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A LANGUAGE TO ORDER THE CHAOS

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The article "chemistry" in Diderot's *Encyclopedia* presented chemists as "a distinct people, still very few, with their own language, their laws, their mysteries, and living almost isolated in the midst of a greater people hardly curious of its business and expecting nearly nothing from its industry (peu curieux de son commerce et n'attendant presque rien de son industrie(1). In order to depict the miserable state of chemistry, Gabriel-François Venel, the chief writer on chemical topics in Diderot's *Encyclopedia*, established a link between the chemical community, its language, and the public perception of the discipline. Despite the deep changes that chemistry has undergone since the mid-eighteenth century, this triple connection still characterizes the identity of chemistry, if we consider chemistry as a culture developed by a specific people. In this anthropological perspective, language plays a chief role in the public perception of chemistry, an esoteric knowledge associated with powerful and obscure practices.

The public, nevertheless, is the consumer of the chemicals produced by this strange people. The chemical formulas, though far beyond the public understanding of science, are tangible and edible products which can serve to poison or to relieve pain. Any serious concern with the ambivalent public image of chemistry implies a thorough reflection on the language of chemistry. This is manifest from Roald Hoffmann's popular publications and Primo Levi's well-known stories and articles(2). The purpose of this lecture is to show that a historical glimpse of the language of chemistry can help demystify the popular demonic image of the chemist.

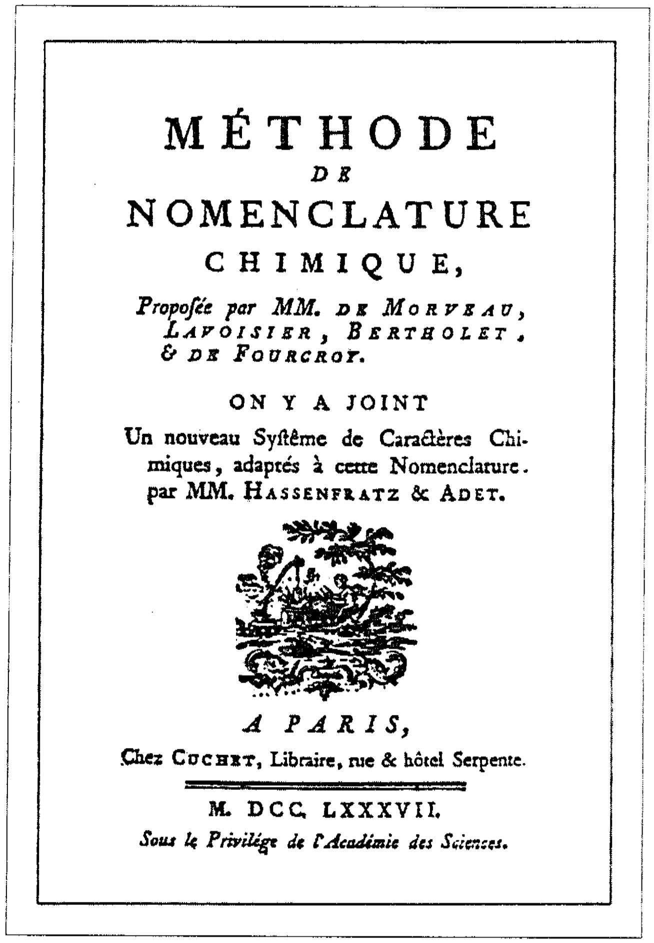
Let us first try to point out what is unique about chemists' language. In chemistry, as in any other science, a good command of the basic vocabulary is a precondition for an academic degree in the discipline. The chemical community, like any scientific community, shares a common jargon and patterns of argumentation and metaphors, as well a set of tacit rules that guarantee a mutual understanding when the official code of language is not respected(3).

The chemical nomenclature, however, records the chemists' unique experience of nature's diversity. Naming is the necessary activity of the intellect that is confronted with a variety of beings. As the population of substances dramatically increased in the late eighteenth century, thanks to improved analytic methods, chemists more and more needed established, systematic names for communicating and for teaching.

