"*The Dignity of a Great Public Building dedicated to Science*". History of the Building of the Chemistry Department of Bonn University, August Kekulé and some Milestones of Organic Chemistry in Bonn

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The building of the old Chemistry Department at Meckenheimer Allee No.168 in Bonn is an architectonical landmark of chemistry buildings in Germany. It is the result of renovation of the old building of the 19th century by the "Rheinische Denkmalpflege" (authority for preservation of historic buildings and monuments) during the years of 1984 through 1987 and gives a good impression of the grace and beauty of old university buildings of that time, see Figure 1. In the following a short history of the building is presented, along with the main scientific achievements of some of the organic chemists who worked in this building. The old Institute Building can now be regarded as an architectural landmark, but the rooms are still used by scientists and students of the departments of geography and microbiology of the university. An index is included of all professors who worked in the building until 1973 (see at the end of this article). Some scientific highlights serve as examples for the fruitful research carried out and of some theoretical concepts developed before World War II, especially the seminal contributions of August Kekulé, an important early work of Hans Meerwein, and the history of "Bonner Punkt" by Wizinger-Aust and Dilthey.

The Founding Idea of the Building by August Wilhelm Hofmann

The Rheinland (Rhine district), and thus Bonn, became Prussian territory after the Congress of Vienna in 1815, and a new university was founded at Bonn by the Prussian King Friedrich-Wilhelm III (gov. 1797-1840) in 1818 [1]. The authorities of the Bonn University, named the "Rheinische Friedrich-Wilhelms-Universität", and the Prussian Government in Berlin decided in 1863 to establish a new chair for chemistry in Bonn and gave a call to August Wilhelm Hofmann (1818-1892) (Figure 2), who was working since 1845 at the Royal College of Chemistry in London. Hofmann was one of the most renowned chemists of the 19th century. The Hofmann degradation of amides to amines and the Hofmann elimination of quaternary tetraalkylammonium hydroxides giving alkenes are found in all textbooks of Organic Chemistry [2].
At that time Chemistry as part of the Natural Sciences was a scientific discipline within the Philosophical Faculty of the University. Thus an "Institute" was both a building and a scientific entity.

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Figure 1. Building with former entrance for the professors at the south-western side[3c]

Hofmann was a student of Justus Liebig in Giessen. Afterwards he habilitated with Karl Gustav Bischof (1792-1870) in Bonn on 28 th April 1845 working in a small laboratory situated in a wing of the castle of Poppelsdorf ("Schloss Clemensruhe") [1b]. This castle was formerly the summer residence of the Archbishop-Elector residing at Cologne. Shortly thereafter in autumn 1845 Hofmann left Bonn when he was appointed as first director of the Royal College of Chemistry in London. When Bischof resigned in 1863 his chair was offered to Hofmann. The underlying idea was to promote trade and industry in Prussia by high-level natural and technical sciences and Hofmann was deemed the personage most worthy of this honorable task. Hofmann accepted with the proviso that a spacious new Institute building should be erected. The Prussian Government agreed and in May 1864 money was granted, finally for the enormous sum of 431,317 Goldmark, the largest amount of money ever spent for a chemistry building at that time.

The plans for the building, drawn and written by Hofmann himself (Figure 4), were directed to August Carl Dieckhoff, a well know contemporary university architect ("Baurat") of Bonn University. Several other buildings by him still stand, including the Villa Hammerschmidt, which served as the "White House of Bonn", and was the official residence of the German Bundespräsident from 1951 to 1994, and also several other buildings, such as the "Akademische Kunstmuseum" in the Hofgarten Park of Bonn.

The location of the new chemistry building was near to the castle of Poppelsdorf, which is on a nearby main street. Ground-breaking began in the autumn of 1864 on a tract of land belonging to the University, and construction for the new laboratory building commenced in spring of 1865. The building authority was optimistic of handing over the new building to the University in the summer of 1867, but it was as late as 11 of May 1868 before the new building could be opened, and there were obvious deficiencies in laboratory equipment, and lack of fully operational rooms for lectures and chemical experiments.

Even before construction on the building began things had changed: Hofmann got a second call in 1864, now from Berlin University, to fill the vacancy due to the death of the famous chemist Eilhard Mitscherlich (1794-1863), who passed away in August 1863. Hofmann was appointed Professor and Director in February 1864 and in May 1865 he moved directly from London to Berlin and Bonn had to look for a new successor to Bischof. The new candidates were Kekulé and Landolt. The latter was Professor since 1857 in the old chemistry premises of the Poppelsdorf castle, where he promoted practical exercises, which had previously been neglected due to lack of skills, equipment and rooms. Landolt was both an excellent scientist and teacher, and in 1869 he accepted a position in Aachen.

The Hofmann/Kekulé Institute Building

The new Chemical Institute at Bonn possesses a monumental construction with four wings and only two floors (Figure 4). It was designed by Hofmann as a "Temple of Science". The aim of Hofmann was to express "the dignity of a great public building dedicated to science" [3]. Historically this was the time of Industrial Revolution, which had started in England, and Hofmann expected that the revolution would also arrive in the Ruhr district of Germany. Bonn was at the edge of this area and other universities did not exist nearby at that time.

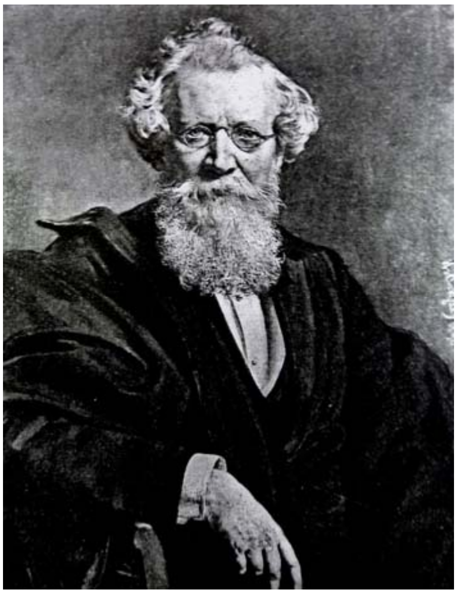


Figure 2. Portrait of August Wilhelm Hofmann (by courtesy of GDCh)

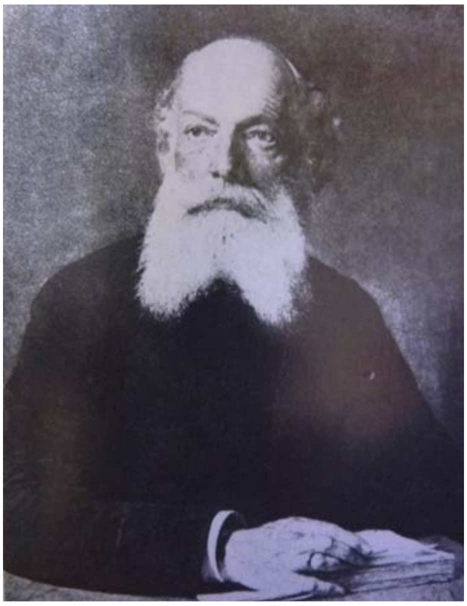


Figure 3. Portrait of August Kekulé (by courtesy of GDCh)

Today the façade of the building and the Poppelsdorf castle with its garden are nearly unchanged. They can be nicely viewed by the use of an internet databank (Google Earth, picture from summer 2010) looking down from a simulated height of ca. 100 m. Using Google's "Street View of Bonn" one can get a good impression of the outside of the building. Recently Meinel has compared this building with other contemporary German chemistry buildings in their functions and disposition like those of the universities of Giessen, Berlin, and Leipzig [4]. The design of an early industrial chemistry building, that of Bayer AG from the town of Elberfeld, from 1889 is included [4]. The old structures in the external and internal architecture reflect the hierarchical social order and structures of that time, rather different from today's chemistry buildings [4]. The lecture hall is at the center of the whole building complex, showing its importance at that time. Chemistry was mainly an auxiliary science for pharmacy at the beginning of the 19th century, for example Justus Liebig at Giessen had to run practical courses for pharmacists early in his career. Chemical industry did not exist except for some production of goods for households and businesses.

