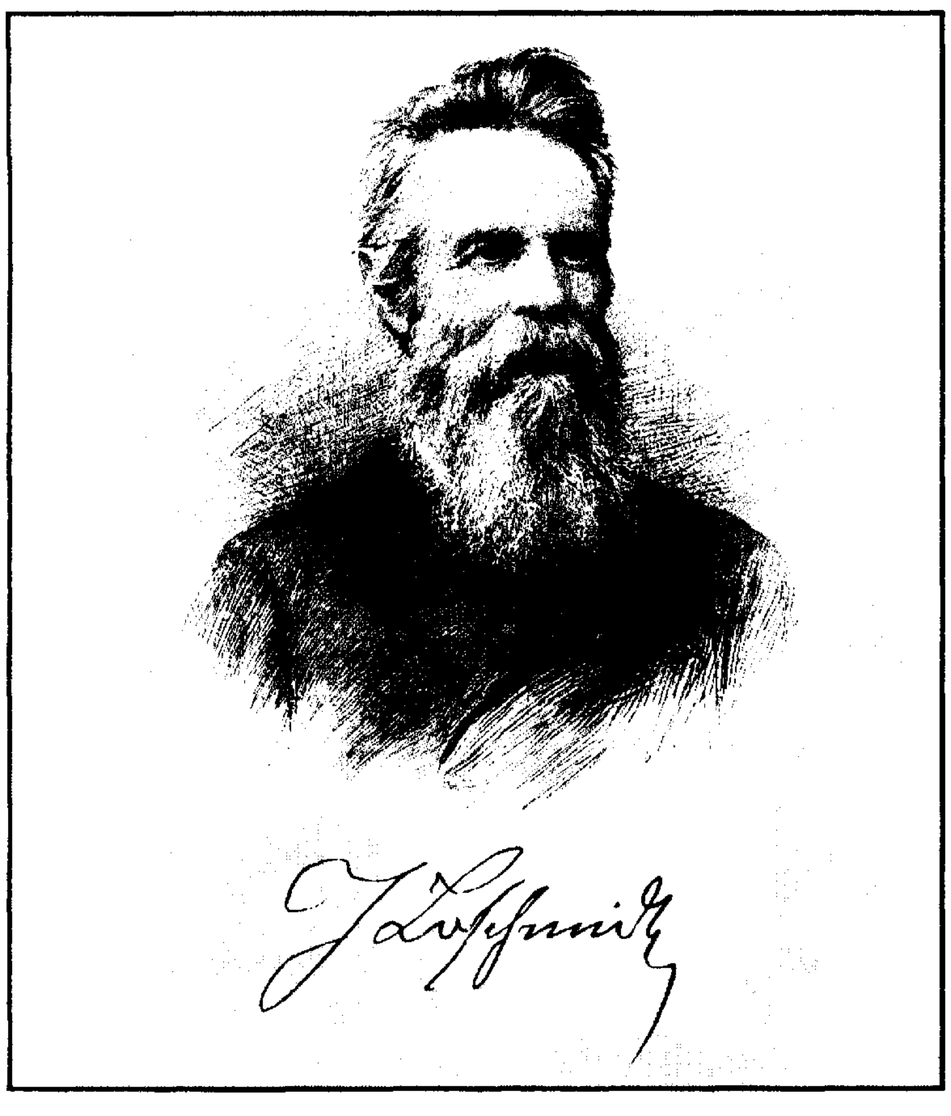
Johann Josef Loschmidt (1821-1895): a forgotten genius

Benzene rings and much more in 1861

William J. Wiswesser



One of the most puzzling problems facing chemists in the middle of the last century was the structure of benzene and its derivatives. Ask chemists anywhere in the world who was the first person to present the structure of benzene correctly, and the answer will be August Kekulé, probably followed by a reference to his dream about a snake biting its tail. Much has been written about this dream, yet it is really quite irrelevant, because Kekulé was not the first chemist to propose the structure of benzene. It was, in fact, Johann Josef Loschmidt who first published the correct structure in 1861.

