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On Kekulé's insight

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Abstract. In this paper, we would like to retake a historical controversy on the alleged discovery of Kekulé's Benzene structure formula from other possible epistemological viewpoints which might perhaps put into a more right historical perspective this apparent and unmotivated riddle, also with the aid of some elementary psychoanalytic considerations. Moreover, one of the purposes of this paper is also that of understanding some possible, general aspects underlying a creative process.

1. Introduction

This paper is centered on the *vexata questio* concerning the so-called *Kekulé's insight*, namely, the alleged question inherent the discovery of the Benzene structure¹. The Benzene, as chemical substance, was isolated by Michael Faraday in 1825 and the qualitative chemical analysis detected only carbon and hydrogen in it, so that its empirical formula is CH. Subsequent repeated analyses and molecular weight determinations² (mainly made by Eilhard Mitscherlich in 1834) have determined to be C₆H₆ its molecular formula. The chemical properties of this substance show a high unsaturation degree (due to its low hydrogen-carbon ratio equal to 1:1) but it is no subject to those typical chemical reactions which characterize the other already known organic compounds, whence it follows that such a substance did should fall into another, new class of organic compounds: indeed, it will be the simplest chemical substance of the so-called *aromatic* compounds class.

Thereafter, one of the main theoretical task was to determine, according to the new Dalton's atomic theory, the possible geometrical configurations related to the disposition of the carbon and hydrogen atoms. This was one of the first historical problem which led to the birth of the Structural Organic Chemistry whose main concept is that of *structure formula* of an organic compound which was born, inter alia, just with the studies of the atomic structure of carbon atom. In this regards, Friedrich August Kekulé (1829-1896), among other things, made fundamental studies in Organic Structure Theory, amongst which some related to the tetravalency of the carbon atom (see [1]); to the modern concept of *desmalusogeny*³ of the carbon in [2], (contemporaneously but independently by Archibald Scott Couper – see [3]) intended as self-linking ability of carbon atoms (see [4]); and subsequently on the structure of aromatic substances (see [5] and [6, 7, 8, 9]) taking as main case-study the Benzene (then called *Benzole*) and its various chemical derivatives.

In particular, in [1] and [2], he studied the structure of the first Alkanes demonstrating that when two carbon atoms are in the same compound, they can unite among them; further, each carbon atom uses one of its four valence bonds to join with the other carbon atom, while the remaining valence bonds are saturated with hydrogen atoms, respecting the tetravalency of the carbon atom. From these studies started the notions of 'structural formula' and 'valence', giving rise to the modern Structural Organic Chemistry that Kekulé will use in his later studies on the Benzene structure. At that time, it was only known the empirical formula of the Benzene and many chemical properties of this compound, amongst which mainly its high unsaturation property; therefore, it was a difficult task to determine the relative positions of double and single covalent bonds amongst the carbon and hydrogen atoms respecting the molecular formula C₆H₆ and explaining its very high unsaturation degree. Following [10], Kekule was an eminent theoretical chemist supporter of the new atomic theory, who gave important contributions to the structural organic chemistry from this new

¹ There not exist direct or primary, original written sources by Kekulé about this question, which has been told by him only orally, in certain public circumstances, so we should take into consideration this his story, in good faith.

² The molecular weight determinations were made possible thanks to the revaluation initiatives of the work of Amedeo Avogadro by Stanislao Cannizzaro, from which, moreover, it was possible begin to think in terms of molecular structure and chemical bond.

³ The modern composite word *desmalusogeny* derives from the Greek terms δεσμός [*desmos*], which means bond or link, and ἄλυσις [*alusis*], which means chain, so that "desmalusogeny" means tendency or ability to form bond chains (see [4]).

viewpoint. In particular, as concerns the Benzene structure formula, after decades of related studies, he first announced preliminary results to the Paris Chemical Society in January 1865 and, in a more complete manner, in a later German language revised and expanded paper (see [11]).

On pages 99-100 of the French paper [6], the Author argues on this question: from some preceding his discussions made in [1] and [2] about tetravalency of carbon and its ability to form chains (concatenation), he considers most likely the existence of a "nucleus with a closed chain" (on the basis of the so-called *Kekulé's sausage formulas* – see [12] – which are conceptually equivalent to the hexagonal one) of carbon atoms instead of a linear chain (see Figure 1), mainly because of symmetry arguments deduced analyzing the unsaturated valences of the resulting carbon atoms of the various chains which show their chemical and physical equivalence; the latter considerations have been developed by Kekulé in [7], where he argues on the chemical equivalence, or indistinguishability, amongst Benzene carbon atoms just due to its high D_{6h} discrete symmetry (see [11] and [13]).

To confirm his structural deductions made in [6], following a previous study of B. Tollens and R. Fittig (see [14]), Kekulé discusses many cases of chemical substitutions (with relative stability problems) of benzenic hydrogen atoms and related resulting chemical compounds, concluding the paper confirming the first annular (see his first *sausage formulas*) structural choice. From these first Benzene structural formulas, Kekulé made further continuous improvements upon such chemical-structural ideas (also through experimental proves reported in [8] – see too [13]) until the paper [9] where he mainly established the existence of two possible isomeric configurations on the alternating position between single and double covalent bonds (in [6] respectively called *single* and *double affinity*⁴). At last, on the basis of his previous above mentioned works, Kekulé argued that, likely, the real Benzene structure is given by a sort of continuous 'equilibrium dynamic oscillations' between these two isomeric structures, albeit these ideas were contemplated and meditated until 1870s but at last explicitly stated in [9] (where it is also graphically represented, for the first time, the celebrated hexagonal Benzene formulas – see Figure 4).

These last considerations on the isomerism problem, however, have been, above all, influenced by preceding fundamental Kekulé's works on mesomeric identification of the reduction products of Fumaric and Maleic acids to Succinic one, and other their Bromine derivatives (see [5]). In 1890, the German Chemical Society organized a symposium, the *Berlin Benzolfest* in Berlin City Hall, in honor of August Kekulé (then called *Kekuléfeier*) for his works on the chemical structure of Benzene, in which the Author revealed his original insight which occurred in 1865 in discovering the celebrated hexagonal Benzene structure: this is what refers the official history about the Kekulé's commemorative speech (see [18] and its English translation [19]; see also [20] and [21]) as also reported by many Organic Chemistry treatises of that time.

In the 20th-century, this Kekulé's admission have aroused various historical and epistemological debates on its presumed truthfulness and validity, until few years ago.

2. First historical considerations

One of the most complete biography on August Kekulé is that due to R. Anschütz (see [22]), who was first a student then the Kekulé's successor in the direction of the Chemistry Department in Bonn; for further biographical notes, see also [10], [67] and references therein. As a student, Kekulé began to study first Architecture (under pressure of his father) but he subsequently (after the death of his father, which took place in September, 1847) he was graduated in Chemistry under the supervision of his teacher J. von Liebig who knew him when he was architecture's student. Nevertheless, his first architectural studies contributed to give him a certain imaginative ability which is turned out to be much important for his creative thought. Following [22] (see also [10]), Kekulé married in 1862 with the Belgian Stéphanie Drory, the daughter of an English gas engineer who was employed in Belgium.

In May, 3 1863 at Ghent (in the French-speaking Belgium), unfortunately his very beloved wife died few days later the childbirth of their first son Stéphan (so named in honor of his wife), and this event marked profoundly the rest of his life. In that period, Kekulé was professor at the Belgian Ghent University since 1858, where he conducted some important researches in chemical structure theory (see [1], [2] and [5]), already mentioned in Section 1. Precisely, in this Ghent period (which was the most scientifically fruitful of

⁴ Affinity is the English translation of the German term *Verwandtschaftseinheiten*, that corresponds to the concept of *valence* introduced by E. Frankland in 1852 and by A.W.H. Kolbe in 1855, but so named by A.W. von Hofmann in 1865 (see [15] and [17]).

his life), Kekulé's work was much influenced by other fundamental works made during his preceding researches conducted in 1850s London and Heidelberg studying periods, beginning, amongst other, to publish too the first volumes of his important textbook on Organic Chemistry. In 1867, Kekulé was called by the University of Bonn. In October, 1876, Kekulé was remarried with Luise Högel (1845-1920) who was his previous housekeeper, but this marriage was very unhappy (even if they had three children). According to [23], Kekulé's health began to gradually fail: he aged prematurely and rapidly, becoming very deaf and shunned friends. All these conditions, together with other various duties, negatively influenced on the scientific production of Kekulé after 1870s, explaining the effective scarcity of it.

For our purposes, it is also important to recall a particular life episode of Kekulé, beyond that already mentioned above, which excited immense interest in the Germany of the time – other particulars of it, will be described in the next section 5. Precisely, according to [22], in 1847, it took place a tragic event in Darmstadt, the murder of the known Countess Görlitz by one of her servant-man, John Stauff, who subsequently tried to burn the Countess' corpus (perhaps, yet not dead) for sidetracking the subsequent investigations. The burning took place in the first evening of June 13, 1847; it had, as first eyewitnesses, a young twenty Augustus Kekulé together his eighteen sister Augusta, who both attended at the macabre scene from the window of their paternal house (see [24]) which was in front of the burning place. They also called their mother and all three saw it flare up high, then decrease, and go out. August Kekulé immediately wanted to bring aids but he was inexplicably stopped by his father (who will dead in the same year – see [10]), so losing valuable time.

Subsequently, in the 1850s, Kekulé, together with his teacher J. von Liebig (who was called as an expert to evaluate the hypothesis of a possible death of the Countess for spontaneously combustion, hypothesis that was then excluded) was an active judicial witness in the related murder trial, evermore bringing with him such a guilt for not having provided aid, as he would have like do. As a matter of fact, the Countess was not in good relationships with his husband, so this last was obviously the first to be suspected of uxoricide; only subsequently it was unmasked the real culprit, precisely their servant-man John Stauff whose murder's motive seemed to be a jewelry theft. During the related trial development, it were filed at the trial records the related stolen jewellery including too a Countess' ring consisting of two intertwined metal snakes biting their own tails (see [25]). Kekulé therefore was aware of all the aspects of this tragic event and of the related trial records; according to [25], this grievous incident made a deep impression on Kekulé who had a sensitive and noble soul. These Kekulé's life events, only apparently irrelevant, will turn out to be instead useful and crucial in the discussion of the next section 5.

3. Further historical-critical remarks

Above all, the papers [18], [20] and [21] have been matter both of subsequent historical studies as concerns the reliability and truthful of what narrated, and of psychological studies as concerns the human creativity insight (see [26] and [29], and references therein, for a recent and comprehensive outlines of the question and of other similar historical situations, by one of the major scholars of the Kekulé's Benzene Problem).

As typical of the human nature, various supporters and opponents (see [28] for a brief partial outline of that) appeared with respect to what told in [18] (and reaffirmed in [20, 21]), raising a related historical *querelle*: we refer to [26], [29] and references therein, for a complete and updated discussion of these last aspects. For our purposes, we consider only some papers relative to such a question, referring precisely to the references just mentioned for a comprehensive related literature overview. Among the opponents, we recall the criticisms moved, for the first time in [30], by H.J. Wotiz and S.F. Rudofsky to the reliability of the Kekulé's report, accomplishing in it a precise historic-bibliographical re-examination of the Kekulé's works. Their subsequent 1984 historiographical work [31] carried out on historical documents of the Darmstadt University Kekulé's archive, lead they to a presumed misconduct by Kekulé in discovering the Benzene structure formula since, according to their opinion, he was to knowledge of the Auguste Laurent work on the same subject.

