getting across to students?

I have spiced my talk with personal reminiscences, general criticism and well-meant advice which will be difficult to implement. But I feel strongly about the neglect of industrial history and would like to see more of it along the lines I have suggested. *The Chemical Industry* books have caused me a lot of work, but they have also given me much personal satisfaction. Rather late in the day I have come to recognize that they could have been done better. Last, but not least, the books have led, quite unexpectedly, to the Dexter Award which gives me very great pleasure.

Dr. Sydney Milton Edelstein, the founder and head of the Dexter Chemical Corporation, has sponsored the award since the 1950s (3). I am proud to have been the recipient for 1988, and I take this opportunity of thanking him through the History of Chemistry Division of the ACS. I hope that in the future, others will be honored for work leading to a better understanding of those two great disciplines - history and chemistry.

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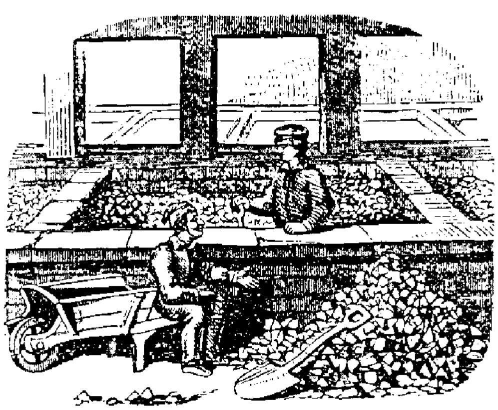
3. A. Ihde, "The History of the Dexter Award. Part I", *Bull. Hist. Chem.*, **1988**, *1*, 13-14 and *Dexter Chemical Corporation: A Company Documentary*, n.d.

4. Anon., *Encyclopedia of Chemistry*, Vol. 1, Lippincott, Philadephia, 1877, p. 168.

Lutz F. Haber, winner of the 1988 Dexter Award, is a retired Reader in Economics at the University of Surrey at Guildford. He lives in Bath and is currently working on a study of the Emperor Haile Selassie's exile in Bath in the late 1930s.



Alum manufacture, circa 1850 (4)

BOOKS OF THE CHEMICAL REVOLUTION

Part I: Méthode de Nomenclature Chimique

Ben B. Chastain, Samford University

Though we celebrate 1989 as its bicentennial, the chemical revolution was actually a complicated process which extended over many years. In this new series, Dr. Chastain provides the modern chemist and teacher with an introduction to some of the key books of the revolution.

In the spring and summer of 1787 a group of statesmen met in Philadelphia and, after much discussion and compromise, produced a document which, despite some early opposition and a continuing series of minor modifications, has become the foundation upon which this nation has been built. We celebrated, and continue to celebrate, the bicentennial of our Constitution's creation (1787), ratification (1788), and implementation (1789).

In Paris, that same spring and summer of 1787, another series of meetings took place which, after discussion and compromise, produced a document - a document which, despite some early opposition and a continuing series of minor modifications, has become one of the foundations upon which our science is built. Its title page reads: *Method of Chemical Nomenclature, proposed by Messrs. de Morveau, Lavoisier, Berthollet, and de Fourcroy; together with a new system of chemical characters [symbols], adapted to this nomenclature, by Messrs. Hassenfratz and Adet. At Paris, the house of Cuchet, bookseller, rue and hotel Serpente, 1787. Under the privilege [sponsorship] of the Academy of Sciences.*

Is a book on nomenclature really as important to chemistry as the Constitution is to the United States? Almost. In 1787, chemistry was in the midst of a revolution (the bicentennial of which we celebrated, and continue to celebrate). Lavoisier and his disciples were winning more and more converts to the "new" chemistry. And contrary to the sentiments expressed earlier by a Miss Juliet Capulet - "that which we call a rose by any other name would smell as sweet" - the leaders of the revolution were convinced that chemical names must be carefully chosen, and that they should convey information about the substances named. The Abbé Bonnot de Condillac, a philosopher who greatly influenced Lavoisier, put it very strongly: "We only reason well or reason badly insofar as our language is well or badly constructed ... The progress of the sciences depends entirely on the progress of their languages" (1). A brief look at the state of chemistry's language in the late 18th century would seem in order.

We can hardly fault the ancients for giving substances names which convey no information on composition; they *had* no information on composition. They had enough problems just in identifying as the same substance specimens prepared in different ways. Names were derived from many and varied sources (2):

* *astrology*: lunar nitre (silver nitrate), sugar of Saturn (lead acetate), martial chalk (iron carbonate)

* *people and places*: Glauber's spirit of nitre (fuming nitric acid); terra anglica rubra (ferric oxide), Epsom salts (magnesium sulfate)

* *color*: magnesia alba (magnesium carbonate), magnesia nigra (manganese dioxide), red precipitate of mercury (the oxide)

* *form*: milk of lime (calcium hydroxide suspension), flowers of zinc, phosphorus, sulfur (oxide, oxide, sublimed element).