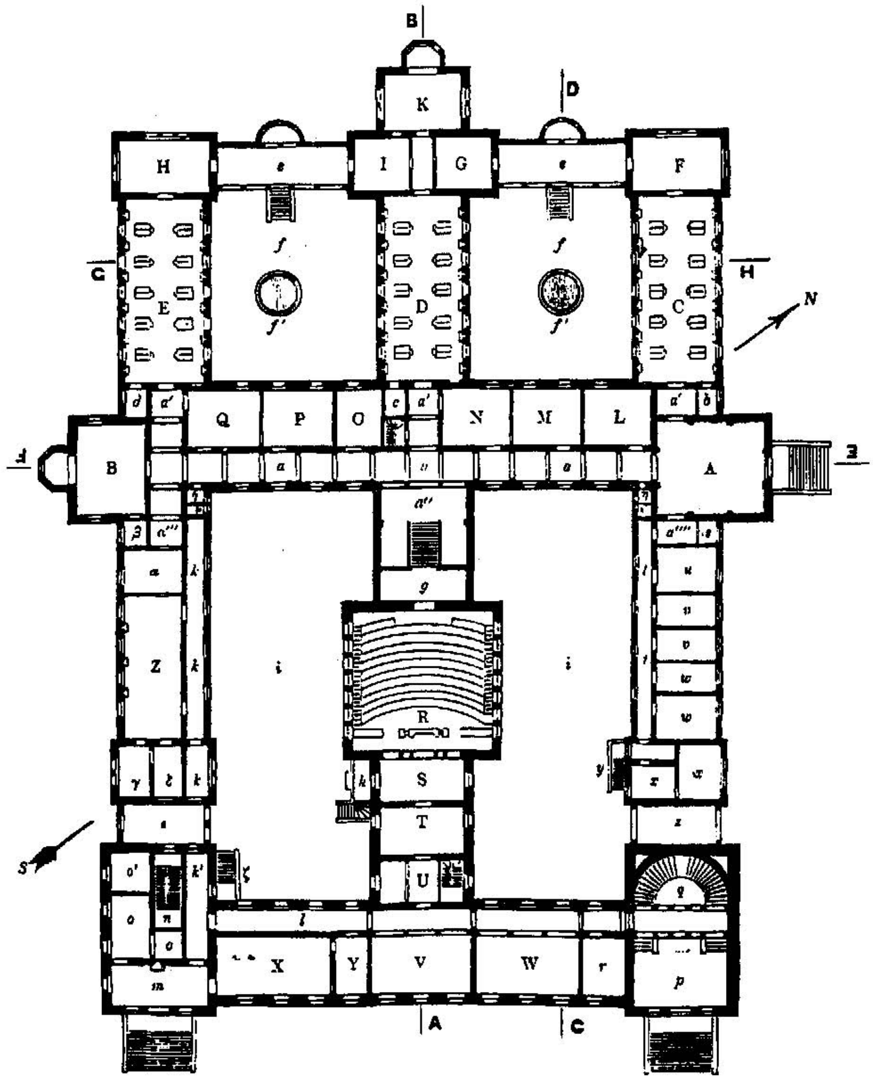


Figure 4. Ground plan of the building showing its rectangular structure with four inside arcades (Lichthöfe)[3c]

Figure 5. Front side of the building at Meckenheimer Allee with memorial of Kekulé[3c]

Figure 6. Details of the frieze at the ceiling in the lecture hall with birds and the signature of Hofmann, after the renovation from 1968[3c]

Some Remarks about the Style of the Outside and Inside Architecture of the Chemistry Building under Kekulé and his Followers

The building was renovated from 1984 to 1987 after a new and modern chemistry building had been erected in Bonn-Endenich at Gerhard-Domagk Strasse in 1973. Now there is enough space for 500 chemistry students besides laboratories for 180 doctoral students. The preceding decade was characterized by the effort for the construction of this new building, because the old building no longer met the demands of the large number of students and professors. Then the old building stood empty for nearly a decade, becoming more and more a ruin, before its renovation in 1987 taking into account all aspects of the preservation of historic buildings and monuments under the authority of the Rheinische Denkmalpflege [3c]. The renovation aimed at restoring the character of the building at the time of Kekulé and his successor, Richard Anschütz.

Figure 4 shows the rectangular structure of the building. Figure 5 shows the South-Eastern front of the building with Kekulé's memorial statue erected by Hans Everding in June 1903, seven years after the death of Kekulé. It is located in front of the building at Meckenheimer Allee. The memorial statue of Kekulé is surrounded by two Egyptian sphinxes - symbols of mystery and wisdom. The front of the building has a palatial appearance in harmony with the other parts of the building. The whole is a masterpiece in neoclassical style inspired by the Schinkel school from Berlin. A detailed introduction into the special architecture can be found in the excellent review of Gisbert Knopp [3c]. At both ends of the building towers containing the entrances are slightly offset from the main façade, which in turn is two stories tall with eleven windows per floor vertically aligned. The towers are nicely decorated with Egyptian emblems and goblets. The rooms at that first floor on Meckenheimer Allee were the spacious living-rooms of Kekulé and his family.

At the Northern side entrance, formerly the students entrance, one can see a gable wall, decorated with idyllic acanthus leaves, in the midst of which is the bust of Pallas Athene with her helmet (Figure 7). A great number of chemistry students and professors went into the department by this entrance, only very few realizing that a Greek goddess was looking down on them. Today the goddess is looking down on students of geography. The inside of the building matches the outside in grace, beauty and harmony: it reflects Humboldt's idea

perfectly (Figures 8-10). The main staircase to the lecture hall inside the building has two flights with an arrangement of the socles with corynthian pilasters.[3c]. The walls above the stairs are decorated with gilded medallions of famous contemporary chemists.
The inside of the building inspired several students of that time, for exmple Van't-Hoff, who wrote to his farther: "The laboratory invited me last Wednesday. It is a Temple! I feel humbleness (Ehrfurcht), when I see the statues of Davy, Cavendish, Lavoisier, and Priestley."[3c]. This may be quite different from the feelings of a students of today, who might not understand the very strong personality cult of that time.

Figure 7. Northern front of the building after renovation with the head of Pallas Athene[3c]

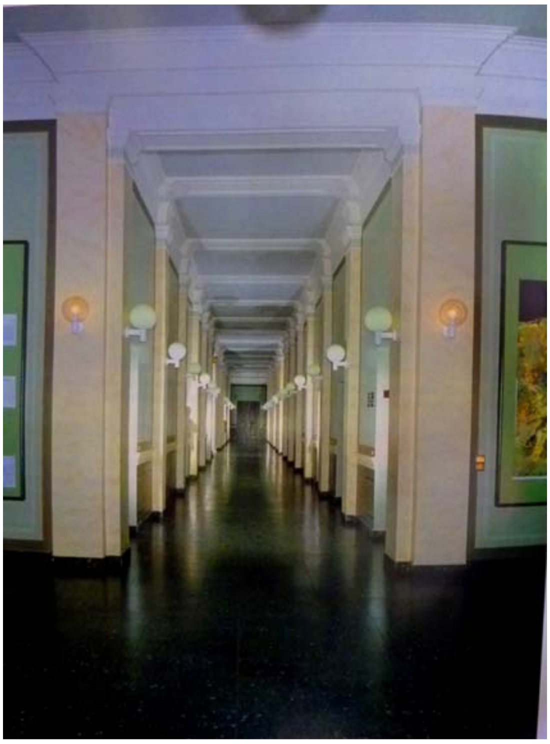


Figure 8. Vestibule at the Side Entrance of the building after renovation[3c]

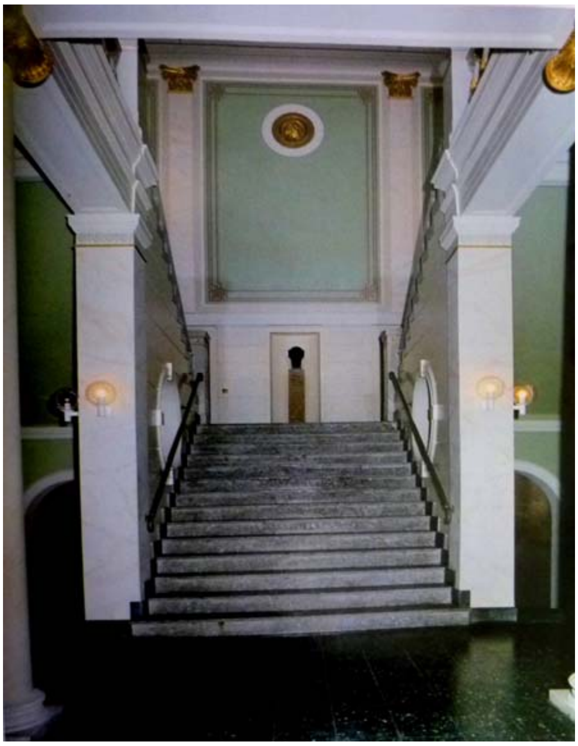


Figure 9. Staircase hall leading to the main lecture hall after renovation[3c]

Figure 10. Staircase hall leading to the main lecture hall, with portrait-medallions at the walls in the first floor[3c]

The gilded medallion in the middle of the entrance of the lecture hall (Figure 9) represents Antoine Laurent Lavoisier (1743-1784). The three medallions at the left on the wall of the first floor show Wilhelm Scheele (1742-1786), Louis Bertholet (1748-1822) and Eilhart Mitscherlich (1794-1863). The hallway shown in Figure 8 starts from the vestibule and ends at the office of Kekulé.

