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HOW TO REACH CONSENSUS IN SCIENCE: A HISTORICAL PERSPECTIVE ON INTERNATIONAL STANDARDS AND NOMENCLATURE ca. 1900

BY

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(Conférence donnée à l'occasion de la remise du Prix Marc-Auguste Pictet 1992)

Ladies and Gentlemen,

I would like to express my sincere appreciation to the Société de Physique et d'Histoire Naturelle de Genève and to M. Jean M. Pictet for the honor they have bestowed on me by awarding me the Marc-Auguste Pictet Prize in the History of Science. It is a rare pleasure for a beginning scholar to be rewarded so magnanimously by the members of a venerable scientific society. I sincerely believe that younger historians of science will see the prize as an added incentive for excellence in future research.

The distinguished Pictet family is connected in many fascinating ways to the history of chemical nomenclature which we are celebrating at this week's symposium of the Swiss Chemical Society. Marc-Auguste Pictet, one of the eight founders of the Société de Physique et d'Histoire Naturelle de Genève, is best known for his researches in astronomy, chronometry and meteorology. However, he received his scientific education and much guidance and support from Horace Benedict de Saussure, and together they became important participants in the chemical revolution initiated by Lavoisier. In addition, Amé Pictet was to represent the Swiss chemists at the 1892 Geneva Congress on chemical nomenclature and on many subsequent occasions.

In today's paper I would like to put the Geneva Conference of 1892 in two contexts, two developments which overlapped and culminated in the scientific meeting which is being celebrated today. The first context is that of the history of nomenclature as a language and a reflection of developments in theoretical and experimental chemistry. The second context is that of a growth in systematization and international cooperation in the last decades of the 19th and early decades of the 20th century. By following the various nomenclature reforms from Lavoisier to the present, I will show how the goals of a standardized chemical language reflect the transition from the

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scientific rationalism of the late 18th century to the scientific pluralism of late 19th and 20th century. And by putting the Geneva Congress in the context of other international meetings we can better understand the intellectual climate of fin-de-siècle science.

As early as 1764, Horace Benedict de Saussure became acquainted with chemical experimentation.[1] He obtained chemicals from the reknowned Parisian scientist and pharmacist Antoine Baumé, and in 1768 travelled to Paris, where he came into contact with a number of Parisian scientists. After his return from France, Saussure's publications included numerous references to chemical literature, most notably to Guyton de Morveau's publications.[2] Guyton soon became the first and foremost reformer of chemical nomenclature, one of the major forces in the formulation of Lavoisier's antiphlogistic chemical revolution. For ten years, beginning in 1777 with the first volume of his *Elements of theoretical and practical chemistry*, Guyton worked on a reformulation and systematization of chemical knowledge, attempting to break with the tradition of alchemical literature and nomenclature and to make chemistry a more broadly accessible science. In 1782, Guyton formulated five new principles of chemical nomenclature proposing simple names corresponding to fundamental properties of chemical substances. Linguistically, Guyton prefered ancient Greek to the then current Latin scientific language. However, Guyton failed in his attempts to put through his broader system of chemical classification (acids, salts, and bases).

On his visit to Paris in 1786, Guyton became acquainted with Lavoisier's experiments. In collaboration with Lavoisier, Berthollet and Fourcroy, four memoirs on the reform of chemical nomenclature were presented to the influential French Academy of Sciences in public sessions during the spring of 1787.[3] In her splendid introduction to a reprint edition of the famed *Méthode de Nomenclature*, the distinguished French historian of chemistry Bernadette Bensaude-Vincent has analysed in great detail the background to Lavoisier, Guyton de Morveau, Berthollet and Fourcroy's volume and the subsequent development of chemical nomenclature. She has convincingly shown how a new chemical language was employed to sustain Lavoisier's antiphlogistic theory and how the nomenclature project was used by the French chemists in order to implement a far-ranging, deep revision of science and, in addition, of the scientific hierarchies and community in revolutionary France. The lack of agreement over chemical nomenclature was to a large extent the result of debates over the phlogiston theory, since one could no longer produce a new chemistry with the language of the old. Thus nomenclature became a tool in favor of one particular fundamental theoretical system rather than a descriptive, linguistic project.

[1] W.A. Smeaton, "The Chemical Work of Horace Benedict de Saussure (1740-1799), With the Text of a Letter Written to Him by Madame Lavoisier, "*Annals of Science* **35** (1978): 1-16, pp. 1-4.