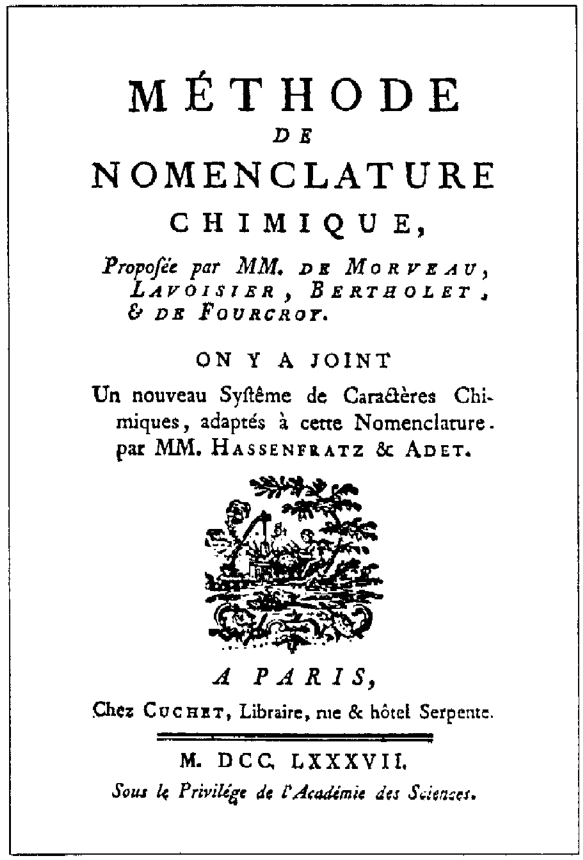
Most of these were still in use in the 18th century! As an example of the chaos which could result, consider the following list: "alkali of wine lees, cineres clavellati, fixed nitre, offa Helmontii, pearl ashes, salt of tartar, vegetable alkali." How many substances are listed here? One. Potassium carbonate.

Some names were quite misleading: "mercurius vitae" (antimony oxychloride) was a deadly poison, "red precipitate of mercury" was not obtained by precipitation, "calx of gold" was really the metal, "fixed sulfur of antimony" contained no sulfur (it was an oxide). You get the idea.

Complaints and criticisms abound in the literature of the 16th and 17th centuries, but few constructive suggestions were forthcoming until the middle of the 18th. Pierre Joseph Macquer published a *Dictionnaire de Chymie* in 1766 which included all known substances, along with a compilation of the criticisms of current terminology and some suggestions for a systematic way to name salts. Several chemists of that day, including Rouelle in France and Bergman in Sweden, had begun to use long descriptive phrases such as "the acid of vinegar joined with chalk" or "sel vitriolique a base de terre argilleuse" (aluminum sulfate), which at least indicated something about composition. Macquer proposed that, e.g., salts of "acide nitreux" might be referred to as "sel nitreux" or just "nitre", as in "nitre d'argent". The use of the longer phrases above was necessitated by the fact that aluminum and calcium had not yet been isolated and named.

Thus the stage was set in the 1780s for real progress in nomenclature. Torbern Bergman set forth a scheme for classifying and naming minerals, using binary names for many salts ("argilla vitriolata") and arguing for Latin as the language of choice in naming substances (it is true that the ease with which adjectives can be made from nouns in Latin leads to smooth binary names like "tartarus citratus"). His work was published in 1784; it showed approval and use of many of the ideas set forth two years earlier by a chemist from Dijon named Louis-Bernard Guyton de Morveau.

Guyton (or M. de Morveau) is the first author listed on our title page; this is appropriate, for most of the basic principles were his. (Actually, the order of the four names is merely that


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.

of seniority - Guyton was born in 1737, Lavoisier in 1743, Berthollet in 1748, and Fourcroy in 1755). Guyton was a professional lawyer and an amateur scientist. As a member of the Dijon Academy, he had both written and spoken about the shortcomings of current chemical nomenclature and was aware of Bergman's work. In 1782, he published a paper (3) in which he set down five principles for a new system of "denominations chimique". In brief, they are:

1. A phrase is not a name; circumlocutions like "the acid of vinegar joined with chalk" should be used only when no shorter expression would be clear;

2. Names should conform with nature (that is, composition); simple substances should have simple names, compounds should show in their names their constituent parts, the names of persons should be shunned.

3. If the character of a substance is unknown, a name which expresses nothing is better than one which may give a false impression (since phlogiston was controversial, "pure air" was a better name than "dephlogisticated air").