In the late nineteenth century, innumerable organic compounds were created by synthesis. This expanding chemical population, which is both the fruit of the chemists' creativity and a terrible burden, required subject indexing and a continuous invention of neologisms. The main problem is that the need for names always anticipates the prescribing of rules for names. To face this challenge, chemists have adopted different strategies over time. The French chemists who set up a system of nomenclature 200 years ago shaped and organized a specific world view that has been deeply transformed over the past two centuries,

Strangely enough, the chemists' changing attitude in the struggle to discipline the ever increasing multitude of chemical substances, has not attracted scholars' attention. Whereas working chemists are extremely concerned with their language and fond of stories behind the names in use, few historians of chemistry have ventured into this domain(4). Maurice P. Crosland's classic *Historical Studies in the Language of Chemistry*, first published in 1962, remains the major reference on the nomenclature that was set up at the time of the chemical revolution(5). Later reforms of the chemical nomenclature are known to us only thanks to chemists who were active participants in the reforms(6). Their historical accounts most often emphasize the role of individuals and the difficult consensus. So omnipresent remain the difficulties of naming, that the past still belongs to the chemists' memory rather than to official history. It is also strange that chemical language has been virtually unexplored by philosophers over the past decades, despite the fashion for the philosophy of language(7).

This lecture is an attempt to outline the underlying philosophy of language in the evolution of chemical nomenclature. In contrasting the *Method of Nomenclature* presented two centuries ago at the Paris Academy of Sciences by four French chemists, Guyton de Morveau, Lavoisier, Berthollet and Fourcroy, with the more recent big reform decided at a Conference in Liege in 1930 by the Commissions on Nomenclature of the Union Internationale de Chimie Pure et Appliquée, I will point out a tension between two rival strategies of controlling the linguistic practices of chemists.


MÉTHODE
DE
NOMENCLATURE
CHIMIQUE,
Propoſée par MM. de Morveau, Lavoisier, Bertholet, & de Fourcroy.
ON Y A JOINT
Un nouveau Syſtême de Caractères Chimiques, adaptés à cette Nomenclature. par MM. Hassenfratz & Adet.
A PARIS,
Chez Cuchet, Libraire, rue & hôtel Serpente.
M. DCC. LXXXVII.
Sous le Privilége de l'Académie des Sciences.

Method of Nomenclature, 1787

An Ambitious Reform

Though Venel complained that chemists were isolated and misunderstood because of their language, he was expecting a revolution, a hero, a new Paracelsus, who would be bold enough to sweep away all prejudices against chemists and to promote chemistry among philosophers. Far from rejecting the artisan's aspects of chemistry, Venel presented the dual nature of chemical practices—both science and arts—as a major strength of chemistry. He proudly claimed that chemistry "held in its body a dual language, the popular and the scientific(8)."

The expected revolutionary hero came twenty years later, but he did not promote the kind of chemistry that Venel advocated. Antoine-Laurent Lavoisier achieved a revolution in chemistry which has been often presented as the origin and premise of the major reform of nomenclature published in 1787. It is thus assumed that the systematic language was the outcome of a major theoretical change. It was a kind of baptism following the birth of modern chemistry, a radical break with the sins of prescientific chemistry. Most often, the nomenclature reform is still presented as Lavoisier's personal achievement. It is hardly mentioned and only as a kind of anecdotal detail that it was a collective enterprise, whose initiative did not belong to Lavoisier.

In my view, this common interpretation obscures the real conditions of the systematization of language which can only be identified if we take into account the various attempts at systematizing names that had been made before the chemical revolution. Throughout the eighteenth-century chemists had been increasingly dissatisfied with their language and some of them like Pierre-Louis-Joseph Macquer or Torbern Bergman made timid attempts at systematizing. Motivation for the increasing concern for reforming the language was based on four major reasons, all belonging to "normal" science and independent of the chemical revolution.