[2] *Elemens de chymie* (1777-78), 3 vols.

[3] It was, according to Bensaude-Vincent, precisely this collective, institutional Character which lent originality to this chemical reform. This first collective work proved so fruitful that it inspired other initiatives. After Lavoisier's death, Berthollet continued to convene scientists in his home and laboratory in Arcueil. In 1807 these informal reunions became official with the creation of the Arcueil Society, which published its own memoirs.

In the preliminary discourse to his celebrated *Elementary Treatise of Chemistry* published in 1789, Lavoisier presented his work on a new chemical theory as the logical and direct consequence of his nomenclature project:

> I did not have for an object when I started this work but to give an extended version of the memoir which I have read in the public session in the Academy of Sciences in the month of April 1787 on the necessity to reform and to perfect the nomenclature of chemistry... While I believed to occupy myself only with nomenclature, while I only had for a goal to perfect the language of chemistry, my work transformed itself unnoticeably, without my being capable of defending myself, into an elementary treatise of chemistry.[4]

Bensaude-Vincent however shows that, according to Lavoisier's manuscripts, it seems that the theoretical project predated that of the nomenclature. "Yet it became essential for Lavoisier to underline the relation between theory and nomenclature, between ideas and words."[5] He relied in this respect on the critique of language formulated by Condillac, who had demanded a complete linguistic break with the past, necessary because wrong words convey a mistaken reality; that the correct facts have to be uncovered and named; and that the only true guide to scientific knowledge should be a faithful adherence to observation and sensation rather than tradition and habit.

It is worth observing that Lavoisier's revolution in chemistry and nomenclature was to a large extent based on his reading of social and political theory. This is a remarkable instance in which an exact science drew its model and its inspiration from the human sciences. Historians of science and historians of philosophy have traditionally shown how the social, political sciences have sought to model their work after the exact sciences, in particular during the late 17th and early 18th century. Thus Lavoisier, in the spirit of the Newtonian principles in physics, also advocated fidelity and truthfulness to nature and the eschewing of hypotheses. In order to reverse the theory of Stahl, Lavoisier and his disciples took recourse to the argument that since phlogiston is only an imaginary entity, contradicted by experience, the new language must reflect the real composition of substances. Thus the language of chemistry became, according to an expression by F. Dagognet, a tableau.[6] And in order to construct this tableau, chemists were to employ the method of analysis and decomposition: first to establish the "facts" of chemistry, later to be described and inscribed in the new language, a nomenclature which was to be "a method of naming rather than a nomenclature," a program rather than a completed edifice. But it seems that the system of nomenclature is a mirror of the process of analysis, not of nature. By analysis and decomposition one arrives at a final product, the result of laboratory manipulation. One does not simply mirror reality, one does not name compounds such as they occur, but such as they are manufactured in the laboratory, a process which Lavoisier formalized in his famous algebraic chemical equations of combination and decomposition.[7]

[4] Lavoisier, *Oeuvres*, T. I, p. 1-2. Quoted in Bensaude-Vincent, p. 12.

[5] Bensaude-Vincent, p. 13.

[6] F. Dagognet, *Tableaux et langages de la chimie*, Paris: Seuil, 1969.

[7] ibid, p. 14ff.

Despite many nationalistic elements in the construction of the new chemical language, Lavoisier's system of nomenclature was soon translated into major European languages: first into a rather abridged German version in 1791[8], expanded in 1793.[9] In its preface, the translator wrote:

> With the powerful progress of the new French or antiphlogistic Chemistry and the probability that it will soon spread, despite the virulent opposition of some German dictatorial (analytical) chemists, over entire Germany and will be taught at the higher schools, it seemed an urgent necessity to make the new nomenclature, which the French, the creators of the new system, have invented and adopted and which serves as the foundation of their theory, known to the German chemists if he is not to lag behind his neighbors, and to translate it accurately into his mother tongue...[10]

Thus, the German translator presented the French nomenclature as lying at the basis of the French theoretical antiphlogistic system.

