Thomas Cooper wrote to Benjamin Rush that "Dr Priestley died at about 11 o'clock without the slightest degree of pain."

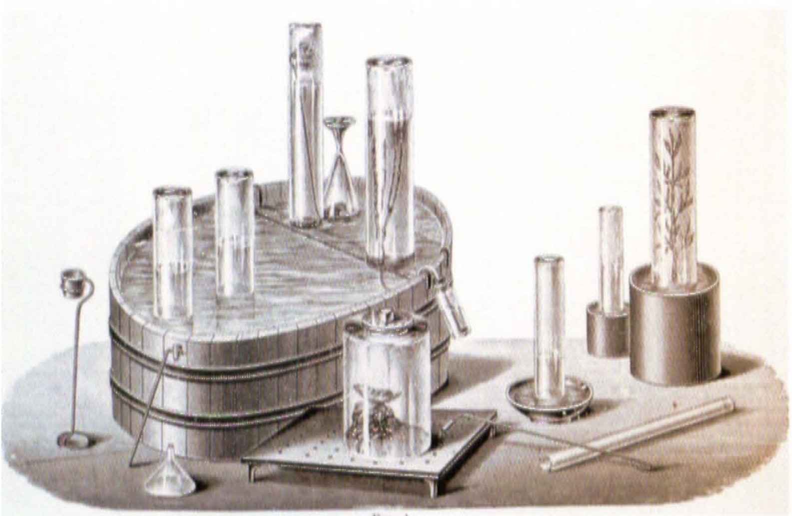
Mary Priestley

The discovery of oxygen

Chemists had traditionally accepted that there were four elements – Fire, Air, Water and Earth. In modern terms, these might be said to correspond vaguely to energy and to matter in its three states. In the eighteenth century, especially in Britain and in Sweden, the first two of these elements began to be seriously investigated. Everyone knew that some samples of air were better than others – that rooms got stuffy, and that wells could be suffocating. By 1756 Joseph Black (1728–99) had established that there were different kinds of "airs" just as there were a variety of liquids and solids. Black followed 'fixed air' (carbon dioxide) through a cycle of reactions. Prepared in a retort, the air bubbled out of a tube under water in a pneumatic trough, and was collected in a bladder or jar. This apparatus allowed chemistry to become the science of matter in all its states. Priestley began his studies with the air emitted in breweries, and found this to be fixed air. He subsequently invented a process for making soda-water.

Phlogiston and oxygen

The prevailing view of combustion in Priestley's day was formulated by J. J. Becher (1635–1682) and Georg Stahl (1660–1734) between 1669 and 1723.



One of Priestley's early experiments in gas analysis

Reproduced courtesy of the Library and Information Centre, Royal Society of Chemistry

A satirical cartoon of the day lambasting Priestley's religious and political views

Reproduced courtesy of the Library and Information Centre, Royal Society of Chemistry

According to this view, combustion of an object was accompanied by the release of a substance known as phlogiston, thought to impart flammability to materials containing it. Where today's chemists sees the *gain* of oxygen, phlogiston theorists saw the *loss* of phlogiston. This theory satisfactorily accounted for many of the experimental observations of that time.

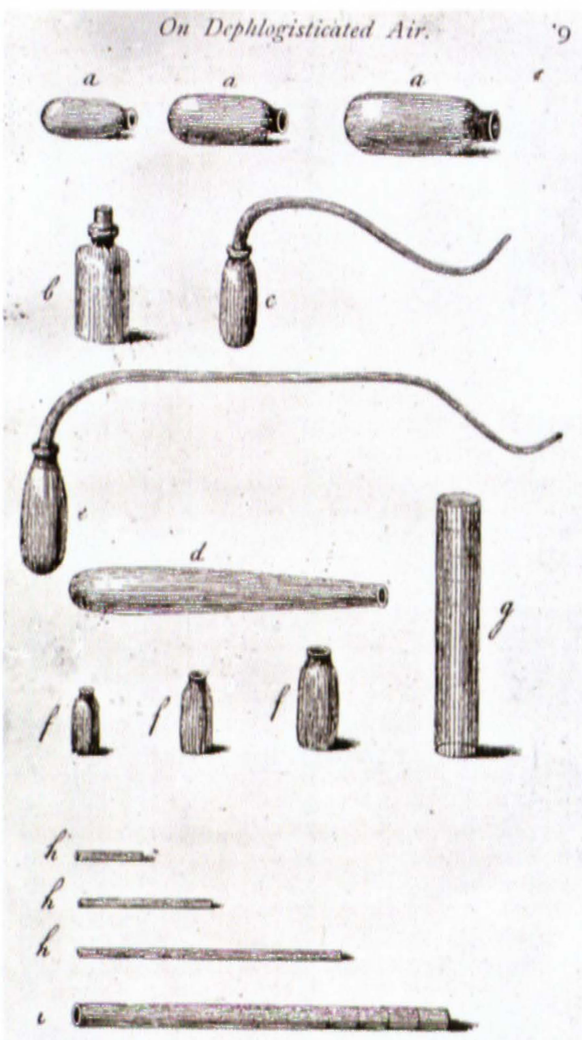
On 1 August 1774, Priestley prepared a sample of a new gas by using a lens to focus sunlight on mercury (II) oxide ("red calx" of mercury) floating on mercury in a glass tube. Over the next several months he found that a candle burned more brightly in this gas than in the atmosphere, and that a mouse would live four times longer in this air. He wrote, "The feeling of it in my lungs was not sensibly different from that of common air, but I fancied that my breast felt peculiarly light and easy for some time afterwards. Who can tell but that in time, this pure air may become a fashionable article in luxury. Hitherto only two mice and myself have had the privilege of breathing it."