Johann Josef Loschmidt was so far ahead of his contemporaries, and so shy and self-effacing, that they may be forgiven for overlooking his monumental contributions to the structural representation of molecules. Today, however, it is a shameful neglect of our chemical heritage to continue to disregard his famous firsts:

1. The first correct cyclic structure of benzene and of many aromatic chemicals, 121 in all.
2. The first representation of the allyl moiety.
3. The first representation of the vinyl moiety and of many others.
4. The first representation of cyclopropane, 21 years before it was made by Freund.
5. The first picture book of molecules, containing graphic displays with atomic domains, rather than abstract bond lines.
6. The first double- and triple-bond marks (within the overlaps).
7. The first realistic displays of atomic sizes and bond distances (largest overlap with triple bonds).
8. The first set of diagrams with correct C = 12, N = 14, O = 16 formulas.
9. The first textbook use of atomic-group symbols.
10. The first use of valence prime marks on these and atomic symbols ("Valenz" was introduced by Wichelhaus in 1868, 7 years later).
11. The first LINE-FORMULA NOTATIONS ("rational formulas").
12. The first revelations of hexavalent and tetravalent sulfur.

It was Richard Anschütz, a Kekulé student, who first recognized Loschmidt's importance. In 1913, he republished Loschmidt's work and graphic representation of molecules, added a brief biography of Loschmidt, and made many comments about the work.[1]

Loschmidt was born to a poor peasant family in a village near Carlsbad, Bohemia, in 1821. In Loschmidt's obituary in 1895, his good friend, Ludwig Boltzmann, related that Loschmidt so hated farm work that his parents considered him useless for anything but studies. Encouraged by his village priest and teacher, he went to high school, and eventually attended Prague University. At the age of 21, he went to the University and the Polytechnic Institute (now the Technical University) in Vienna, first studying philosophy and mathematics, and then the natural sciences, physics and chemistry.

Loschmidt then became involved in several industrial ventures in Lower Austria, Styria, Bohemia and Moravia, making potassium nitrate and oxalic acid, among other products. These ventures were technical successes but financial failures. In the early 1850's, he returned to Vienna penniless, took a job as a concièrge, and then qualified as a school teacher.

Loschmidt was always attracted to the major theoretical problems in the natural sciences, and today he is best remembered for the "Loschmidt Number", his 1865 calculation of the number of molecules in one milliliter of an ideal gas.

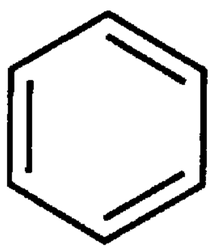
Four years earlier, however, he had published privately what can be called the monograph of the century. This was a modest octavo booklet containing a 47-page essay entitled *Constitutions-Formeln der organischen Chemie in geographischer Darstellung*.[2]

In each generation since, someone has recognized and written about Loschmidt's greatness. It was a brief reference to Loschmidt's work in Kekulé's famous paper presented in Paris in 1865 and published in *Bull. Soc. Chim. Fr.* **1865**, *3*(2), 100 that kindled Richard Anschütz's interest. Intrigued, he tried to find out more. At first, all he could discover was a brief description in a reference by Hermann Kopp, a German crystallographer, the teacher and friend of Kekulé. Eventually he obtained a copy of Loschmidt's pamphlet from an antiquarian book dealer in Vienna. In the comments which he added to his 1913 reprint, Anschütz expressed the amazement with which he read this little work. He immediately wondered whether Kekulé had also read it, and, if not, where he had heard about Loschmidt's work. He came to the conclusion that Kekulé had definitely not read the book but believed that he must have heard of it from Hermann Kopp who

had written the abstract for *Liebigs Jahresbericht* **1861,** *1,* 335. Unfortunately, Kopp was not well versed in organic chemistry and probably did not realize the full significance of the work he was reviewing.