In Switzerland, Saussure experimented increasingly during the late 1770s and early 1780s with chemical methods of analysis and decomposition in connection whith his mineralogical studies of the Swiss Alps. By 1788 he had become one of the first foreign converts to Guyton's and Lavoisier's new chemistry. In 1789 Marc-Auguste Pictet was listed by Fourcroy as belonging, together with Cavendish, James Watt, Monge, Laplace, van Marum and Chaptal to the new adherents of the antiphlogistic theory. Danielle Plan, J. Deshusses and William Smeaton have pointed out that Pictet's "conversion... was particularly important,"[11] since he immediately began teaching the new chemistry that same year at the Geneva University.

Yet soon afterwards, Humphry Davy showed that acids are not formed by the combination of oxygen with a base, a development which should have led to a reformulation of the "new" French nomenclature. But in the middle of the Napoleonic campaigns, the time of reforms was past. Berzelius wrote in his treatise of chemistry "It follows that if one were to look for a name for this substance one would not choose the

[8] By D.C. Girtanner in Berlin bey Ungern, mentioned in Meidinger's translation, p. 4.

[9] Morveau, Lavoisier, Berthollet and de Fourcroy. *Methode der chemischen Nomenklatur für das antiphlogistische System*, with a Preface by R. Schmitz, Georg Olms Verlag: Hildesheim/New York, 1978. Reprint of Vienna edition 1793. Original title: *Methode der chemischen Nomenklatur für das antiphlogistische System* von Hrn de Morveau, Lavoisier, Berthollet und de Fourcroy. Nebst einem neuen Systeme der dieser Nomenklatur angemessenen chemischen Zeichen, von Herrn Hassenfratz und Adet. Aus dem Französischen zum Gebrauche hoher Schulen bey deutschen Vorlesungen über die antiphlogistische Chemie, von Karl Freyherrn von Meidinger, k.k. N.Oe. Landrechts- Sekretär, der Akademie der Wissenschaften zu München, der Kurpfalzbayerischen Gesellschaftsittlich – und landwirtschaftlicher Wissenschaften zu Burghaufen, der Gesellschaft naturforschender Freunde zu Berlin und der Arkadier zu Rom und Görz Mitglied. Mit VII. Kupfertafeln. Wien, M.DCC.XCIII. (1793) auf Kosten des Herausgebers und in Kommission bey Christ. Fried. Wappler. On inner leaf: "Den Freunden des antiphlogistischen Systems gewidmet."

[10] p. 1 (numbered as p. 2) The editor of the reprint edition mentions that the original pagination mistakes have been retained.

[11] Smeaton, p. 10. Danielle Plan, "Un Genevois d'autrefois. Henri Albert Gosse (1753-1816), "*Bulletin de l'Institut National Genevois* **39** (1909), 1-522. i-cxi. (fn 41), xviii-xx. J. Deshusses, "Le physicien Marc-Auguste Pictet et l'adoption de la doctrine de Lavoisier par les savants genevois," *Bulletin de l'Institut National Genevois* 61 (1961), 100-112 (p. 110).

name of oxygen but since it has been adopted generally it would be inconvenient to change it because a false theory has introduced its usage".[12] It was during the early years of the 19th century that numerous new substances, in particular organic compounds, created the need for a redefinition of the laws of chemical composition and nomenclature. Simple combinations of two elementary substances had become insufficient explanatory tools. New concepts, such as that of the radical, redirected the discourse of chemists towards chemical functionalism. Dumas exhorted his students at the Collège de France in 1836: "Si j'en étais le maître, j'effacerais le mot atome de la science, persuadé qu'il va plus loin que l'expérience; et jamais en chimie nous ne devons aller plus loin que l'expérience."[13] Later on he wrote that in the nomenclature of organic substances one should pay little attention to their origin and much more to their derivatives.

When I began reading material in preparation for today's lecture, I turned first to the most authoritative and most readily available sources in the history of chemistry. Organic nomenclature had not been among my research topics, yet I had been interested in exploring the manner in which scientists in a number of disciplines attempted to reach consensus, through publications, through official and private correspondence, memoranda and, particularly, through mettings, conferences, and congresses, national and international. Thus in my dissertation I devoted space to the First International Solvay Congress in Physics, held in Brussels at the end of 1911. The Congress, which was the first to address the then incipient quantum theory of radiation and of matter, had been convened neither by a theoretical nor an experimental physicist, but by the physical chemist Walther Nernst, in collaboration with the chemical industrialist Ernest Solvay. In his short opening address to the Congress, Nernst reminded the physicists of the 1860 Karllsruhe Congress of chemistry, where an attempt had been made to redefine the system of atomic weights. Despite the fact that no complete understanding had been reached, the Karlsruhe meeting had a marked effect in that it drew general attention to atomic notions, and as Nernst claimed, "soon afterwards complete clarity was achieved..." Echoing views which he had earlier expressed in his convocation letter to a number of prominent European scientists, Nernst ended his lecture by expressing the hope that the Solvay conference would as well "have an important influence on the development of physics."

