

Kekulé Escapes, Popper As Well

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“The virtue will not be taught, as little as the genius ... therefore we would be foolish to expect that our ... ethics would arise virtuous men, nobles and saints, and also that our aesthetics would arise poets, artists and musicians.”^[1] Because of this statement of Arthur Schopenhauer it is obviously also foolish to expect from our science philosophies the creation of scientists or even support for the practical scientific work. Therefore it is not astonishing, that Jerome A. Berson in his essay “Kekulé Escapes, Popper Notwithstanding”,^[2] in which he applies the theoretical guidelines of science, proposed by Sir Karl Raimund Popper, especially the falsification criterion, to the real events of the development of Kekulé’s formula of benzene, comes to the conclusion, that “the issue of whether a theory is logically testable can hardly be of great concern to the working chemist”,^[2] because a logic of science, as Popper’s, cannot be a practical guidance for the education of scientists.^[3]

Furthermore Berson shows in his argumentation, that Popper’s falsification criterion, applied to Kekulé’s formula of benzene, had led to its rejection by the community of organic chemists of the 19th century, and “much of the development of the subject in that period would have been retarded”,^[2] and he concludes, that this shows, “why we should resist attempts to force our research efforts onto this Procrustean bed”,^[2] because “the progress of chemical research cannot be reasonably expected to stand still until enough time has passed for the means finally to emerge that can test a theory by the falsification protocol.”^[2] Therefore he rejects the logic of science, attributed to Popper, especially the falsification criterion as a useless “Procrustean bed”.

However, to recognize the significance of philosophical theories and the knowledge derived from them, one must first be clear what philosophy actually can do. Schopenhauer answers this question, with the quotation: “The philosophy can nowhere do more, than to interpret and explain the existing, to bring to the clear and abstract perception of reason, the essence of the world, which *in concreto*, this is as a sense, is pronounced clearly to everybody, but this in each possible relation and from each point of view.”^[1]

However, a philosophy which will do this, had naturally to be able to describe the occurrences of an actual scientific

development. But this is exactly what Popper’s theory, in Berson’s description, apparently does not do, because there its statements are in discrepancy to the actual development. To decide if this is because of the theory or Berson’s interpretation of it, one must scrutinize in a practical way Popper’s own description:

“Early during this period I developed further my ideas about the *demarcation between scientific theories* (like Einstein’s) and *pseudoscientific theories* (like Marx’s, Freud’s, and Adler’s). ... I shall say here a few more words on the *problem of demarcation* and my solution.

- 1) As it occurred to me first, the problem of demarcation was not the problem of demarcating science from metaphysics but rather the problem of demarcating science from pseudoscience. ...
- 2) My main idea ... was this. If somebody proposed a scientific theory he should answer, ..., the question: “Under what conditions would I admit that my theory is untenable?” In other words what conceivable facts would I accept as refutations, or falsifications, of my theory?
- 3) I had been shocked by the fact that the Marxists ... and the psychoanalysts ... were able to interpret any conceivable fact as a verification of their theories. This, ..., led me to the view that only attempted refutations which did not succeed *qua* refutations should count as “verifications”.
- 4) I still uphold (2). But when a little later I tentatively introduced the idea of *falsifiability ... of a theory as a criterion of demarcation*, I ... found that every theory can be “immunized” ... If we allow such immunization, then every theory becomes unfalsifiable. Thus we must exclude at least some immunizations.

On the other hand, I also realized that we must not exclude all immunizations, not even all which introduced *ad-hoc* auxiliary hypothesis. For example the observed motion of Uranus might have been regarded as a falsification of Newton’s theory. Instead the auxiliary hypothesis of an outer planet was introduced *ad-hoc*, thus immunizing the theory. This turned out to be fortunate; for the auxiliary hypothesis was a testable one, ..., and it stood up to tests successfully. ...

In spite of the fact that all this was clearly stated in my *Logik der Forschung* ... a number of legends were propagated about my views.^[4] First, that I had introduced falsifiability as a meaning criterion rather than as a criterion of demarcation. Secondly, that I had not seen that immunization was always possible, and ... [that] therefore ... none [theory] could simply

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be described as “falsifiable”. In other words my own results were, in these legends, turned into reasons for rejecting my approach.”^[5, 6]

So Berson’s description of Popper’s philosophy must be corrected in three points. 1) As a philosophy Popper’s logic of science is not to be understood as a concrete guideline,^[3] but serves as all sciences as a description of the “essence of the world”.^[1] 2) The falsification criterion is contrary to the legend, by which Berson was taken in, not the fundamental characteristic (criterion of meaning) of science in Popper’s mind, but serves merely to its demarcation from pseudo-science.^[7] 3) A *fundamental* prohibition of the ad-hoc rescue of falsified theories, as it is stated by Berson, belongs also to the sphere of the legend and not to the structure of Popper’s thoughts.^[7]

As the falsification criterion cannot be seen as the central point of Popper’s theory, the revised version of Popper’s philosophy, gives special emphasis to the statement quoted by Berson, “that progress can be made only by a series of conjectures and refutations.”^[2] Popper illustrates this central point of his theory using a “four step scheme, that is characteristic for the science theory.”^[8] and that “appears in the following way: 1) *The older problem*; 2) *conjectural formation of theories*; 3) *attempts to their elimination* by critical discussion, including experimental test; 4) *the new problems*, which arise from the critical discussion of our theories.”

