Netherlands has now almost changed beyond recognition. Within a decade, the discipline has been largely recast. And that is surely no small feat.

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A History of Chemistry in the Netherlands

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Review of: H. A. M. Snelders, *De geschiedenis van de scheikunde in Nederland. Van alchemie tot chemie en chemische industrie rond 1900* (Delft: Delftse Universitaire Pers, 1993; ISBN 90-6275-815-0) 211 pp.

Snelders' *History of Chemistry in the Netherlands* is written to commemorate the establishment in 1893 of the Dutch Chemical Society. It is published under the auspices of the Society and advertised to its members. Certainly Dutch chemists form the main group for which the book is intended. Certainly it will be also interesting for the small Dutch speaking community of professional historians of science. Whether Snelders' work will satisfy the chemists can only be answered by themselves.

Snelders' task is not an easy one. Chemistry before Lavoisier is not easily accessible to the chemists of today. Their knowledge of modern chemistry is more a barrier than an entrance to the past. And chemistry in the Netherlands cannot be understood detached from chemistry elsewhere, neither now nor in the past. The few great chemists of the Netherlands will attract more interest than the many skilled colleagues that left thousands of published papers and books only known to the specialised historian. Writing about the great Dutch chemists can better be undertaken in the framework of a general history of chemistry. A local history must give some attention to the 'second rank' contributions. These conflicting requirements can only be met by the creative imagination of the writer. Whether Snelders has succeeded in this will be answered after discussing his work.

The book starts with a historiography of chemistry in the Netherlands. Snelders demonstrates that active interest in the history of chemistry was already manifest among Dutch chemists from the eighteenth century onwards. Professional historians of chemistry are however a recent species and the interest of these professionals has generally not been directed towards the development of chemistry in the Netherlands. In fact Snelders is the only science historian with a longstanding interest in the history of Dutch chemistry, and is consequently predisposed to write this book and condemned to carry out his task without an existing professional tradition in the subject. He chooses, not unexpectedly, a chronological order, with emphasis on the aspects to which he has already contributed with original research.

The story commences in the second chapter, on alchemy in the Netherlands. Although the existence of "esoteric alchemy" is mentioned (p. 27), 'alchemy' in this chapter is taken as the attempt to make gold from the base metals and to prepare a drug acting as an elixer of life and a panacea. Snelders' story lists alchemical books published in the Netherlands, mainly during the seventeenth century, and offers biographical details about Dutch alchemists of the same period.

One of these, the 'bergmeester' (mining engineer) Goossen van Vreeswyk, receives special attention. His search for the philosopher's stone, which resulted in the recognition of the uselessness and vanity of this pursuit, is followed. The story of two 'successful' transmutations concludes this chapter. Especially the last one, that of the famous Becher, makes a thrilling story. His project, the isolation of gold from sand, tried out under governmental supervision and found profitable, was never implemented on an industrial scale. Although Becher claimed that the gold extracted from the sand would be regenerated by the sun, it is questionable whether the project can be considered a transmutation. It can be compared with Haber's project to isolate gold from seawater as tried out during the 1920s under the auspices of the German government.

What is missing from this chapter is the sixteenth and seventeenth century context of practical alchemy, the 'philosophical chemistry' of the Renaissance, as treated so well by Alan Debus.[1] The cultural background of Renaissance chemistry might offer a better perspective to the actions of Dutch chemists, and allow escape from an anecdotal treatment.

A proper treatment of 'philosophical chemistry' would equally have revealed the artificiality of the distinction between chemistry and alchemy that is used by Snelders to separate this chapter from the next (on "Chemistry in the seventeenth century: iatrochemistry and chemical technology"); as a result, two successive chapters somewhat incongruously treat one and the same period.

