## Friedrich August Kekulé
## A Short Biographical Sketch

Today, we are able to write the structure of DNA, map the human genome, and understand the functions of proteins. The seeds for achieving such feats were sown during the middle of the nineteenth century. The structure of a molecule gives the positional relationship of various atoms comprising it. The properties and reactions of a molecule and its interactions with other molecules are entirely controlled by its structure. It was a formidable task at the time of Kekulé to develop the principles that would form the foundation of the great edifice of structural chemistry. It was a time when even the atomic weights were still not quite settled, and the analytical methods were crude. However, the single-minded devotion of many scientists to solve these problems led to considerable success, and we are now reaping the benefits of their endeavour. Though there were many of Kekulé's contemporaries like Frankland, Couper, Kolbe, Crum Brown and Odling in the forefront of this effort, Kekulé's contributions are acknowledged most widely. It is said, "*Kekulé's work and personality both have a charm which pervades even the printed page, and the elegance of his theories has a character of individuality which one usually associates with the great artists and the poets*".

Although Kekulé lived for 67 years, his active life was much shorter, as his health had started failing much before he was fifty years old. However, by that time he had already made an indelible mark on the vast firmament of chemical sciences.

Friedrich August Kekulé was born in 1829 at Darmstadt in Germany. After early schooling in his native town, where he studied drawing and mathematics, he went to the University of Giessen and specialized in architecture. The lectures of Liebig, who was Professor of Chemistry there, were a big attraction. Kekulé attended them in his spare time while studying architecture. Liebig's lectures inspired Kekulé so much that he soon changed his career by becoming a designer of molecules instead of houses. It was a kind of coup that tremendously benefited chemistry, perhaps at the cost of architecture. Kekulé also had the good fortune of studying under such great masters as Dumas and Wurtz in Paris. Between 1854 and 1856 he worked as assistant to a chemist by name Stenhouse in London, where he acquainted himself with Williamson, Frankland and Odling, and brought out his first publication, *Valence in Organic Compounds* in English. He was appointed as Dozent (a university faculty position below that of a Professor) at Heidelberg University in 1856, a post he held for two years till he was called upon to be Professor of Chemistry at University of Ghent in Belgium. After working there till 1867, he returned to Germany, when his fame was at its peak, to be Professor of Chemistry at the University of Bonn, where he worked till his death in 1896.

Among many of his achievements as teacher and researcher, the most outstanding contributions of Kekulé to chemistry are, his (i) firm proposal of quadrivalency for carbon, (ii) visionary hypothesis of the chain forming ability of carbon, i.e., bonding of unlimited number of carbon atoms to one another, and (iii) the magnificent theory of benzene structure, which is considered as one of the most glorious breakthroughs during the initial stages of the development of structural chemistry.

One would be amazed to know that such brilliant achievements of Kekulé actually came through his habit of dozing off frequently without much regard to place or time. His two ideas of far reaching consequences, namely, (i) imagining the extended linking of carbon atoms, and (ii) visualizing the ring structure for benzene, are described by him as being born from the dreams he saw during such reveries. He has narrated these dream episodes beautifully in his publications. The narration is so lucid that the reader would get on his mental screen a vivid picture of the themes.

If one takes into account the fact that we are now able to read our genetic code, one would realize the importance of the beginning made by Kekulé in elucidating the seemingly simple structures of organic molecules based on visions experienced through his dreams. History and legends abound with characters in whose life their dreams have played significant and decisive roles. But they may not probably match the dreams of Kekulé which have strongly influenced the course of scientific progress ever since. There is a magical quality and poetic charm in the way Kekulé gives account of his dreams.

