Jons Jakob Berzelius

This Swedish researcher helped consolidate the transformation of chemistry from art to science.

Richard A. Pizzi

Many historians of science view the beginning of the 19th century as the dawn of a new era in chemistry. Antoine Lavoisier's controversial challenge to the phlogiston theory had been accepted throughout most of Europe, and the supporters of the old chemistry were losing their grip on the educational and research institutions. The novel concept of galvanism gave inspiration to new investigation and new theories, and led to important work by men like Humphry Davy and John Dalton.

Perhaps the most systematic thinker and institutional organizer in this period of transformation was the Swedish scientist Jons Jakob Berzelius. Among the most prominent chemists of his day, Berzelius was known as a methodical experimenter who could summarize and correlate the work of others with his own inquiries and direct the field toward general theories. Very much, in fact, like Lavoisier himself.

Berzelius is probably best known for three achievements: the construction of a theory of electrochemical "dualism," the establishment of the first list of atomic weights for elements, and the invention of chemical symbols. But he also discovered a number of elements, wrote the standard chemistry textbook of his era, and became an effective institutional administrator late in his career. He was, in short, one of the critical figures in the development of modern chemistry.

Early Life

Berzelius was born on August 20, 1779, in Wafversunda, Sweden. His father was a teacher, but he died of tuberculosis when the boy was only four years old. Berzelius's mother remarried two years later, uniting her family of three children with the five offspring of a widowed pastor named Ekmarck. This union ended sadly two years later when Berzelius's mother died, leaving him an orphan.

Berzelius lived in his stepfather's house for a few years after his mother's death, but he was unhappy. When Ekmarck remarried in 1790, his new wife treated the Berzelius children poorly. Later in life, Berzelius recalled this period of his youth with dismay. He stated that, unlike most people, he had no "joyful recollections" of childhood. As a young man, Berzelius desired to leave his stepfather's house at the earliest opportunity.

Jons Jakob Berzelius, 1779–1848

That chance came in 1793. Berzelius began attending a secondary school in Linkoping and worked as a private tutor to the children of a wealthy landowner. He also labored in the fields and slept in a cold storeroom amid sacks of potatoes. During these difficult years, Berzelius developed an interest in natural history, inspired by an encouraging teacher and by reading the works of Carl Linnaeus, known today as the father of taxonomy. He spent many days collecting plants and birds.

Rejecting the influence of his foster parents, who wished him to become a pastor, Berzelius decided to study medicine after graduation from secondary school. In an interesting historical aside, given his future success, Berzelius's graduation report indicated that his future prospects were "uncertain" because "his morals are not good." Nevertheless, he enrolled in the medical school at the University of Uppsala in 1796. Forced to leave school after one term because of financial difficulties, Berzelius once again took a job as a tutor for a brief period, and returned to his medical studies after earning a scholarship.

A Nascent Chemist

It was in 1798 that Berzelius took his first course in chemistry. It was not an auspicious beginning for the future scientist. He almost failed the final examination, and survived the year only because of his good grades in physics. His academic difficulties notwithstanding, during the next term Berzelius began carrying out experiments in the laboratory of a Professor Johann Afzelius, a chemist who is remembered only for his most famous student. It was while working in this laboratory that Berzelius first acquired a profound interest in chemistry.

Because Professor Afzelius did not spend much time in the laboratory overseeing the work of students, Berzelius realized that he could do whatever he wished. He began performing experiments on various subjects and started systematically replicating experiments that he learned from reading chemistry books. He paid the laboratory assistant a small fee for the use of chemicals from the university pharmacy.

Professor Afzelius eventually discovered that his student was working secretly in the laboratory, but instead of criticizing Berzelius, he invited the young man to use the lab equipment during normal hours. Berzelius's early academic papers grew out of those days of student experimentation. His first published article was a chemical analysis of

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mineral water taken from a nearby health resort. He also wrote three other "dissertations," which he gave to Afzelius, who hoped to have them published by the Swedish Academy of Science. Unfortunately, the academy rejected the pieces because they contained some of Lavoisier's concepts, those new ideas about chemistry that were still not accepted by the old guard at the Academy.