In fact, according to Wotiz and Rudofky, the French chemist Auguste Laurent (see [32]) had expressed a his own conjecture on the Benzene structure, hypothesizing for it a possible hexagonal closed form (to this purpose, see page 408 of his posthumously published work [33] in which Laurent first proposed this geometrical structure for certain chemical substitutions – chlorinations – of the Benzene's hydrogen atoms). Wotiz and Rudofky have found historical confirmations of the knowledge of the Laurent's book by Kekulé, so it is likely that he have tried inspiration from this. The criticisms of Wotiz and Rudofsky have continued in other papers (see [34, 35]) and collected works (see [36]). The Authors of the papers [19] and [23] also

express perplexities about discoveries made through dreams, which appear to be exceedingly rare (according to B. Vanderbilt – see [23]). We instead think that, if the Wotiz and Rudofsky Kekulé's misconduct thesis were true, Kekulé himself wouldn't have been so stupid to publish these alleged Laurent's ideas in a French journal. Instead, among the supporters, a predominant position is above all played by A.J. Rocke who has immediately rebutted the Wotiz and Rudofsky theses (see [37]), his historical studies instead having led to retain somewhat valid the historical tradition which wants true the Kekulé's dreaming story (see also [10]) and the good faith of what said in [18], at least as concerns the occurrence of a dream experience by Kekulé⁵.

In [51], the Author confirms the important role played by dreams, forms of dreaming and visions⁶ in many discoveries and progresses of the chemical thought, analyzing many historical cases, among which the Kekulé's one, provided that the related insight contents be supported and subsequently elaborated by the powerful rational thought tools. On the same line of thought are [39, 40]: in particular, the Author of the paper [40], amongst other, criticizes those who have a rigid positivistic view of the science progress in which the irrational aspects of thought are completely relegated to the margins. According to the historical tradition (as, for instance, that reported by many Organic Chemistry textbooks of that time), August Kekulé had two dream experiences or reveries (*Träumerei*) related to his celebrated insight: the first seems to be a reverie (or day-dreaming) occurred in a Horse-drawn omnibus in London in 1854 while returning from the home of his close friend and colleague Hugo Müller, and the second in Ghent during a short rest whilst he was dozing before a fireplace fire, in a period in which the younger widower was writing the second volume of his celebrated Organic Chemistry treatise (see [41, 42, 43]) and taking care of his beloved son Stéphan in a touching way (see [25]).

In both experiences, it seems (following [44]) that he saw "chains of six carbon atoms disposed like a snake twisting and curling until one gripped his own tail and the picture whirled scornfully before my eyes". The same Kekulé said that after these experiences, he devoted many night hours studying on these insight motives trying to transform their imaginative content into scientific and rational arguments. The first reverie, according to a plausible historical reconstruction of the facts done in [45], seems, at first sight, to be very unlikely simply because of the material and logistic conditions in which should have had to perform this omnibus travel: in fact, at that epoch, the Horse-drawn omnibus travel was so uncomfortable, physically demanding and disturbing to make impossible every form of mental and physical relaxation; as we will see, nevertheless, other points of view about this last question are possible. The second dreaming experience, instead, according to A.J. Rocke, should be considered historically founded or else quite probable. Exactly, following [28], Rocke agrees with Wotiz and Rudofsky on one point, precisely, that the Benzene structure could not have entered into Kekulé's mind fully formed in a dream.

According to Rocke, the inspiration of the dream has provided only one aspect of a creative process that also included experimental and theoretical work. Further, although, in principle, it's impossible to prove or disprove the occurrence of a dream, nevertheless there is a compelling historical evidence to indicate that Kekulé indeed have had such a fruitful experience. On the other hand, according to what said by Kekulé himself in [18] (we follow its partial English translation [19] based on [20]), this first reverie was properly inherent to the origin of the new Structural Organic Chemistry and not to the Benzene theory (to whom, instead, Kekulé reconnects his second Ghent reverie). Further, following [46], a similar experience was also felt by H.J. Poincaré, as regards the conceiving of some his new ideas on complex function theory, during a carriage ride travel, hence likely feeling the same discomforts felt by Kekulé in his London Horse-drawn omnibus travel. I think in the good faith of all these historical sources, thinking that if the travel has a very long duration, the human mind could fall into a drowsiness state under a continuous, periodic and repetitive not excessive undulations (cradle effect-like). Furthermore, he had discussed, throughout a summer evening, of chemical arguments with Müller, which lived on the opposite end of London with respect his residence in a suburb called Clapham Road to whom came back with the last omnibus, observing the general desolation of the city streets (which are so full of life at the other times); all these conditions seemed therefore to be favorable for setting up a possible drowsiness condition.

⁵ In this paper, we fully agree with Rocke's theses

⁶ This term must not be intended in a negative psychopathological sense. According to [39], the thought by images, supported by strong emotional contents which should be transformed into a constructive sentiment (according to A.R. Damasio), is a fundamental source of inspiration, and it was just an essential component of the scientific work of A. Kekulé since was at the basis of his celebrated *eureka-experience* in discovering fundamental structural-chemical properties of the Benzene. Besides, the same Kekulé observed (see [23]) as part of his success were due to the fact that his training and experience did not take place in one 'school of thought' and, above all, to his early training in Architecture which stimulated his visual intuition and imagination.

Besides, if we want in detail to examine the Kekulé's story according to [19], then it is necessary to recall that the Kekulé's consciousness was reawakened by the cry of the omnibus conductor, so that, if we just want to reject the hypothesis of a drowsiness dreaming, then it is possible to think to a sort of fixed open eyes mental estrangement in which Kekulé had such imaginary configurations. A same type of this last mental experience it is recounted by J. Hadamard (together with other similar accounts by other scientists, collected by Hadamard) in [46], when he was concentrated in thinking to solve a given mathematical question that, in most cases, is referred to be reached above all by images, on the other hand also confirmed by the same Kekulé who reported as, thanks to his previous architecture studies, he had an irresistible urge to mentally visualize everything, so considering the imagination as the first and most important way to think⁷. According to Kekulé, of which we retrospectively looking his life, the human being is clearly the product of the social-cultural conditions in which he grew up, and no merit accrues to him for what he becomes.

Hence, both the above mentioned stories might have a their real and truthful historical foundation if correctly framed in the right historical context: for instance, according to what said in [19] (and above all to A.J. Roche), the first Kekulé reverie experience cannot be properly related to the Benzene structure theory but to the birth of the new structural theory of carbon organic compounds (whence the concept of desmaltusogeny of carbon, its tetravalency, and so on) because its content is related to many mental images concerning different types of not well identified carbon atom chains variously disposed. Again following [19], the second Kekulé's dream experience took place in Ghent when he stayed in an elegant bachelor quarters: he was intent to write his famous textbook but the work did not progress because 'his thoughts were elsewhere', so that he turned the chair towards the fire and began to doze, dreaming atoms gamboling before his eyes to form various types of structures which gradually came to configure they as long rows, sometimes more closely fitted together, and all twining and twining in a snake-like motion until one of the snakes seized hold its own tail to form a closed structure whirling mockingly before his eyes.

Subsequently, he awoke for spending the rest of the night working out rationally on what dreamed, since himself stated the unavoidable necessity to treat the dream insight content by means of the rational waking understanding. It is possible to presume a certain memory confusion in the Kekulé account [18], likely due to the old age and to the ill-health conditions present since the end of 1870s, as already remembered in Section 2 (see also [47]). Following [48], in History of Science are relevant the mythical influences from a historiographical viewpoint since, according to the anthropologist Pierre Smith (which, in turn, retakes some related notions of his teacher C. Lévi-Strauss), the mythical thought is always present in every personal past autobiography involving individual and collective memory aspects, often distorting the historical reality when the Author tries to recall and to tell its own past experiences. The philosophers and historians of science (amongst which T.S. Kuhn and G. Holton) tell certain their personal cases concerning interviews to some important exponents of the modern science, obtaining a logical and perfect scientific biography which resulted to be quite dissimilar from that inferred by the original sources; in a certain sense, the past autobiographies told by the protagonists themselves had been constructed so perfect and logic to be effectively those really happened according to the protagonist, even if the exact historical truth was different.

According to C. Lévi-Strauss and François Jacob, the *myth* is essentially an 'excess of sense' given by who think only to repeat simply it, that is to say, the myth is always semantically distorted whenever it is repeated. This fact shed a certain shadow of discredit on the history of science if it is no taken into account, and it may be included in the wider unavoidable problematic concerning the so-called *personal equation* (which will be reconsidered in another place). This imply the need for consideration of psychoanalytical methods to analyze and to treat such a type of historiographical problems (if nothing else, to reduce the influence of the ineliminable personal equation effects) of which an example is given by the case study treated in the present paper (and the need for such a historiographical tool is also confirmed by [49] – see next sections 4 and 5); therefore, from this perspective, it is possible that the Kekulé's account may have a certain degree of authenticity not complete: for instance, analyzing the original Kekulé's papers related to the Benzene structure, it is possible to reconstruct a most convincing story with respect to those already existent and based on an almost literary interpretation of what autobiographically told in [18] that, as just said, it may be quite distorted by the myth. We will try to pursue such a viewpoint as regards the Benzene problem.

First, it is doubtless the fact that Kekulé known the various preceding works on the structure of Benzene as made, for instance, by A. Laurent, J.J. Loschmidt (see [25]), A. Ladenburg (see [51]), as well as by the

⁷ On the other hand, the recent neuroscience researches seem just to confirm this Hadamard's consideration since they have found a very close functional interconnection between the frontal area (mainly deputed to rational thought) and parietal ones (in which it is mainly elaborated the visual experiences).

Russian school of A.M. Butlerov, V.V. Markovnikov and others, this last having also gave fundamental contributions to the modern structural chemistry (see [52]) starting from 1861 and independently by the other foreign schools (see also [53, Vol. 1, Vol. 3]); further, according to [17] and [52], A.M. Butlerov was the first that used the term of chemical structure. The history of organic chemistry (see [54]) also include many other contributions to the 19th-century Benzene structure theory, among which those of A.K.L. Claus, J. Dewar, J.H. Van't Hoff, H.E. Armstrong, J.F.W. von Baeyer, C.K. Stadler, H. Wichelhaus, E. Bamberger, J.A. Le Bel, T. Körner, E.C. Crocker, J.N. Collie and F.K.J. Thiele, but their theoretical and experimental value is not higher than that of the Kekulé's work, as we will see later.

Following [25], it is much difficult, if not impossible, to separate the Kekulé's contributions in developing the new structural organic chemistry theory from those of his predecessors and contemporaries; on the other hand, Kekulé himself by no means invariably claimed complete originality for his ideas, coherently with a gradual and continuous constructive process with which the scientific knowledge progresses along its historical evolution. In this respect, see what is said in [19] on Kekulé's thought about a scientific discovery: among other things, Kekulé confirms both the fact that our knowledge is the result of what has been said by our predecessors and that according to which the growing intellect or creative thought does not think in leaps.

From what has been said above, we instead consider as most probable the following historical situation. Kekulé begin to study the Benzene structure evidently knowing what was known at that time, hence taking into account the preceding works of his predecessors (like, for instance, A. Laurent and J.J. Loschmidt) and contemporaneous, which had only set up approximate circular or closed structures for the Benzene molecule without much more exact explanations about the possible bonds among carbon and hydrogen atoms respecting their valences. Moreover, many of the related results achieved by the just above mentioned authors resulted to be almost mistake – with some exception as regards the Dewar's contributions – or, however, they resulted to be of few importance for the later historical evolution of the structural chemistry thought.

The real historical importance of the Kekulé's work on Benzene structure does not regard the hexagonal structure of this molecule (in a certain sense, already essentially known in its closed geometrical form) but instead it concerns the birth of the basic concept nowadays known as *chemical resonance* (or *mesomerism* or *aromaticity* – see [55] – according to the time) since his conception of a dynamical equilibrium oscillation between double and simple bonds into the Benzene molecule – as said, matured along a decennial work from 1860s to 1870s – must be intended as a prodromal one with respect to the modern theory of chemical resonance (see [56]). Precisely, as already said in Section 1, since the early Kekulé's works on this subject, the Author had hypothesized a first form of alternation between single and double bonds among carbon atoms, beginning from the consideration of his known 'sausage formulas' (in [6] – see Figure 1), then formulating a unique annular geometrical form more symmetric in [42] (see Figure 2) till his final historical formulas in [9] (see Figure 3) which will be called, with modern terminology, *Kekulé's resonance formulas* (see Figure 4 for a their modern notation).