August Kekulé's lone reference to Loschmidt's work is in a single sentence in that French paper of 1865 *"Elle me parait préférable aux modifications proposées par M.M. Loschmidt et Crum-Brown."*

Kekulé proposed the hexagonal structure (I) of benzene.



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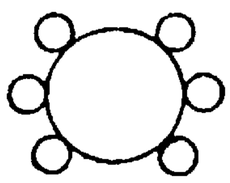

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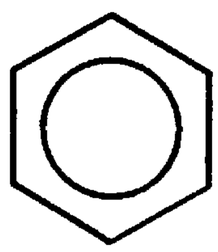

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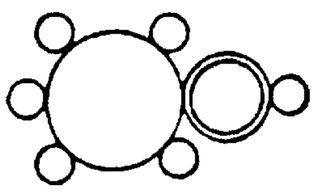
Four years earlier, Loschmidt had proposed the circular (II) structure 185, in the work of 1861. Few chemists now using III realize how close this is to Loschmidt's formulation. Phenol was shown as 186, anisole as 187, toluene as 197, 121 aromatic compounds in all, many of these correct.



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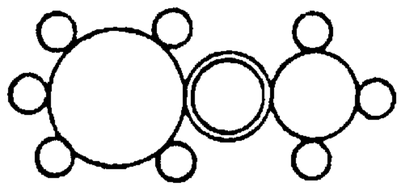

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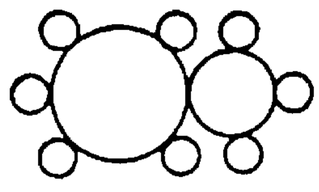

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In 1945 Moritz Kohn wrote an article about Loschmidt based on Anschütz's biography, and published it in the *Journal of Chemical Education.*[3] Three years later, Hubert de Martin wrote a dissertation[4] at the University of Vienna.

Dr. de Martin's well written thesis refers to many original documents and gives a number of details of Loschmidt's personal life, few of which were mentioned by Anschütz. At the age of 66 Loschmidt married his housekeeper Karoline Mayr, 25 years his junior. Their only son, Josef Karl, died of scarlet fever in 1898, at age ten, three years after his father's death. Karoline Loschmidt lived until 1930, when she died of cancer.

Dr. de Martin also discusses Loschmidt's chemical essay of 1861 in detail (pp 58–64 in the thesis), and concludes that it was almost unknown because it was privately printed and was not read by chemists who understood it—until Anschütz read it some 50 years later. Thus it is clear that, although Loschmidt is well known among physicists for the Loschmidt/Avogadro number, he remains virtually unknown among chemists.

In order to make his work more widely available, Aldrich is offering copies of Anschütz's republished work of 1913, including his comments on Loschmidt's work. This is much easier to use than the 1861 book, because the original fold-out plates, which are clumsy to handle and which can be torn easily, have been reduced in size. Also, Anschütz has made some minor corrections to the structures. But for the serious chemical historian, Aldrich also offers copies of the small book of 1861 together with the seven fold-out plates. In that book of 54 pages, the first 47 deal with 368 chemical structures, including 121 of aromatic compounds. The remaining six pages deal with studies in physics, gas kinetics, unrelated to chemical structures.

Two important questions arise: why has Loschmidt not been recognized as the first person to depict correctly the structures of benzene and many other compounds, and why was his genius as a chemist not recognized by scientists in Vienna?

The answers to both questions lie in the personality of Loschmidt himself. He was a shy and self-effacing man who never travelled outside the Austro-Hungarian Empire, who never pushed himself to publish in the major chemical journals or to give lectures at important international meetings. His small book was a masterpiece, but who knew about it? In contrast, August Kekulé was a world-famous professor, a great lecturer and teacher, and author of the most widely read textbooks of his time.

In 1890, the 25th anniversary of 'his' formulation of the structure of benzene, Kekulé spoke of his dream. Perhaps he really did have that dream, based on what he had heard of Loschmidt's work. It is not of great importance; Loschmidt had published his simple and brilliant work four years earlier.