The renovation received the strong and active support of Heinrich Lützeler, former professor of art history at Bonn University, who pressed for restoration of this old building because of its unique architecture. Now this building can be compared with other old historic chemistry buildings, like that ~~one~~ of Justus Liebig in Giessen. However the building in Bonn is not open to the public, since it is still used both by the departments of Geography and Microbiology of the University, while the building in Giessen is now a museum open to the public. The building in Bonn was an exceedingly expensive investment during its construction, as well as in its renovation.

August Kekulé, the first Ordinarius (Director) of the new Chemical Institute in Bonn

August Kekulé (1829-1896) [5, 6] became the successor of Hofmann in Bonn after Hermann Kolbe (1818-1884) from Marburg declined a call to come to Bonn, preferring instead to go to Leipzig. Kekulé, like August Wilhelm Hofmann a former student of Liebig in Giessen, was thereafter Privatdozent to Robert Bunsen in Heidelberg and then Professor at Ghent University in Belgium. Before his stay in Giessen he had spent one semester in his hometown at the Darmstadt Polytechnicum [5].

Hans Landolt, Professor in Bonn since 1857 (see above), was co-director of the Institute for only two years before he went to the Technische Hochschule (Technical University, in those days called a *Polytechnikum*) at Aachen in 1869.

Kekulé had studied two disciplines, architecture as well as chemistry, and his architectural knowledge helped him to direct the finish of the building rapidly and efficiently. He followed the building concepts laid down by Hofmann and moved in on May 11, 1868. From this time more than 105 glorious years followed for this building. Kekulé also resided in the building in eleven elegant rooms at the first floor of the front at Meckenheimer Allee. Some individuals might remember the location of the old chemistry library, which was a part of the former bedroom of Kekulé. There were also special rooms for the maid and for visitors. There was even a ball room "amply satisfying the social requirements of a chemistry professor of the second half of the nineteenth century" as described by Hofmann [3f]. It was quite common for German ordinarii of that time to live at their institutions. Kekulé had a special entrance to his private rooms at the Northern front by a vestibule at the ground floor (Figure 1). The building front on Meckenheimer Allee has two towers, mentioned above, each with an additional floor. The left one was used as an apartment for a scientific assistant of the director. For example, Otto Wallach, Kekulé's assistant for lectures (Vorlesungsassistent) lived in it for some time. This apartment was still used as private apartment until 1968, finally by the chief secretary of the department, Frau Rosine Jung, as reported at her 106th birthday in Bonn's newspaper "Generalanzeiger" on 28th September 2008. This entrance for the professors was separate from the entrance for students at the right (Northeast) side of the building complex. Therefore, the building reflects the class-consciousness of Bismarck's "Dreiständestaat" (state of three social classes). Famous scientists were promoted from the ranks of lower nobility, which permitted them to add the prefix "von" to their name. Contrary to this kind of honorific, Kekulé could trace his nobility by his genealogy: his son Stephan Kekulé proved that the family originated from the town called Stradonitz (Stradonice in Bohemia) at the beginning of the 17th century. Therefore, King Wilhelm II ennobled August Kekulé to Kekule von Stradonitz on 27th April 1895, one year before his death [7]. This noble name must be written without the French accent aigu over the e, and Kekulé's father living in Darmstadt had performed this self-imposed change to avoid the mispronunciation as "Kekyl".

Richard Anschütz, a former student and quasi-successor of Kekulé (after the very short one year interregnum (1897-1898) of Theodor Curtius) published the most comprehensive biography on Kekulé in 1929 [5]. The interest continues today: in 2010 Allan J. Rocke, Henry Eldridge Bourne professor of history from Case Western Reserve University, ~~has~~ published an extended monograph on Kekulé [6]. Many other articles about Kekulé and his work can be found in English, German, and other languages.

Kekulé's Contributions to Organic Chemistry -
"Chemistry is the Science of Metamorphosis of Matter"

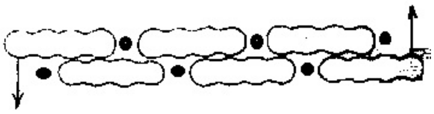
Kekulé was already known for his formulation of a special hexagonal ring structure for benzene before he came to Bonn. He wrote the first two volumes of his textbook "Lehrbuch der Organischen Chemie" (Textbook of Organic Chemistry) [8] while he was professor in Ghent. He wrote a third volume of this textbook, on aromatic compounds, later in Bonn together with his coworkers, R. Anschütz and G. Schultz [9]; it was published in 1882. This book was not the only contemporary text-book of Organic Chemistry as Hermann Kolbe had published his comprehensive textbook "Ausführliches Lehrbuch der Organischen Chemie" (Detailed Textbook of Organic Chemistry) in 1854 and several editions followed in later years [10]. Another contemporary textbook was that by Alexander Butlerov (1828-1886) "Lehrbuch der Organischen Chemie zur Einführung in das spezielle Studium derselben" [11], which was first published in Russian in 1864 and translated into German by the author himself four years later. Butlerov was a prominent chemist working at Kazan State University in Russia and later in St. Petersburg. He is regarded, along with Kekulé, as one of the founders of organic structural theory. Kekulé's textbook may be regarded as the best of these three contemporary books due to its elegance and clear style.

"Chemistry is the Science of Metamorphosis of Matter, its Fundamental Principle is not the Existing Substance but its Past and Future". That was the motto, expressed by Kekulé in the introduction of his textbook. The early part of the textbook consists of two volumes containing altogether 1510 pages. In it all findings of contemporary Organic Chemistry were treated completely and exhaustively. The book cites about 500 references, as given at the bottom of each page. The references are mostly taken from Liebigs Ann. Chem. Pharm. Beside this leading journal in Germany of that time there were also the Zeitschrift für Chemie and Journal für Praktische Chemie. Annalen der Chemie was founded in 1832 by Liebig and changed its name several times. Ber. Dtsch. Chem. Ges. was founded later, in 1868, and also changed its name several times. In 1997 both journals came finally to their end as German journals and were transformed into European journals, edited by several national chemical societies. The periodical *Angewandte Chemie* was founded in 1888, only this journal survived its German sisters. Besides the above mentioned German journals there was the Journal of the Chemical Society, published in Great Britain, and ~~the~~ Bull. Soc. Chim. Fr., published in French. Only two national journals have survived the European globalization process so far, these are the British and Swiss chemical journals, respectively.

Kekulé’s as well as Kolbe’s textbooks can be regarded as ~~a~~ kinds of early versions of “Beilsteins Handbuch der Organischen Chemie”, which appeared in 1882 in its first edition. Conrad Beilstein (1838-1906) had studied with Kekulé in Heidelberg and worked in Göttingen and then in Saint Petersburg.

Organic chemistry was defined by Kekulé as the chemistry of carbon compounds arranged in special classes of compounds. All structures had to be deduced from the knowledge of ~~its~~ elemental analysis and the molecular weight of the compounds, as well as their chemical properties. The atomic weights of carbon and oxygen were still under debate and not exactly known until the Karlsruhe Conference in September 1860. Physical and theoretical chemistry plays a paramount role in the first volume of Kekulé’s book, consisting of 766 pages, showing the prime importance of this field for Kekulé.

Kekulé suggested a cyclic structure for benzene. In the beginning he avoided this wording, instead he used the term: a nucleus with a “closed chain” structure, see formula **1** in figure 11 (taken from [8], in Tafel 1, p. 198]. He claimed 25 years later that he found the cyclic structures of this compound with the formula C_6H_6 by a special dream, as described below. In his textbook of 1863 [8] he draws six tetrahedra for the six carbon atoms, connected by their edges, see formula **2**.



