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ONE of the most popular students in an eastern high school lay dying on a hospital bed. Above him was a tent-like contrivance with tubes leading to tanks at the side of the bed. An "oxygen tent" it was called and through it fresh oxygen was reaching the boy's lungs. It was too late, however, for such measures. The tent, rushed from a nearby city, could not save the dying youth. Pneumonia claimed another victim.

The day following the funeral, his classmates gathered in the school's corridor. They were discussing some form of permanent memorial. Someone suggested a plaque; another thought a picture should be hung in the school library. Suddenly one of the boys cried out—"I have it! Let's raise money for an oxygen tent for our hospital. Then no one else need ever die because of lack of modern science."

Modern science, indeed! Little did these boys and girls know as they performed simple experiments in the school's chemical laboratory, that Priestley, the discoverer of oxygen, had, 150 years ago, envisioned just such use of the oxygen for enfeebled lungs.

Nor did many of these students realize as they stopped in the "Sweets Shoppe" for a soda that it was this same Priestley who first made "soda water" (a weak solution of carbon dioxide) and that it was he who, right here in America, discovered carbon monoxide and paved the way for the manufacture of common illuminating gas.

But who was Priestley? When did he live and where? What manner of man was he who made so many important chemical discoveries?

Joseph Priestley was an Englishman. He was born on March 13, 1733, in Fieldhead, near Leeds. His father was a poor cloth dresser and the family was in most humble circumstances. When Joseph was nine years old his mother died and he went to live with an aunt, his father's sister. Both his father and his aunt were strict Calvinists and were very religious. Young Priestley attended a neighborhood free school and learned Latin and Greek as well as a smattering of Syriac, Chaldean and a bit of Arabic. During vacations he studied Hebrew from a dissenting minister and in after years was able to read the Scriptures in both the original Greek and the Hebrew. Apparently Priestley learned little mathematics and chemistry. His whole training was intended to equip him for the ministry. Even as a youth, however, he displayed an independent mind and a spirit of free inquiry which was characteristic of his whole life. His aunt sought to have him a communicant of her church but the lad's replies to the minister's questions and his refusal to accept certain doctrines so dismayed the minister that Priestley was denied admission.

Several years later at the age of 22 years, however, he received his "orders" and became a dissenting minister (one opposed to the established Church of England). His first parish was a small congregation at Needham.

His annual stipend was only thirty pounds, however, so that it was necessary for him to eke out his livelihood by teaching and tutoring on the side.

A PROLIFIC WRITER

Priestley was evidently a most intense young man. He not only had positive beliefs but he seemed prone to "burst into print" at the slightest provocation. Perhaps this was because he suffered from an incurable stammer and found the pen easier than the tongue as a vehicle of expression. At any rate, he was a prolific writer on all and sundry subjects. During his lifetime it was estimated that his "publications" numbered 141, only seventeen of which were on scientific subjects.

Priestley stayed at Needham for about three years and then his congregation grew restive, finding his advanced religious views a little too much for their slow minds. For another two years Priestley gave all his time to private tutoring and then, in 1761, was fortunate enough to obtain a position teaching languages at Warrington Academy.

The school was a Dissenters school and was a hotbed for political and religious debate and argument. Priestley fitted perfectly into its picture and not only achieved a reputation for having a "liberal" mind but also acquired a wife.

One day, Priestley, his own classes over, dropped into a lecture on chemistry being given by a fellow teacher, Matthew Turner. This was Priestley's first introduction to science and he was most interested, returning time

and again for further instruction. A short time later Priestley was visiting in London and while there met Benjamin Franklin—our own "Poor Richard." Franklin had come to London to intercede for the American Colonies before King George the Third. Priestley, always a champion of the oppressed, became greatly concerned about the Colonies and espoused their cause militantly from that time on. The many sided Franklin also aroused Priestley's interest in electricity, describing his kite experiments and offering to send Priestley books and pamphlets on the subject. So engrossed in the subject did the preacher become that he planned to write a "History of Electricity." Indeed it is believed that he actually did write such a book, though naturally his scanty knowledge of the subject was hardly sufficient to make it very much worth while.