In the confrontation with the development of Kekulé’s formula of benzene, Popper’s revised logic has now to show, if it is in agreement with the real occurrences of the 19th century. These events are, in terms of the above scheme, as follows: 1) the *older problem*: The proposition of an appropriate chemical formula for benzene; 2) *conjectural formation of theories*: The description of benzene as 1,3,5-cyclohexatriene. The next step:

3) *attempts to their elimination* through critical discussion and experimental tests, is the critical point in Popper’s scheme, and therefore it needs a more detailed explanation. The experimental results obtained during the scrutiny of Kekulé’s hypothesis, show, because of the absence of the expected two *ortho* isomers, that the proposed structure represents only a very inexact approximation of the reality, and that therefore, the assumption benzene might be 1,3,5-cyclohexatriene, should be eliminated from the canon of the valid theories of organic chemistry. On account of this “falsification”,^[9] Ladenburg proposed his prism structure, which Berson points out, according to the state of the art of that time “does not suffer this deficiency” (the missing two *ortho* isomers).^[2, 10]

In agreement with Popper’s logic of science, Kekulé tries to immunize his structure proposal. Popper says on this score: “... often even a real scientist will try to defend a theory ... against attempts of falsification. From the point of view of science theory this is absolutely welcome; because how could we otherwise distinguish between *real* falsifications and *apparent* falsifications?”^[11]

On this occasion, as Berson emphasizes, Kekulé abstains to “bring into play ... escape mechanisms as the possibility that the properties of the two isomers called by his original theory

were so similar that the compounds were experimentally indistinguishable,”^[2] and also on the remark, that “one could not be sure that further isomers might not be found sometime in the future.”^[2] These immunizations would escape the experimental test and would be, according to Popper, forbidden.

Instead of this approach Kekulé proposes, to rescue his formula of benzene, “a completely new and unprecedented hypothesis which significantly modified his theory”,^[2] as an ad-hoc rescuing hypothesis. Berson describes these hypothesis in the following way: “Kekulé’s new argument amounts to the assertion that he wrote double and single bonds in benzene to keep track of the tetravalence of carbon, not to represent their actual nature. Instead, all C–C bonds ... are *equivalent*. He suggested that the best explanation ... for this new type of bonding was given by his collision theory.”^[2]

However, the here described ad-hoc rescuing hypothesis, “the molecule is regularly hexagonal”,^[2] *together* with the “collision theory” or rather its simplified formulation as bond oscillation, proposed for its justification, is according to Popper’s logic of science allowed, because its introduction increases the “degree of falsifiability of the system”. Certainly, Berson correctly emphasizes: “In Kekulé’s time ... techniques ..., which today provide direct information about molecular symmetry ... and convince ... that the assumption of equivalent C–C bonds ... is true, lay decades in the future.”^[2] But Popper says explicitly, “that the use of a theory for the purpose of *predicting* some specific event is just another aspect of its use for the purpose of explaining such an event. And since we test a theory by comparing the events predicted with those actually observed, our analysis also shows how theories can be *tested*.”^[12]

The application of Kekulé’s theory in the 19th century and “the tremendous flowering of synthesis and the discovery of an abundance of new reactions and structures”^[2, 13] resulting from this application, shows that the scrutiny of its prediction was possible with the methods of the 19th century and that it therefore indeed was undertaken on a broad range of “falsification experiments”. This scrutiny led to “the growing conviction that, *for whatever reason*, the C1–C2 and C1–C6 bonds in benzene were structurally equivalent.”^[2] This “*for whatever reason*”, stated by Berson, is nothing else but the fourth step in Popper’s scheme, “*the new problems*, which arise from the critical discussion.”^[8]

However, for the 19th century, which was caught up in the classical mechanics (“collision theory”)^[2] these new problems were soluble only by “hypotheses of embarrassment”,^[2, 14] and the development of quantum mechanics in the 20th century was necessary to propose, returning to the starting step of Popper’s scheme, *conjectural theories* for these now *older problems*.

Thus, the course of the scientific development corresponds perfectly with Popper’s statements, although his logic of science, published in 1934, was unknown by the scientists involved. That Popper’s logic of science really brings, “which *in concreto*, this is as a sense, is pronounced clearly to everybody, to ... the ... abstract perception of reason”,^[1] shows besides the above confrontation of the theory with the occurrences described by Berson, especially his own statement: “... our decision on whether to continue to use the

theory must be based upon pragmatic considerations: does it predict new phenomena or rationalize a body of information?"^[2, 15] Here he acts "*in concreto*"^[1] in the same way, as it is described by Popper's logic of science, that he scrutinizes theories using their predictions and their possible explanations. Therefore his explicit disapproval of Popper's thoughts, especially the "criterion of falsification" is unfounded.