In 1802, Berzelius received his degree in medicine, but instead of becoming a practicing physician he decided that his future lay in research. He took a volunteer position as an assistant at the School of Surgery in Stockholm. While this job offered Berzelius a place to do research in his spare time, it did not offer him the means to support himself. Berzelius had a small inheritance from his parents, but nowhere near enough to provide a comfortable living. Still, the young scientist was determined to become a researcher.

A "Dual" Career

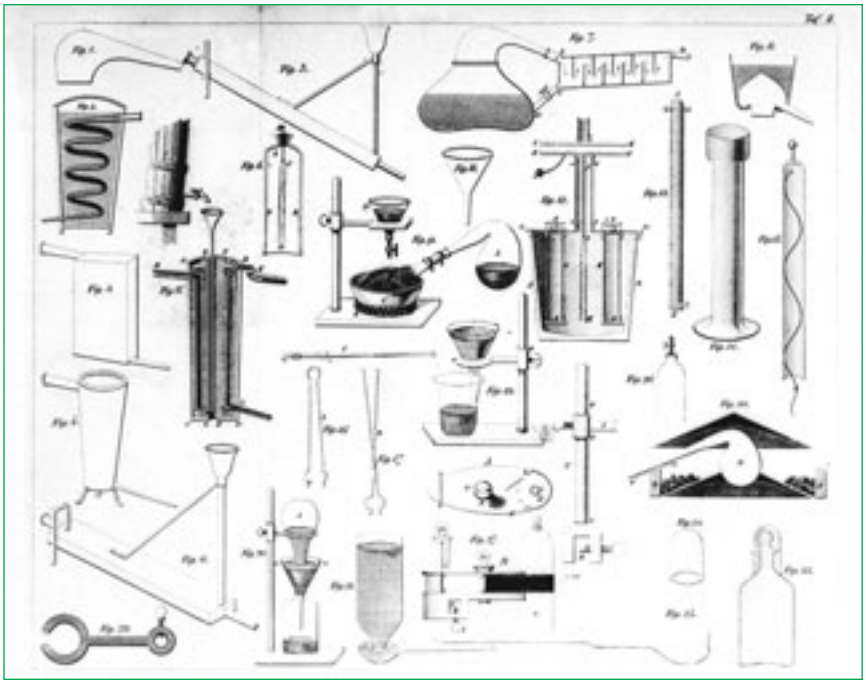
Around this time, Berzelius became friendly with a mine owner named Wilhelm von Hisinger. The industrialist shared the scientist's interest in chemistry, particularly experiments involving the relatively new Voltaic pile, with which Berzelius had conducted a few experiments during medical school. Hisinger and Berzelius constructed their own Voltaic pile and ran experiments on various salts. They learned that the alkalis and earths migrated to the pile's negative pole and that oxygen, acids, and oxidized substances migrated to the positive pole.

Berzelius and Hisinger published an article announcing their finding in 1803, about three years prior to Humphry Davy's famous article on the same subject. Davy's article is considered more important, however, as he determined that the alkalis were compounds and he was able to isolate the alkali metals. Still, this early Berzelius article displays the ideas that led to his dualistic electrochemical theory.

Berzelius clung to the dualistic theory his entire life, even in the face of the considerable criticism that would ultimately lead the scientific community to reject it. The dualistic theory held that atoms were charged and chemical combination resulted from the mutual neutralization of opposite charges. While useful at the time, this theory (which was based on a type of generalized ionic bond concept) obviously did not hold universally, especially as was quickly apparent in organic chemistry, with the inevitable need to explain covalent bonds.