Believing that science was public knowledge and progressed fastest when information was rapidly made available, Priestley published his discoveries speedily: and thus was first in print with the announcement of his new air. Believing the phlogiston theory, Priestley concluded that this air in which everything burnt so well must therefore be very hungry for it, being 'dephlogisticated'. If we look upon phlogiston as material, this seems strange; if we see it as chemical energy, it seems more familiar. Priestley and his contemporaries could not yet make that distinction, but we should not mock him for reluctance to abandon an idea which had been fruitful and still made sense to him, as a guide to the preparation and isolation of many other new airs.

Priestley's contemporaries

Carl Wilhelm Scheele

Carl Wilhelm Scheele (1742–86), an apothecary in Sweden, had found in 1773 that air had two components,'foul air', which would not support combustion, and 'fire air' which would. He prepared a sample of fire air from saltpetre and sulphuric acid at least a year before Priestley isolated it. Scheele wrote up his discoveries in a book, but it was not published until 1777: he blamed the publisher and printer, but it seems more likely that the delay was caused by his patron Tobern Bergman (1735–84) who wrote an introduction. Scheele had in fact discovered oxygen, but the delay in publication meant that Priestley's discovery was the first to become known.



Experimental apparatus used by Priestley

Antoine Lavoisier

The French aristocrat and scientist Antoine Lavoisier (1743–94) was also investigating the chemistry of gases and metallic calces (the powdery residues, almost always oxides, left after heating substances strongly in air). In 1774 Shelburne took Priestley with him on a diplomatic visit to Paris, and while there Priestley met Lavoisier who was trying to bring order into chemical theory. He was dissatisfied with chemical nomenclature, and with what he saw as the incoherence of phlogiston theory. Priestley told him about the new air, giving Lavoisier the clue for what he was to call his chemical 'revolution'.

Lavoisier's work was quantitative in nature; his careful measurements led him to the conclusion that since the calces weighed more than the original metals, combustion must involve a combination with a substance from the air, rather than a loss of phlogiston. Burning meant combination with Priestley's new air, or gas, to which he gave a new name. Noting that higher oxides were acidic, he generalised prematurely and called the gas "oxygen", meaning acid-generator. Priestley did not accept all of Lavoisier's views and continued to uphold the phlogiston theory until he died.

Lavoisier saw further than Priestley or Scheele the implications of what they had isolated. He therefore also plays a significant part in the history of the discovery of oxygen.

Priestley's laboratory at Bowood House

The History of Bowood House

Bowood House was built on the site of a hunting lodge in 1725. The estate was bought in 1754 by the first Earl of Shelburne, who improved the house and gardens and whose family still live at Bowood today.

The house originally comprised two buildings: the 'Big House' and a separate service wing known as the 'Little House', now converted into the home of the ninth Marquis and Marchioness of Lansdowne. During the 1760s, the second Earl of Shelburne employed Robert Adam to build a magnificent Orangery across the front of the Little House. In the 1770s, the two houses were joined by the construction of a great drawing room; during the same period, the park was landscaped by 'Capability' Brown.