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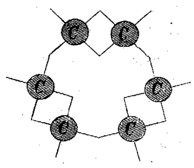

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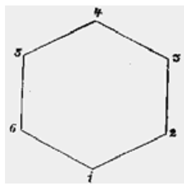

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Figure 11. Three different formulae, **1-3** of the ring structure for benzene given by Kekulé in vol. 2 of his textbook of 1863[8]

Structure **2** is drawn on page 496 of the second volume of his textbook [8], in addition, on page 514 there is an alternative structure for benzene as hexagon, with “six hydrogens at the corners”, see structure **3**. These two structures may seem contradictory for us today. Structure **2** represents a nonplanar, distorted tetrahedral model used in 1866, see Fig. 26 in ref. [25a]. Kekulé also used the “sausage” formulae in his book for other organic compounds several times. These formulae resulted from the “type theory” of Gerhardt, which was still used by most contemporary chemists. A theory of constant valences for elements did exist, and lines were regarded as metaphors for the number of the valences, since the theory of electrons as binding partners in molecules were not known at this time. Kekulé tried to postulate a D_{6h} – like structure for benzene by using the term “vibration” of the six carbon atoms, and later his followers used the term “oscillation,” without an exact definition (see discussion below). Kekulé did not realize in the beginning, that the structure of a compound - the term “constitution” was used by him - has its own reality. He claimed that structures should be only used as models for reality. In Ghent he used “sausage” models made from wood. They are still preserved in the museum of the University, see the sausage structure of methyl chloride, formula **4** ([6], p. 82). Kekulé later changed his “sausage”-model and used an alternative structure for benzene, shown by structure **2**, which was developed by him in 1866. He founded the new field of aromatic compounds, to complement the known field of aliphatic compounds (“Fettkörper”). He published his concept in 1865, first in French in Bull. Soc. Chim. Fr. [12a], followed by an extended paper in German of 68 pages “Untersuchungen über aromatische Verbindungen” (Investigations on Aromatic Compounds) in Ann. Chem. Pharm. [12b]. Starting from this time the chemistry of the class of aromatic compounds became very important for synthesis of industrial dyes and pharmaceuticals, and became the backbone of industrial chemistry. In addition, starting from Kekulé‘s concept of the cyclic benzene structure the theory of aromaticity became one of the most important concepts in Organic Chemistry, see below.

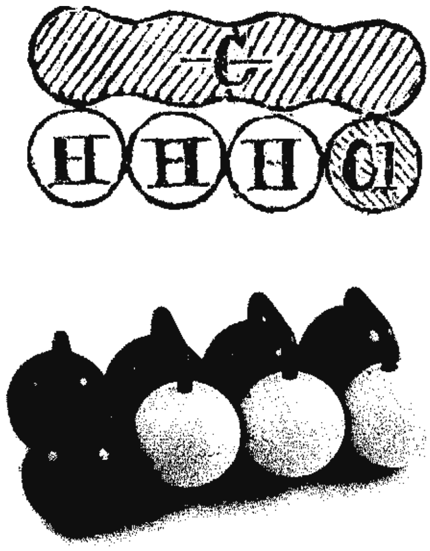

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Figure 12. Wooden model of “sausage” structure of methyl chloride **4**[6]

Kekulé’s Dream, the “Kekulé Riddle”

Kekulé’s dream, as he himself called his imagination of the ring structure of benzene in 1890, prompted a large number of investigations by both chemists and by psychologists. Actually this was Kekulé’s memory of his second dream. He apparently had it in Ghent in the course of the year 1861 while sitting and working at his fireplace during the night. The first dream happened to him earlier, in 1854 on the top of a bus in London. The most important papers on this subject are summarized in a series of 19 essays in the book edited by J. H. Wotiz [13]. The ring structure was a symbol of a special Egyptian snake, the ouroboros (a serpent eating its own tail) as an alchemistic symbol, which was under taboo in modern chemistry [14, 15]. It is of interest that Alexander Mitscherlich (1908-1982), well known for his important books and essays on recent German history and psychology, who was the grandson of Eilhard Mitscherlich (see above), published his interpretation of Kekulé‘s dream in 1972 in the journal “Psyche”, a journal founded by him [16]. There he speculates that Kekulé had his dream while sitting and working at the fireplace at night expressing his sexual desires by this special metaphor, a snake. Kekulé was alone in his apartment, he was a 26 year old widower at this time. This publication prompted several contradictory responses by other psychologists, claiming that Mitscherlich’s analysis was incorrect and that Mitscherlich as a disciple of Sigmund Freud might not be truly competent with regard to this subject [17]. Another explanation was given by Wizinger-Aust [18]. According to him, this was an association to an important event in the life of Kekulé as a young boy. He witnessed a crime in the form of arson which occurred in a neighboring house of his parents in Darmstadt in 1847. A golden ring with the emblem of an ouroboros was an important indication to clarify this crime by the judges at the court. Finally, there is also a critical but speculative review of the dream of Kekulé by Wotiz and Rudofsky, which questions the reality and honesty of this event as reported by Kekulé much later, during the "Benzolfest" in 1890 [19]. According to these authors the dream was not true, but invented by Kekulé to demonstrate his extraordinary creativity. One may say that most of the essays in the book of Wotiz contain much speculation, and it seems better to trust the more profound book of A. J. Rocke [6].

General Relevance and Importance of Kekulé's Structure for Benzene

Kekulé finally received the credit by most of the chemical community for elucidation of the cyclic benzene structure as a hexagon, which was found by him by a kind of trial and error approach. There were three other contemporary scientists who suggested alternative cyclic structures for benzene. Joseph Loschmidt (1821-1895), a physicist and outsider in the field of chemistry from Bohemia, published privately his own concept in 1861 „Konstitutionsformeln der Organischen Chemie in graphischer Darstellung" [20], and A. S. Couper (1831-1892) [21], a Scottish organic chemist who also proposed a cyclic structure for benzene. The book of Loschmidt was neglected for a long time, but Kekulé was aware of it according to a private letter to Erlenmeyer ("Loschmidt's Confusionsformeln", [5]), as also noted in the related essays in the book of Wotiz [13].

Loschmidt became famous for his important contributions in physical chemistry, the "Loschmidt number", which bears his name and is found in most textbooks of physics and physical chemistry. Since Loschmidt's book predates the publications on benzene of Kekulé some scientists accused Kekulé of plagiarism [13]. Heilbronner and Hafner concluded recently that the cyclic formula of Loschmidt is an important and creative concept as a picture, but is significantly different from that of Kekulé, which uses defined carbon atoms as part of the regular hexagon [22]. There was also a third concept for the structure of benzene given by Paul Havrez, a French chemist [23]. These three-dimensional formulae **6** and **7,** were already cited in Kekulé's textbook (see [8], in the footnote on p. 515 of vol. 2).

5 **6** **7**

Figure 13. Formulae for benzene given by J. Loschmidt **5**, and P. Havrez, **6** and **7,** respectively

It is quite normal in the history of science that an important idea arises in different places at the same time. Kekulé had the great advantage to work and discuss new and unresolved problems within his large group of talented students and they gave the credit of priority of the hexagon structure of benzene to their master due to their dedication and loyalty. Moreover Kekule's prestige in the scientific community at large would also have played an important role in these discussions. G. P. Schiemenz tried recently to resolve the problem of the priority claim of Kekulé by a critical essay [24]. Kekulé also contributed significantly to the new theory of organic structures [25]. In September of 1861 M. Butlerov gave a talk in Speyer in Germany (at Jahrestagung Deutscher Naturforscher) on the development of his "Structural Theory for Organic Compounds". There he defined the concept of a "chemical structure as a unique configuration of atoms defined by the connections between the individual atoms" [26].

What kind of carbon hexagon did Kekulé use for his structure? Formula **2** given in Kekulé's book represents a kind of conjugated cyclohexatriene structure with D_{3h} symmetry. However this structure does not agree with the number of substitutional di- and polysubstitued derivatives of benzene. Kekulé realized that all six carbon atoms must be equivalent: "Jedes Kohlenstoffatom steht zu seinen Nachbarn in genau derselben Beziehung" implying there is only one ortho-isomer of disubstituted derivatives of benzene. Therefore, all six bonds in benzene must be equivalent, and benzene must be a regular hexagon with D_{6h}-symmetry. Kekulé postulated in 1872 that the two equivalent cyclohexatriene minima with D_{3h} symmetry are converted very rapidly into one symmetrical structure [27]. This corresponds to the "oscillation theory" proposed by Kekulé. However this is not quite correct. Kekulé also gave another explanation: namely that intramolecular thermal vibrations of the two different but equivalent structures of the benzene molecule result in an average completely symmetrical structure. Balaban et al. have recently analyzed this subject in detail [28]. According to these authors Kekulé suggested in 1872 a "vibrating or collision model", which is not identical with an "oscillation model". One has to realize that electron theory did not exist and Kekulé did not have a choice. Therefore, his vibrating theory model may be regarded as an anticipation of the oscillation model.
Kekulé played an important part in developing the final benzene structure during the time of 1865-1869, together with the similar ideas and contributions of his students and colleagues such as A. Claus, A. Butlerov, T. Körner and A. Ladenburg [24].