As regards the historical Kekulé's resonance formulas (see Figure 3), the Author finally states that there is a sort of continuum and dynamical equilibrium oscillation, or an overlapping, between them, the Benzene molecule does not identifying with any of these, singly chosen, but simultaneously with both. From these last basic considerations, Kekulé did give rise to the concept of (chemical) *resonance* and to the notion of *resonance hybrid*, which will be rigorously defined only with the advent of Quantum Mechanics. Indeed, starting either from first forms of this concept due to C.K. Ingold (who first introduced the term resonance⁸ or mesomerism), J.W. Armit, R.J. Robinson and others (see [56, 57] and references therein) and with the definitive pioneering works by L.C. Pauling and coworkers (see [58, 59]) on the one hand (with the use of Valence Bond Theory) and with those of E. Hückel (see [60, 61, 62, 63]) on the other (with the use of Molecular Orbital Theory), contemporaneously and independently one from each other (see [64] and also [66, 68] for a comparison of these two computational methods), it has been possible to explain the exact electronic structure of the Benzene molecule, also explaining all its own physical-chemical characteristics (among which, the equal length of each carbon-carbon bond, D_{6h}-symmetry, high unsaturation degree, and so on). The concept of resonance considered by these authors is that introduced by W. Heisenberg (see [65])

⁸ When we speak of 'resonance' about Kekulé work on Benzene structure theory, it is evident as such a term should be intended as not explicitly known to his mind, although implicitly his work is just oriented toward the institution of this concept which will take place only with the advent of the atomic mechanics. The Kekulé idea as regards this, concerned the alternation of the single and double bonds among Benzene carbon atoms.

during some of his studies of the quantum symmetry properties of certain identical physical systems. The two Kekulé's formulas, nevertheless, did not explain the main chemical properties of the Benzene, so that it took place the so-called *Benzene problem* (see [68]) which was gradually approached and solved with different trials, concepts and methods till the definitive main comprehensive theories of L.C. Pauling and E. Hückel.

Therefore, we presume that Kekulé have did contextual confusion between his two dreams (probably due to the above mentioned motivations), especially in the second one where he perhaps intended to refer to the remaining carbon free valences (one electron per carbon atom) and not to the carbon atoms, supposing already known a sort of hexagonal structure for Benzene, hence to the problem related to the localization of the single and double affinities in such a closed chain of carbon atoms, as effectively seems to suggest [6]. Thus, it is very likely that, when he talk about a dreaming of atoms gamboling before his eyes, we should intend electrons instead of atoms which will go gradually to dispose in circle manner around the Benzene ring, according to his vision of a snake seizing its own tail.

So, assuming that it was however known (already before Kekulé's work) the fact that the Benzene had a some annular structure, the real historical problem was not the hexagonal configuration of Benzene molecule but instead the localization of its single and double affinities within it, and, as already sight, this problem was however already mentioned by Kekulé in [6]. Nevertheless, to want to be picky, even if this tail-devouring snake should be referred to the localization of the various free carbon affinities, it is no possible to known when exactly such a dreaming insight took place, that is to say, whether relatively to the discover of his sausage formulas (Figure 1) or rather to the resonance ones (Figure 3) since, as already said, Kekulé referred such circumstances over thirty years later with all the possible mnemonic confusions (besides suggested too by some strange situational analogies present in both the dreaming experience stories). In [49], it has been hypothesized that such a second dreaming experience would took place in 1864 and related to the subsequent 1865 Kekulé's publication [6].

Therefore, the only way to overcome these historical indeterminacies consists in looking to the possible metapsychological aspects of the question on the basis of the original sources, as we will try to do in the next sections after having briefly analyzed the modern scientific consequences that had the Kekulé's work. Precisely, the work of L.C. Pauling and G.W. Wheland ([58]) starts just from the fundamental Kekulé's resonance formulas and others similar, calculating the energy resonance of the Benzene as enthalpy variation by hydrogenation between the real substance and that expected by one of its theoretical model.

Their results show as a good theoretical approximate model for the Benzene molecule is given by the set (which is called a *resonance hybrid* of the Benzene) involving a linear combination of the wave functions corresponding to the two known Kekulé's structures (see Figure 4) plus the three Dewar's structures (see Figure 6), even if the first two contributes approximately for 80% while the second three for the remaining 20%. Hence, the two Kekulé's resonance formulas, with good approximation, represent the Benzene molecule better than all the others. The resulting key concept related to that of resonance is that of electronic delocalization over the planar structure of the Benzene molecule, in the sense that it is like if there were a sort of continuous ring formed by π -electrons symmetrically arranged with respect to the Benzene molecular plane (see Figure 5), just allegorically similar (or alluding) to the Kekulé's dreamed tail-biting snake.

In this respect, the Benzene resonance hybrid is often denoted by a hexagon having an inner circle (see Figure 4), just indicating this basic π -electronic delocalization but that also recalls (or resembles to) an *Ouroboros* (see Figure 7). For the correct meaning of the resonance hybrid see what is said in [69] (in which there are also useful historical notes about these arguments) and [70]: no one of the already known canonical forms represents a real molecule, and the Benzene neither contains in equal proportion all these forms nor there is a tautomeric equilibrium (the famous 'Kekulé's oscillations') among them, as well as it is not also possible to say that this molecule is into one form for a certain time interval and subsequently into another.

The real Benzene structure cannot be explained with a unique structural model: at this regards, it is useful another mythological analogy explaining this situation, namely that according to which the case of the Benzene is similar to the rhinoceros (there exist an analogue, but less meaningful, history relative to the mule) considered as a hybrid between the unicorn and the dragon, even if this does not mean that it is unicorn for an instant and dragon for another; the rhinoceros is ever and only a real and existent rhinoceros, whereas the unicorn and the dragon are both imaginary.

Also these last considerations on the nature of a resonance hybrid bring back us to one of the main meaning of the *Ouroboros*, that of 'The One-All' (see next Section 4), so that these considerations lead us to think that the Kekulé's second dreaming experience effectively was referred to the notion of π -electron delocalization (said in modern terms) instead of the hexagonal Benzene structure. Namely, at the light of what has been just

said, it is quite likely that the celebrated Kekulé's tail-devouring snake took place just for this motivation, that is to say, for searching a possible localization of the single and double covalent carbon-carbon bonds explaining the physical-chemical properties of the Benzene, and not for determining the relative geometrical disposition of these atoms. This historical viewpoint will be substantiated by the considerations made on the next sections. However, as remarked by [71], the first Kekulé's sausage formulas have been quite underestimated from the historical viewpoint: they are reported in Figure 1 where each 'sausage' indicates a carbon atom, two of their contacts denote a double affinity whereas only one of their contacts denotes a single affinity; finally, the arrows at the extremes indicate a single affinity between the related carbon atoms from which they departing, whereas the dots denote the hydrogen atoms.

According to [71], these Kekulé's sausage formulas have played an important role in the next developments of the closed ring structure of Benzene. This cumbersome symbolism used by Kekulé, according to which the symbol of a chemical element was represented by many circles how many was its valence, was first employed by him in [41]: therefore, for example, the hydrogen atom was symbolized by one circle, the oxygen one by the fusion of two circles, the carbon atom by the fusion of four circles, and so on. In the subsequent Kekulé's work on the Benzene structure, he made rarely use of the Benzene geometrical structure formulas, and this proves as he was interested much more to the inner chemical structure of such a compound (as, for instance, the relative positions of single and double bonds) than its geometrical configurations.

To him, it was enough to know that the Benzene had a closed structure, and this fact, as said, was already much or less explicitly known into the scientific chemical community of the time, so that it is possible to say that Kekulé had, as a difficult task to solve in the middle of 1860s, the problem of localization of the free carbon atom affinities (or valences) within this hexagonal configuration of Benzene structure, respecting the carbon tetravalency and the various bonds with the hydrogen atoms. The real historical question, therefore, would be related to this localization problem rather than possible geometrical configurations, and very likely this problem was already substantially resolved by Kekulé in [6].

4. On the history of *Ouroboros*

According to [72] (for further interesting historical notes on *Ouroboros*, see also [49] and [73]), the *Ouroboros* (whose one of the main symbolic representations is given in Figure 7 drawn from an incision of a Greek manuscript of 2327 B.C. – see [74]) is a very old religious, mythological and alchemical symbol which has had a variety of meanings and present in almost all mythologies; however, from its historical evolution, it is possible to identify some constant and common meanings as that symbolizing the essential Unity of Matter and, in particular, the Work which had neither beginning nor end. According to the Egyptian mythology and the early pre-Socratic philosophy, the Primeval Serpent represents the manifestation of the Creator-Spirit assigning to everything its own essence; hence, the tail-eating serpent is considered as creator of multiplicity and also symbolizing the creation by word of the God-Spirit.

From these conceptions, it will follow all the other future interpretations of this symbol (see [72] and references therein for a first comprehensive view of this argument). In [72], together an interesting history of this symbol, it is also depicted the main *Ouroboros* symbols and their inscriptions with related meanings mainly in mythological-alchemical context: one of the main, the simplest, basic and recurring, is $\epsilon\nu\ \tau\acute{o}\ \pi\acute{\alpha}\nu$, that is to say 'The One is the All' or 'All things are One' and it is a formula expressing unity in diversity, according to early pre-Socratic philosophy. The subsequent elaborations of the theme 'The One is the All' will be integrated with further inscriptions which recall the essential dualistic and cyclic nature (namely, the circular and eternal time flowing) of the 'Unity of All' because it also first denotes the separation of the All out of the One and the ultimate return of the All into the One; this dualistic nature seems likely to recall or symbolizes the two compositions of the serpent poison, or venom. Hence, the various manifestations of the *Ouroboros* emphasize the cyclic nature of what it symbolizes: the idea of a growth, or regeneration, ending in a reversion to the primary state. In the illustrations from Hellenistic alchemy, this has been qualified by the inscriptions confirming and stressing the rise of multiplicity from the undifferentiated, followed by the return of the different forms into the One.

The *Ouroboros* has also represented the symbol of the *prima materia* and as starting point of the alchemical conceptions of Unity of Matter, Cosmic correspondences, the development of Opposites, and so on (about this, see some meaningful hints in [72], whereas for more information about the relationships between Alchemy and Chemistry see, for instance, [75, 76]); further, again following [72], starting from a Mystery Religions conception according to which upon a man's death, its soul departs from the body in the guise of a

serpent, the Alchemy retaken (following Porphyrius) this symbolic activity of the serpent considering the Spirit corresponding to mercury and its "seed" (or source) symbolized by the Ouroboros. The Mercury is a chemical element closely connected to the Ouroboros from the alchemical viewpoint (that is to say, considering the latter as a *mandala* of Alchemy), and this consideration, amongst others, will be important for the interpretations of the next section. For the later psychoanalytic considerations of the next Section, it is fundamental to consider the interpretations of this symbol according to the Jungian Analytic Psychology, of which one of the leading exponents was Erich Neumann (1905-1960): of this Author, we mainly follow the basic works [77, 78].

Following [79, Chap. 3], the basic maxima of Alchemy was 'solve et coagula' – namely, separate and recombine; as known, the Alchemy tended to understand the World in terms of Basic Opposites. The combinations of opposites into one entity is properly called a 'chemical wedding', and the Union of Mars (a symbol of the male factor – see [80]) with Venus (a symbol of the female factor – see [80]) is, par excellence, an emblematic exemplification of this conjunction process, symbolizing the royal or divine marriage. The theme of the coniunctio had occupied the minds of the alchemists for seventeen centuries; its motif has also an intrinsic archetypal character: as mythologem, it denotes the *hiéros gámos*, or the divine marriage, as well as the *unio mystica*, that is to say, it expresses the archetype of the union of opposites or polar pairs (according to Jung). As archetype, it therefore represents the life and the essence of the nonindividual psyche, belonging to the so-called *collective* unconscious, and although this psyche is innate in every Individual, it can neither be modified nor possessed by him personality; it is the same in the Individual as it is the crowd and ultimately in every body as well as it is the precondition of each individual psyche, just as 'the sea is the carrier of the individual wave'.