The second Earl, British Prime Minister from 1782 to1783, was made Marquess of Lansdowne for his role in negotiating peace with America after the War of Independence. He furnished Bowood with a superb collection of paintings and classical sculpture, but unfortunately died deeply in debt, obliging the second Marquess to sell most of the collections. The third Marquess, Chancellor of the Exchequer in 1805, restored Bowood House to its former glory. He commissioned CR Cockerell to design the chapel and the library and Sir Charles Barry to build the clock tower, and the third Marquess is also responsible for the terrace gardens and for collecting many of the paintings and sculptures in the house today.

The Bowood Napoleonic Collection arrived via the fourth Marchioness, daughter of Napoleon's *aide de camp*. The fifth Marquess succeeded in 1866 and became Governor-General of Canada and Viceroy of India. However, at the end of the 19th Century, the family fortunes were again in decline. The Lansdownes now lived in smaller and more comfortable rooms in the Little House and the Big House was used only for entertaining. This situation continued during the sixth Marquess' time and until after the second world war when the seventh Marquess and his brother were tragically killed in battle in 1944, the title and property passed to their cousin.

During the war the Big House was first occupied by a school and then by the RAF, but by 1955 had become so dilapidated that the eighth Marquis took the difficult decision to have it demolished. His son, the present Marquis, took over the management of Bowood in 1972. The house and gardens were open to the public in 1975 and the restaurant, shops and garden centre were added in 1980.

Priestley and the Earl of Shelburne

The second Earl of Shelburne was a close friend and major benefactor to Priestley while he conducted many of his most important experiments.

Priestley arrived at Bowood House in 1773, receiving £250 a year and a house in nearby Calne for his work as librarian and literary companion to Shelburne. He was also tutor to the Earl's two sons. The financial security and light workload associated with this position allowed Priestley to devote much of his time to his experiments, while providing the social status and proximity to London that gave him a chance to meet the great scientists of the day at the Royal Society. In 1774 he accompanied the statesman Shelburne on a tour of Europe, where Priestley was able to discuss his recent work with eminent scientists such as Lavoisier.

This close relationship grew strained as Shelburne was asked to mediate in the American War of Independence. Although Priestley refrained from political writing that might embarrass his employer, he supported the colonists in their bid for independence. Priestley's continued transatlantic correspondence with his friend Benjamin Franklin also led to an unfounded charge that Shelburne was corresponding with the enemy. Shelburne and Priestley decided to part company in 1780 but they were never enemies – Priestley received £150 a year from Shelburne for the rest of his life.

Science at Bowood

Other notable scientists have also enjoyed the atmosphere at Bowood. Preistley's laboratory, now an ante-room to the library, was later used by the Dutch physician Dr Jan Ingenhousz (1730–1799) who discovered the process of photosynthesis in plants and worked on inoculation against smallpox.

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The Historic Chemical Landmarks Programme

The Historic Chemical Landmarks Programme recognises our scientific and technical heritage and encourages the preservation of historically important achievements and artifacts in chemistry, chemical engineering, and the chemical process industries. It helps to remind chemists, historians, students and teachers of how chemical discoveries are made and developed, and how they are exploited for the benefit of people.

The Programme is applied in a number of different ways. An historic chemical landmark designation marks a milestone in the evolution of the chemical sciences and technologies. The designation of sites and artifacts notes events or developments of clear historical importance to chemists and chemical engineers. Collections can also receive the designation, thus recognising the contributions of a number of objects with special significance to the historical development of chemistry and chemical engineering.

The American Chemical Society started a National Historic Chemical Landmark Programme in 1992 through its Division of History of Chemistry. It has now been extended internationally. The Royal Society of Chemistry has joined the American Chemical Society in designating Bowood House as an international Historic Chemical Landmark, the third to be designated in the UK under the Programme.

For further information about the Historic Chemical Landmarks Programme contact: The American Chemical Society, Office of Communications, 1155 Sixteenth Street, N.W., Washington D.C. 20036, USA. Tel: 800-227-5558, Ext 6274; Fax: 202 872-4377; e-mail: nhclp@acs.org; http://www.acs.org or
Royal Society of Chemistry, Burlington House,
Piccadilly, London W1J 0BA, UK.
Tel: 020 7440 3317; Fax: 0120 7437 8883;
e-mail: WellsT@rsc.org; http://www.rsc.org

American Chemical Society
1155 Sixteenth Street, N.W.,
Washington D.C. 20036, USA.

Royal Society of Chemistry
Burlington House, Piccadilly,
London W1J 0BA, UK