According to the eminent historian Eric Hobsbawm, the decades between 1880 and 1914 were characterized "by the novel tendency to define a nation in terms of ethnicity and especially in terms of language."[14] Hobsbawm argues that "we are now so used to an ethnic-linguistic definition of nations that we forget that this was, essentially, invented in the later nineteenth century," when the "definition and programme of

[12] Bensaude-Vincent, p. 24-25. Berszelius, *Traité de chimie*, trans. Valerius, vol. 1., p. 77. Bruxelles, 1839.

[13] J.H. van't Hoff. "Hundert Jahre in der Molekularwelt, 1811-1911," Vortrag gehalten zu Groningen am 21 April 1911 in der 13. Versammlung holländischer Naturforscher und Aerzte, *Zeitschr. f. Elektrochemie* 17 (1 Juli 1911), 485-496, p. 485.

[14] *Age of Empire*, 144.

nationalism" was transformed, such that in particular for smaller nations (Irish, Basque, Baltic, Jewish, Macedonian) language and identity became intimately connected in their quest for recognition and territorial independence. "The 'national languages' in which they discovered the essential character of their nations were, more often than not, artefacts, since they had to be compiled, standardized, homogenized and modernized for contemporary and literary use, out of the jigsaw puzzle of local or regional dialects which constituted non-literary languages as actually spoken."[15] Not just small populations linked language to nationhood. So did the nation-states: Just as the French Republic had turned peasants into Frenchmen, so most of the European states devoted much effort in creating an educational system with a unified national language, thus making "language into the primary condition of nationality."[16]

It so happens that the last decades of the 19th century were also those in which, according to general knowledge, most scientific groups became "professionalized and institutionalized." The two phenomena are not unrelated. The birth of new scientific disciplines, or subdisciplines, has been dated as of these same generations. The 1880s witnessed the expansion of physical chemistry, biochemistry, experimental psychology with the attendant landmarks: the proliferation of chairs, institutes and journals, the influx of foreign students into the European, primarily German, academic graduate seminar and laboratory, the establishment of professional organizations and more generally, the beginnings of international meetings, congresses and networking.

I would claim that Nernst's invocation of the Karlsruhe Congress of 1860 points to a key ingredient in his personal and professional self-image, one that is consistent with his previous activity on behalf of physical chemistry as a new science. Between 1840 and 1900 some 600 international meetings, conferences, and congresses took place mainly in Europe, but also in the US and South America. Initially, the most famous ones had been organized around Universal Expositions, celebrating the height of the British Empire, or the centenaries of the American and the French Revolution. Railways and the steamship had made such transnational meetings possible. In the 1840s and 1850s it was mostly charitable institutions, peace activists and some isolated professional groups who had convened. And it was only in 1860 that scientists convened for the first time at the Karlsruhe Congress of chemistry; while in 1899 the French Physics Society recommended that an International Congress of Physicist should be convened in Paris in 1900 in order to present a comprehensive summary of the definitive state of scientific knowledge at the turn of the century. The organizers wished to paint with wide strokes a tableau of the ideas and hypotheses by which one explains the constitution of nature and the laws which govern ist. Nernst had attended the Paris meeting, where 80 scientific papers were presented, as an official representative of German science, but his intention in Brussels were to duplicate in significance the Karlsruhe meeting.

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[15] ibid, 147.

[16] ibid, 150.

Therefore I will discuss the events which led up to the Karlsruhe Congress and later to the international meetings of fin-de-siècle. My conclusion will be that during the second half of the nineteenth century a spirit of hope in successful cooperation was professed as a desirable agenda, but that in reality these hopes were frustrated. They were frustrated not by the inability of scientists to agree, but by the emergence of a pluralism of scientific languages and scientific conceptions of nature.