1) Enlightenment chemists wanted to rid themselves of the alchemical heritage of names full of mythological references. They had the feeling that they were par-

ticipating in a kind of renaissance of chemistry and wanted a language more adapted to this branch of the philosophy of nature. They were encouraged in this direction by the initiatives of natural scientists, especially Carl Linnaeaus, who had introduced a systematic nomenclature in botany. Following Linnaeus, the Swedish chemist Torbern Bergman (1735-1784) made several attempts at renaming salts and minerals(9).

2) Because eighteenth-century chemists had better analytical procedures (solvent extraction in addition to distillation), they were able to distinguish between various substances and complained that one name referred to different substances, or, symmetrically, that various names were used for one single substance. Exchanges between chemists all over Europe coupled with an intense activity of translations made these flaws particularly visible. The main impulse came from the chemistry of salts which provided the first basis for a systematic nomenclature.

3) It is important to emphasize the role of classification as a condition underlying all nomenclature. Eighteenth-century chemists developed a consistent classification of salts around the distinction between middle salts, double salts, triple salts...(10). In 1744 and 1755, Guillaume-François Rouelle introduced the generic term "base" for all alkalis and redefined salts as the products of the action of an acid on a base. He then classified salts into three groups: neutral salts, acid salts, or basic salts according to the proportion of the reagents(11). This classification made possible a binomial nomenclature of chemical salts first outlined by Pierre-Joseph Macquer (1718-1784).

4) Finally, new names were badly needed for novel, recently identified substances. A host of new metals recently isolated, such as cobalt and vanadium, had been named after Swedish deities. By contrast, with the development of pneumatic chemistry in the 1760-70's, a dozen newly identified gases or "aeriform fluids" were given systematic names. Some of them expressed one characteristic property: "fixed air" for carbon dioxide because it was fixed in solids; "inflammable air" for hydrogen; or Feuerluft, the name given by William Scheele to the future oxygen. Joseph Priestley, who isolated the same substance, named it after its supposed composition and chose the term "dephlogisticated air." In short, systematic names were gradually introduced in the course of the 18th century, but chemists lacked general agreement within their own community on the principles of naming.

The main initiative for a new nomenclature came from Louis-Bernard Guyton de Morveau (1737-1816), a lawyer and a well-known chemist from Dijon. In 1782 Guyton authored a bold project for reforming the entire chemical nomenclature(12). His reform was based on the assumption that denominations should reveal "the nature of things," like the botanical nomenclature set up by Carl Linneus, although Guyton chose Greek rather than Latin etymologies (presumably because of his

Guyton de Morveau

strong opposition to the language of the Jesuits). Guyton's general principle was: simple names for simple substances and compound names for chemical compounds which express their composition. When the composition is uncertain, Guyton proposed, an arbitrary and meaningless term is to be preferred. In itself, the project of making an artificial language for chemistry, breaking with the traditional language forged by the users of chemical substances over centuries, was ambitious and revolutionary. However, Guyton was extremely modest. He clearly stated in the beginning of his memoir, "I know that it is only through convention that the value of terms can be fixed, and I am further than anyone from the pretension of changing them by the authority of my opinion(13)." His reform was clearly designed to reach a consensus among European chemists.

However, when he arrived in Paris in January, 1787, to submit his project of a systematic nomenclature to the Paris Academy of Sciences, he found the chemistry "classe" divided by the controversy over phlogiston chemistry. He met with Antoine-Laurent Lavoisier (1743-1794), Claude-Louis Berthollet (1748-1822), and Antoine-François de Fourcroy (1755-1809), all three partisans of the antiphlogistonist theory. They "converted" him to the new doctrine and persuaded him to revise his project accordingly. In a few weeks, the four of them transformed Guyton's earlier outline of a new language into a weapon against phlogistonists(14). His initial project had thus been deeply changed during the six months he spent in Paris. The word "phlogiston" was eliminated, while terms such as "hydrogen" (generator of water) and "oxygen" (generator of acids) reflected Lavoisier's alternative theory. Lavoisier also provided a philosophical legitimization for the new language by referring to Condillac's philosophy of language(15). He assumed that words, facts, and ideas were, so to speak, three various faces of one single reality and that "une langue bien faite est une science bien faite." Linguistic customs and chemical traditions carried only errors and prejudices. By contrast, a language proceeding from the simple to the complex would keep the chemists on the track of truth. The language of analysis that Lavoisier and his collaborators promoted, a "method" rather than a "system," was said to reflect nature itself. Actually, nature was identified with the products of chemical manipulations performed in the laboratory. The name of every compound was the mirror image of the operations of its decomposition.