Following his contacts with Franklin, Priestley became more and more interested in scientific research and continued his chemical studies until they were interrupted by his resignation from the Academy faculty. This followed a disagreement with the school trustees and Priestley accepted the pastorship of a congregation at Mills Chapel, near Leeds.

"SODA WATER" IN A BREWERY

His new parishioners were to find, however, that his new interest—chemistry—was occupying more and more of his time and his thought. Next door to his church was a brewery. Priestley was intrigued by the gases which bubbled from the beer vats and, much to the amusement of the workmen, spent days at a time seeking to capture these in bottles. Priestley had read of the experiences of Black, the eminent chemist in heating limestone and of the gases obtained therefrom. It seemed to him that the beer bubbles had similar properties. Unable to obtain enough of the gas from the beer vats, Priestley set up a crude laboratory in his parsonage and repeated Black's experiments. He captured some of the gas (or "air" as he called it) and tested it with water. It was not very soluble, but some of it did mix. In this way in a very few minutes he created some "exceedingly pleasant sparkling water resembling Seltzer water." It was really "soda water," a weak solution of carbon dioxide in water.

Having informed the Royal Society of his discovery, Priestley was invited to appear before that body and describe it. This he did with the result that he was asked to appear before the College of Physicians and give them the benefit of his experiments. After bubbling some of the gas through water he invited the physicians to taste it. They were greatly impressed and voted to recommend it to the Navy as a remedy for scurvy.

For his work Priestley received the Copley medal and was made a member of the Royal Society, a great honor then, a great honor today.

Recognition spurred further efforts. Priestley knew little, of course, about research methods, his chemical training had been too brief, but fortunately for posterity he continued his study of gases.

In fact his lack of training may have been, in his case, a help rather than a hindrance, for, not having a definite object in view and possessing an inquiring rather than a strictly methodical scientific mind, Priestley went ahead with what James Watt, in a letter, called "his random haphazarding."

He had no means with which to buy laboratory apparatus and, for that matter little was available for his purposes. Such as had been devised was chiefly for solids and liquids and was ill-fitted for experimentation with gases.

Other scientists had tried to collect these "airs" in balloon-like bladders. These were clumsy at best and were not transparent. Priestley, forced to rely upon his own ingenuity, contrived the method still being used of collecting the gases over liquid mercury. This proved advantageous particularly with gases soluble in water and resulted in a number of discoveries other experimentors had missed because of the fact that the gases they evolved had immediately disappeared in the water. Priestley's use of mercury prevented this.

One gas he produced by heating common salt with vitriolic acid and found hydrochloric acid. Priestley's name for it was muriatic acid. Its use is widespread today. Further study of these "airs" enabled him to isolate ammonia gas and by combining the hydrochloric gases and the ammonia gases he evolved a white powder—ammonium chloride, the electrolyte in dry batteries. Other experiments gave added knowledge—*first* knowledge—of the gases of nitrous oxide, sulphur dioxide, hydrofluoric acid and other gases and gave to Priestley the name "Father of Pneumatic Chemistry." Overshadowing all these, however, was his greatest discovery and the one inseparably linked with his name, Oxygen.

THE DISCOVERY OF OXYGEN

ABOUT this time—1774, Lord Shelbourne, a wealthy and "liberal thinking" nobleman became interested in Priestley. Lord Shelbourne shared some of Priestley's political views and all of his chemical beliefs and was desirous of aiding both. He offered to finance Priestley's further experiments, paying Priestley an attractive annual stipend, equipping a complete laboratory and providing a residence nearby for Priestley's family.

The clergyman accepted, resigned from Mills Chapel and continued his experiments at Lansdowne House, Lord Shelbourne's home. This pleasant relationship continued for eight years and many of Priestley's finest accomplishments were achieved during that time. One particularly will always be associated with Lansdowne House.