Nernst conceived of physical chemistry as a "new language," in his words a "diplomatic mediator" between physics and chemistry. The seeds for self-conscious historical writing, had been earlier sown by Ostwald, who wrote in the 1890s that the work that "emerged from the rooms of the Leipzig physical-chemical institute" by a handful of scientists were analogous to the "events connected with the elaboration of the antiphlogistic theory by Lavoisier and his collaborators." Western science had undergone, for the past two centuries, a process of increasing democratization as far as its language and accessibility were concerned. And in the transition from the common Latin vocabulary to that of national, vernacular vocabularies, science had become a national rather than an international affair. The early efforts to institute the language of mathematics as a universal replacement of Latin were heroic but never devoid of local particularism. Not only had Bishop Sprat urged the transition from "the Artifice of Words" to the "bare knowledge of things," from experience to experiment, to "a close, naked, natural way of speaking; positive expressions... and preferring the language of Artizans, Countrymen, and Merchants, before that, of Wits or Scholars," but he also extolled the English "Universal Temper," their "climate, the air, the influence of the heaven, the composition of the English blood; as well as the embraces of the Ocean" which were meant to make England "a Land of Experimental Knowledge." Thus the Royal Society, while aiming to transform science and invent a new language of public experimentation and universal language of calculation and measurement, still defined itself in terms of particular national experiences. When Henry Oldenbourg returned from his celebrated European tour in the late 1650s, he described the meetings of the Parisian Montmor Academy with great admiration, and yet noted that "the French naturalists are more discursive than active or experimental. In the meantime the Italian proverb is true: **Le parole sono femine, li fatti maschii.**"[17] Thus, at the hands of Oldenbourg and Sprat, the promotion of experimental knowledge of facts was to be a definitely masculine enterprise of particularly British character. Not only that but, as Schaffer and Shapin have argued, and as Svetlana Alpers has shown for Dutch painting, the seventeenth century created the conventions and the craft necessary to produce a faithful mirror of reality according to Hooke's precepts: the "sincere hand" and the "faithful eye."[18]

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[17] Daniel J. Boorstin, *The Discoverers*, New York: Random House, 1983, pp. 389, 394-5.

[18] S. Shapin and S. Schaffer, *Leviathan and the Air-Pump*, Princeton: Princeton University Press, 1985, p. 18. See S. Alpers, *The Art of Describing*, London: John Murray, 1983, pp. 72-73, quoting Hooke, *Micrographia* [1665].

In 1858 Stanislao Cannizzaro had published "Sunto di un Corso di Filosofia Chimica" in *Il Nuovo Cimento* in which he argued for the correctness of Amedeo Avogadro´s atomic hypothesis, proposed half a century earlier (1811), and neglected by most chemist until the Karlsruhe meeting. Some 140 prominent chemists convened in Karlsruhe at the initiative of the famed August Kekulé. Some of the participants, like Kekulé, were already firm supporters of Gerhardt's atomic weights, which were based on Avogadro's hypothesis; others prefered Berzelius's weights or Gmelin's equivalents. In one of "the most widely circulated text-books of the period",[19] *Fownes' Chemistry*, the atomic theory was still viewed by "many super-cautious chemists"[20] as "at best but a graceful, ingenious, and its place useful hypothesis."[21] There is evidence of this attitude as late as 1869 in Williamson's lecture to the Chemical Society of London[22] and the discussion which followed. Sir William Tilden, a past president of the society, later remarked that "Some thought to perceive a distinction between physical atoms and chemical atoms, but generally they seem to have retained the fundamental notion of Dalton, which conceives each atom to be a sphere existing either alone or in close contiguity with other similar atome, and separable more or less from one another by the influence of heat. Students at this time were generally unfamiliar with the word 'molecule,'[23] for chemists spoke as complacently, and in a sense as justly, about an *atom* of water as about an atom of oxygen. For the most part they had also never heard the name of Avogadro." At the time of Cannizzaro's work, "the conception that the ultimate particles of the elements themselves might contain more than one atom had not been commonly accepted. It was believed that combination could only occur between substances of opposite chemical or electrochemical character, hydrogen with oxygen, for instance, but that hydrogen could unite with hydrogen... was not generally admitted."[24]

It seems that Kekulé's aim in calling for a congress was foremostly chemical nomenclature rather than questions of atomic weights[25], although the formal invitation drawn up by C. Weltzien, Kekulé and Wurtz stated the aims as:

> More precise definitions of the concepts of atom, molecule, equivalent, atomicity, alkalinity etc.; discussion of the true equivalents of bodies and their formulas; initiation of a plan for a rational nomenclature.[26]

[19] Tilden, Sir William A. "Cannizaro Memorial Lecture," delivered on June 26th, 1912, in *Memorial Lectures delivered before The Chemical Society* 1901-1913, Vol. II. London: Gurney and Jackson, 1914. (Tilden is pas president of the Society.), pp. 199-215, p. 204.