With the proposal of the structure of benzene by Kekulé an intensive research effort for theories of the notion of aromaticity began, and it became one of the most important concepts of Organic Chemistry and a highly investigated topic in the field of theoretical chemistry. It is still under discussion today [29]. The early history of the development of aromaticity by chemists including H. E. Armstrong, E. C. Crocker, and J. J. Thomson leading finally to E. Hückel's theory (the [4n+2] rule as criterion for an aromatic cyclic structure with conjugated double bonds) is nicely described in a recent review [28]. Schleyer suggested his NICS (nucleus-independent chemical shift) concept to calculate values for aromaticity and antiaromaticity of any cyclic organic or inorganic compound with conjugated double bonds [30].
Kekulé also studied several other topics of Organic Chemistry, e.g. he considered with Schrötter in 1879 the isomerization of n-propyl- to isopropyl bromide by treatment of the primary bromide with anhydrous aluminium bromide [31a]. These authors suggested an elimination-addition of HBr as the mechanism. A 1,2-hydride shift of a carbocation intermediate may be an alternative interpretation today.

The School of Kekulé and his Students

Kekulé was the mentor of several very talented students, who habilitated with him. Among them were Richard Anschütz, Ludwig Claisen, Heinrich Klinger, Otto Wallach and Julius Bredt. Otto Wallach was his "Vorlesungsassistent", he later became professor at the University of Göttingen and was awarded the Nobel Prize in 1910 for his studies on terpenes. J. Bredt obtained a chair at TH Aachen and Bredt's rule (a double bond is not allowed at a bridgehead position of a polycyclic hydrocarbon) is still common knowledge of organic chemists. Kekulé supervised about 26 wissenschaftliche (scientific) assistants, who did their habilitation with him, and most of them gained professorships. He declined a call to a chair as successor of Liebig in München. Since the Nobel Prize was not inaugurated until 1900, Kekulé could not receive it, but three of his former students became Nobel laureates. Hendricus van't Hoff (Nobel Prize in 1901) and Emil Fischer (Nobel Prize in 1902) were only undergraduate students with Kekulé. Wallach did his habilitation with him. This is a truly remarkable result.

Kekulé himself received numerous national and international awards and honorary degrees [25a]. In 1966, which was the centenary of the benzene hexagon structure, two stamps with the portrait of Kekulé were issued, a 25 Pfennig stamp by the DDR (German Democratic Republic) and a 3 Franc stamp by the Belgian Mail (Figure 14). The Bundesrepublik Deutschland produced a poorly conceived stamp (the third one in Figure 14) with the wrong D_{3h} structure of benzene and with HCC angles of 90^o [32].

Due to Kekulé's strong personality and creativity he founded a large and very influential school of Organic Chemistry in Germany. He was glorified as a hero by some of his students and supporters, but some critical views have appeared recently [13]. A famous scientist deserves a critical but fair treatment. Kekulé was an internationally-minded personality, he collaborated actively with colleagues from Switzerland, France and England and spoke English and French fluently, since Ghent was francophone at that time.

Figure 14. Three stamps issued in 1966 at the centenary of the benzene structure, two with the portrait of Kekulé and one with the wrong benzene formula.

The new Chemical Institute had at its beginning, as mentioned above, two heads: Kekulé and Landolt. Both were appointed as directors and heads of the new Chemical Institute on 1 June 1867. It was as early as May 1868, when the new building was opened, that both were able to devote their energy to their real assignment: chemistry. But the new building was not yet fully operable. In a letter of 5 May 1868 to the Philosophical Faculty Landolt complained that he had to postpone or even cancel some of his duties, e.g. teaching obligations and practical exercises due to lack of fully equipped rooms and technical facilities (Bonn University Archive, file no. PF-PA 298). Landolt, coming from Breslau University to Bonn, where he had taught for 10 years prior to Kekulé's call to Bonn, was appointed as Professor in Bonn on 31 October 1857 to support the chemical education in the premises of the Poppelsdorf caste. There he held lectures and laboratory experiments under inappropriate conditions. He worked in the new Institute building for less than two years. When he followed a call to the Polytechnikum (a kind of Technical University) at Aachen in autumn of 1869, Kekulé became the sole Institute Head.

Kekulé stayed in Bonn as director of the Chemical Institute until his early death in 1896. He was buried at the cemetery of Poppelsdorf in an honored tomb, which can still be visited. Theodor Curtius became his successor, beginning his duty on 1st April 1897, but one year later he left Bonn on 1st April 1898 for the chair in Heidelberg as successor of Victor Meyer [3b, p. 130]. Curtius' successor Richard Anschütz, disciple of Kekulé, was appointed on 1 April 1898 and took up his duty as Director and sole Institute Head between 1898 and 1921. His successor was Paul Pfeiffer, see Table 1 below.

On the working level, below the director with his own staff and laboratory, there were three sections/departments/divisions ("Abteilungen"): organic chemistry, inorganic chemistry, analytical and physical chemistry: pharmaceutical chemistry: and toxicology, food chemistry, and technical chemistry. The names and tasks of these *Abteilungen* and their heads changed from time to time (see some examples in the last column of Table 1).

Further History of the Building and of the Chemistry Institute at Bonn

Due to an increasing number of students two enlargements of the building became necessary after the first construction performed under Kekulé, the first one in 1874-1876, the second one in 1899-1901 under Anschütz. Thereafter 340 students could study in Bonn in eight different laboratories. Minor additions and building modifications were carried out in 1905, 1909, 1910, and 1913. The last major extension of the building before the Second World War was performed between 1926 and 1929 and included some new rooms and laboratories, and enlargement of the lecture hall.

Kekulé and Anschütz worked mainly in the field of organic chemistry before specialisation arose in chemistry. Both chemists lectured also in the field of inorganic, analytical, and physical chemistry with the assistance of their co-workers at that time. In 1879 the formerly independent Pharmaceutical Laboratory was incorporated physically into the Chemical Institute building to form a joint unit called *inorganic and pharmaceutical section*. Due to the growing importance of pharmaceutical chemistry this section eventually became an own division in 1924 and thus was no longer a department/section (Abteilung) within the Chemical Institute but it remained still on the premises of the Chemical Institute building. It was shut down in 1939 and re-established in 1947 in the old chemistry building. Eventually in June 1956 a new Pharmaceutical Institute was opened at Kreuzbergweg.

Physical chemistry became an independent, separate section within the chemistry department by the appointment of A. von Antropoff in 1924. After W. Groth (1904-1977) was appointed as the first full professor for physical chemistry in 1950, he moved to his new building of physical chemistry at Wegelerstrasse in 1954, a place which is quite close to the old chemistry building.

In **Table 1** (shown at the end of this article) all 37 chemistry professors from Kekulé's time through 1973 are listed. Their names are arranged according to the year of their appointment as professor in Bonn. Some of them were famous scientists and dedicated teachers. Full professors, who stayed in the position as director for a long time in Bonn were A. Kekulé, R. Anschütz, P. Pfeiffer, B. Helferich, O. Schmitz-DuMont, R. Tschesche, R. Appel, and H. Puff. It is remarkable, that only three institute heads (apart from Curtius' short interregnum, he was active in Bonn from April 1897 to April 1898) steered this renowned "temple of science" over a period of 80 years (1867-1947), a "temple" which was used for more than a century until 1973/74, before a new building was opened.

Some Chemistry Professors (see Table 1) worked as heads of the Institute only for a short period like H. Landolt (co-director 1867-1869) and T. Curtius (successor of Kekulé). W. Groth, professor for physical chemistry in Bonn (1950-1972) worked only for a short interim period as guest in the Chemistry building, therefore, he is not listed in the Table.

Due to the fact that the authors of this article are organic chemists, and two of them spent about a decade of their lives in this building and that this journal covers subjects of Organic

Chemistry two selected additional landmarks of Organic Chemistry will be described in the following sections.