Antoine-Laurent Lavoisier

Like most nomenclatures, this one was based on an implicit classification. Instead of the traditional naturalists' taxonomic categories of genus, species, and individual, the chemists' classification was structured like a language with an alphabet of thirty-three simple substances distributed into four classes: 1) "simple substances belonging to the three realms of nature" (including caloric, oxygen, light, hydrogen, and nitrogen; 2) "nonmetallic oxidizable and acidifiable simple substances;" 3) "metallic oxidizable and acidifiable substances." 4) "earthy salifiable simple substances." This classification was a compromise between the old notion of universal principles and the definition of element as a unit of combination. The simple substances only made up the first column of a synoptic table summarizing the whole system(16). Tables were a favorite means of representation, which Foucault depicted as the center of knowledge in the "classic era(17)." However, the table displayed at the Academy of Sciences in 1787 and the tables published in the second section of Lavoisier's *Elements of Chemistry* differed from the previous "tables of relations" used by the eighteenth-century chemists(18). Affinity tables represented a condensation of knowledge painstakingly acquired through thousands of experiments. Lavoisier's tables incorporated empirical knowledge but were rather aimed at ordering the material world like a language, an analytical language modeled after Condillac's Logic. The grammar of this language derived from a dualistic theory of combinations. It was implicitly assumed that chemical compounds, whatever their mineral, vegetable, or animal origin, were formed by two elements or two radicals acting as elements.

While Lavoisier pretended that the new language mirrored nature, many of his contemporaries objected that such terms as oxygen were theory-laden rather than mere expressions of well-established facts. From all over Europe, chemists tried to discuss the reform and to improve a number of names. Alternative proposals were made for oxygen, because Lavoisier's theory of acids was not widely accepted, and for *azote* (from a + zoion = not for animals), because many other gases besides nitrogen are not fit for animal life. The French chemists led an intensive campaign of persuasion by involving Madame Lavoisier in translations and entertaining; they created their own journal, the *Annales de chimie* in 1789. Finally, thanks to many translations of the textbooks written by Fourcroy, Chaptal, Lavoisier, and Berthollet, the French nomenclature was widely accepted by 1800. Adoption implied various strategies of linguistic adaptations. A number of chemists resented the French hegemony in a domain which, in principle, should be universal. German and Polish chemists chose to translate the French-Greek terms into German (for instance, *Sauerstoff* for oxygen and *Wasserstoff* for hydrogen), whereas English and Spanish chemists simply changed the spellings and the endings of the terms.

Thus the long term project of reform of the nomenclature which mobilized the chemical community through the course of the eighteenth century played a key role in Lavoisier's revolutionary strategy. It encouraged his project of eradicating past and present knowledge in order to found chemistry on a *tabula rasa*. Moreover, as Lavoisier pointed out in his *Elements of Chemistry*, the analytical language, inviting the chemical student to proceed from the-simple-to-the-complex facilitated the teaching of chemistry.

It is important, however, to reconsider this reform in the broader perspective of the *longue durée* and, more importantly for our present purpose, to appreciate its impact on the discipline of chemistry. It must be noted

Claude-Louis Berthollet

that the new language, forged by academic chemists, prompted alienation between them and the dyers, glassmakers, pharmacists, and manufacturers who were more concerned with the terms inherited from their own traditions. Certainly compositional names, as well as the constitutional formulas that were later derived from them, provided significant information for chemists whose main goal was to determine the nature and the proportion of the constituents of inorganic and organic compounds. Nevertheless, these names deprived the pharmacists of knowledge about the medical properties implicit in many traditional terms. Thus the new nomenclature contributed to the subordination of pharmacy to chemistry and, more broadly, to the redefinition of chemical arts as applied chemistry(19).