According to Jung, the *coniunctio* is an a priori image which occupies a prominent place in the history of man's mental development, as evidenced by the subsequent fundamental work of E. Neumann (see [77]). According to [81] and [73], the alchemists were intrigued by the fact that hybrid forms are able to contain apparently incompatible elements or "opposites" (*coniunctio oppositorum*): the visible element is somehow combined with its hidden (invisible) opposite and, according to Alchemy, incompatible elements can coexist into one because the dominant factor temporarily represses the opposite one, and vice versa in a second moment, so giving rise to a hybrid form. According to C.G. Jung, the Ouroboros must be considered as a symbol of a "coniunctio oppositorum": the serpent that fertilizes and gives birth to itself, by definition an *increatedum* despite the quotation, from the *Rosarius*, according to which the Mercurius noster nobilissimus was created by God as a res nobiles; following [82, Chap. 3], the Mercury symbolizes the prima materia intended as the world-creating spirit imprisoned in matter, the vital principle, the hermaphrodite who was in the beginning, represented as a tail-eater dragon – that is to say, the Ouroboros – which will split into the opposite pair female-male and reunited into the coniunctio; this chemical element is metallic and liquid, matter and spirit, cold and fiery, poison and healing draught, hence a symbol uniting all the opposites, whence the almost same meaning of the Ouroboros symbol (see also Figure 7 and its meaning). In the important work [57], the same Jung considers, among other things, an interpretation of the Kekulé's dream fundamentally as a vision of the coniunctio, so that this is likely the most plausible interpretation of the Kekulé's dream.

On the other hand, following [74, Cap. 13], the Ouroboros symbolizes the union (coniunctio) of opposites because its head and its tail are united even if they represent opposites, whilst, when the opposites (the head and the tail) touch, then it follows a fluid that the alchemists call mythical or divine water, that Marie-Louis Von Franz defines fluid (or sense) of life. The fundamental work [77] outlines a possible explanation of the origin of consciousness starting from the archetypal structure of collective unconscious through a certain psychological reinterpretation of the 1866 fundamental biogenetic law of E.H. Haeckel and O.F. Müller according to which the ontogenies is a recapitulation of phylogenies. According to the Preface to [77] by C.G. Jung, Neumann starts from the so-called *matriarchal symbolism*, to whom belong the Ouroboros, to describe the phylogenetic development of the consciousness: the Chapter 1 of the Part A of [77] is just devoted to this symbol and its meanings.

The Ουρόβορος (from οὐρά which means "tail" and βόροϛ which means "devouring", that is, the "snake seizing its own tail") is the self-referential primordial unity of opposites (that is to say, the symbol of integration and assimilation of the opposites which cannot be separated each from other) and the archetype of the ἓν τὸ πᾶν (that is, 'The One-All' or 'The One, The All') as already said above. From an Analytic Psychology viewpoint, it symbolizes the "containing round", that is to say, the primitive womb or the maternal uterus, as well as the progenitors as unity of the opposite elements of the pair female-male (like mother and father joined together into a perpetual cohabitation) in which the primordial father is merged

with the primordial mother into the ouroboric unity; so, the primeval progenitors are all the world, the primordial symbol of the eternal life, the perfect from which everything arises, the eternal existence that generates, gives birth, kills and reanimate herself. The unity of these opposites represents the existence, independently by the same opposites, or else the transcendental divine existence. In this regards, Neumann explicitly advices of the fact that these last interpretations does not must be intended in sexual sense but instead as many meanings symbol of the origin (of the life, of the consciousness), the Ouroboros therefore having a preponderant creative maternal character which will constitute the subsequent primordial female archetype known as the *Great Mother* (see [78, Prima Parte, Cap. 2]) which, amongst other, contains the female and male symbols (see also [80]). Following [78, Cap. 14], the alchemistic symbol of growth is the ascendant serpent: precisely, this process of transformation is represented by the shaft-pillar around which is twisted the double snake of the opposites which must be unified.

This shaft is crowned by a Queen-Mercury which has a scepter in his hand, this scepter being the fusion of the Hermes-Æsculapius Therapeutic Verge (surrounded by snakes) with the Cretan Lily Scepter which symbolizes the Queen or the Goddess. To the bisexuality of Mercury corresponds the ouroborically female-male nature of the Female Archetypes of the Great Mother, which unites into itself the figure of the Goddess-Virgin (the Lily) with the healing and generating transformation character (of Hermes-Caduceus). This gives another meaningful mythological symbolic relationship between the Ouroboros and the Mercury. On the other hand, the alchemical symbol of Mercury (see [73] and [80]) is the same of the astrological symbol of the planet Mercury; the chemical element Mercury is considered as one of the primordial elements of matter (see [72]).

It is essentially represented by a stylized serpent and assumed to symbolize the transcendental aspects of the passage from live to death, the principle of the duality of Nature, hence the result of the combination of opposite or complementary elements, the beginning and the end of every body, so that, as already seen above, evident are the many analogies existing with the symbolic meanings of Ouroboros: in fact, following [80], already Carl Linnæus used this symbol to denote a hybrid (or hermaphrodite) plant specious, hence symbolizing a *coniunctio oppositorum*. Moreover, following [73], the alchemists considered everything subject to a flux, to a continuous mutation and the Mercury, because of its physical-chemical properties, was taken as characteristic symbol of this fact. Furthermore, Sulphur and Mercury constitute a typical dual pair of opposites whose union can generate a soul and become an immortalizing agent. The Sulphur is considered the fixed and active male principle, whereas the Mercury is considered the volatile and passive female principle; but to the female character is also symbolized by Venus to whom is alchemically associated the chemical element Copper.

As well as the consciousness combats against the unconscious (the fight against the Dragon – see [77]), so the alchemist battles the Verdigris (*Viriditas*) from the Bronze. But just from this purification of the Bronze that will become Green-Gold, we deduce as the *Viriditas* symbolizes the hidden perfection and truth, the unseen power which will give life (the greenness – the pure Bronze arising from its cleaning by the Verdigris) and that must come to the light, the mystery of the transformation. Following [83], the Ouroboros is the symbol of the undifferentiated totality, the One into itself. It is one of the main mythologems of the Egyptian, Jewish and Greek mythologies in which it denotes the totalizing and self-sufficient circularity. The Great Mother archetype is a mythological evolution of the original Ouroboros.

Erich Neumann describes the tendency to reimmerse into the undifferentiated as an *ouroboric incest* that is a symbolic form of entry into the mother, or a sort of union with her, which is opposed to other later forms of incest (see also [77]), so that it symbolically represents the death, the dissolution of the son into the mother. To the ouroboric incest follows the *matriarchal incest* which represents a castration, a dissolution of the egoic consciousness which is unable to face the forces symbolized by the Great Mother. The opposition of the son-lover to the Great Mother is an expression of the general tendency toward the neumannian *centre-version*, that is to say, the tendency of a certain totality to create the unity into its parts and to synthesize their differences into unitary systems. Therefore, in order to the Ego may support the comparison with the archetypal Mother, it must individually consolidate as consciousness of itself and to be hence sufficiently strong to split the original undifferentiated situation into opposite pairs.

Erich Neumann has always shown a particular sensibility towards the female psychology dimension from which he derives his interest for creativity intended as element of the Jungian *Anima* (taking into account the female procreative character). Following [77], the Ouroboros also symbolizes the creativity of the beginning of the psyche from an undifferentiated state of union of opposites, hence it represents the creativity of this new beginning symbolized by the wheel that does rotate itself, that is to say, the first circular movement of the upward spiral of the human development. As already said, the archetype, as universal structural element

of the collective unconscious, is not only a driving force of the human psyche but it must be intended as an unconscious conception with pregnant symbolic content.

Hence, with the archetypal symbolic image is connected a semantic sense – by means of a mythologem – which may be meaningful only for a developed and mature consciousness; no one intellectual formulation can reach, even approximately, the richness and the expressive power of a mythical image which, for its original and primordial character, it can be only reproduced through a language by images. According to [77], behind the actions that the Ego coordinates with the decisional and volition spheres, there is the instinct and, in general, there are fundamentally instincts and archetypes behind the attitudes and the decisions of consciousness (with different degree of influences in primitives and children with respect to the modern adult man). All the considerations made in this section will be very important for the following one.

5. Some psychoanalytic considerations

Kekulé's insight has been at the centre of many psychoanalytic and psychological interpretations as well as the starting point of interesting speculations about creative processes. In [84], the Freudian German psychoanalyst and psychiatrist Alexander Mitscherlich (also grandson of the chemist Eilhard Mitscherlich, mentioned in section 1), on the basis of the orthodox Freudianism, gave an interpretation of the Kekulé's dreaming snake, intended as phallic symbol, and due to repressed and frustrated sexual desires because of his condition of single, reaching even to think to a masturbation by Kekulé facing the fireplace. We however consider this interpretation completely inappropriate both for the probably presence of his beloved son Stéphan and mainly for the sensual, noble and romantic character of Kekulé (see what said in [38]); moreover, he was in a particular period of his life, since by a short time he had tragically lost his beloved wife during the May, 1863 childbirth of their first son Stéphan which he took care of him in a very melting way, and, at last – following [25] – Kekulé was above all a thinker, a dreamer, an artist, and, as such, he was highly impressionable.

All these character qualities induce us to believe Kekulé as a sensitive and romantic soul and not so ignobly materialistic as pictured by Mitscherlich, which with very difficult he would remembered such a squalid scene in a public conference in his honor. On the other hand, a not circular snake is a Freudian phallic symbol whereas a circular snake (like the Ouroboros) should represent a female genital organ instead than a male one. Further, as said, we think that Kekulé wouldn't have remembered a similar, squalid event almost thirty years later if it there weren't was a more suitable and transcendent emotive involvement than that produced by a vulgar masturbation. So, knowing however the important work made by Alexander Mitscherlich despite this strange interpretation, we are very inclined to think that this irreverent interpretation of the Kekulé dream be due to a particular effect of the personal equation of Alexander Mitscherlich (1908-1982) certainly unconsciously due by the fact of being himself a grandson of the chemist Eilhard Mitscherlich (1794-1863) who was one of the main Kekulé rivalry protagonist of the researches on Benzene structure theory and other chemical contentions.

From our point of view, the most important interpretation of Kekulé's dream is given by J. Le Soldat in [85] in which the Author starts from a sever critical re-examination of the paper [84] and proposing, amongst other, as alternative of interpretation of the Kekulé's dreamed Ouroboros, that according to which this symbol is the production of latent feelings of strong (œdipus) guilt associated with early death of his wife. In [47], the Author considers the Kekulé's dreaming experience from the cognitive psychology viewpoint as belonging to the class of the so-called *janusian* and *homospacial* processes which are forms of primarily conscious creative cognition, assuming the Kekulé's insight not due to a real sleeping condition but instead to an imaginative experience in a vigil state.

It is also important some studies made by S. Mahdihassan in [49] and [73] (see references therein too). In the first paper, the Author considers basic to consider the psychoanalytical methods to examine the Kekulé's dream, especially from the Jungian psychoanalytic viewpoint, trying to single out where Kekulé had saw the Ouroboros symbol, but does not going in deep according this way. The Author noticed in [49] various historical sources confirming an eventual visual cognition of such a depiction by Kekulé, but in [73] he also states that there is no reliable evidences of say this. Nevertheless, after the publication of [49], the Author received some comments on his paper, through which he known two new Kekulé's life episodes that, according to him, should have confirmed a visual cognition of the Ouroboros by Kekulé.

The first comment concerned the already mentioned paper [25] not previous known to Mahdihassan, in which is narrated the above mentioned fact related to the jewel theft of the Countess Görlitz, whereas the second came from an indirect story told by a pupil of Kekulé according to which him was walking in Ghent

(in the year 1864) thinking about some problems related to the Benzene structure, until he was found to be in front of a drugging's shop on the door of which was drawn a figure similar to an Ouroboros; furthermore, Mahdihassan dwells to tell other particularities of this indirect story, concerning the Eastern European sources of the Kekulé's family and on a presumed belief according to which Eastern European are believed to be more imaginative than Western ones, very little relevant in our opinion.