Kekulé describes the dream he saw while he was in London (1854-56) that led him to propose the catenation property of carbon as follows. *"During my stay in London I resided for a considerable time in Clapham Road in the neighbourhood of the Common...One fine summer evening I was returning by the last omnibus...I fell into a reverie, and lo, the atoms were gamboling before my eyes! Whenever, hitherto, these diminutive beings had appeared to me, they had always been in motion; but upto that time I had never been able to discern the nature of their motion. Now, however, I saw how, frequently, two smaller atoms united to form a pair; how a larger one embraced two smaller ones; how still larger ones kept hold of three or even four of the smaller; whilst the whole kept whirling in giddy dance. I saw how the larger ones formed a chain, dragging the smaller ones after them, but only at the ends of the chain...The cry of the conductor, 'Clapham Road', awakened me from my dreaming, but I spent a part of the night in putting on paper at least sketches of these forms. This was the origin of the structural theory."*

The second important vision appeared to Kekulé in 1862, and that guided him to develop the celebrated scientific theory of benzene in 1865. He writes about it thus. "*...I was sitting writing at my text book, but the work did not progress; my thoughts were else where. I turned my chair to the fire and dozed. Again the atoms were gamboling before my eyes. This time the smaller groups kept modestly in the background. My mental eye, rendered more acute by repeated visions of this kind, could now distinguish larger structures, of manifold conformation: long rows, sometimes more closely fitted together; all turning and twisting in snakelike motion. But look! What was that? One of the snakes had seized hold of its own tail, and the form whirled mockingly before my eyes. As if by a flash of lightning I awoke; and this time also I spent the rest of the night in working out the consequences of the hypothesis. Let us learn to dream, gentlemen, then perhaps we shall find the truth...but let us beware of publishing our dreams before they have been put to the proof by the waking understanding.*"

Kekulé emerges as a great intellectual, and a visionary with a creative mind and splendid style of narration. But he seems to have had some moments, in his life when his vision failed him. One such

weak point has been mentioned by van't Hoff, who was Kekulé's student in Bonn during the winter of 1872-73. He says, "*... when, as a young student in the University of Bonn, I first became acquainted with chemistry, under the instruction of one of the most noted chemists, Kekulé, that science was pronounced by our master to have reached a dead point, and to be without visible prospect of new advance...and yet only a few years after Kekulé's unfortunate utterance (a sort of remark, we may say in passing, such as a teacher ought perhaps never to make before his pupils) then arose the conceptions of stereochemistry, giving birth to a new, but now well-developed and vigorous, branch of our science*".

It is interesting to note and rather hard to believe that Kekulé could not visualize a bright future for science, in spite of his fantastic imaginative power. This is probably because he had struggled too hard to solve the problem of the structures of very simple molecules, and could not have visualized then, the days when extremely complex molecules would be identified, synthesized and put to very complex uses within a matter of a hundred years after him. He had to face also much criticism initially against his benzene structure.

A rather controversial issue noted about Kekulé is on the background information that was available to him when he was developing the theory of benzene structure. There is a remark that he had not given due credit to an Austrian chemist, by name Loschmidt, who had formulated benzene nucleus as a cyclic entity in 1862 itself. It is also recorded that Kekulé had seen, in an 1857 paper, hexagons being used for depicting molecular units in chemical reactions, though the geometric figure was not meant to represent benzene nucleus. Such arguments are advanced to imply that rings and hexagons were used in the chemical literature of that time and that Kekulé was not unaware of these facts. Such issues seem to be too trivial and do not in any way diminish the genius of Kekulé. The scientific quality of his theory of benzene structure was far superior to any other put forth at that time, and now we know that benzene nucleus looks very much like the way Kekulé had imagined it to be. The applicability of his theory to practical problems and its predictive capability were wide ranging, and both stimulated tremendous scientific activity. Kekulé became a celebrity in his lifetime. To mark the 25 years of the formulation of benzene structure a special international conference was held in 1890. As long as we try to learn about molecules through their structures, Kekulé will be remembered.

**Suggested Reading**


[1] E J Holmyard, *The Great Chemists*, Methuen & Co., London, 1928.

[2] F J Moore and W T Hall, *A History of Chemistry*, McGraw Hill, London, 1939.

[3] J P Snyder, *Nonbenzenoid Aromatics*, Vol. I, Academic Press, New York, 1969.

[4] *Memorial Lectures 1901-1913*, Chemical Society, London, 1914.

[5] J H van't Hoff, *Physical Chemistry in the Service of Sciences*, The Decennial Publications, The University of Chicago Press, Chicago, 1903.

[6] E Farber, *Evolution of Chemistry*, Ronald, New York, 1952.



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