The chemical language built up by the four French chemists was an integral part of Lavoisier's attempts to promote and legitimize a new practice of chemistry. Analytical procedures controlled by the balance displaced and discredited experimental results based on qualitative data, whereas phenomenological features such as odors, colors, taste, and appearance, were discarded from the nomenclature. For instance, the "white lead" and the "Prussian blue" used by dyers became, respectively, "lead oxide" and "iron prussate." "Stinking air" was renamed "sulfuretted hydrogen gas." The new language not only ignored the chemists' senses, but it also deprived the chemical substances of their history by banishing all reference to their geographical origins or to their discoverers.

In fact, the principles of the new language were never strictly applied. First, in the domain of inorganic chemistry, a decisive break occurred in the early nineteenth century when, after isolating chlorine, Humphry Davy (1778-1829) established that some substances—hydrochloric acid, for instance—exhibited characteristic acidic properties even though they did not contain oxygen. Oxygen should have been renamed, but custom prevailed over the imperative of systematization. Over time, as many elements were isolated with the help of electrochemistry, odors and colors were restored into the nomenclature. For instance, chlorine, bromine, and iodine were coined after the Greek terms chloros meaning green, *bromos* meaning stink, and *iodes* for violet. As regards the vegetable and animal bases and acids, Lavoisier and his colleagues confessed that they were forced, in the manner of old chemists, still to name them after the substances from which they were obtained. In fact, their method of nomenclature did not apply to the realm of organic chemistry. The medical virtues of plant materials, the geographical origin, and even the mythological tradition still provided bases for naming the active principles isolated in the early nineteenth century as exemplified by the word "morphine," named after Morpheus, god of dreams, or by the name "strychnine" for the active principle extracted from the "bois de couleuvre" (*strychnos colubrina*)(20). Even geographical data resurfaced; the term "benzene," for instance, reminds us of the resin produced by the bark of a tree native to Sumatra and Java with the name Styrax benzoin; "gutta percha," a gum which played a crucial part in the development of the electric telegraph, was named after the Malay *getha percha* tree in 1845. Nineteenth-century nationalism pervaded chemical language: gallium, discovered by a French chemist, and germanium, another element predicted by Mendeleev, were followed by scandium and polonium. Even the banished Latin language resurfaced with the alphabetical symbols, initials of Latin names, that were introduced by Berzelius (1779-1848) in 1814(21).

To summarize, the first reform of the chemical nomenclature was certainly a revolutionary enterprise aimed at creating an artificial language, breaking with the past of the discipline. The nomenclators acted as legislators in the name of rationality, in strict conformity with the Enlightenment belief in the authority of reason. However, the construction of the new language of chemistry was not the result of Lavoisier's revolution in chemistry. Rather than being inspired by a radical theoretical breakthrough, it was tactically used as a weapon in the revolutionary process.

Moreover the ideal of systematization pervading eighteenth-century chemistry, which presided over the creation of an artificial language for chemistry, remained an ideal often contradicted by daily usage. It is this tension between the ideal general rules and the constraints of daily use which seems to me a characteristic feature of the creation of the language of chemistry. But what about the later reforms? How are we to characterize the philosophy of the twentieth-century reforms of language?

Antoine-Francois de Fourcroy

An Endless Process

In the twentieth century, the reform of nomenclature is no longer synonymous with a single and extraordinary event. Rather it has been a continuous process of revision and an integral part of what is called "normal science." The language of chemistry is no longer a national or a transnational issue in the hands of a few motivated individuals(22). It is an international enterprise, fully integrated into the process of internationalization of science which developed in the late nineteenth century. The Commission for Nomenclature, first coordinated by the Union of the chemical societies, later became a permanent institution, a sub-section of the Union internationale de chimie pure et appliquée (UICPA), created in 1919, with French as its official language. Germany, Austria, and Hungary were excluded because of the boycott of German science by the allied nations after the Traité de Versailles. After the interruption of its activity because of World War II, the International Union was re-established as the International Union of Pure and Applied Chemistry (IUPAC). The two commissions on nomenclature appointed as early as 1921 were much more than a simple by-product of the internationalization of science. As emphasized in a number of studies, the commission acted as a driving force, though the concern for international coordination never completely abolished national rivalries(23).