In any case, even admitting the existence of a certain confusion between the above mentioned Kekulé's dream experiences, we however think that almost one of these dreaming experience has took really place, also according to the fundamental historical work of A.J. Rocke (as already said, one of the main scholar of this historical problem), and, if so, then, from the following considerations, it must be related to the Benzene structure problem and not to the general structure theory of organic compounds (as said in the first dreaming experience).

Our interpretation of the Kekulé's dream is therefore as follows. First, following [77, Parte Prima, A, Cap. 1], the unconscious contents does not communicate by means of the usual Aristotle Logic but symbolically and following another Logic (the Logic of Unconscious – see the studies of I. Matte Blanco): for instance, a certain group of symbols may stand to indicate, by analogy and/or free association, a certain rational content or object otherwise unrepresentable. Therefore, the main and, in a certain sense, unique way with which the unconscious does expresses, is the symbolic one. From what has been said in section 2, it is out of doubt that the premature 1863 childbirth death of the beloved first Kekulé's wife was a very traumatic event for all the rest of his life, considering his sensible character. As said, he took care of their son Stéphan in a very loving manner, trying to do in such a way he had everything.

But there was also another almost concomitant traumatic event in the Kekulé's life (already mentioned in section 2), the murder of the Countess Görlitz (which had no children and a bad character) to whom he couldn't provide help because of an unmotivated his father prohibition (which besides will die in the same year). Nevertheless, he was an active witness of the relative 1850 judicial process against the murderer, her personal servant-man John Stauff, and hence he was aware of all the judicial hearings and trial records. To this point, it is needful to describe some of the main psychological characteristics of the personality of John Stauff that emerged from the trial. We follow the very detailed story told in [24], from which are drew the major part of what said about this strange history.

According to [24], the personal Countess' servant-man John Stauff mainly grew up with his father Henry, a knife-grinder and sold knives since the death of his wife (nevertheless occurred when John was already mature), and with the remaining two sisters (one yet in America) and another major brother Jacob (who was a military); his father and his brother were subsequently also accused of support to the jewelry theft by John Stauff. He had entered in the Grand Ducal Army servant service in 1844 and in 1846 he become servant in the Görlitz family, getting their confidence. But, curiously enough, in the autumn of 1846, he had expressed a wish to a chambermaid of the Countess 'because both the Countess and her pack of jewels, bracelets and all, might be burnt in one heap', like he already had an unconsciously presentiment of what that effectively will happen. This fact was confirmed too by the trial account of a Görlitz house maid. It was also referred that he was apparently religious whilst accompanied himself with women of bad character and was also deep in debt. At this point, during the trial, it is indispensable to report what said in [24], according to which

«Throughout the trial, he maintained his composure, his lips closed, his color pale, without token of agitation. But the man who could have stood by without showing emotion at the opening of the coffin of his 'mistress', at the sight of the half-burnt, half-decomposed remains of his victim, must have had powers of self-control of no ordinary description. During the trial he seemed determined to show that he was a man of some culture; he exhibited ease of manner and courtesy towards judges, jury, and lawyers. He never interrupted a witness, and when he questioned them, did so with intelligence and moderation. He often looked at the public, especially the women, who attended in great numbers, watching the effect of the evidence on their minds. But, when, as now and then happened, some ludicrous incident occurred, he laughed over it as heartily as the most innocent looker-on».

By this description clearly emerges a very difficult capacity of relationship with the female. John Stauff was imprisoned and subsequently tried the Count forgiveness, giving a self-styled spontaneous confession (see [24]) to obtain a reduction of the sentence years. For our purposes, it is important to notice the following particular of the confession: precisely, after he have reconstructed the murder scene, finally he planned what will have to do after the Countess killing, saying that

«In the meantime, I had been considering what to do, and had formed my plan. Now my opportunity had arrived, and I hastened to put it into execution. My plan was to efface every trace of my deed by fire, and 'to commit suicide' if interrupted».

Nevertheless, nothing can be said about the trueness of his confession (very likely false) which seems however constructed with the intention to prove his not premeditation, and in fact he was able to obtain a free pardon after twenty-five years of incarceration. He went to one of his sister in America. From what has been said above, it is likely to suppose that he had never said the real truth (see for instance the complicity between Henry Stauff and his son John, after the latter was prisoner, in inventing false but plausible accounts of their previous conducts, the false specious request of forgiveness by the Count, etc). Further, it is noteworthy recall the superb behaviour of the Countess which always flaunt her superiority (both social and economic – see [24]) with respect to his husband; she, moreover, was very vain, miserly and often looked over her jewelry to whom she kept so much, so that we can metaphorically say that she symbolically represented the 'terrible mother aspects to whom it was very difficult to conquer her own treasure' (according the Neumannian theory of consciousness development).

As already said in section 2, first it was accused her husband of the murder even because their relationships were bad and because he had also been nominated her unique heir by the same Countess. Subsequently, it was arrested their servant-man John Stauff because he had attempted to poison the widower Count Görlitz too through verdigris; this last event besides was discovered by a maid of Görlitz house. In the same period, another scandal jumped to the forefront of the crime news, precisely the fact that in France, the Duke of Praslin had murdered his wife and when he was about to be arrested the duke had poisoned himself, so that also this almost similar event was known to the collectivity and perhaps captiously exploited by John Stauff. The defendant testified at the trial saying that, about a week later the murder, the jewelry found to his father were promised to him by the same Count because suspected of the murder of the Countess; these were hence taken over by John and hidden into a stocking, hence he instructed his brother Jacob to take and give them to the father.

In particular, for our purposes, it is also important to observe some behaviours by John Stauff emerged from what said above. First, he had care to remove the bell-rope in the Countess' parlour (the bell-rope form resembles that of a vase, a clear female symbol – see [78, Cap. 4]) and, second, during the judicial process, he have had mainly care only to see continuously the female audience present in courtroom, as just said above. Moreover, it was established that the Countess Görlitz had been first attacked in her room, and, after a desperate struggle which went on in both parlour and boudoir, she had been first stunned with headshots, then strangled – very likely in the later afternoon of June, 13 1847 – and after robbed of her jewelry; subsequently, her servant-man tried to set fire the body of the Countess (maybe, not fully dead), producing a house fire. From our point of view, than the one just said, the subsequent attempts of poisoning (by means of verdigris) of the Count Görlitz, can shed light on some possible predominant unconscious motivations of this murder by John Stauff. Just the poisoning through verdigris symbolically means the return to the ouroboric state because, as seen, this is the alchemical meaning given to this chemical mixture (see the previous section).

From these few but meaningful information, it is likely that John Stauff had developed a negative form of the Œdipus complex (see [87]) in which the child feels love for the parent of the same sex and jealous hate for the parent of opposite sex; further, it is also conceivable that he be lived in a family with a predominant patriarchal principle. The women, as seen, have played a fundamental role in the life of John Stauff even if it is almost surely that he does not had a very good relationship with them, or rather with the good mother aspects.

However, we may to presume that the most of these information, from the contingent viewpoint, were known to Kekulé because, as already said, he taken active part to the trial with deep emotional involvement (even seen his young age at the time of the events), and also because the tragic event aroused deep sensation in Germany at that time. On the other hand, as said in [19] and in the above section 3, the second and most important dreaming experience took place in Ghent about 1864, very likely in a later afternoon or in the first evening, when Kekulé was writing, in an almost darkened room, parts of his celebrated *Lehrbuch der Organischen Chemie*, stating that his work did not progress because his thought was elsewhere. We remember that, almost in the same period, Kekulé tragically lost his beloved first wife and that he was forced to take care alone of their son Stéphan, onerous task that however Kekulé achieved with loving care and devotion, concentrating in himself both the matriarchal and patriarchal contributions to provide for his psychic development.

It is also possible to infer as Kekulé ever remained emotionally tied to the memory of his beloved Stéphanie Drory because his second 1876 marriage, which turned out to be a ruin, was just with their first housekeeper, and this fact, from our viewpoint, seems to reflect the fact that he wanted, in a some manner, to stay linked to that first affective situation tragically interrupted. From 1876 onwards, for various reasons (see section 3), the Kekulé life was a continuous and gradual worsening, this also testifying the very poor subsequent scientific production of the same Kekulé. At this point, retaking the above mentioned Ghent dreaming experience in which Kekulé wasn't able to continue in his work since his mind was elsewhere – we say that he thought to his wife – he turned toward the fireplace to meditate watching the fire burning until fell asleep while, very likely, his son Stéphan was with him; it is said that were already night. It was just during this short period of sleep that Kekulé had his celebrated whirling Ouroboros dream.

Therefore, if we admit that Kekulé was working on Benzene structure theory, then, taking into account what has been said in the preceding sections, one of the most plausible historical explanation of the Kekulé dream may be as follows, according to the Jungian *amplificatio* interpretation method (see [86]). Probably, the particular emotive situation in which Kekulé was in that moment [his thought toward his wife and their just born son] and the mediation in the light of the burning fire of fireplace [which remember to him the tragic end, also occurred in a 1847 evening, of the Countess Görlitz, and related subsequent known events and news] were at the basis of the latent content of his dream. Besides, the just mentioned particular emotive situation in which Kekulé could be, is confirmed by a careful Leslie Willson translation of the German paper [18] (see [47]) from which it results that Kekulé exactly stated that «turned the chair to face the fireplace and slipped into a languorous state».

Rather, as observed by [86], a man who have tragically lost a very dear person, can feel certain remorse and (œdipus) guilt sentiments for what happened, especially when this lost person is the own wife during a childbirth since the father felt himself called into question because coparticipant of the pregnancy act; further, in the latter situation, the father can also feel certain castration sentiments as a consequence of the positive form of the Freudian Œdipus complex (see [87]) which surely Kekulé overcame. These sentiments of guilt and remorse (as confirmed by J. Le Soldat), besides may be put into association with the same ones felt by Kekulé for no having try to lend first aids to the Countess Görlitz accident. The two main events thus characterizing this Kekulé's dream are the emotionally conscious reminiscence of the childbirth death of his first wife and the unconscious emersion of the murder of the Countess Görlitz, which have been freely associated during the Kekulé's look of the burning fireplace (evoking the house fire of the Countess Görlitz, occurred in a day time almost equal to that of this dreaming experience).

Both events have many common elements relatively to one of their possible Jungian psychoanalytic interpretations. Indeed, on the one hand we have the murder of a female (the Countess Görlitz) by her son-lover (the servant John Stauff) at the peak of his negative form of the Freudian Œdipus complex which must be reinterpreted, following [77, Parte I, B., Cap. 2], in Jungian-Neumannian sense as the Killing of the Mother which is one of the main aspect of the Hero's Fight Myth: the son born from the division of the undifferentiated Ouroboros into the dual pair formed by the primordial parents, towards the development of his consciousness, and combatting against these two opposite ouroboric poles (the Fight against the Dragon, that is to say, the relationships with parental images, to conquer his/her own psychological autonomy), that is, against the primordial parents in which assume an important symbolic meaning first the Killing of the Mother (from which follows the patriarchy) and the next Killing of the Father (from which follows the matriarchy).

The first one precedes the second one and it represents the overcoming of the libido inertia symbolized by the maternal dragon (the unconscious), through which the son will have his masculinity character; in general, there is a great, innate fear of the male regards the female, or else, of the Animus with respect to the Anima. Along this hard battle, there is an unavoidable fear of the Dragon, that is to say, the fear of the male in front of the aggressive and destructive aspects of the Great Mother female archetype (Terrible Mother, or else the Gorgon with her hundred snakes) which can be overcoming only with a matriarchal incest (positive aspect of the Freudian Œdipus complex) with the Terrible Mother. As the same E. Neumann says (see [77, Parte I, B, Cap. 2, p. 146]), the aggressive and destructive elements of the Great Mother can be also appear in symbolisms and rites disjoint from it and translated into single figures like servants (see the servant-man John Stauff), priests, animals, and so on. The Great Mother and, in general, the female, is synonymous of unconscious as well as threat of castration and death for the male.

