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# Friedrich Wöhler

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# FRIEDRICH WÖHLER

*Born:* July 31, 1800; Eschersheim, near Frankfurt am Main
*Died:* September 23, 1882; Göttingen, Germany
*Area of Achievement:* Chemistry
*Contribution:* Wöhler synthesized urea in 1828 and thus first demonstrated that organic materials, heretofore believed to possess a vital force, need not be made exclusively within living organisms. He also isolated aluminum metal in 1827 and discovered the elements beryllium and yttrium.

## *Early Life*

Born in the village of Eschersheim to Anton August Wöhler and his wife, Anna Katharina Schröder, Friedrich Wöhler received his early education from his father, who had been Master of the Horse to the Prince of Hesse Kassel and subsequently one of Frankfurt's leading citizens. As a child Wöhler pursued both mineralogy and chemistry as hobbies and, in addition to public school, received tutoring in Latin, French, and music. Indeed, Wöhler's early years imbued him with the Romantic spirit of the day. He studied music and poetry, and the well-known landscape painter Christopher Morgenstern encouraged him in artistic endeavors. Yet Wöhler also showed an early interest in science, as he built voltaic piles from zinc plates and some old Russian coins and experimented with the reactive elements phosphorus and chlorine. Between 1814 and 1820, Wöhler attended the *Gymnasium* to prepare himself for the University of Marburg, where he began to study medicine and won a prize for his work on the transformation of waste substances into urine. Yet it became obvious to him, at this early stage of his career, that his interests lay more in chemistry than in medicine, and thus he went to Heidelberg, where he studied under the well-known Leopold Gmelin. At Heidelberg, Wöhler earned his medical degree in 1823; rather than seek employment as a physician, however, he received permission to work in Stockholm with Jöns Jakob Berzelius, perhaps the greatest figure in chemistry of the day.

It was in Stockholm that Wöhler gained the scientific and technical skills that were crucial to his future career, as he was carefully trained in exact chemical analysis using such simple tools as a platinum crucible, a balance, and a blow pipe. This expertise, coupled with his interest in cyanic acid and the cyanates, ultimately led to investigations that transformed the fundamental nature of modern chemistry.

## *Life's Work*

At the beginning of the nineteenth century, organic chemistry was normally associated with the extraction, isolation, and identification of animal and vegetable matter for medicinal purposes. It was thought that only in the animal and vegetable kingdom could organic molecules be synthesized and

form organized bodies. The presence of a vital force was attributed to this unique chemistry found only in living systems. Organic chemistry, then, was a science concerned primarily with understanding the nature of life and creation—not merely a study of isolated reactions of carbon-containing compounds. The concept of vitalism discouraged the use of the theory of chemical affinities associated with mineral or inorganic chemistry in explanations related to the organic branch of the discipline. Thus Berzelius wrote in 1819 that his electrochemical theory could not be applied to organic matter, because, in his opinion, the influence of a vital force led to entirely different electrochemical properties. Wöhler's researches would subsequently refute this idea and thus unify the animal and mineral branches of chemistry.

Upon returning from Berzelius' laboratory in 1825, Wöhler began his teaching career at an industrial school in Berlin. He soon began communicating with University of Giessen professor Justus von Liebig, who had learned exact chemical analysis from Joseph-Louis Gay-Lussac in Paris. The two quickly formed a lifelong friendship and began collaborating on problems of mutual interest. For some time, Liebig had been working on explosive fulminates, and, during the course of these investigations, he prepared a compound that was similar in composition to silver cyanate, a compound Wöhler had prepared in 1823. Despite the fact that silver cyanate and silver fulminate had the same empirical formula, AgCNO, they had different chemical and physical properties; it remained for Berzelius in 1830 to call the new phenomenon isomerism.

Wöhler's studies on the cyanates directed him to reexamine reactions that he had initially undertaken while a student in Berzelius' laboratory, thus setting the stage for his artificial synthesis of urea, which stands as a milestone in the history of science. Wöhler prepared urea by first reacting lead cyanate with ammonia. Beautiful white crystals appeared that, when treated with nitric acid, were transformed into lustrous flakes of a substance he quickly recognized as urea. In February of 1828, Wöhler boasted to Berzelius that he had prepared urea without the kidney of man or dog. Wöhler's synthesis marked the beginning of a new chemistry in which distinctions between inorganic and organic fields were blurred. Wöhler's career was now on the rise, and in 1831 he left Berlin for Kassel, where he held a similar position. Tragedy struck amid his early scientific triumphs, however, for a year later his young wife and cousin, Franziska Wöhler, died. For consolation, Wöhler went to Liebig's laboratory, where they collaborated on an important paper dealing with oil of bitter almonds (benzaldehyde). In their investigations they demonstrated that a group of atoms remained unchanged through a series of chemical operations, and to this fundamental unit they gave the name benzoyl. This discovery played a major role in debates of the 1830's dealing with radical theory.