The new strategy of the chemical community concerning nomenclature was gradually set up with the institution of international disciplinary conferences in the nineteenth century. The Karlsruhe Congress of 1860 can be seen as the first international conference of chemists aimed at ruling over names and formulas. However, it was a single extraodinary event motivated by a climate of crisis. The chaos of formulas and of atomic weight values that hindered mutual understanding was described as a threat to the advancement of chemistry. Rather than the expression of an organized international community of chemists, the Karlsruhe Congress of chemists was due to the initiative of August Kekulé, who managed to mobilize a hundred colleagues from all over Europe(24).

By contrast, the reform of nomenclature became a feature of normal science in the late nineteenth-century with the institution of regular international conferences. Following the first International Conference of Chemistry held in Paris in 1889, a special section was appointed under the leadership of Charles Friedel (1832-1899), who was in charge of preparing a set of recommendations to be voted during an international conference on chemical nomenclature held in Geneva in April, 1892. The rules were aimed at coordinating the individual attempts made at systematizing the nomenclature of organic compounds. For instance, Williamson introduced parentheses into formulas to enclose the invariant groups as in $Ca(CO_3)$, for example, and proposed the suffix ic for all salts(25). Hofmann introduced the systematic names for hydrocarbons with suffixes following the order of the vowels in order to indicate the degree of saturation: ane, ene, ine, one, une(26). A great confusion once again reigned in the language of chemistry. Instructions were given in the various scientific journals which sprang up in the late nineteenth century. The aim of the Geneva Nomenclature was mainly to standardize terminology and to make sure that a compound would appear under one single heading in catalogs and dictionaries. The Commission for Nomenclature felt sufficiently authoritative to propose an official name for each organic compound. Official names were to be built upon the molecular structure and should be as revealing of constitution as were chemical formulas. Names were based on the longest continuous chain of carbons in the molecule, with suffixes designating the functional groups and prefixes denoting substituent atoms. Sixty-two resolutions were adopted by the Geneva group, which only considered acyclic compounds.

However, once again the ideal of systematization was contradicted by daily practice. The official names were never applied in practice although they are still included in modern textbooks because they provide governing principles. After WWI two permanent commissions were set up by the UICPA. The Commission for the Nomenclature of Inorganic Chemistry appointed the Dutch chemist W. P. Jorissen as chairman, and the Commission for the Nomenclature of Organic Chemistry also appointed a Dutch chemist, A.F. Holleman, as chairman. The choice of leaders representing a minor linguistic area clearly indicated an attempt towards a universal language that would not reflect the hegemony of a nation. In 1922, both commissions formed a working party with representatives of various linguistic areas for preparing the rules. Not only educators but also journal editors were invited to join. Following regular meetings in 1924, 1927, 1928, and 1929, the working party in charge of organic chemistry issued reports that were publicized for submission to criticisms and then amended before the final vote in Liège(27). The working party in charge of inorganic chemistry also met several times before issuing the final rules at the Tenth Conference of the UICPA in Rome in 1938. The new regime of naming was thus characterized by a long process of negotiations that allowed for the coinage of new terms familiar to chemists before their official adoption and for a consensus before the final vote(28). Whereas the Geneva Conference, presided over by Friedel, was dominated by the "French spirit and the French logic(29)," the Liège rules codified suggestions by American chemists, particularly A.M. Patterson, who was directly connected with *Chemical Abstracts*. The Germans, though excluded because of the boycott, were consulted and finally invited to Liège(30).