On Sunday evening, August 1, 1774, Priestley sat in his laboratory working on a most interesting experiment. He had been having trouble heating solids in his furnace and had evolved the idea of using a large burning glass. By the use of this sun glass he had heated red mercury and had collected the resulting "air" in a bottle placed over a trough of mercury. This

bottle of "gas" was in front of Priestley. A lighted candle stood nearby. In a moment of idle curiosity and with no purpose in mind, Priestley inserted the candle in the bottle "just to see what would happen." No doubt he expected to see the flame extinguished just as were the burning chips when he inserted them in his soda water gas. But here apparently was a new kind of "air." Instead of the candle being put out its flame burned brighter than ever. Priestley became most excited. He lighted a taper and thrust it into the colorless gas. This blazed violently. He inserted burning charcoal and it sparkled and crackled like a thing possessed. Surely, thought Priestley, there must be something about this "air" that made things burn.

Priestley continued his experiments for weeks, fascinated with its possibilities. Small animals like mice, he found, lived in this new air but died in equal volumes of common air.

Priestley tried experiments on himself. He inhaled the air and found that while it was not perceptibly different from common air "his breathing was lighter and easier for some time afterward." He determined that this new air was five or six times as pure as ordinary air. He foresaw many uses for the good of mankind, "it may be peculiarly salutary for the lungs in certain marked cases . . ." he wrote. The oxygen tent and the gas mask are proof of his vision.

He also envisioned the modern blow pipe and the oxyhydrogen torch, both to appear years later.

Priestley's study of the air had, prior to this, convinced him that the vegetable world had certain restorative powers. He had found that a plant gave renewed vitality to the air in which candles had burned or animals had breathed. His studies had given him a sound understanding of the principles of respiration.

Other experimenters working along similar lines had exploded the theory that the atmosphere was a single element. They had proven that there were several gases in the air.

Priestley believed that the gas he had discovered was "dephlogisticated air" for he was a firm believer in Becher's soon-to be-exploded theory that a substance called "phlogiston" was an ingredient of all combustible things and was given up in burning. He did not realize, perhaps, that he had "solved the profound enigma of the atmosphere" by his discovery of the most important element of the earth—that he had isolated pure oxygen.

PRIESTLEY AND LAVOISIER

THE discovery of oxygen naturally increased Priestley's fame. He traveled on the continent with his patron, Lord Shelbourne, and met Lavoisier, the most famous chemist of France, and other notables. To Lavoisier Priestley explained his experiments and the French savant hastened to send for some red mercury and repeat them as soon as the preacher-chemist had departed. In fact Lavoisier, according to some writers, sought to share the glory of the great discovery. It is certainly true that he never mentioned Priestley in telling of his (Lavoisier's) experiment in making oxygen. There is, however, no doubt that Priestley was the real discoverer of the element.

Returning to England, Priestley continued his experimentation, but his chemical research did not monopolize all of his time for he plunged with new vigor into political and theological discussions. He was a thorn in his government's side and constantly incurred the displeasure of High Churchmen because of his divergent viewpoint.

Yet Priestley was not by nature pugnacious or militant.

He believed what he believed honestly and sincerely. Certainly Americans must applaud his vigorous defense of the American Colonies and his opposition to King George's treatment of them.

In 1780 Priestley parted with Lord Shelbourne and removed to Birmingham. There was no breach with his patron. The two parted friends and Priestley was to enjoy a pension the rest of his life. Perhaps the preacher figured that his presence in Lansdowne House might ultimately prove embarrassing to his host, for it has been said—"By some strange irony of fate this man (Priestley) who was by nature one of the most peaceable and peace-loving of men, singularly calm and dispassionate . . . acquired the reputation of being perhaps the most cantankerous man of his time."

The early years in Birmingham were most enjoyable for Priestley. He traveled in scientific circles and revelled in the companionship of distinguished men of science and of letters. This relationship, however, began to be broken down as Priestley took sides in the French Revolution and published a biting reply to Burke's attack on the revolutionists.

For his defense Priestley was made a citizen of France. This honor served only to fan the flames against him and against Dissenters in general. On July 14, 1791 as a group met in a Dissenters Chapel to celebrate Bastille Day, the fury of the mob broke loose. The chapel was burned as well as the homes of many dissenters. Priestley was a particular object of the mob's wrath. His manuscripts and his laboratory were burned, all his apparatus was smashed, and he was forced to flee to London for his life.

This was too much for even his fellow scientists. Their political opinions overcame their scientific judgment.

Priestley was no longer welcome in the Royal Society and soon resigned. Snubs and rebuffs were his lot and in April, 1794 at the age of 61 years he sailed for America —an exile from his own country.