The Terrible Mother is the archetypical symbol of the destructive character of the Great Mother, all the dangerous affects and instincts being her productions; it denotes the castrating and negative characters (matriarchal castration) against which our Hero must combat for conquering its autonomy from the ouroboric

state, reappropriating of the positive and benevolent aspects of the Great Mother. Following [77, Parte I, B, Cap. 2, pp. 155-156], there exists a particular phase in the history of humanity which is lived as a real drama: it is the primitive myth intermediate between the Great Mother epoch and the Fight amongst the Dragon stage whose historical protagonist is the won Œdipus and not the Œdipus Hero whom history is that tragically represented by the Æschylus' Oresteia tragedy for Orestes or by the Perseo or Heracles mythes. The main argument is the win of the son that kills the mother to avenge the father which together will introduce the patriarchy against the matriarchy.

Therefore, it is evident as the murder of the Countess Görlitz may be symbolically considered as the killing of the Terrible Mother by the son-lover John Stauff to avoid the castration, whereas the death of the first beloved Kekulé's wife due to the birth of their son Stephan symbolically correspond to the killing of the Good Mother by the son for giving to him the life; further, correspondingly, we have a first castration anxiety sense due to a negative form of the Freudian Œdipus complex by John Stauff (the won Œdipus) as consequence of the Terrible Mother threats (that will be killed) and a subsequent castration anxiety sense due to a positive form of the Freudian Œdipus complex by Kekulé (the winner Œdipus) who first believed himself unconsciously co-responsible of his beloved wife death (corresponding to the Good Mother). Once having achieved the Killing of the Mother, the Hero must continue his Fight against the Dragon to conquest the Princess and her Treasure, entering on the next phase corresponding to the Killing of the Father in order to can birth his autonomous consciousness and to avoid the patriarchal castration (behind which there is the devouring power of the Ouroboros – see [77, Parte prima, B, Cap. 3]). The fight against the primordial parents must be intended in the transpersonal sense, that is to say, their images must be intended in transpersonal sense and can be equipped with a strong power unconscious action, even if the real parents also play a certain consistent role in guiding this symbolic action.

Further, we can substantially to identify various types of Jungian *coniunctio oppositorum* between two opposite archetypal complexes, because, than that just above described, it is possible considering other opposite or polar pair, as, for instance, the following one. In fact, on the one hand, we have the history of the consciousness development of John Stauff, by him symbolically (or transpersonally) lived, whose fight against the dragon begins with the killing of the mother (the Countess Görlitz) and the subsequent killing of the father (the attempted verdigris poisoning of the Count Görlitz which however remained alive surely without strong guilt senses for the death of the Countess) till the conquer of the treasure (the stolen jewelry) with final dead of the son (the imprisonment of John Stauff and his expected suicide in case of failure – see the above citations), whereas, on the other hand, we have the birth of the son (the Kekulé's son Stéphan) with the killing of the mother (the dead of Kekulé's wife Stéphanie Drory) by the living father (the Kekulé's guilt sense, coparticipant of the childbirth dead).

Therefore, respectively, on the one hand we have the subsequent death and burning of the terrible mother (the Countess Görlitz) by the patriarchal son-lover with a negative form of the Freudian Œdipus complex (John Stauff) which during the attempts to kill the father (the verdigris poisoning attempt of the Count Görlitz) himself will death (his imprisonment) with definite departure from the father (the Count Görlitz), whereas, on the other hand, we have the initial death of the good mother (the beloved Stéphanie Drory), to give live to her son, by the matriarchal father with a positive form of the Freudian Œdipus complex (the creative, romantic and soulful spirit of Kekulé necessarily is of matriarchal type or, however, with a strong component of it) which will take care of him, does not ever separating from him.

The fire plays an important symbolic role as well because, following [78, Cap. 14], it essentially denotes the luminous male-son principle experienced by the female-mother in which it is concealed and that it is put in movement only by the male, emerging to set up the patriarchal principle; hence, we have a correlation between fire and son (belonging to the *hiéros gámos* archetype), the son-sun as well as a correlation between the night and the mother, the mother-moon. Such a luminous principle can arise into two forms, a good one as high light and a bad one as fire, even if the male will remain ever depending by the female (from here, the general male aggressiveness). The latter may be appear as a diabolic and devastating instance, and the emersion of the son-sun from the mother-moon will become a conflict between patriarchy and matriarchy, between sun and moon in which the first is the death and the second the life. This implies the mythological death marriage between sun and moon: the dying moon escapes hiding towards the underworld, whereas the sun, as negative male principle, ravishes the female raping and killing her.

The birth of the son is the result of this death marriage in which the patriarchal Ouroboros is joined with the female. From what has been said about John Stauff, it has emerged that he already had unconsciously planned this tragic event for instance when he wanted a personal female servant for the Countess to avoid a burning of herself and her jewelry. It seems therefore that John Stauff had never been born because this life

conduct, initially irreproachable when his mother was alive – as said in [24], John Stauff was a skilled, religious and disciplined schoolboy – and that, after his death, it is like if he had lost any live reference except that of his patriarchal father. He lived in the pleromatic phase (see [77, Parte Prima, A, Cap. 1]), in the maternal Ouroboros, from which it emerges the Ego as embryonic germ under its dominance but having a certain degree of autonomous existence with a substantial good great mother character; the process of emancipation of the Ego from the unconscious ouroboric state is a traumatic, burdensome and painful exceptional experience but which must be overcome.

After the death of his mother, he remains alone in the world, maybe he unconsciously considers this event as a voluntary abandonment by his mother (on the other hand, his immature character was highlighted by the final part of the above first citation drawn from [24]), remaining at the mercy of the destructive patriarchal forces. Therefore, having never left the maternal Ouroboros, he wanted symbolically to be reborn, to redevelop his consciousness in transpersonal way through the Görlitz family (and having as unique parental reference the paternal patriarchal one), starting from the related fight against the dragon first with the killing of the mother (the Countess), then with the killing of the father (the Count) till the conquest of the treasure (the jewel stolen), establishing the negative patriarchy principle (with the burning); but this fight has not been won by the hero, because the killing of the father has failed (the failed Count poisoning with the verdigris, discovered by a female servant) leading to the death of the hero (the imprisonment, with an expected suicide), hence returning to the maternal ouroboric state (from which he failed to emerge), this last aspect, on the other hand, being in part confirmed by the fact that he went to one of his sisters in America after he will be released.

Therefore, he wants to be reborn but symbolically dies in spite of his real father were alive, having lost his fight against the dragon. The Kekulé's guilt thinking to the loss of his wife giving birth to his son and felt by him in an evening in front of the burning fireplace, is unconsciously associated with the same guilt felt by Kekulé as concerns the tragic evening end of the Countess Görlitz in which also symbolically took place the death of a son already born dead (John Stauff) which will want to be reborn at the mercy of the destructive patriarchal father. This last interpretation full of opposite aspects clearly leads to a *coniunctio oppositorum* in turn leads to the maternal Ouroboros, from which followed the related Kekulé's dream. Hence, this hoped self-regeneration, or rebirth, of the hero (John Stauff) has been symbolically concluded in the Kekulé's unconscious by means of the association of the patriarchal hero death with the matriarchal birth of his own son Stéphan by the death of his beloved wife which will re-establish the transformation process towards the psychic autonomy. Finally, we recall as the concept of opposite pair also plays an important analogous role in the Freudian theory with the concept of *ambivalence* (see [87]) which explain, amongst other, as the same Oedipus conflict has such an ambivalent nature.

Thus, in the Kekulé's unconscious have been freely associated two almost concomitant events one opposed to the other (*coniunctio oppositorum*), the death of the patriarchal son (John Stauff) and the birth of the matriarchal son (Stéphan Kekulé); both events took place in the evening when the moon appears and the sun sets, at the light of the burning fire. In other words, both these events symbolize the return to the maternal ouroboric state, in which the cycle of life ends and begins; from here, the ouroboric symbol dreamed by Kekulé. Hence, both these cases are one opposable to the other, giving rise to a *coniunctio oppositorum*, as the same Jung said (in [82]) about the interpretation of the Kekulé's insight but without explain the nature of this polar pair.

Concluding, hence, all the possible above interpretations substantially lead to a *coniunctio oppositorum* related to the initial female archetype of the unconscious Great Mother, symbolically just represented by the maternal Ouroboros, or else the return to the maternal ouroboric state, whose one of the main aspects (see [78, Cap. 3]) is its transformation character (in Kekulé's dream corresponding to the whirling continuous rotation of his celebrated tail-eating snake), or, finally, to the ambivalence connate to the Oedipus complex nature (the won Oedipus against the winner Oedipus). Therefore, this Kekulé's *coniunctio oppositorum* dreaming experience (in the Jungian-Neumannian sense) must be interpreted as a creative form of relationship with unconscious material archetypically structured, which can be consciously acquired in symbolic manner only.

In this case, the ouroboric symbol stands for the set of the inseparable and opposite two Kekulé's resonance formulas (see Figure 3) which yet does not explain in a complete manner the real nature of the Benzene electronic structure (as will be known later from the rigorous quantum mechanics treatment of this resonance problem), as, on the other hand, it must be since such an ouroboric hybrid (of resonance) essentially represents an unconscious archetypal content, hence per se exactly incognizable but only approximately symbolizing; thus, the right hand side of Figure 4 is just a modern chemical symbolic denoting the

Ouroboros, or else one of its possible representation, whereas the two formulas on the left hand side denote the two opposite aspects in *coniunctio oppositorum*.

On the other hand, as is known, the real exact structural representation of the Benzene electronic configuration is formally described only in terms of hybrids of resonance, that is to say, through mathematical entities which give only approximate quantum mechanics knowledge (besides, the orbital molecular and valence bond theories as well-known approximate methods which historically have had important contributions just from the study of this structural problem), coherently with the archetypical nature of the Ouroboros (whose origins, we repeat, are alchemical – see [77] and [78]).

6. Conclusions

It is evident as the social context may also mystify the history of scientific realities and institutions (see [88] and [89]) and one of this case is just that treated in this paper. It is known as one of the main assignment and validation tool of the *eponymy* (which is opposed to the sociological concept of *anomy* in the sense of R.K. Merton and S. Stigler) is given by certain synchronic social-cultural selection circuits regulated by more or less objective and conscious particular rules of the time (concerning the sociology of cultural institutions – see [88] and also [89]), among which the authority, the leadership and the various charismatic aspects of the presumed Authors of a given discovery or invention, neglecting others who may have also had a fundamental (if not equal or major) role to reach it; a simply corollary of this is the so-called *Matthew effect* due to R.K. Merton (see [90, 91]).

One of the main task of the History of Science is just try to put diachronically remedy to such unjust misunderstandings, ‘giving to Cæsar what who is of Cæsar and to God what who is of God’, when possible, and the main motivation of this paper is just of this spirit as regards a particular case-study. In fact, the Kekulé insight has also been considered from the social-cultural context viewpoint because, as the same Kekulé said (see [19]), «in a given historical period certain ideas are in the air», that is to say, the times are in a certain sense ‘mature’ to make a discovery or an invention, according to the so-called *naturalistic* point of view of the History of Science (see [92]) and also according to a modern cognitive psychology trend named *extended or collective cognition* (see [93]). Hence, as regards the case-study here considered, in a certain sense it might have been true that the general academic and scientific leadership and authority of the Kekulé’s personality (see [25]) have constituted the reasons of why the hexagonal benzene structure was attributed to him and not to others, if this were the historical reality.

Instead, we have tried to prove as the real historical question did not regard the hexagonal Benzene structure, which we have seen to be known to many Kekulé’s predecessor and contemporaneous chemists, but the prodromal phase concerning the so-called *electronic delocalization* problem (said in modern terms), by means of a psychoanalytic reinterpretation of what is known about the Kekulé’s life, in a sufficiently objective way (see [18] and its English translations [19] and [20]; see also [22]): in few words, we want to prove as the Kekulé’s work on Benzene structure theory should be intended as *prolegomena* to the fundamental notion of resonance rather than to the discovery of its annular structure, and in this Kekulé was really the first author to introduce such a concept.