The style of the Liège nomenclature is quite different from that of Geneva. No more official names. The committee report, unanimously adopted in Liège conformed to the linguistic customs of *Beilstein* and of *Chemical Abstracts* with minor corrections. Rule 1 reads as follows: "The fewest possible changes will be introduced into the universally adopted terminology." Liège, however, broadened the scope of the Geneva nomenclature. Rules were set up for naming the "functionally complex compounds," *i.e.*, those bearing more than one type of function. In the final vote it was decided that both the official Geneva names and the Liège nomenclature could be used. The ideal of systematization thus gave way to a more pragmatic strategy. Flexibility and permissibility were considered as the most efficient means to favor a general adoption of the standard language in the daily practices of chemistry, whether it be in textbooks or journals, in the classrooms or the factories. Since Liège, this pragmatic attitude has prevailed in all successive revisions, in Lucerne (1936), in Rome (1938), and after World War II in Paris (1957). The current nomenclature is by no means as systematic as that the 1787 reformers had envisioned. Trivial names—not referring to the structure of the compounds—coexist with systematic names, conforming to the rules. In fact, both in inorganic and organic chemistry, a majority of names are semi-trivial, *i.e.*, a mixture of anecdote and of constitution(31).

In conclusion, what can be retained? Since 1787, it has been tacitly assumed that chemical compounds are formed like words and phrases out of an alphabet of elemental units, whose combinations allow building up an indefinite number of compound words, according to a complex syntax. Whatever the identity of the basic units—elements, radicals, functions, atoms, ions, molecules—the linguistic metaphor still inspires contemporary chemists. "Chemistry is structured like a language." This assertion, paraphrasing what the French psychoanalyst Jacques Lacan stated about the unconscious, is the main feature of the chemists' language policy(32).

This brief survey of two major reforms of language reveals deep institutional changes in the chemical community. In 1787, the reform of language was achieved in less than six months by a small group of four chemists clearly identified as French scientists. In 1930, a permanent commission of delegates from various linguistic areas prescribed dozens of rules aimed at standardizing the nomenclature of organic compounds.

The evolution of chemical language over the past century can be described as a retaliation of daily users against legislators. More precisely, the imperative of systematization gave way to the imperative of standardization. This more modest attitude, prevailing up to the end of the twentieth century, reveals two deep changes in the culture of chemistry. The chemists confronted with the increasing difficulty of keeping up with systematic names for extremely complex compounds have renounced their ambition of submitting the molecular world to their ideal of rational systematization. Definitely for modern chemists, the real is by no means rational. As in Diderot and Venel's times, chemists are less 'architects of matter' than dusty laborers trying to discipline a jungle of mixtures, a field certainly controlled by laboratory experiments but still at the mercy of unexpected circumstances.

Twentieth-century reforms also betray a changing attitude towards the chemical heritage received from the past. Clarence Smith, a member of the working party for the Liège nomenclature, suggested in 1936 that, "Could we but wipe out all existing names and start afresh, it would not be a very difficult task to create a logical system of nomenclature. We have, however, to suffer for the sins of our forefathers in chemistry"(33). This statement, contrasting with the revolutionary attitude of 1787, brings us back to the feeling of belonging to a damned people as expressed by Venel. Like Venel in 1753, we might want to promote the "sapientia chymica," a chemical wisdom.