[20] Tilden, 204.

[21] 6th ed. 1856, edited by Bence Jones and Hofmann, p. 10, quoted Tilden, p. 204.

[22] Journ. Chem. Soc., 1869, **22**, 328.

[23] "The word *molecule* was occasionally used by Dalton, eg. "Chemical Philosophy," Vol. I., p. 70, and in the sense of atom by Ampère (*Ann. Chim. Phys.*, 1814, **90**, 43.)" This is fn. in Tilden, p. 204.

[24] Tilden, 205-6.

[25] Crosland, Maurice P. *Historical Studies in the Language of Chemistry*, Cambridge, Mass.: Harvard University Press, 1962, p. 343.

[26] From Clara deMilt, "The Congress at Karlsruhe," *J. Chem. Ed.* **28** (1951), 421-425, p. 412. She mentions that the above is a translation of the German circular, dated July 10, 1860, although

We can glimpse many significant similarities between the Karlsruhe Congress and the Geneva Conference of 30 years later. In Karlsruhe, a steering committee composed of eight distinguished chemists (among them Kekule, Cannizzaro, and Wurtz,) and chaired by Kopp was entrusted with the preparation of a list of questions regarding atoms, molecules, radicals and equivalents. In the meeting, no general agreement was reached, and Cannizzaro attempted in vain, in lengthy discussions, to persuade the audience of the soundness and correctness of his views. Eventually, dissent prevailed. At the close of the meeting, Kopp and Erdmann argued that no vote can be taken on scientific matters and that each scientist should be completely free in making such decisions. Tilden was critical of the lack of success at the Karlsruhe Congress: "But it is not creditable to the chemists of 1860 that the Congress... should have dispersed without a general acceptance of the fundamental principles which to us seem unasailable." Tilden finds only one possible excuse, namely that the anomaly of vapour densities in the dissociation of compounds such as sulphuric acid had "not been cleared away." However, "to contend, as some speakers seemed to have done [at the Congress], that these subjects are matters of opinion, and that every scientific man is entitled to perfect freedom in respect to the views he adopts, is to misunderstand the case. In art, in which field sentiment, emotion, and taste are the only considerations involved, complete freedom is clearly necessary, but in science whenever facts have been established and an agreement has been arrived at in regard to fundamental assumptions, reason ought to be the only, as it is, the sufficient, guide."[27]

Although no consensus whatsoever emerged from this famous chemistry congress, two young participants must have been substantially influenced by Cannizzaro's paper. Dimitri Mendeleev and Lothar Meyer were both in attendance, and within less than a decade they produced their fundamental papers on the classification and periodization of chemical elements based on Avogadro's and Cannizzaro's work. Meyer later reminisced about the congress:

> I... received a copy [of Cannizzaro's paper] which I put in my pocket to read on the way home. Once arrived there I read it again repeatedly and was astonished at the clearness with which the little book illuminated the most important points of controversy. The scales seemed to fall from my eyes. Doubts disappeared and a feeling of quiet certainty took their place. If some years later I was myself able to contribute something towards clearing the situation and calming heated spirits no small part of the credit is due to this pamphlet of Cannizzaro. Like me it must have affected many others who attended the convention. The big waves of controversy began to subside.[28]

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were English and French circulars as well. The German version was dated July 10, the English July 1. She also quotes from Anschutz, p. 671. Crosland gives the quote as: "Definition of important chemical ideas, such as those expressed by the words: atom, molecule, equivalent, atomic, basic. Examination of the question of equivalents and chemical formulae. Establishment of a uniform notation and nomenclature. "See R. Anschutz, *August Kekulé*, Berlin, 1929.

[27] Tilden, 210.