Nevertheless, one can be of the opinion, "that the philosophers are wasting our time and their own".^[2] Because for what serves a philosophy, which only puts into words, which ("*in concreto*, this is as a sense"^[1]) is already known? To give a tentative explanation for the waste of my and the reader's time on this article, we can think about the ethics mentioned by Schopenhauer^[1] in the following way. Certainly they will not "arise virtuous men, nobles, and saints", but one will concede, that the maxims proposed there, could be used in the sense of the Categorical Imperative, *as the basis of a universally valid legislation*, which would allow the virtuous men to be virtuous, the nobles to be noble, and the saints to be sacred, without being victims of the immorality.

In the same way Popper's call for a critical discussion can serve as basis of a science code, which guarantees this call. Also the significance of the falsification criterion should be emphasized here, because if one rejects it as a "Procrustean bed"^[2] the empirical science loses its distinctive feature from the occasionally successful pseudosciences. And a social situation, in which the science without a severe demarcation criterion to pseudoscience could run into trouble, is conceivable. For instance to justify why public funds are used for pharmaceutical research, while well sold, that is socially accepted scientific(?) books, show that with a handful of blooms, picked at a peaceful brook, diseases can be controlled, and without side effects. But if we support Berson, we cannot refuse *esoteric theories*, his argument that their rejection "does not take into account the historical context",^[2] and that therefore their present application, even at the expense of the empirical science, cannot be opposed, because logically future scrutiny of their statements is not ruled out.

[1] A. Schopenhauer, *Sämtliche Werke, Bd. 2* (Ed.: A. Hübscher), Brockhaus, Wiesbaden, 1972, p. 321, quoted from A. Schopenhauer, *Die Welt als Wille und Vorstellung, Bd. 1*, Reclam, Stuttgart, 1990, pp. 387–388; own translation.

[2] J. A. Berson, *Angew. Chem.* 2000, 112, 3173–3176; *Angew. Chem. Int. Ed.* 2000, 39, 3045–3047.

- [3] That Popper does not intend to draw up actual guidances is confirmed by the following quotation: "I believe that the function of a scientist or of a philosopher is to solve scientific or philosophical problems, rather than to talk about what he or other philosophers are doing or might do." (K. R. Popper, *Conjectures and Refutations*, Routledge & Kegan, London, 1969, p. 66).
- [4] Remark of Popper on the text: see Chap. 1 of K. R. Popper *Conjectures and Refutations: The Growth of Scientific Knowledge*, Routledge & Kegan, London, 1963 and later editions.
- [5] Remark of Popper on the text; for a much fuller discussion see sections 2, 3, and 5 in: *Replies to My Critics: The Philosophy of Karl Popper (Library of Living Philosophers, Vol. II* (Ed.: P. A. Schilpp)), Open Court, La Salle, 1974.
- [6] K. R. Popper, *Unended Quest. An Intellectual Autobiography*, Fontana/Collins, London, Glasgow, 1974, pp. 41–42.
- [7] This statement is based on Popper's own statement in [6].
- [8] K. R. Popper, *Alles Leben ist Problemlösen*, Piper, München, 1994, p. 32; own translation.
- [9] If, as Berson states explicitly in his reply (next article), the equivalence of all C–C bonds is already embodied in the original theory, the actual observation of only one *ortho* isomer is not an experimental falsification.
- [10] If Kekulé's theory of 1865 already embodies the equivalence of all C–C bonds, Ladenburg's critic concerns only its graphical presentation, or points to a *new* problem (why the bonds are equivalent?; step 4 in Popper's scheme), respectively. To jeopardize the original theory, Ladenburg's alternative should not only solve the problem of equivalent bonds, which it solves only apparently,^[2] but it should also solve "all these problems, which the old theory already had solved, at least as well." (K. R. Popper, ref. [8], p. 28; own translation). However, Berson's description does not show this. Therefore the "collision theory" is not an ad-hoc hypothesis to rescue the *unjeopardized* original theory, but rather an independent hypothesis to solve *new* i.e. *other* problems. Berson's discussion of its validity as an ad-hoc auxiliary hypothesis is therefore invalid and unnecessary.
- [11] K. R. Popper, ref. [8], p. 26; own translation.
- [12] K. R. Popper, *The Open Society and its Enemies, Vol. II*, Princeton University Press, Princeton, 1971, pp. 262–263.
- [13] That only the original theory was tested and applied in the 19th century, as Berson says in his reply, means that the "collision theory" was ignored and had no share in the mentioned successes.
- [14] The "collision theory" is such a *hypothesis of embarrassment* to solve a *new* problem: the nature of the bond in benzene and the chemical bond in general. In this field the progress really was at a standstill until not only a new theory (quantum mechanics) for its description, but also "until enough time has passed for the means finally to emerge that can test a theory by the falsification protocol."^[2]
- [15] With this attitude would Berson apply the "collision theory" himself? By his own statement it does not predict new phenomena, and the experiments realized in the 19th century were rationalized with the original theory.