Snelders discusses the rebirth of philosophical atomism and the mechanistic interpretation of chemical processes as the main innovations of the seventeenth century. Then he describes the development of iatrochemistry, i.e. the explana-

[1]Alan G. Debus, *The Chemical Philosophy, Paracelsian Science and Medicine in the Sixteenth and Seventeenth Centuries* (New York, 1977).

tion of the vital functions by chemical processes, from Sylvius, still under the influence of Paracelsus and van Helmont, towards the Cartesian systems of van Hogeland, Craanen, Overkamp and Blankaart. Amazingly, the most influential chemist of the seventeenth century in the Netherlands and the pivotal figure in Debus' description of Paracelsian science and medicine in this century, Jan Baptist van Helmont, is only mentioned in passing. It is clear that this is the consequence of Snelders' implicit evaluation of the importance of neo-Paracelsian chemistry compared with that of the new mechanical philosophy. As Paracelsus and van Helmont were practising chemists and convinced that nature's secrets could only be uncovered in the laboratory, it may be questioned whether the mechanical philosophy is of greater importance for the history of chemistry than their 'chemical philosophy'. Fermentations and acid-base reactions as explanatory tools are more sensitive to falsification than the speculative explanations of the Cartesians.

The third chapter also describes the development, during the seventeenth century, of the teaching of chemistry in the universities of the Republic. As there is no detailed information available about the content of the courses and laboratory facilities the emphasis is on organisation and personalia. Snelders' description of the chemical industry of the seventeenth-century Republic, "a loose collection of little factories for making or refining vinegar, gunpowder, potash, campher, borax and candles," gives only detailed information about the preparation of cinnabar. The chapter closes with an evaluation of the contributions of Drebbel and Glauber to the development of chemical technology.
Snelders discusses the controversies centring around Drebbel in modern historiography and summarizes his theoretical ideas. It would have been enlightening to situate these ideas and those of the other practising chemist, Glauber, in the spectrum of contemporary chemical thinking. For the latter a short biography and an enumeration of some of his chemical technological and analytical discoveries is given.

The fourth chapter, on the eighteenth century, introduces the nature of combustion and of chemical affinity as the central chemical problems of the period. The affinity tables are characterised as classification schemes (of displacement reactions), independent of theories about attractive forces, and typical to the century. What about Newtonian influence on the basic tenets of such tables?

Subsequently the phlogiston theory is introduced, with its broad explanatory possibilities with respect to combustion, calcination, fermentation and putrefaction.

Entering again the scene of the Dutch Republic, Snelders discusses firstly the chemistry of Boerhaave. He starts with the puzzling statement that "Boerhaave accepted the four Aristotelian elements ... as the four physical instruments of chemical analysis" (p. 57). I would suggest that only 'fire' specified as Boerhaave's 'materia ignis' can be considered such an instrument. The material principle of combustibility, Boerhaave's 'pabulum ignis' (the food of fire), during combustion separated from combustible bodies by the action of the materia ignis, cannot be considered as an instrument of analysis. And it is much more reasonable to identify the 'materia ignis' with the Cartesian 'subtle matter' than with the Aristotelian fire. Equally puzzling is Snelders' statement that Boerhaave's 'pabulum ignis' cannot be compared with Stahl's phlogiston, followed by such a comparison, resulting in many similarities and only one difference: calcination is, according to Boerhaave, a change in the state of the metal under the action of the 'materia ignis'.

One might ask why Boerhaave's *Elementa Chemiae* had such a strong impact everywhere in Europe. His influence in Holland is mentioned, but not explained. The chemists of the eighteenth century experienced Boerhaave's *Elementa Chemiae* as a clear and critical analysis of fundamental and physical chemical and physical theories, confronted with the results of experimental science and a cautious and restrained attempt to remove inconsistencies by introducing hypotheses within the framework of contemporary Cartesian and Newtonian thought. This presumably made this work a starting point and a great help for theoretical chemists, Lavoisier included, confronted with the same inconsistencies and with equal respect for the cumulative attainments of experimental chemistry.[2]

Snelders points to Boerhaave's plea for an "empirical rational method" as a reason for the retardation of acceptance of the phlogiston theory before 1770, considered to be the fruit of a "theoretical descriptive method" (p. 61). Such a distinction is not very elucidating, certainly not if confronted with his characterization of the phlogiston theory as explaining many chemical processes qualitatively and emphasising that the theory is "logical" (p. 54).