[28] L. Meyer, in the German translation of Cannizzaro's paper, published in *W. Ostwald's Klassiker der Naturwissenschaften*, No. 30. Engl. transl. as *Alembic Club Reprint*, No. 18, Alembic Club, Edinburgh, re-issue edn., 1947. Quoted in Aaron J. Ihde, *The Development of Modern Chemistry*. New York: Dover Publications, 1982, p. 229.

Four years later, Meyer published his book *Die modernen Theorien der Chemie*, based on Avogardro's work, which became an influential text in theoretical and physical chemistry. Mendeleev, who had spent several years studying chemistry in Heidelberg, attended the Karlsruhe conference on his way back to Russia. He was then 26 years old. Both Meyer and Mendeleev published their separate versions of a periodic table of elements in 1869.

But the drive to standardize nomenclature and notation came, to a great extent, from publishers of chemical reference books and journals. Thus the *Journal* of the Chemical Society of London published in 1879 a series of rules for the guidance of contributors[29], such as the use of prefixes ortho, meta, and para for the benzene ring positions or the rules for the use of the term ether. In the first volumes of the chemists's bible, **Beilstein's Handbuch**, published during 1880-1883, its famed Russian editor set down the nomenclature he intended to use.[30]

At the Paris International Congress of Chemistry, which took place on the occasion of the 1889 Paris Exhibition, whereone of the items on the agenda was entitled "Etude des réformes à apporter à la nomenclature en chimie organique." On this occasion, in its session of August 3, the Congress decided to appoint an International Commission charged with studying nomenclature problems, which had become increasingly complex and often confusing, allowing for a multiplicity of names for one and the same compound. They were often dependent on the radical chosen as a root name while, inversely, the names thus chosen were not sufficient to distinguish among the various isomers. Twenty five chemists from 14 countries, including the USA, Chile, Russia, Romania and Turkey agreed to serve on this commission, under the direction of Charles Friedel. They met five days later, appointing a sub-committee composed of members residing in Paris. Over the next 13 years, this sub-committee met in some 45 sessions and produced five reports which were circulated among European chemists and journal editors.

These reports set the bases for a conference to be held in Geneva during the Easter week of 19-22 April, 1892. Amé Pictet participated as one of the six Swiss representatives, together with C. Graebe, P.A. Guye, A. Hantzsch, D. Monnier, and R. Nietzki. "The meetings were entirely intimate, without pose or pretense and everyone, as true good colleagues, attempted only to dissipate difficulties and find a new, practical and fruitful path for a good understanding in organic chemistry..."[31] Those who met under Friedel's presidency in seven meetings at the Hotel Metropole in the center of town never seemed to envisage that their conference would resolve all issue at hand. They expected to meet for a longer session, and in fact "several chapters of the Paris sub-commission's report were never discussed in Geneva due to lack of time."[32]

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[29] Crosland, p. 345. *J. Chem. Soc.* **35** (1879), *Transactions*, pp. 276-81.

[30] Crosland, p. 347.

[31] C.I. Istrati, *Studiu relativ la o nomenclatura generala in chimia organica*, Bucuresti: Editiunea Academici Romane, 1913, p. 25.

[32] ibid., p. 25.

As one of four elected secretaries of the conference, Pictet compiled one of the most important historical and scientific documents regarding the Geneva nomenclature,[33] a document which in my view served as an important foundation for Pieter Eduard Verkade's essays in the *History of the Nomenclature of Organic Chemistry*.[34] Pictet, later as representative of the *Helvetica Chimica Acta*, remained an active participant in the more recent developments in organic nomenclature.

However, the Geneva conference turned out to be less international than the Paris meeting. Differences among the national delegations emerged on the first day of deliberations. The French subscribed to the view that a multiplicity of names may be employed for the same compound, in particular for teaching purposes, whereas the Germans, led by the doyen of German chemistry, Adolph von Baeyer, disagreed, arguing that a nomenclature should primarily benefit the researchers. The convention accepted a proposal, contra Baeyer, to first mention the side chains and then the main hydrocarbon structure, and the functions before the main structure, such that "in speech or writing we stand suspended for a few moments."[35] They suggested that the primary goal of the Geneva meeting should be the formulation of univocal, official names for each chemical compound, a proposal which eventually prevailed. But the resolution adopted was one of tolerance, since it stated that

> In addition to the usual name, every organic compound should be given an official name... The Congress would like authors to adopt the custom of mentioning the official name in brackets in their publications after the name chosen by themselves.[36]