In 1807, at the age of 28, Berzelius was appointed as a professor at the School of Surgery. While this was an honor, it was also a needed financial boon since Berzelius had been in debt for his entire adult life. He had accrued a significant financial liability from a failed venture into industrial vinegar production and desperately needed additional income. His financial status improved as the years passed, and he slowly paid off his creditors. In one interesting financial development, Berzelius's income improved significantly during the Napoleonic war. Professors at the School of Surgery were considered the equivalent of army officers and were paid double their peacetime salaries.

One year after his appointment to the professorship, Berzelius was elected to the



Chemical and distillation apparatus as illustrated in Jons J. Berzelius's textbook.

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Swedish Academy of Sciences. Not yet 30 years old, he was well on the way to a prestigious career in European science. That same year, he published the first edition of his chemistry textbook, the *Schoolbook of Chemistry*, which became standard in Swedish universities. While important for its role in the education of Swedish chemists and medical students, this book is equally significant for detailing the results of the many hours of experimentation that led to its writing. In preparing his textbook, Berzelius initiated the research for which he became famous—the determination of the atomic weights of the elements.

By the Numbers

Berzelius determined that the atomic numbers used by John Dalton were not accurate enough to allow Dalton's atomic theory to be of practical use. Thus, he decided to carry out the work of discovering the atomic weights of elements himself. He recommended the use of oxygen as a standard instead of hydrogen, which Dalton had preferred, because the determination of atomic weights was based primarily on the analysis of oxides. In some cases, however, he used hydrogen as the standard because such usage was common in a number of countries, especially England.

Berzelius published his first table of atomic weights in 1814. As might be expect-

ed, the original table shows many incorrect quantities, but most of the values listed approach contemporary standards quite closely. He achieved such precision with a relatively poorly equipped laboratory and limited access to chemicals. In early 19th-century Sweden, very few chemicals were available commercially. Most compounds had to be prepared meticulously in the research laboratory. Berzelius even prepared his own hydrochloric acid from sodium chloride and sulfuric acid. He had no professional assistance in his laboratory until the 1830s (other than one or two medical students), and he paid for all his chemicals and apparatus himself. His achievement is even greater in light of these difficulties.

Symbolic Achievements

The practical need to deal with so many compounds motivated Berzelius to create a system of symbols for the elements. He suggested the first letter of the element's name as the symbol. Berzelius also used superscripts to represent the combining proportion of the atoms of elements in a compound. The modern usage is subscripts, but the concept nevertheless originated with Berzelius. He also is responsible for coining a number of modern chemical terms, including catalysis, isomerism, and protein.

With his increasing fame in the scientific world, it is not surprising that Berzelius enjoyed a rise in social status. The king of Sweden raised Berzelius to the nobility in 1818. Two years later, he was elected secretary of the Swedish Academy, a position he held for the remainder of his life. He was granted a pension by the Swedish Metallurgical Society and by the government. Over the next 20 years, he made many trips throughout Europe, meeting with the leading scientists on the Continent. By the time Berzelius retired from teaching in the early 1830s, he had finally escaped the financial difficulties that had dogged him all of his life.

Having spent all of his adult life as a bachelor, Berzelius decided to marry at age 57. He once commented that he had avoided marriage primarily because it would interfere with his scholarly life, but he experienced a change of heart as he aged. After his marriage in 1835, Berzelius did very little original research but spent much time defending his theories against criticism. Younger scientists exposed flaws in the older man's theories, and Berzelius did not take criticism lightly. As he grew older, his health deteriorated significantly, and he could no longer summon enthusiasm for the work he had once done. On August 7, 1848, both legs paralyzed and confined to a wheelchair, Berzelius died, less than two weeks shy of his 69th birthday. Although he did not achieve the renown of his contemporary and rival Humphry Davy, Jons Jakob Berzelius was nonetheless a vitally important figure in the rise of modern science.

Further Reading

FECS Millennium Project; www.chemsoc.org/networks/enc/FECS/Berzelius.htm.

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