Hans Meerwein and his Study of the Rearrangement of Camphene-Hydrochloride to Isobornyl Chloride

In 1920 Hans Meerwein described the intramolecular rearrangement, which occurred in dehydration of isoborneol into camphene [34a]. He was working in Bonn as titulary- and extraordinary professor. In 1922 he investigated with Konrad van Emster the rearrangement of camphene-hydrochloride to isobornyl chloride [34b]:

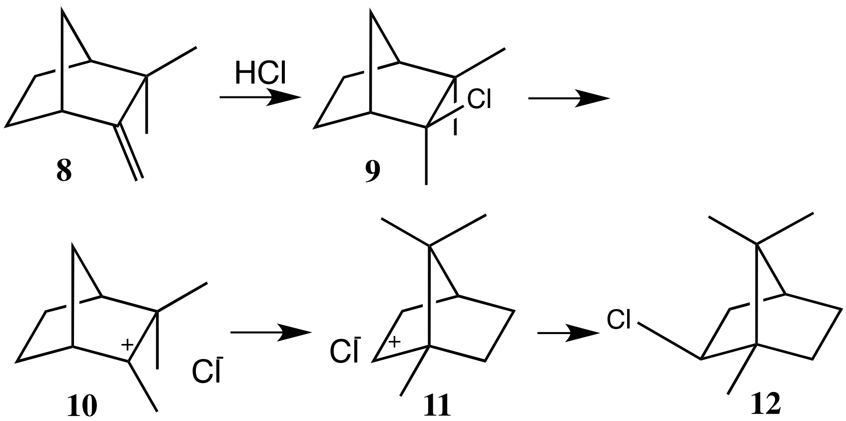

Figure 15. The Wagner-Meerwein rearrangement: conversion of camphene-hydrochloride (**9**), prepared from camphene (**8**), into isobornyl chloride (**12**) via intermediate carbocations (**10)** and (**11**).

They used ten different solvents to study this reaction and found that the reaction followed first-order kinetic behaviour. Rates were determined by titration of HCl formed from the tertiary chloride as starting material using half-normal concentration KOH in ethanol with eosin as indicator. The rates depend strongly on the polarity of the solvent in the reaction mixture. Meerwein and van Emster correlated the rate at 20^{o}C with the dielectric constants of the solvents and they postulated a carbocation as the intermediate, derived from camphene-hydrochloride by ionization. The intermediate tertiary carbocation rearranges to the secondary isobornyl-cation. They did not localize the charge, but they drew the charge in brackets at the two formulas. In general, they applied aprotic polar solvents but they also used cresole and liquid sulfur dioxide. In these ionizing solvents the reaction was very fast. The enhancement of the reaction rate by addition of metal chlorides ($SbCl_5$, $SbCl_3$, $FeCl_3$) was also studied. Today this effect is called electrophilic catalysis. They also measured the enthalpy of the reaction by using a crude calorimetric method and observed the subsequent thermal rearrangement (*endo-exo* isomerization) of isobornyl- into bornyl chloride. The thermal equilibria of the isomers of the two bicyclic secondary chlorides in various solvents were measured. The higher reactivity of camphene-hydrobromide compared to the chloride was already observed by the authors and is mentioned in their paper.
The carbocations postulated to occur during the rearrangement are short-lived intermediates. The stable triphenylmethyl cation had already been generated independently in 1901 in concentrated sulfuric acid by the groups of J. F. Norris [34c] and that of F. Kehrmann and F. Wentzel [34d]. A. Hantzsch in Leipzig investigated these species during the period from 1908 until 1919 by conductivity measurements [34d].

The majority of Meerwein's German colleagues neither understood nor liked this comparatively long, more theoretically oriented paper; they thought that this kind of study belonged into the hands of more competent, physical chemists. Meerwein was not invited to give lectures on his findings, nor was he cited. Meerwein's paper can be regarded as pioneering work of a field, which later become known and named as physical organic chemistry. This field restarted about ten years later by investigations of the school of C. K. Ingold in England [35]. Meerwein used preferentially dipolar aprotic solvents in his study, different from protic solvents like acetic acid, water and ethanol, which were used by Ingold and his followers. The reaction was named then as a solvolysis reaction [36]. Beginning in the 1930s this field came more and more into the hands of famous American schools like that of S. Winstein, P. D. Bartlett, D. J. Cram, P. v. R. Schleyer, H. C. Brown, and G. A. Olah [36]. Winstein performed solvolysis studies of several substrates and he realized in 1977, that ion pairing plays an essential role in substitution reactions of S_{N1} type [37] as well as in electrophilic addition reactions [37]. Meerwein realized this effect already when he added HCl to camphene in ether at low temperature, which led to some amount of rearranged isobornyl chloride. As he wrote in a footnote: *Diese Erscheinung spricht dafür, dass bei der Anlagerung von Salzsäure an Camphen zunächst eine sich leicht umlagernde Vorverbindung entsteht* (this phenomenon indicates that in the addition of HCl to camphene a "pre-compound" is produced first) [34]. In 1968 Winstein called this species of "Vorverbindung (precompound)" the intimate ion pair [37]. The ion pair plays an important role in the so-called internal return of the intermediate carbocations formed in solvolysis reactions [36, 37]. Today these species can be modeled and explained by appropriate density functional theory calculations [38].

Due to the complete lack of acceptance and resonance by his German colleagues Meerwein did not pursue this kind of research. Instead he preferred to work in synthetic organic chemistry. But he did this also with great success. In 1923 he went from Bonn to Königsberg, from there he came finally to Marburg in 1926 [39].

The term Wagner-Meerwein rearrangement has become generally accepted in the terminology of Organic Chemistry, although L. Ruzicka gave Wagner the sole credit for this type of rearrangement [40]. Georg Wagner (1848-1903), like A. Butlerov, was a Russian chemist from Kazan State University, who worked later in St. Petersburg and finally in Warsaw. He had published several papers in German in Berichte der Deutschen Chemischen Gesellschaft during his stay in St. Petersburg. His famous paper on the terpene rearrangement [41] is written in Russian. It is cited by Meerwein, but unfortunately this paper has never been translated, neither into German or English. Wagner's famous paper along with his picture can be found in the SI of this paper. One of us (D. L.) saw in 1964 some of the equipment, which was used by Meerwein for his early studies in Bonn.

The "Bonner Punkt" by W. Wizinger and R. Dilthey, a Landmark in the Theory of Color (1928)

In 1928 Dilthey and Wizinger published a paper in Journal für Praktische Chemie, "Über eine Erweiterung der Wittschen Farbtheorie auf koordinationschemischer Grundlage ("On an Extension of Witt's Theory of Color on the Basis of Coordination Chemisty)", which turned out to become a landmark paper in the theory of color [42]. The principle of the term "inherent chromophore" was developed therein: the colour is amplified by introduction of auxochromic and suppressed by hypsochromic groups at the aromatic moiety. This principle was demonstrated by several triphenylmethane dyes like crystal violet (**13**). A series of papers on this phenomenon and its theory was published by the authors in the same journal during the following years.

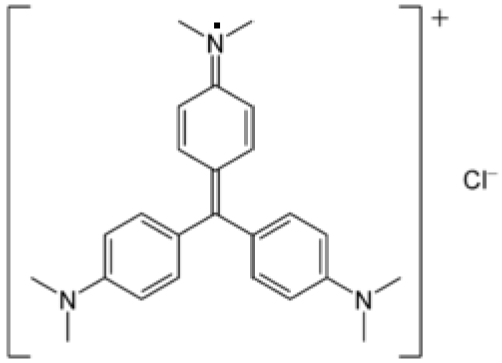

Figure 16. Structure of crystal violet (**13**) as drawn by Wizinger and Dilthey[42]

The color was attributed to the existence of an unsaturated trivalent carbon atom, which was drawn with a point. Later it was shown that the unsaturation reflects not a radical but a resonance-stabilized carbocation. Later in 1962 Heilbronner investigated this effect in depth by more sophisticated physical methods and by use of theoretical calculations [43]. It should be mentioned that Robert Wizinger (also written as Wizinger-Aust) was forced by the Nazi regime to emigrate in 1937 to Switzerland, see below. There he founded later the “Institut für Farbenchemie” at Ciba Corp. in Basel.