These official names were to be constructed on the most "objective basis," essentially following the carbon skeleton structure, while the substituted atoms would be described by prefixes or suffixes. This first organic nomenclature gave priority to structure, but was limited to acyclic compounds and left unsolved the problem of compounds which had more than one function. In his meticulous and highly informative standard history of The Development of Modern Chemistry, the noted pioneer historian of science Aaron Ihde wrote the following about the Geneva Conference on Organic Nomenclature:

> The study commission... advanced nomenclatural propositions based on its work over the three-year period [since the International Congress of Chemists held in Paris in 1889]. These were approved by some forty members in attendance, and an official nomenclature was established for organic chemistry.

And he further noted that "The Geneva nomenclature has received official acceptance among international chemical groups."[37] But in fact, for various reasons, foremost

[33] Amé Pictet, "Le congrès international de Genève, pour la réforme de la nomenclature chimique," *Archives des sciences physiques et naturelles*, Troisième période, **27** (Mai 1892): 485-520.

[34] Pieter Eduard Verkade's *History of the Nomenclature of Organic Chemistry*, Dordrecht/Boston/Lancaster: Reidel, 1985.

[35] ibid., p. 26.

[36] Crosland, p. 349.

[37] Ihde, p. 339.

among them that of incompleteness, the Geneva rules were not implemented in the daily practice of the growing number of highly specialized chemists.[38]

The Geneva conference urged a nomenclature based on constitution without however effecting any thorough transformation of chemical language and nomenclature, reinforcing the status quo and implicitly backing the use of trivial and popular names. The sub-committee urged that names be based on the principle of substitution and on chemical formulae. The Geneva meeting reached agreement on only a limited number of issues regarding in essence only hydrocarbons and their acids. Aromatic compounds were discussed but no decisions were taken.[39]

Thirty years later, the new International Union of Chemistry, acting on a suggestion by Sir William Pope, appointed a nomenclature commission formed by the editorial staffs of chemical journals. The commission formulated the Liège rules of nomenclature which were however even less revolutionary than those pronounced in Geneva forty years earlier. They agreed that "as little change as possible is to be made in terminology universally accepted" and decided not to deal with compounds such as proteins, vitamins and hormones, which were to be handled by a biochemical nomenclature commission.[40] The ambition of an official name was renounced and it became sufficient to adopt the habits in use by seeking to improve them somewhat,

> this report does not wish to intervene into the editorship of the *Beilstein*, nor into that of the chemical abstracts. These works have followed their own system of nomenclature over a period of many years and are in fact very similar to the rules adopted now. In its editorship the committee has rather chosen to follow usage as much as possible...; has proposed some simplifications and... the elimination of some incorrect names. It hopes that the flexible system of nomenclature thus created will be used more and more by authors.[41]

In Liège, priority was given to chemical functions, and the rules adopted were completed in Lucerne in 1936; in Rome, 1938; and later in London in 1947. There the International Commission urged simplicity, conformity with the usage in existence in journals, monographs, and industrial texts, the continuation of the use of trivial names; it eventually only recommended an increased effort in systematizing existing and future names.

The history of chemical nomenclature could in many ways bre used as a guide and a reflection in our understanding of the development of the physical sciences since the Scientific Revolution of the 17th century. If language and science are both the products of cultural history, mutually reinforcing form and contents of scientific knowledge, then the path traversed by modern chemistry since Lavoisier's *Traité de chimie élémentaire* mirrors to a considerable extent the path from Newtonian to modern physical

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[38] Bensaude Vincent calls them a dead letter.

[39] ibid., pp. 350-353.

[40] ibid., p. 354.

[41] Bensaude-Vincent, p. 32. Préambule aux règles de Liège, quoted by N. Lozac'h, *Nomenclature de la Chimie Organique*, Paris, 1957, p. 10.

conceptions of nature. In 1789, the chemists had to systematize less than a hundred known metals and gases. For that they proposed the forging of a corporate merger between classical Greek and the melodious French language. And despite the fact that chemical nomenclature was used as a tool for a new chemical theory which hoped to entrench itself firmly in natural explanation, it seems to me that once the complexity of the natural world began to be accepted in all its manifestations, ranging from atoms and molecules to nuclei and electrons, the language of that science inevitably became multiple and pluralistic as well.