Anschütz began his comments about Loschmidt (page 99) with the words: "The Austrian physicist, Joseph Loschmidt . . . was originally a chemist." Clearly, Anschütz thought of Loschmidt first and foremost as a physicist.

It must have been unusual for a man to come to Vienna penniless, to start as a caretaker, a "Hausbesorger", and eventually to qualify as a university professor. That he finally became a close personal friend of Josef Stefan and Ludwig Boltzmann (much younger men who were the greatest Viennese physicists of their time) is evidence that he was appreciated but, again, almost entirely as a physicist and physical chemist.

In 1866, he became Privatdozent at the University of Vienna, and, two years later, Associate Professor. He was elected to the Royal Academy of Sciences (Kaiserliche Akademie der Wissenschaften) in 1867, and the following year the University gave him the honorary degree of Doctor of Philosophy. The next year he founded the "Chemisch-Physikalische Gesellschaft", a society of chemists and physicists in Vienna, and in 1875 became the chairman of the Physical Chemistry Institute. He became Dean of the Faculty of Philosophy in 1877, and in 1885 was elected to the Senate of that faculty. Despite these honors, all his contemporaries failed to realize that that tiny book of 1861 was really the masterpiece of the century in organic chemistry.

Acknowledgements:

I would like to thank Dr. Christian Noe and Dr. Alfred and Isabel Bader for their exceptional help with this essay.

References:

1) Anschütz, R. *Konstitutions-Formeln der organischen Chemie in graphischer Darstellung,* Loschmidt, J., republished in Ostwald's *Klassiker der exakten Wissenschaften,* Leipzig, 1913.
2) Loschmidt, J. *Chemische Studien, A. Constitutions-Formeln der organischen Chemie in geographischer Darstellung, B. Das Mariotte'sche Gesetz,* Vienna, 1861.
3) Kohn, M. *J. Chem. Educ.* **1945,** 381.
4) Loschmidt, J. *Sein Leben und Wirken.* Ph.D. thesis of Hubert de Martin, submitted to the faculty of philosophy of the University of Vienna in November, 1948. 235 typewritten pages, with documents.

About the Author

William J. Wiswesser graduated with a B.S. from Lehigh University in 1936 and received an honorary D.Sc. from Lehigh in 1974. He has worked for the Hercules Research Center, Trojan Powder Co., Picatinny Arsenal, Cooper Union, Willson Products, and the U.S. Army at Fort Detrick and is presently working in the Weed Science Research Laboratory, Agricultural Research Service, U.S. Department of Agriculture. His interest in simplifying chemical structure descriptions began in college when he developed a chemical shorthand based on valence-line diagrams. Today, some 50 different research organizations have more than three million Wiswesser Line Notation (WLN) records in their computers. He has written or coauthored over 50 papers, and is editor of *CWIK List News* (Chemical World Index Key) as well as the *Pesticide Index.* He is past chairman of the Lehigh Valley Section and of the History of Chemistry Division of ACS. His honors include the U.S. Army Exceptional Civilian Service award, the first "Reading Chemist of the Year" award, the Austin M. Patterson award, the Herman Skolnik award of the ACS Division of Chemical Information, the Chemical Notation Association award, and the 1981 award of the Institute of Information Scientists.

Chemische Studien - A. Constitutions-Formeln der organischen Chemie in geographischer Darstellung. B. Das Mariotte'sche Gesetz, by J. Loschmidt, Vienna, 1861, 54 pages.*

The first representation of the cyclic structure of benzene and many more aromatic chemicals. Contains complete set of fold-out plates of molecular structures.

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J. Loschmidt's Konstitutions-Formeln der organischen Chemie in graphischer Darstellung, by R. Anschütz, Wilhelm Engelmann, Leipzig, 1913, 160 pages.*

Richard Anschütz, a Kekulé student, republished Loschmidt's book (described above) including the molecular structures, and added many of his own comments as well as a brief biography of Loschmidt.

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*We wish to thank the National Library in Vienna for their help with these.