Some Remarks about Chemistry in Bonn during the Time of 1933-1945

History of chemistry in Germany between the time of 1933 and 1945 was under general taboo until the publication of the book of Ute Deichmann in 2001 [44]. In this book there is a list with eleven professors of the chemistry faculty of Bonn for the year 1950. Most of them had joined the National Socialist (Nazi) party organizations, which was quite normal for university professors in Germany. In 1999 H.-P. Höpfner published a monograph, “Die Universität Bonn im Dritten Reich” (the University of Bonn during the Third Reich) [44], with a special chapter about the status of chemistry in Bonn. Paul Pfeiffer was sole director of the Chemical Institute 1922-1947, (see Table 1). According to Höpfner’s book Pfeiffer was not a member of any Nazi-party organization nor did he participate in political actions. Prior to 1933 he was member of the “Deutschnationale Volkspartei”, a more conservative party in the Republic of Weimar. Like Heinrich Wieland in München [45] he behaved as a man of honesty in this difficult time. Two professors had to suffer from the NS-regime: H. Rheinboldt was forced to emigrate to Sao Paulo in Brazil in 1937, because his grandfather, H. Caro was of Jewish descent. Caro is known in inorganic chemistry for invention of Caro’s acid (H_2SO_5).
Robert Wizinger (-Aust) was critical about the regime and did not want to join any Nazi organizations. Therefore, he “choose” (was forced) to go to the ETH Zürich in 1937. In his book “Chemische Plaudereien”, Verlag der Buchgemeinde Bonn, published in 1942, there is a chapter on “Gaskampf und Gaskampfstoffe”, a good introduction into chemical warfare of that time. In general, he expresses in his book a nonbiased but pacifistic standpoint especially in the discussion of the chemical warfare chapter. After the war he re-established good and

friendly connections to his old alma mater, just like Thomas Mann, see below. Wizinger-Aust was a broad-minded and educated chemist. He wrote also popular chemistry books, which stimulated young people like one of us (D. L.) to study chemistry.

Quite the opposite was the behaviour of A. von Antropoff, full professor of physical chemistry (Table 1). He demonstrated his dedication to the Nazi regime by several public speeches, he himself put the nazi-flag on the roof of the main university building; details can be found in the monograph of Höpfner, which also discusses his ambivalent character [47]. According to some witnesses to D. L. he was the only chemistry professor who lectured in his SA (storm trooper) uniform. He also played a sinister role in the civil degradation of the honorary doctorate of Thomas Mann, which finally happened in December 1936. This honour title was given to Thomas Mann by the University of Bonn in 1919, but in 1936 he lost his degree. In 1946 he got his title back by the authority of the University. These facts are reported in the excellent book of Paul Egon Hübinger, published in 1974 [47]. At that time Hübinger was full professor of history in Bonn. The special activities of v. Antropoff, who is cited 18 times, are discussed therein. Therefore, the "denazification" (Entnazifizierung) of v. Antropoff was difficult to achieve after the war. The same was true of M. von Stackelberg. Both professors were of Baltic (Estonian) descent (Table 1). As a matter of fairness one should say, one of us (D. L.) discussed this matter with Prof. J. Goerdeler (Table 1) in 1966, he replied "Prof. Antropoff was a convinced Nazi member, but he never did any harm to his colleagues". It should be mentioned that Prof. Goerdeler was the nephew of Carl Friedrich Goerdeler, who was the former mayor of Leipzig and was close to the ideas of the "Kreisauer Kreis". They opposed Hitler and C. F. Goerdeler was sentenced to death in January 1945 and executed on 2nd February 1945.

Effect of World War II and Postwar Time

The institute was forced to close its doors for beginning students in 1944. The building was not severely damaged, only near the very close end of the war in February 1945 the Eastern front tower was hit by some phosphorus bombs during an air raid. This event led to burning out of this part of the building, but the damage was repaired soon after the war. The professors and students of the faculty of Protestant Theology could use some rooms of the Chemistry Department as guests at the end of 1945 (Winter Semester 1945/46) for their lectures and seminars, since all their own buildings in the city were completely destroyed [48].

Finally it should be mentioned that the Gesellschaft Deutscher Chemiker (GDCh) declared Kekulé and the Institute, founded by him to the "Historische Stätten der Chemie" (historical places of chemistry) on 9th May 2014. The "Kekule Symposium," organized by GDCh and the chemists of the University of Bonn, celebrated the remarkable day by several seminars given by international experts [49].

Acknowledgements

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Table 1: **Chemistry Professors in the old Chemical Institute of Bonn University (1867 – 1973).**
– The names are arranged according to the year of appointment as Professor in Bonn –
As of July 2017

	Name	Place and date of birth/ death	Professor in Bonn [i]	Focus of chemical research (by way of examples)	Habilitation, assignment in Bonn, additional remarks
1	August **Kekulé**	Darmstadt 7.9.1829 – Bonn 13.7.1896	1867-1896	aromatic compounds, theoretical and structural organic chemistry, ring structure of benzene	habilitation with R. Bunsen (Heidelberg 15.3.1856). Head of Institute together with Landolt (1867-1869), sole Head of Institute (1869-1896)
2	Hans Heinrich **Landolt**	Zürich 5.12.1831 – Berlin 15.3.1910	(1857-1867) [ii] and 1867-1869	physical and analytical chemistry	habilitation with C. Löwig (Breslau 30.10.1856). Head of Institute together with Kekulé (1867-1869).
3	Theophil **Engelbach**	Mainz 4.9.1823 – Bonn 1.4.1872	1869-1872	pharmaceutical and analytical chemistry	habilitation with H. Will (Giessen 9.5.1857). Head of inorganic section
4	Theodor **Zincke**	Uelzen 19.5.1843[iii] – Marburg 17.3.1928	1873-1875	aromatic compounds	habilitation with A. Kekulé (Bonn 6.7.1872). Head of inorganic section (successor of Engelbach)
5	Otto **Wallach**	Königsberg 27.3.1847 – Göttingen 26.2.1931	1876-1889	organic chemistry, terpenes	habilitation with A. Kekulé (Bonn 4.2.1873). Head of inorganic section and Head of pharmaceutical section (established 1879). Nobel prize 1910
6	Richard **Anschütz**	Darmstadt 10.3.1852 – Darmstadt 8.1.1937	1884-1921	organic chemistry, structure of organic compounds	habilitation with A. Kekulé (Bonn 7.11.1878). Successor of Curtius; sole head of Institute (1898-1921); Institute's Head in charge 1.4.1921-1.5.1922 [iv]

7	Heinrich **Klinger**	Leipzig 16.10.1853 – Groß-Steegen (Ostpreussen) 1.3.1945	1889-1895	pharmaceutical chemistry, photoreduction of carbonyl compounds	habilitation with A. Kekulé (Bonn 9.11.1878). Head of inorganic section and Head of pharmaceutical section (successor of Wallach)
8	Alfred **Partheil**	Zerbst 1.5.1861 – Königsberg 22.4.1909	1896-1903	organic chemistry, analytical chemistry, chemistry of arsenic and mercury	habilitation with E. Schmidt (Marburg 7.11.1892). Head of pharmaceutical section since 1895 as successor of Klinger
9	Theodor **Curtius**	Duisburg 27.5.1857 – Heidelberg 8.2.1928	1897-1898	synthetic organic chemistry	habilitation with O. Fischer (Erlangen 12.3.1886). Successor of Kekulé; sole Head of Institute (1897-1898)
10	Julius **Bredt**	Berlin 29.3.1855 – Honnef 21.9.1937	Febr.1897-Sept.1897	organic chemistry, structure of camphene	habilitation with A. Kekulé (Bonn 3.7.1889)
11	Eberhard **Rimbach**	Jülich 26.12.1852 – Bonn 3.11.1933	1898-1913	analytical, inorganic, and physical chemistry, chemistry of rare earths	habilitation with H. Landolt (Berlin 28.7.1892). Head of the analytical and inorganic chemistry section
12	Georg **Schroeter**	Passenheim/ Ostpreußen 10.5.1869 – Berlin 14.10.1943	1903-1909	organic chemistry, rearrangement reactions, theory of dyeing	habilitation with R. Anschütz (Bonn 23.7.1898)
13	Georg **Frerichs**	Riepen near Etzel in Ostfriesland 4.11.1873 – Bonn 28.4.1940	1903-1924 (1939)	pharmaceutical chemistry and toxicology, arylhydantoines, berberine	no habilitation.[v] Head of pharmaceutical section since 1903. Since 1.10.1924 Head of the newly established Pharmaceutical Institute. Retired 1939
14	Carl	Siegen	1908-1935	food chemistry,	habilitation with

