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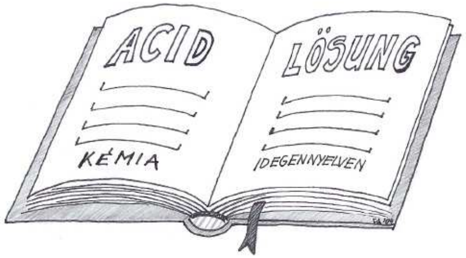

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Joseph Priestley: Discoverer of Oxygen

When Joseph Priestley discovered oxygen in 1774, he answered age-old questions of why and how things burn. An Englishman by birth, Priestley was deeply involved in politics and religion, as well as science. He immigrated to America when his vocal support for the American and French revolutions made remaining in his homeland untenable.

Some 2,500 years ago, the ancient Greeks identified air — along with earth, fire and water — as one of the four elemental components of creation. That notion may seem charmingly primitive now. But it made excellent sense at the time, and there was so little reason to dispute it that the idea persisted until the late 18th century. It might have endured even longer had it not been for a free-thinking English chemist and maverick theologian named Joseph Priestley.
Priestley (1733-1804) was hugely productive in research and widely notorious in philosophy. He invented carbonated water and the rubber eraser, identified a dozen key chemical compounds, and wrote one of the first comprehensive treatises on electricity. His unorthodox religious writings and his support for the American and French revolutions so enraged his countrymen that he was forced to flee England in 1794. He settled in Pennsylvania, where he continued his research until his death.
But the world recalls Priestley best as the man who discovered oxygen, the active ingredient in our planet's atmosphere. In the process, he helped dethrone an idea that dominated science for 23 uninterrupted centuries: Few concepts "have laid firmer hold upon the mind," he wrote, than that air "is a simple elementary substance, indestructible and unalterable."
In a series of experiments culminating in 1774 — conducted with the kind of equipment on display in his Pennsylvania home — Priestley found that "air is not an elementary substance, but a composition," or mixture, of gases. Among them was the colorless and highly reactive gas he called "dephlogisticated air," to which the great French chemist Antoine Lavoisier would soon give the name "oxygen."
It is hard to overstate the importance of Priestley's revelation. Scientists now recognize 92 naturally occurring elements-including nitrogen and oxygen, the main components of air. They comprise 78 and 21 percent of the atmosphere, respectively.

Determining the composition of air

In the mid-18th century, the concept of an element was still evolving. Researchers had distinguished no more than two dozen or so elements, depending on who was doing the counting. It wasn't clear how air fit into that system. Nobody knew what it was, and researchers kept finding that it could be converted into such a variety of forms that they routinely spoke of different "airs."

Bubbling Beverages

In 1767, Priestley was offered a ministry in Leeds located near a brewery. This abundant and convenient source of "fixed air” — carbon dioxide from fermentation — sparked his lifetime investigation into the chemistry of gases. He found a way to produce artificially what occurred naturally in beer and champagne, as well as in the baths of the fabled resort of Spa in Belgium: water suffused with the sparkling effervescence of carbon dioxide. The method earned the Royal Society's coveted Copley Prize and was the precursor of the modern soft-drink industry.

The principal method for altering the nature of air, early chemists learned, was to heat or burn some compound in it. The second half of the 1700s witnessed an explosion of interest in such gases. The steam engine was in the process of transforming civilization, and scientists of all types were fascinated with combustion and the role of air in it.

British chemists were especially prolific. In 1754, Joseph Black identified what he called "fixed air" (now known to be carbon dioxide) because it could be returned, or fixed, into the sort of solids from which it was produced. In 1766, a wealthy eccentric named Henry Cavendish produced the highly flammable substance Lavoisier would name hydrogen, from the Greek words for "water maker."

Finally in 1772, Daniel Rutherford found that when he burned material in a bell jar, then absorbed all the "fixed" air by soaking it up with a substance called potash, a gas remained. Rutherford dubbed it "noxious air" because it asphyxiated mice placed in it. Today, we call it nitrogen.

But none of those revelations alone tells the whole story. The next major discovery would come from a man whose early life gave no indication that he would become one of the greatest experimental chemists in history.

By the age of 34, Priestley was a well-established and respected member of Britain's scientific community. He was still paying a price for his religious nonconformity, however. When the intrepid explorer Captain James Cook was preparing for his second voyage, Priestley was offered

the position of science adviser. But the offer was rescinded under pressure from Anglican authorities who protested his theology, which was evolving into a strongly Unitarian position that denied the doctrine of the trinity.

In retrospect, the Cook affair may have been all for the best. In 1773, the Earl of Shelburne asked Priestley to serve as a sort of intellectual companion, tutor for the earl's offspring, and librarian for his estate, Bowood House. The position provided access to social and political circles Priestley could never have gained on his own, while leaving ample free time for the research that would earn him a permanent place in scientific history.

He systematically analyzed the properties of different "airs" using the favored apparatus of the day: an inverted container on a raised platform that could capture the gases produced by various experiments below it. The container could also be placed in a pool of water or mercury, effectively sealing it, and a gas tested to see if it would sustain a flame or support life.

In the course of these experiments, Priestley made an enormously important observation. A flame went out when placed in a jar in which a mouse would die due to lack of air. Putting a green plant in the jar and exposing it to sunlight would "refresh" the air, permitting a flame to burn and a mouse to breathe. Perhaps, Priestley wrote, "the injury which is continually done by such a large number of animals ã is, in part at least, repaired by the vegetable creation." Thus he observed that plants release oxygen into the air—the process known to us as photosynthesis.

On August 1, 1774, he conducted his most famous experiment. Using a 12-inch-wide glass "burning lens," he focused sunlight on a lump of reddish mercuric oxide in an inverted glass container placed in a pool of mercury. The gas emitted, he found, was "five or six times as good as common air." In succeeding tests, it caused a flame to burn intensely and kept a mouse alive about four times as long as a similar quantity of air.

Priestley called his discovery "dephlogisticated air" on the theory that it supported combustion so well because it had no phlogiston in it, and hence could absorb the maximum amount during burning. (The year before, Swedish apothecary Carl Wilhelm Scheele isolated the same gas and observed a similar reaction. Scheele called his material "fire air." But his findings were not published 1777.)

Whatever the gas was called, its effects were remarkable. "The feeling of it in my lungs," Priestley wrote, "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."

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