We have also seen that the use of psychoanalytic tools are indispensable as historiographical methods in certain historic reconstructions, and that considered in this paper is just one of this case-study. It follows a non-existence of any riddle about the Kekulé work but only a mere historiographical insufficiency as concerns the historical analyses conducted on this case. In this paper, we have in particular followed the basic work of Erich Neumann on the historical development of the human consciousness: his fundamental work [78], as witnessed by the Preface of C.G. Jung to it, is centered on *matriarchal symbolism* whose main mythologem is that of the *Ouroboros*, so that it seemed to us appropriate to consider, also from the epistemological viewpoint, as his work were the most suitable to explain the Kekulé’s insight just based on this mythological symbol.

The Jungian interpretation of the Kekulé’s dream we think to be most adapt because the same C.G. Jung was one of the main proponents (together with the known physicist W. Pauli) of the fundamental role played by the mythology in the scientific development (in this case, of the Alchemy in the development of Chemistry, that have occupied the scene until the end of the 18th-century and played a very fundamental epistemological role in the foundation of the Jungian psychology). Furthermore, the particular case-study here considered shows as very close are the relations between unconscious structures (in this case, the archetypical ones) and certain fundamental quantum mechanics concepts (in this case, the birth of the modern quantum chemistry concept of resonance from the Kekulé’s formulas), a way already glimpsed by

John Von Neumann (see, for instance, his concept of *collapse* of the wave function of a given quantum system with the consciousness of the observer).

Thus, having put into a more right historical framework this unmotivated *querelle* about the Kekulé's insight, which we consider historically very likely but related to another important chemical concept different from that concerning the circular Benzene structure, it is possible to re-evaluate the Kekulé's contributions also to the psychology of creativity through his personal testimonies which had been destitute of foundation if it were accepted the various criticisms of specious falsity and misconduct by Kekulé on this question (whose good faith has been perorated by Rocke). In particular, according to [39], it follows that Kekulé was a visionary, a researcher for which sudden insights, with a strong emotional-sentimental content, constituted a basic structural element of his creativity mind, whose contents must be, however, subsequently subject to rational examination.

On the other hand, the same Kekulé's testimonies (see [19]) may be also considered as a link-point between the so-called *naturalistic* and *personalistic* viewpoints in the History of Science (see [92]) which should be considered as inseparable each other. Indeed, when himself said that «the human being, it seems clear, is the product of the conditions in which he grew up and no merits accrues to him for what he becomes», he means that it is indispensable the role played by the social-cultural institutions in the psychological formation of a human being (naturalistic component), whereas the same his own case here studied shows the presence of a personalistic component as well. In fact, we have seen as the hexagonal structure of the Benzene was somehow known to many chemists of the time (naturalistic view) but he was also the first to put his attention to a physical-chemical problem never treated before (even remotely), namely that of the electronic delocalization, as we have here tried to prove.

7. References

- [1] A. Kekulé, Über die sogenannten gepaarten Verbindungen und die Theorie der mehratomigen Radicale, *Justus Liebig Annalen der Chemie und Pharmacie*, 104 (2) (1857) pp. 129-150.
- [2] A. Kekulé, “Über die Constitution und die Metamorphosen der chemischen Verbindungen und über die chemische Natur des Kohlenstoffs”, *Justus Liebig Annalen der Chemie und Pharmacie*, 106 (2) (1858) pp. 129-159.
- [3] A. S. Couper, “Sur une nouvelle théorie chimique”, *Annales de Chimie et de Physique*, 53 (3) (1858) pp. 469-489.
- [4] E. Stocchi, C. Mesiani, *Chimica Organica Razionale*, Casa Editrice La Prora, Milano, 1969.
- [5] A. Kekulé, “Untersuchungen über organische Säuren”, *Justus Liebig Annalen der Chemie und Pharmacie*, 119 (1) (1861) pp. 129-138 und pp. 338-380, 120 (2) (1863) pp. 85-116.
- [6] A. Kekulé, “Sur la constitution des substances aromatiques”, *Bulletin de la Société Chimique de Paris*, 3 (2) (1865) pp. 98-110.
- [7] A. Kekulé, “Note sur quelques produits de substitution de la benzene”, *Bulletin de l'Académie Royale de Belgique Cl. Sc.*, 19 (1865) pp. 551-563.
- [8] A. Kekulé, “Untersuchungen über Aromatische Verbindungen”, *Justus Liebig Annalen der Chemie und Pharmacie*, 137 (2) (1866) pp. 129-196.
- [9] A. Kekulé, “Über einige Condensationsproducte des Aldehyds”, *Justus Liebig Annalen der Chemie und Pharmacie*, 162 (1872) pp. 77-124.
- [10] W.H. Brock, “August Kekulé (1829-1896): Theoretical Chemist”, *Endeavour*, 20 (3) (1996) pp. 121-125.
- [11] J.C. Slater, *Quantum Theory of Matter*, McGraw-Hill Book Company, Inc., New York, 1968 (Italian Translation, *Teoria Quantistica della Materia*, Zanichelli Editore, Bologna, 1980).

- [12] F. Longo, *General Chemistry*, McGraw-Hill Book Company, Inc., New York, 1974 (Italian Translation, *Chimica Generale*, Piccin Nuova Libreria, Padova, 1978).
- [13] H. Hartmann, “The Formula of Benzene. A Short History of the Problem”, *Angewandte Chemie*, 4 (9) (1965) pp. 729-798.
- [14] B. Tollens, R. Fittig, “Über die Synthese der Kohlenwasserstoffe der Benzolreihe”, *Justus Liebig Annalen der Chemie und Pharmacie*, 131 (3) (1864) pp. 303-323.
- [15] W.G. Palmer, *A History of the Concept of Valency to 1930*, Cambridge University Press, Cambridge, UK, 1965.
- [16] R. Zingales, “Nascita ed evoluzione del linguaggio chimico”, *Quaderni di Ricerca in Didattica (Science)*, G.R.I.M. (Department of Mathematics, University of Palermo, Italy), 1 (2010) pp. 61-84
- [17] L.C. Pauling, “Kekulé and the Chemical Bond”, in: *Theoretical Organic Chemistry*, Kekulé Symposium organized by the Chemical Society and IUPAC (Section of Organic Chemistry) – 1858, Butterworths Scientific Publishers, London, 1959.
- [18] A. Kekulé, “Benzolfest: Rede”, *Berichte der Deutschen Chemischen Gesellschaft*, 23 (1) (1890) pp. 1302-1311.
- [19] O. T. Benfey, “August Kekulé and the Birth of the Structural Theory of Organic Chemistry in 1858”, *Journal of Chemical Education*, 35 (1) (1958) pp. 21-23.
- [20] F.R. Japp, “Kekulé Memorial Lecture”, *Journal of the Chemical Society (Transactions)*, 73 (1898) pp. 97-138.
- [21] J. Gillis, “Auguste Kekulé et son œuvre, réalisée a Gand de 1858 a 1867”, *Memoires de l'Academie Royale de Belgique*, 37 (1) (1866), pp. 1-40.
- [22] R. Anschütz, *August Kekulé*, Band 1: Leben und Wirken, Band 2: Abhandlungen, Berichte, Kritiken, Artikel, Reden, Verlag Chemie, G.M.B.H., Berlin, 1929.
- [23] B. Vanderbilt, “Kekulé’s Whirling Snake: Fact or Fiction?”, *Journal of Chemical Education*, 52 (11) (1975) p. 709.
- [24] S. Baring Gould, *Historic Oddities and Strange Events*, Methuen and Company Publisher, Ltd., London, 1891.
- [25] P.E. Verkard, “August Kekulé”, in: *Theoretical Organic Chemistry*, Kekulé Symposium organized by the Chemical Society and IUPAC (Section of Organic Chemistry) – 1858, Butterworths Scientific Publishers, London, 1959. Published also in *Proceedings of the Chemical Society*, 1958, pp. 205-240.
- [26] A.J. Rocke, *Image and Reality: Kekulé, Kopp and the Scientific Imagination*, The University of Chicago Press, Chicago and London, 2010.
- [27] C. Zampi, S. Della Sala, “Il trillo del diavolo: quanto e come lavora la mente durante il sonno”, *Psicologia Contemporanea*, 188 (2005) pp. 18-23.
- [28] S. Borman, “19th-century Chemist Kekulé Charged with Scientific Misconduct”, *Chemical and Engineering News*, August 23, 1993, pp. 20-21.
- [29] A.J. Rocke, *The Quiet Revolution: Hermann Kolbe and the Science of Organic Chemistry*, The University of California Press, Berkeley & Los Angeles, 1993.

- [30] H.J. Wotiz, S.F. Rudofsky, "Was there a conspiracy when Kekulé's first German benzene-structure paper was frequently listed as published in 1865?", *Journal of Chemical Education*, 59 (1) (1982) pp. 23-24.
- [31] H.J. Wotiz, S.F. Rudofsky, "Kekulé's Dreams: Fact or Fiction", *Chemistry in Britain*, 20 (1984) pp. 720-723.
- [32] C. deMilt, "Auguste Laurent, Founder of Modern Organic Chemistry", *Chymia*, 4 (1953) pp. 85-114.
- [33] A. Laurent, *Méthode de Chimie*, (publié posthume par Jean-Baptiste Biot.), Imprimerie de MalletBachelier, Paris, 1854.
- [34] S.F. Rudofsky, H.J. Wotiz, "Psychologists and the Dream Account of August Kekulé", *Ambix*, 35 (1) (1988) pp. 31-38.
- [35] H.J. Wotiz, S.F. Rudofsky, "The Unknown Kekulé", in: *Essay on the History of Organic Chemistry*, edited by J.G. Traynham, Louisiana State University Press, Baton Rouge and London, 1987, pp. 21-34.
- [36] *The Kekulé Riddle: a Challenge for Chemists and Psychologists*, edited by H.J. Wotiz, Glenview Inc. and Cache River Presses, Carbondale and Vienna, Illinois, 1993.
- [37] O.B. Ramsay, A.J. Roche, "Kekulé's Dreams: Separating the Fiction from the Fact", *Chemistry in Britain*, 20 (1984) pp. 1093-1094.
- [38] E. Farber, "Dreams and Visions in a Century of Chemistry", in: *Kekulé Centennial: A Symposium*, edited by D.T. Benfey, Washington D.C., Advances in Chemistry, Series No. 61, American Mathematical Society, 1966, Ch. 8, pp. 129-139.
- [39] H.E. Fierz-David, "August Von Kekulé's chemische Visionen", *Gesnerus*, 1 (1944) pp. 146-151.
- [40] F. Strunz, "Preconscious Mental Activity and Scientific Problem-Solving: A Critique of the Kekulé Dream Controversy", *Dreaming: Journal of the Association for the Study of Dreams*, 3 (4) (1993) pp. 281-294.
- [41] A. Kekulé, *Lehrbuch der Organischen Chemie*, Band 1, Verlag von Ferdinand Enke, Erlangen, 1859.
- [42] A. Kekulé, *Lehrbuch der Organischen Chemie*, Band 2, Verlag von Ferdinand Enke, Erlangen, 1863.
- [43] A. Kekulé, R. Anschütz, G. Schultz, *Lehrbuch der Organischen Chemie*, Band 3, Verlag von Ferdinand Enke, Stuttgart, 1882.
- [44] E.S. Lipeles, "Friedrich August Kekulé", *Journal of Chemical Education*, 58 (8) (1981) pp. 624-625.
- [45] A.D. Dayan, "The circumstances of Kekulé's "molecular dream" in London in 1854", *Bulletin for the History of Chemistry*, 31 (1) (2006) pp. 28-30.
- [46] J. Hadamard, *The Psychology of Invention in the Mathematical Field*, Princeton University Press, Princeton, New Jersey, 1945 (Italian Translation, *Psicologia dell'invenzione in campo matematico*, Raffaello Cortina Editore, Milano, 1993).
- [47] A. Rothenberg, "Creative cognitive processes in Kekulé's discovery of the structure of the Benzene molecule", *The American Journal of Psychology*, 108 (3) (1995) pp. 419-438.
- [48] M. Piattelli-Palmarini, *Scienza come Cultura. Protagonisti, Luoghi e Idee delle Scienze Contemporanee*, edizione paperback, Saggi Oscar Mondadori Editore, Milano, 1992.