The main part of this chapter is devoted to the introduction of Lavoisier's 'New Chemistry' in the Netherlands. The pivotal figure in Snelders' detailed story is van Marum, who in the 1780s obtained international fame through his experiments with the electrostatic generator of Teyler's Foundation in Haarlem. Initially van Marum and his collaborators (in particular Paets van Troostwijk) explained the effects of discharges through the newly discovered gases with an adapted phlogiston theory, identifying electricity and phlogiston. During a stay in Paris, in 1785, van Marum was exposed to Lavoisier's New Chemistry, and after reflection on the results of further experimentation back home van Marum became convinced of the veracity of the oxidation theory and of the likelihood of Lavoisier's caloric theory. Van Marum became the most important propagator

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[2]See in particular H. Metzger, *Newton, Stahl, Boerhaave et la doctrine chimique* (Paris, 1930; reprint 1974).

of the New Chemistry in the Netherlands. He improved on and demonstrated Lavoisier's experiments and in 1787 wrote a lucid sketch of Lavoisier's theory (in Dutch).

It was Snelders who after Levere's seminal contribution (1969) on van Marum's role, took the lead in research about the reception of Lavoisier's theory in Holland. There is one weakness in his account: the reproduction of the contemporary reactions of the Dutch Stahlians to the New Chemistry and their explanation of the new data of pneumatic and electric chemistry. What for instance does Snelders mean when he summarizes Paets and van Deinum as follows: "... metals consist of a metallic earth and phlogiston. If they give off phlogiston to dephlogisticated air, a metal calx remains. No acid is formed because it remains bound to the calx" (p. 71).[3] The last sentence is rather enigmatic. The reader will be puzzled still more if he knows that, according to Paets and van Deinum, by phlogistication of 'dephlogisticated air' acid is formed. Such difficulties can be avoided by a more detailed exposition of the alternative to Lavoisier's theory offered by these Dutch chemists. Although it is understandable that winners of the scientific contest get more attention than losers, especially when the scientists of our time are the public, nevertheless winners and losers deserve equal respect.

The caption of the last part of the fourth chapter (Chemical Industry) does not cover its content. Only one paragraph gives information about chemical factories. The rest is devoted to current thoughts about the practical importance of chemistry and of chemistry education and to the actions of scientific societies, municipal governments and private citizens directed to their realisation. Snelders does not recognize any impact by the chemistry of the eighteenth century on chemical manufacturing.

"Chemistry in the Netherlands during the nineteenth century" is the heading of the fifth chapter and the subject of the following chapters which treat especially van 't Hoff, Bakhuis Roozeboom and the chemical industry. The fifth chapter deals with a survey of university education in chemistry before 1840, followed by a summary of the theoretical ideas of the main Dutch chemists of this period. These appear not to be very original as seen against the background of contemporary European chemistry. Only Buys Ballot's treatment of the chemical bond with the use of force functions around 'atom' centres, is treated as an exception. Buys Ballot, who denied dependence on Boscovitch, was, according to Snelders, influenced by Laplace, who used similar, although less specified force functions.

The period 1840-1870 is, according to Snelders' story, dominated by Gerrit

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[3]The translation is that of Snelders in H.A.M. Snelders, "The New Chemistry in the Netherlands," *Osiris* S. 2, 4, 1988, pp. 121-145, on p. 135.

Jan Mulder, professor of chemistry in Utrecht. His international reputation was based on his research on proteins, which brought him in conflict with Liebig. Also his views on agricultural chemistry conflicted with those of Liebig.

Mulder's importance for chemistry in the Netherlands is based on his introduction, first in the Clinical School in Rotterdam, and then in the University in Utrecht, of intensive laboratory practice in the service of chemistry teaching. Research was not a priority in practical chemistry teaching, as it was in Liebig's laboratory in Giessen.

Twenty-two dissertations prepared under Mulder's supervision reflect his broad research interests. Several of his students implemented Mulder's educational ideas in different teaching establishments in the Netherlands. Snelders also describes Mulder's involvement in the establishment of chemical research in the Dutch Indies, as adviser to the government and as educator of specialised chemists and pharmacists. Together this makes a convincing story, that catches the interest of the reader.