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16. The second column included the combinations of simple bodies with caloric (*i.e.*, put in gaseous state); the third column included the compounds of simple substances with oxygen; column 4 the compounds of simple substances with oxygen plus caloric; column 5 included oxygenated simple substances combined with bases (*i.e.*, neutral salts); column 6 is a small division for "simple substances combined in their natural state;" see Ref. 14, 75-100.
17. M. Foucault, *Les mots et les Choses*, Gallimard, Paris, 1968, 86-91.
18. L. Roberts, "Setting the Tables: The Disciplinary Development of Eighteenth-Century Chemistry as Related to the Changing Structure of its Tables," in P. Dear, Ed., *The Literary Structure of Scientific Argument*, Un. Pennsylvania Press, Philadelphia, PA, 1991, 99-132.
19. A. C. Déré, "La réception de la nomenclature réformée par le corps médical français," in B. Bensaude-Vincent and F. Abbri, *op. cit.*, Ref. 12, 207-224; J. Simon, The Alchemy of Identity: Pharmacy and the Chemical Revolution (1777-1809), Ph.D. Dissertation, Un. Pittsburgh, 1997.
20. The term morphine was coined in 1828 by Péligot and the word strychnine chosen by Pelletier and Caventou in 1819.
21. It was Berzelius who rejected the pictograph symbols used by Dalton and introduced the letters of the alphabet, index numbers, dots, and bars. Proportions were indicated by superscript figures or symbols. On the debates caused by the introduction of symbols, see T. L. Alborn, "Negotiating Notation: Chemical Symbols and British Society, 1831-35," *Annals of Science*, **1989**, *46*, 437-460, and M. J. Nye, *op. cit.*, Ref. 3, 91-102.
22. C. Meinel, "Nationalismus und Internationalismus in der Chemie des 19. Jahrhunderts," P. Dilg, Ed., *Perspektiven der Pharmaziegeschichte: Festchrift für Rudolf Scmitz*, Graz, 1983, 225-242.
23. B. Schroeder-Gudehus, "Les congrès scientifiques et la politique de coopération internationale des académies des sciences," *Relations internationales*, **1990**, *62*, 135-48; E. Crawford, *Nationalism and Internationalism in Science 1880-1939*, Cambridge Un. Press, Cambridge, 1992; A. Rasmussen, L'internationale scientifique, 1890-1914, Ph.D. Dissertation, Ecole des Houtes-Etudes en Sciences Sociale, Paris, 1995; Vol. 1, forthcoming, éditions de la découverte, Paris, 1998.
24. The Karlsruhe Congress of 1860 can be seen as the first international conference of chemists aimed at ruling over names and formulas. However, it was a single, extraodinary event which was not followed by regular meetings. Rather than the expression of an organized international community of chemists, it was due to the initiative of August Kekulé, who managed to mobilize his colleagues from all over Europe. See M. J. Nye, *The Question of the Atom: from the Karlsruhe Congress to the First Solvay Conference, 1860-1911*, Thomas, Los Angeles, CA, 1984, 633-34. See also B. Bensaude-Vincent, "Karlsruhe, septembre 1860: l'atome en congrès," *Relations internationales*, "Les Congrès scientifiques internationaux," **1990**, *62*, 149-169.
25. W. H. Brock, "A.Williamson," in C. C. Gillispie, Ed., *Dictionary of Scientific Biography*, Charles Scribner's Sons, New York, 1970-.
26. A. W. Hofmann, *Proc. R. Soc. London*, **1866**, *15*, 57, quoted by J. Traynham in M. Volkan Kisakürek, *op. cit.*, Ref. 6, 2.
27. The main criticisms came from Victor Grignard, who wanted to restore the Geneva rules, and from B. Prager and R. Stelzner.
28. P. E. Verkade, *A History of the nomenclature*, *op. cit.*, Ref. 6, 127.
29. Ref. 28, p. 8.
30. On the boycott of Germany by the allied nations after World War I, see B. Schroeder-Gudehus, *Les Scientifiques et la paix*, Les presses de l'université de Montréal, Montréal, 1978, 131-160.
31. IUPAC, *Nomenclature of Inorganic Chemistry*, Butterworths Scientific Publications, *London*, 1953; 2nd ed., 1970; B.P. Black, W.H. Powell, and W.C. Fernelius, *Inorganic Chemical Nomenclature: Principles and Practices*, Washington, DC, 1990; P. Fresenius and K.

Görlitzer, *Organic Chemical Nomenclature,* Hellis Harwood, Chichester-New York, 1989.

32. See also P. Laszlo, *La parole des choses*, *op. cit.*, Ref. 2.
33. C. Smith, *J. Chem. Soc.,* **1936,** 1067, quoted by James G. Traynham, *op. cit.*, Ref. 6, 6.

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