- [49] S. Mahdihassan, "The probable origin of Kekulé's symbol of the benzene ring", *Scientia*, 95 (2) (1960) pp. 48-53.
- [50] J.J. Loschmidt, *Konstitutionsformeln der Organischen Chemie in graphischer Darstellung*, Wilhelm Engelmann, Leipzig, 1861.
- [51] V.M. Schelar, "Alternatives to the Kekulé Formula for Benzene: the Ladenburg Formula", in: *Kekulé Centennial: A Symposium*, edited by D.T. Benfey, Washington D.C., Advances in Chemistry, Series No. 61, American Mathematical Society, 1966, Ch. 10, pp. 163-194.
- [52] H.M. Leicester, "Kekulé, Butlerov, Markovnikov: Controversies on Chemical Structure from 1860 to 1870", in: *Kekulé Centennial: A Symposium*, edited by D.T. Benfey, Washington DC, Advances in Chemistry, Series No. 61, American Mathematical Society, 1966, Ch. 2, pp. 13-23.
- [53] A.N. Nesmejanov, N.A. Nesmejanov, *Fondamenti di Chimica Organica*, 4 voll., Edizioni Mir, Mosca, 1984-1985.
- [54] W. von Eggers Doering, "Tropylium and related Molecules", in: *Theoretical Organic Chemistry, Kekulé Symposium* organized by the Chemical Society and IUPAC (Section of Organic Chemistry) – 1858, Butterworths Scientific Publishers, London, 1959.
- [55] J.F. Labarre, F. Crasnier, "Critique of the Notion of Aromaticity", *Topics in Current Chemistry - Electronic Structure of Organic Compounds*, 24 (1971) pp. 33-54.
- [56] T. M. Krygowski, M. K. Cyrański, Z. Czarnocki, G. Häfeli, A.R. Katritzky, "Aromaticity: a Theoretical Concept of Immense Practical Importance", *Tetrahedron*, 56 (13) (2000) pp. 1783-1796.
- [57] D.P. Craig, "Aromatic Character", in: *Theoretical Organic Chemistry, Kekulé Symposium* organized by the Chemical Society and IUPAC (Section of Organic Chemistry) – 1858, Butterworths Scientific Publishers, London, 1959.
- [58] L.C. Pauling, G.W. Wheland, "The Nature of the Chemical Bond. V. The Quantum-Mechanical Calculation of the Resonance Energy of Benzene and Naphthalene and the Hydrocarbon Free Radicals", *The Journal of Chemical Physics*, 1 (1933) pp. 362-374.
- [59] L.C. Pauling, E. B. Wilson, *Introduction to Quantum Mechanics*, McGraw-Hill Book Company, Inc., New York and London, 1935 (Italian Translation, *Introduzione alla Meccanica Quantistica*, Piccin Editore, Padova, 1968).
- [60] E. Hückel, "Quantentheoretische Beiträge zum Benzolproblem. I. Die Elektronenkonfiguration des Benzols und verwandter Verbindungen", *Zeitschrift für Physik*, 70 (3/4) (1931) pp. 204-286.
- [61] E. Hückel, "Quantentheoretische Beiträge zum Benzolproblem. II. Quantentheorie der induzierten Polaritäten", *Zeitschrift für Physik*, 72 (5/6) (1931) pp. 310-337.
- [62] E. Hückel, "Quantentheoretische Beiträge zum Problem der aromatischen und ungesättigten Verbindungen. III", *Zeitschrift für Physik*, 76 (9/10) (1932) pp. 628-648.
- [63] E. Hückel, "Grundzüge der Theorie ungesättigter und aromatischer Verbindungen", *Zeitschrift für Elektrochemie und Angewandte Physikalische Chemie*, 43 (1937) pp. 752-788.
- [64] A. Karachalios, *Erich Hückel (1896-1980): From Physics to Quantum Chemistry*, Boston Studies in the Philosophy of Science, Volume 283, Springer Science Business Media, New York, 2010.
- [65] W. Heisenberg, "Mehrkörperprobleme und Resonanz in der Quantenmechanik", *Zeitschrift für Physik*, 38 (1926) pp. 411-426.

- [66] C.A. Coulson, *Valence*, Clarendon Press, Oxford UK, 1961 (Italian Translation, *La Valenza*, Zanichelli Editore, Bologna, 1964).
- [67] R. Wizinger-Aust, “August Kekulé, Leben und Werk”, in: *Kekulé und seine Benzolformel*, Berichten vorgestellt auf der Jahrestagungen von der Gesellschaft Deutscher Chemiker von 1965, Verlag Chemie, Weinheim, 1966, pp. 7-32.
- [68] S. Kikuchi, “A History of the Structural Theory of Benzene – The Aromatic Sextet Rule and Hückel’s Rule”, *Journal of Chemical Education*, 74 (2) (1997) pp. 194-201.
- [69] N.L. Allinger, M.P. Cava, D.C. De Jongh, C.R. Johnson, N.A. Lebel, C.L. Stevens, *Organic Chemistry*, Worth Publishers, Inc., New York, 1976 (Italian Translation, *Chimica Organica*, Zanichelli Editore, Bologna, 1981).
- [70] E. Cartmell, G.W.A. Fowles, *Valence and Molecular Structure*, Butterworths and Company Publishers, Ltd., London, 1966 (Italian Translation, *Valenza e struttura molecolare*, Zanichelli Editore, Bologna, 1970).
- [71] O.J. Walker, “Kekulé’s ‘sausage’ Formulæ”, *Journal of Chemical Education*, 53 (1) (1976) pp. 27-28.
- [72] H.J. Sheppard, “The Ouroboros and the Unity of Matter in Alchemy: A Study in Origins”, *Ambix*, 10 (2) (1962) pp. 83-96.
- [73] S. Mahdihassan, “Kekulé’s dream of the Ouroboros and the significance of this symbol”, *Scientia*, 96 (1), (1961) pp. 187-195.
- [74] M.L. Von Franz, *Alchemy. An Introduction to the Symbolism and the Psychology*, Inner City Books Publisher, Toronto, 1980 (Italian Translation, *Alchimia*, Bollati Boringhieri Editore, Torino, 1984).
- [75] J.M. Stillman, *The Story of Alchemy and Early Chemistry*, Dover Publications, New York, 1960.
- [76] *Alchemy and Early Modern Chemistry: papers from Ambix*, edited by A.G. Debus, Jeremy Mills Publishing, Huddersfield, UK, 2004.
- [77] E. Neumann, *Storia delle origini della coscienza*, Casa Editrice Astrolabio-Ubaldini Editore, Roma, 1978.
- [78] E. Neumann, *La grande madre. Fenomenologia delle configurazioni femminili dell'inconscio*, Casa Editrice Astrolabio-Ubaldini Editore, Roma, 1980.
- [79] C.G. Jung, *Mysterium Coniunctionis: An Inquiry Into the Separation and Synthesis of Psyche Opposites in Alchemy* (1955-56), in *Collected Papers of C.G. Jung*, Vol. XIV, Bollingen Series, 2th edition, Princeton University Press, Princeton, NJ, 1970.
- [80] W.T. Stearn, “The male and female symbols of biology”, *Taxon*, 11 (4) (1962) pp. 109-113.
- [81] H. Zwart, *Understanding Nature. Case Studies in Comparative Epistemology*, Springer Science Business Media, New York, 2008.
- [82] C.G. Jung, *Psychology and Alchemy* (1944), in *Collected Papers of C.G. Jung*, Vol. XII, Bollingen Series, 2th-edition, Princeton University Press, Princeton, NJ, 1970.
- [83] C.G. Jung, *The Practice of Psychotherapy: Essays on the Psychology of the Transference and other Subjects* (1966), in *Collected Papers of C.G. Jung*, Vol. XVI, Bollingen Series, 2th edition, Princeton University Press, Princeton, NJ, 1970.

- [84] A. Mitscherlich, “Kekulé’s Traum. Psychologische Betrachtung einer chemischen Legende”, *Psyche*, 26 (9) (1972) pp. 649-655.
- [85] J. Le Soldat, “Kekulé’s Traum. Ergänzende Betrachtungen zum ‘Benzolring’”, *Psyche*, 47 (2) (1993) pp. 180-201.
- [86] A. Carotenuto, *Trattato di Psicologia della Personalità*, Raffaello Cortina Editore, Milano, 1991.
- [87] J. Laplanche, J.B. Pontalis, *The Language of Psycho-Analysis*, The Hogarth Press Ltd. and The Institute of Psycho-Analysis, London, 1973 (Italian Edition, *Vocabolario della psicoanalisi*, 2 voll., Editori Laterza, Bari, 1973).
- [88] R. Collins, 1975, *Conflict Sociology – Toward an explanatory science*, Academic Press, Inc., New York (Italian Translation, *Sociologia*, Nicola Zanichelli Editore, Bologna, 1980).
- [89] S. Schaffer, “Making Up Discovery”, in: *Dimensions of Creativity*, edited by M.A. Boden, The MIT Press, Cambridge, Massachusetts, 1996, Ch. 2, pp. 13-51.
- [90] R.K. Merton, “The Matthew Effect in Science”, *Science*, 159 (3810) (1968) pp. 56-63.
- [91] R.K. Merton, “The Matthew Effect in Science, II”, *Isis*, 79 (1988) pp. 606-623.
- [92] D.P. Schultz, *A History of Modern Psychology*, Academic Press, New York and London, 1969 (Italian Translation, *Storia della psicologia moderna*, Giunti-Barbera, Firenze, 1974).
- [93] D. Theodore, “Was Kekulé’s Mind Brainbound? The Historiography of Chemistry and the Philosophy of Extended Cognition”, *Spontaneous Generations: A Journal for the History and Philosophy of Science*, 3 (1) (2009) pp. 158-177.

8. Figures

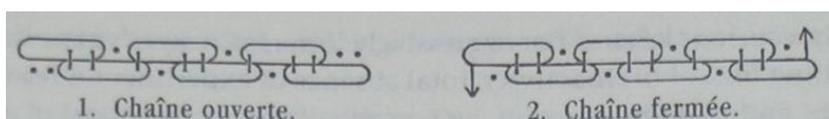


Figure 1

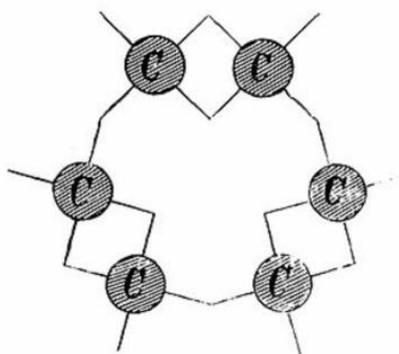


Figure 2

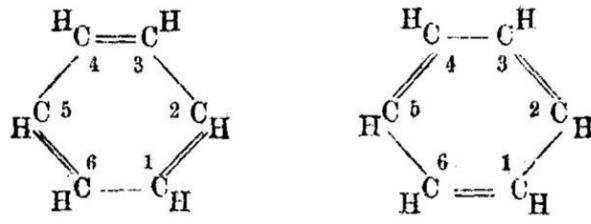


Figure 3

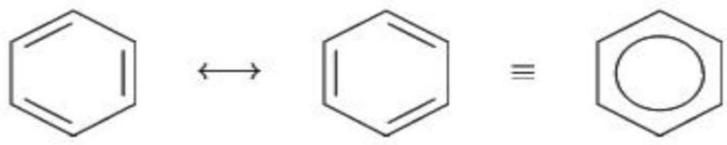


Figure 4

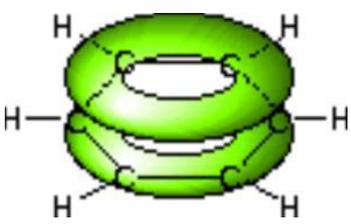


Figure 5

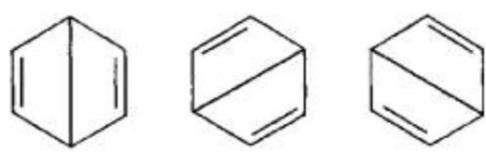


Figure 6



Figure 7