That cannot be said of the overview of the last thirty years of the nineteenth century: the main actors (van Bemmelen, Franchimont, van 't Hoff, Bakhuis Roozeboom, Lobry de Bruin, Holleman, Oudemans jr. and Hoogewerff) are quickly passed over with some biographic information and remarks on their research. Presumably Snelders wished to leave enough room for an extensive treatment of the best known of these, van 't Hoff and Bakhuis Roozeboom.

The sixth chapter is devoted exlusively to van 't Hoff. Following a short biography, his scientific work is reviewed. The introduction of the tetrahedrically directed valencies of the carbon atom to explain optical isomerism receives a detailed and clear treatment. But the comparison of van 't Hoff's and Le Bel's theories is not to the point. According to Snelders, Le Bel's simultaneous publication only supposed mirror symmetry of asymmetric molecules, as already envisaged by Pasteur. Van 't Hoff started from tetrahedral arrangement around the carbon atom. I would say that the tetrahedral arrangement of four different atoms or groups around the carbon atom (a geometrical specification of asymmetry) is, according to Le Bel, a possibility, not a starting point to the theory. This specification made van 't Hoff's treatment vulnerable to immediate criticism, but appeared to be very fruitful in retrospect. Snelders concludes: "because van 't Hoff possessed more 'imagination' and because his subject (?) was more general (?!) he got most of the criticism" (p. 119).

The short discussion of van 't Hoff's more pretentious *Ansichten über die organische Chemie* show that Snelders as van 't Hoff is not a philosopher of science. Snelders cites confusing statements of van 't Hoff: "the spatial arrangement of atoms ... was based on the relation between optical activity and chemical constitution ... I wanted also to learn the relationships between *chemical* properties and chemical constitution" (p. 122), and "the constitutional formula of a substance is not only a symbolic expression of the composition but reveals ... the intimate nature of that substance" (p. 123). These statements are not helpful for understanding that a nineteenth-century constitutional formula was always related just to chemical properties, while the proportional formula reflected elemental composition. We have to consider whether van 't Hoff used 'constitutional formula' in an unusual way. In his discussion of the *Ansichten*, Snelders clearly follows Ernst Cohen's biography of van 't Hoff,[4] with some enigmatic personal additions, e.g.: "van 't Hoff hoped to extend the stereochemical knowledge with the knowledge of all properties of organic compounds" (p. 123).

The discussion of the *Études de dynamique chimique* (1884) and of the 1885 papers in the Swedish Academy of Science Proceedings are mainly summaries with historical comments derived from van 't Hoff's 1904 discourse on "How the theory of dilute solutions originated." Snelders' summary of the *Études* is short and his treatment of the 1885 papers defective. The analogon of Boyle's law for solutions was not derived from thermodynamics (p. 126, 127). Nor was the analogon of Gay Lussac's law derived with the help of a cycle consisting of isotherms and adiabatic curves (p. 126-127), but with an isothermal reversible cycle. That the analogy is not a coincidence was not supported by de Vries' measurements on isotonic solutions, unintelligibly summarized (p. 127). As van 't Hoff explained in 1904, and Snelders mentions seven pages further down, the 'constant' in $P_{osm.}V$ = const.T appeared by calculation to be, unexpectedly, nearly equal to R. The introduced correction term i ('constant' = i.R) is nearly equal to 1. The following statement of Snelders is inconsistent: "R ... appeared not to be constant by comparison of ... dilute solutions. The osmotic pressure ... was found much too high. Consequently van 't Hoff introduced a coefficient i that, according to him, does not deviate much from 1" (p. 128).

Substantial deviations of i from 1, measured in case of electrolytic solutions, were explained by Arrhenius through the application of his theory of electrolytic dissociation. Snelders reviews the fate of the electrolytic dissociation theory and van 't Hoff's attitude: his unconditional support in the beginning and his caution expressed in his discourse of 1904.

A short paragraph discusses the origin of van 't Hoff's theory of solid solutions. In some cases it is not a pure substance that is freezing out of a melt, but a solid which is a mixture of the components of the melt. In these cases the theory of dilute solutions was applied.

After a listing of van 't Hoff's pupils and collaborators in Amsterdam and the subjects investigated under his supervision, and particularly a short review on the

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[4]Ernst Cohen, *Jacobus Henricus van 't Hoff. Sein Leben und Wirken* (Leipzig, 1912), particularly pp. 142-149.

life and work of his most original pupil, van Laar, Snelders describes van 't Hoff's work in Berlin (1896-1911).