	Kippen-berger	23.5.1868 – Bonn 31.3.1937		analytical chemistry	G. Lunge (Zürich 8.3.1895). Head of food chemistry section (1905-1935)
15	Conrad **Laar**	Hamburg 22.3.1853 – Bonn 11.2.1929	1910-1928	organic chemistry, photochemistry. The term *tautomerism* was introduced by him in 1885	habilitation with K. Kraut (Hannover 30.10.1883)
16	Alfred **Benrath**	Düren 4.5.1878 – Neuen-dettelsau[vi] 18.1.1969	1913-1923	analytical, inorganic and physical chemistry, complex compounds in aqueous systems, photochemistry	habilitation with H. Klinger (Königsberg 11.5.1905). Head of the analytical and inorganic chemistry section (successor of Rimbach)
17	Hans **Meerwein**	Hamburg 20.5.1879 – Marburg 24.10.1965	1914-1922	organic chemistry, cationic rearrangements, carbocations as intermediates	habilitation with R. Anschütz (Bonn 14.7.1908)
18	Julius **Gewecke**	Hannover 12.11.1877- Bonn 28.7.1933	1916-1933	analytical chemistry	habilitation with R. Anschütz (Bonn 26.10.1908). Doctorate both in chemistry (1903) and medicine (1919)
19	Paul **Pfeiffer**	Elberfeld 21.4.1875 – Bonn 4.3.1951	1922-1947	inorganic complex compounds, quinones	habilitation with A. Werner (Zürich 7.8.1901). Successor of Anschütz; sole Head of Institute (1922-1947). Head in charge of the Pharmaceutical Institute (1947-1949)
20	Walther **Dilthey**	Rheydt 26.3.1877 – Zülpich 24.6.1955	1922-1947	organic chemistry, relation between colour and structure of dyes	habilitation with A. Werner (Zürich 9.7.1904). Head of the organic chemistry section (successor of Meerwein)
21	Gustav	Reichen-	1924-1927	analytical and	habilitation with

	Jantsch	berg/ Bo- hemia 9.7.1882 – Vienna 1.5.1954		physical chemistry, chemistry of rare earth elements	A. Werner (Zürich, April 1911). Head of the analytical and inorganic chemistry section (successor of Benrath)
22	Andreas **von** **Antropoff**	Reval (Tallinn) 16.8.1878 – Bonn 2.6.1956	1925-1945	adsorption effects of gases, physical properties of noble gases, variant design of the periodic table	habilitation with G. Bredig (Karlsruhe 9.5.1919). 1925 Head of the (1924 newly established) physical chemistry section
23	Heinrich **Rheinboldt**	Karlsruhe 11.8.1891– Sao Paulo 5.12.1955	1928-1933	organic chemistry, organic sulphur and selenium compounds, reaction of nitrosyl chloride with organics	habilitation with P. Pfeiffer (Bonn 29.2.1924). Head of the analytical and inorganic chemistry section (successor of Jantsch)
24	Eduard **Hertel**	Düsseldorf 11.7.1899 – Bonn 27.8.1954	1931-1937	physical chemistry, crystal structure of organic compounds, examination of chromophoric groups	habilitation with P. Pfeiffer (Bonn 31.7.1925)
25	Robert **Wizinger-** **Aust**	Vic-sur-Seille 28.4.1896 – Basel 1.4.1973	1934-1938	chemistry of dyes, relation between colour and structure	habilitation with P. Pfeiffer (Bonn 17.12.1927)
26	Otto **Schmitz–** **DuMont**	Pretoria 13.2.1899 – Bonn 20.4.1982	1936-1967	inorganic chemistry, reactions in liquid ammonia, colour and constitution of complexes	habilitation with P. Pfeiffer (Bonn 28.11.1926). Head of the analytical and inorganic chemistry section (successor of Rheinboldt); Head of (new) inorganic department (1960-1967)
27	Mark **von** **Stackelberg**	Dorpat (Tartu) 16.12.1896 –	1936-1965	electrochemisty, polarography	habilitation with P. Pfeiffer (Bonn 16.7.1930)

		Bonn 4.4.1971			
28	Hermann-Josef **Antweiler**	Köln 23.11.1909 – Bonn 21.1.1979	1946-1974	technical chemistry	habilitation with P. Pfeiffer (Bonn 10.1938)
29	Burckhardt **Helferich**	Greifswald 10.6.1887 – Bonn 5.6.1982	1947-1955	carbohydrates, enzymes	habilitation with E. Beckmann (Berlin 23.7.1920). Successor of Pfeiffer; sole Head of Institute (1947-1955). Institute's Head in charge 1955–1960
30	Ernst **Kordes**	St.Petersburg 19.1.1900 – Bonn 27.12.1976	1956-1968	solid state chemistry of glasses and crystals	habilitation with K. H. Scheumann (Leipzig 27.2.1931)
31	Joachim **Goerdeler**	Magdeburg 12.9.1912 – Bonn 1.8.2007	1959-1977	organic chemistry, heterocycles	habilitation with B. Helferich (Bonn 9.7.1952)
32	Friedhelm **Korte**	Bielefeld 24.11.1923– Attenkirchen 06.05.2013	1959-1972	organic chemistry, ecological chemistry	habilitation with R. Tschesche (Hamburg 26.2.1954)
33	Rudolf **Tschesche**	Liegnitz 11.5.1905 – Bonn 13.2.1981	1960-1973	isolation, structure elucidation, and biochemistry of natural products (steroids, saponins, alkaloids, cardiac toxins, triterpenes, etc.)	habilitation with A. Windaus (Göttingen 26.2.1935). Head of (new) organic department (1960-1973). Institute's Head in charge 1973-1975
34	Rolf **Appel**	Hamburg 25.2.1921– Bonn 30.1.2012	1962-1986	inorganic sulphur, nitrogen and phosphorus compounds, organophosphorus compounds and phospha-alkenes and alkines	habilitation with M. Becke-Goering (Heidelberg 2.2.1955). Head of inorganic department alternately with Puff (1967-1986)
35	Heinrich **Puff**	Mannheim 1.11.1921– Bonn 24.2.2017	1967-1987	inorganic chemistry, chemistry of ternary mercury compounds	habilitation with R. Juza (Kiel 29.2. 1960). Head of inorganic department alternately with Appel (1967-1987)

36	Günter **Bergerhoff**	Bonn 28.2.1926	1968-1991	structural inorganic chemistry, x-ray structures	habilitation with O. Schmitz-DuMont (Bonn 13.2.1963)
37	Heinrich **Wamhoff**	Bonn 3.3.1937– Bonn 13.4.2014	1972-2002	organic chemistry, photochemistry, heterocycles	habilitation with F. Korte (Bonn 20.12.1971)

Basic data, mainly taken from Wenig, were supplemented, corrected where necessary, and updated by the authors and by data provided by both, state and university archives.
(O. **Wenig** (Herausgeber): Verzeichnis der Professoren und Dozenten der Rheinischen Friedrich-Wilhelms-Universität zu Bonn 1818–1968. H. Bouvier & Co. und Ludwig Röhrscheid, Bonn, 1968.)

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[i] The first date gives the year in which the person was appointed „Professor“ by Bonn University or the year in which the person, being already Professor, was called to Bonn. The last date indicates the year of leaving Bonn, retirement or death.
If a date beyond 1973/74 is given for a Professor it indicates that he continued his work in the new Institute building in the city of Bonn.

[ii] Landolt, recommended by Löwig, moved 1857 from Breslau to Bonn and was appointed as Professor on 31 October 1857 working in the very simple chemistry premises of the Poppelsdorf Castle. When Kekulé was appointed as director (1 June 1867) of the newly built Institute (1867 still under construction) Landolt was appointed as co-director the same day. He left Bonn (October 1869) appointed as Professor in Aachen (Polytechnikum). - Wenig (p. 169) gives a wrong date for Landolt’s first Bonn appointment: 31 October 185**8**). –

[iii] Zincke himself gave two seemingly inconsistent dates: 14 June 1843 (Archive of Bonn University; see O. Wenig, p. 347), and 19 May 1843 (Archive of Marburg University, 1920). The latter is his date of birth whereas the former is a misreading of the Uelzen church register. (Church register of St. Marien, *baptisms 1843*, No. 52).

[iv] Anschütz retired on 1 April 1921. P. Pfeiffer was appointed as his successor on 24 February 1922 and moved from Technical University Karlsruhe to Bonn. By order of the Minister of Science, Arts and Education Anschütz was Institute’s Head in charge from his retirement until 1 May 1922 (see ref. [3a], p. 366). In May 1922 Pfeiffer took up his duties as new Institute Head.

[v] Neither the University archive in Bonn nor that in Braunschweig could confirm Frerichs’ habilitation. He was H. Beckurts’ assistant from 1899–1903 during the latter’s tenure as Head of the Braunschweig Chemical-Pharmaceutical Institute. The fact that Frerichs was called to Bonn (November 1903) as Professor – definitely without habilitation – was very unusual at that time.

[vi] Some handbooks erroneously give Ansbach as place of Benrath’s death. (Written message of 14 March 2011 by the City of Ansbach, confirming Neuendettelsau as place of death).