Liebig and Wöhler continued to work together during the 1830's, even

though Wöhler returned to Kassel, where he remarried. In 1836, Wöhler succeeded Friedrich Strohmeyer at Göttingen and filled this chair for almost half a century until his death in 1882. While Wöhler worked on various problems related to organic chemistry during his first few years at Göttingen, by 1840 he increasingly turned to the study of inorganic and mineralogical chemistry. Perhaps his reorientation was the result of the frustration of working in the field of organic chemistry at that time. The field was experiencing a kind of chaos because of internal reorientation in terms of nomenclature and central concepts related to molecular structure.

Wöhler's previous background in inorganic and mineralogical chemistry had been a solid one, the result of his studies with his former mentor Berzelius on silicon, selenium, and zirconium. Indeed, in 1827 he had been the first scientist to isolate metallic aluminum by reacting a small quantity of potassium with an excess of aluminum chloride. By 1850, Wöhler was active in preparing a large number of metallic salts, and later in 1862 he was the first to synthesize calcium carbide from acetylene. Other important contributions included the preparation of silicon hydride, silicon chloroform, iodoform, and bromoform.

Unlike his close friend Liebig, Wöhler remained interested and active in chemical research until his death. Friedrich Wöhler's professional accomplishments encompassed broad areas within chemistry, and he stands out in an era in which the discipline was transformed in terms of both theoretical knowledge and technical methods.

### *Summary*

During the past four decades, historians of science have debated the significance of Friedrich Wöhler's synthesis of urea. The importance of Wöhler's investigation lay not in his refutation of the concept of vitalism but in the development of ideas related to structural chemistry. His demonstration of the isomeric relationship between urea and ammonium cyanate further exposed previously little-known chemical complexities that could be best understood in terms of molecular structure. For chemists such as Wöhler, Berzelius, and Liebig, the vital force apparently remained a viable scientific concept even after 1828.

The experimental synthesis of acetic acid by Hermann Kolbe in 1844 and the synthesis of methane and acetylene by Marcelin Berthelot in 1855 and 1856 contributed to the decline in popularity of the vitalistic theory. More significant, however, as Timothy Lipman has suggested, is that vitalism's importance in organic chemistry declined by the mid-nineteenth century, when the life sciences became increasingly specialized. Organic chemistry dealt with compounds of carbon atoms; physiology focused on organic functions; but neither subdiscipline examined the creation of life. Thus, for the organic chemist, vitalism was no longer a necessary concept.

*Bibliography*

Ihde, Aaron. *The Development of Modern Chemistry*. New York: Harper & Row, 1964. This general survey in the history of chemistry includes a thorough discussion of Wöhler's chief contributions to both organic and inorganic chemistry. It is essential in placing Wöhler's work within its proper intellectual context.

Keen, Robin. "Friedrich Wöhler and His Lifelong Interest in the Platinum Metals." *Platinum Metals Review* 29 (1985): 81-85. A well-researched and clearly written article that not only provides an overview of Wöhler's life and professional career but also focuses upon his work in the isolation of aluminum and the separation of iridium and osmium. In addition, Keen links the careers of two of Wöhler's students, Wilhelm Carl Heraeus and Heinrich Rössler, to the development of the platinum industry.

Lipman, Timothy O. "Wöhler's Preparation of Urea and the Fate of Vitalism." *Journal of Chemical Education* 41 (1964): 452-458. Lipman's essay on vitalism and Wöhler provides a model of careful research and critical thinking for scholars working in the field of the history of chemistry. Lipman's purpose is to settle the issue of whether Wöhler's 1828 synthesis of urea overturned vitalistic notions in organic chemistry. In the process of demonstrating that Wöhler's experiment was one of a number of facts that accumulated during the first half of the nineteenth century that made vitalism untenable, the author thoroughly characterizes the place of vitalism in chemistry both before and after 1828.

McKie, Douglas. "Wöhler's Preparation of Urea and the Fate of Vitalism: A Chemical Legend." *Nature* 153 (1944): 608-610. This work strongly argues that Wöhler's 1828 synthesis of urea had far less influence in refuting the doctrine of vitalism than previously believed. Indeed, McKie attempts to shatter a legend that emerged long after Wöhler's early experiments, a legend perpetuated by successive generations of chemists.

Smith, Edgar F. "Some Experiences of Dr. Edgar F. Smith as a Student Under Wöhler." *Journal of Chemical Education* 5 (1928): 1554-1557. In 1928, Edgar Fah Smith of the University of Pennsylvania, one of the leading figures in the development of chemistry in nineteenth century America, reminisced to a small group of chemists, one of whom recorded the conversation. Smith's recollections are a delightful account of one student's experiences in Göttingen and provide an interesting view of Wöhler as a mentor of graduate students.

Warren, W. H. "Contemporary Reception of Wöhler's Discovery of the Synthesis of Urea." *Journal of Chemical Education* 5 (1928): 1539-1553. Although somewhat dated in terms of scholarship, this essay traces the response of several important chemists to Wöhler's 1828 synthesis of urea. By carefully examining contemporary correspondence, periodical literature, and books, the author argues that by 1840 a number of chemists

were convinced of the significance of Wöhler's work in the changing views concerning vitalism and thus of the boundaries between organic and inorganic chemistry.

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