Why did van 't Hoff choose the formation of the Stassfurt salt deposits as his research subject for the rest of his life? Snelders follows Cohen almost literally: it was the only promising part of his Amsterdam programme which could be continued in Berlin.[5] His explicitly expressed desire to devote himself to a task of national relevance, also stressed by Cohen, is not mentioned. One would expect that the wishes of van 't Hoff's employer, the German government, had some influence.

Snelders restricts himself to enumerating the earlier purely scientific researches on phase transitions, transition temperatures in particular, which can be seen as a preparation of the Berlin program. Van 't Hoff's phase diagram of the Stassfurt salts, published in 1904, is reproduced as a summary of the Berlin research till then. Snelders' evaluation of van 't Hoff's critical attitude towards Gibbs' phase rule again rests heavily on Cohen's biography.[6]

There is no doubt that van 't Hoff deserves the attention given to him in this chapter. However, a clearer scientific and more independent historical and philosophical evaluation of his thermodynamical contributions to chemistry is still a desideratum. Snelders' text also needs an acknowledgement of his dependence on Ernst Cohen.

The discussion in the next chapter, of the work of van 't Hoff's successor in Amsterdam, Bakhuis Roozeboom, is also not very original. In the description of Roozeboom's road to phase transitions and the phase rule Snelders follows the biographical tribute by van Bemmelen, Jorissen and Ringer in the Berichte of 1907.[7] Roozeboom's research in Amsterdam is summarized with the help of a list of the dissertations prepared under his supervision. The chapter closes with a few remarks on the organisation of Roozeboom's classic: *Die heterogenen Gleichgewichte vom Standpunkte der Phasenlehre*, the people who continued his work in the Netherlands, the reasons for its slow acceptance and with a short biography of Ernst Cohen.

The eighth chapter, on the Dutch chemical industry in the nineteenth century commences with a complaint about the lack of historical research on this subject. At the beginning of the century, chemical products were still prepared in little factories run by pharmacists. The end of the century saw much activity, reflected in the list of chemical factories in the Dutch chemical yearbook of 1899. The chapter gives some disconnected information on changes in produc-

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[5] *Ibid.*, pp. 366-368.

[6] *Ibid.*, pp. 499-503.

[7] J.M. van Bemmelen, W.P. Jorissen, W.E. Ringer, "Hendrik Willem Bakhuis Roozeboom," *Berichte der Deutschen Chemischen Gesellschaft* 40, 1907, pp. 5141-5174.

tion and the firms producing sulphuric acid, dyestuffs, coal gas, fertilizers, candles, and soda.

Also the state of chemical education in the service of manufacturing is characterized: the teaching of chemical technology in the universities since 1815 and the establishment of the Polytechnic in Delft in 1864 reflected the Government's interests, the establishment of private schools for practical chemical training at the end of the century and the interest of trade and industry in the training of professional chemists.

The last chapter tells the story of the foundation of the Dutch Chemical Society, and concludes that a new period in the history of chemistry in the Netherlands had started.

Conclusion

After scrutinizing the chapters, I cannot escape the conclusion that Snelders might have turned his story into a more captivating one. The reader is exposed to a profusion of detail, but an organizing conception is absent. It might be unjust to make such demands: pointing to missed opportunities is easier than writing a forceful history of chemistry in the Netherlands. The writing of such a history certainly requires the encyclopaedic knowledge that Snelders shows. But it needs a conception which apparently could not be produced at the moment it was required.

The resulting work seems quickly assembled, frequently summarizing without sufficient understanding, sometimes suggesting independent judgment in cases where Snelders follows others without sufficient acknowledgement. Snelders' system of references in particular must be criticised. His most important sources are not clearly stated but, on the other hand, he refers explicitly to the original publications which his immediate sources mention. This results in an occasionally undue suggestion of independent evaluation of the original publications.

Snelders' work is a very useful introduction to the history and historiography of chemistry in the Netherlands. We learn much that is new on a great variety of topics; but the last word on this neglected subject has certainly not yet been spoken.

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