PRIESTLEY IN AMERICA

In America Priestley found a warm welcome. He was greeted in New York by Governor DeWitt Clinton and representatives of all the leading societies of the city as well as by his two sons who had preceded him.

Purchasing a plot of 300 acres on the Susquehanna River at Northumberland, Penna., Priestley settled down to pass his remaining years. He frequently visited Philadelphia and became intimate with George Washington, Thomas Jefferson, John Adams and other notables. He preached often in Philadelphia churches and stimulated the progress of chemistry in America through his contacts with the University of Pennsylvania. His active days were over, however, and aside from the discovery of carbon monoxide he made no further contributions to chemical research. The death of his wife and favorite son within a few months of each other caused him great grief and on February 6, 1804, in the midst of dictating a scientific article to his secretary, he died.

The chemists of America have kept his home in perfect preservation and in a memorial museum nearby is much of the apparatus he used, most of which was made by his own hands. A visit to this memorial is both an education and

an inspiration, for as Lord Brougham points out in his *Lives of Men of Letters and of Science* "Priestley presents one of the memorable examples of knowledge pursued, science cultivated and even its bounds extended by those whose circumstances made their exertions a continued struggle against difficulties which only virtue and genius like theirs could overcome."

SOURCES

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"PYREX" LABORATORY GLASSWARE

ANOTHER FAMOUS NAME IN CHEMICAL HISTORY

FROM the time when early chemists turned from the exclusive study of solids and began to investigate the properties of liquids and gases, one of the most important materials for fabricating their apparatus was glass. It was smooth, hard, moderately resistant to chemical attack, and—above all—transparent. But it had a most serious defect: It melted under high temperatures, and it broke under sudden heat or cold.

Some progress was made in our own country in the early part of this century in producing a glass with greater resistance to heat, but in this field Germany and Austria led the world. Then came 1914, and the World War. Imports from Germany were abruptly ended.

At Corning, New York, the Corning Glass Works was already producing highly viscous borosilicate glasses that compared very favorably with the imported product. These glasses were making a notable contribution to the safety of railroad travel in heat-resistant lantern globes and signal lenses that would withstand the combination of heat from the oil flame within, and rain and snow without. And, in addition, Corning was one of the few industries at the time that had a well-established research department—an organization of chemists, physicists and engineers who were already transforming the making of glassware from a handicraft to a scientific process.

So Corning was well equipped to meet the emergency

created by the war. With its scientists, its extensive plant and plant equipment, and a large body of expert craftsmen, it was finally able to produce a glass not only resistant to heat shock, but also more resistant than other glasses to the action of chemicals.

One of the "Pyrex" brand glasses was developed to possess an extremely low co-efficient of thermal expansion represented by the decimal .0000032. And this unique feature made possible glassware with thicker walls—greater mechanical strength. America had at last produced the ideal glass for laboratory apparatus.

"Pyrex" brand flasks and beakers quickly came into widespread—almost universal—use throughout the laboratories of the land. Other items were made of this same glass: test tubes, bulbs, funnels, dishes, graduated ware, condensers—a complete line of heat-resistant laboratory glassware. This new ware was so superior to the foreign-made product that after the war it continued to hold first place in this country, and its use has spread throughout the world.

The rapidly expanding market for "Pyrex" brand glasses, not only in laboratory ware but in many other and very diverse products, made possible and even demanded a great extension of manufacturing facilities—larger and more efficient ingenious machinery, scientifically designed annealing lehrs, standard practice, sub-division of operations—in fact, all the economies and improvements attainable through the most modern methods of efficient production. "Pyrex" brand products were made better and better—and in many instances lower in price.

Constant advances and improvements in laboratory glassware have been made through the continuous research of a notable group of scientists. These men at Corning are still pioneering, marking out new trails in the fabrication of heat-resistant glass. In their diverse fields of chemistry, physics and engineering, they are coordinating their studies in perfecting the quality, reducing the cost, and increasing the usefulness of Corning products.

Their work goes on, but so much has already been accomplished that if their achievements were to end today, "Pyrex" brand glass would always be a famous name in chemical history.

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Research in Glass