4. For new names, the roots should be chosen from the most common dead languages - Latin and classical Greek - so that derived forms would be clear.

5. Names should be chosen so that the "genius" of the language used is taken into account; nouns should be easily turned into adjectives.

From these principles he then derived a series of proposed names for bases, acids, and salts. Most of these found their way into the 1787 *Méthode*.

Antoine Lavoisier hardly needs an introduction; his experiments, which established the nature of burning and led to the overthrow of the phlogiston theory, have been discussed in detail elsewhere (4). Here we merely mention that throughout his experimentation he was always concerned to choose expressions and names which would avoid misunderstandings. (For example, he did not wish to refer to one of the constituents of a solid calx as an "air", so he coined a term - he referred to the substance which combines with metals in calcination as the "principe oxigine"). We have already noted his great interest in the ideas of the philosopher Condillac regarding language.

Claude-Louis Berthollet was also a well-known chemist of the day, having done important work on chlorine, ammonia, and prussic acid, and their practical uses. In his writings he preferred to use long descriptive phrases for substances rather than the old names, but he did not issue any clarion calls for nomenclature reform. In fact, his name on the title page of *Méthode* may be more due to his prestige and his early support of Lavoisier's oxygen theory than to any specific contribution to the work. He did, of course, take part in the discussions that spring and summer.

The fourth author, Antoine Francois de Fourcroy, is perhaps the least well-known, as well as the youngest. Like Berthollet, he had been trained to be a physician, but became interested in chemistry instead. He proved to be a brilliant lecturer, and taught during the last two years of his medical studies. His first official appointment was to the faculty of the Royal Veterinary School, but after only a few months the post of Professor of Chemistry at the prestigious *Jardin du Roy* became available, and Fourcroy was appointed to the post (incidentally, the other major candidate was Berthollet). He gave his lectures in the old amphitheatre, which seated 600 and was nearly always overcrowded. A new one was constructed in 1787 with double the capacity; it was enlarged in 1794. According to Fourcroy's biographer, W. A. Smeaton, "Great audiences of all classes and all nations spent hours, tightly packed, almost fearing to breathe, their eyes fixed on his. He could see those who were not convinced, or did not understand, and he would go over the subject in a different way, more than once if necessary, until he saw the whole audience equally satisfied" (5). He also wrote a widely-read text on natural history and chemistry. He was, in fact, in an excellent position to promote the rapid spread of the "new chemistry" and its nomenclature.

Louis-Bernard Guyton de Morveau (1737-1816)

The gathering of these four men in Paris early in 1787 (Guyton came from Dijon and stayed about eight months) originally had more to do with Lavoisier's new experiments in support of his oxygen theory than with nomenclature. Berthollet had been converted in 1785, Fourcroy in 1786 and Guyton was finally convinced in 1787. Because of the previous interest of at least three of the four in improving the terminology used in chemistry, it was decided that a detailed new system should be presented as soon as possible. The result was the *Méthode de nomenclature chimique*.

The first section of the book consisted of the text of a paper which Lavoisier had delivered in April to a public meeting of the Academy of Sciences (he, Berthollet, and Fourcroy were members of the Academy; Guyton, who came from the provinces, was not). The paper gives the background of the suggested reform and credits those who had worked on nomenclature in the past - Macquer, Baume, Bergman, and especially Guyton. Lavoisier praised the latter for his willingness to sacrifice his own ideas and previous work to the present collaboration. He described their conferences, which ranged over the whole of chemistry as well as the metaphysics of language, as being quite free of personal considerations. The rest of his presentation deals mainly with Condillac's ideas on the importance of language. He stresses that what they propose is a *method* of nomenclature, which should easily adapt itself to new substances, and should only require minor reforms in the future.

The second section was the text of a paper which Guyton had presented to a private meeting of the Academy about two weeks after Lavoisier's. It sets forth the details of the scheme, explaining how special care had been taken in the naming of "simple bodies", since these names would be used in constructing those for compounds. There were 55 "simple bodies", in five classes (details below), and he explained how they decided on such things as the uniformity of gender and the consistency of endings.

This was followed by a paper, written by Fourcroy, explaining the details of a large, folding table which was inserted in the book. This table contained the new names for the simple substances, their compounds with oxygen (this usually meant acids), examples of their salts and other compounds, and alloys. When needed, old equivalents for the new names were given. As Fourcroy says: "It is evident that we have created but a very few absolutely new words, except such as were indispensably necessary to indicate substances which were unknown before ... In following the order of the substances denominated in the first column, from which all the other names are derived, it will appear that we have not made any new words but oxygen, hydrogen, and azot" (6). The five classes in that first column were:

1. The simplest substances - light, caloric, oxygen, hydrogen, azot (caloric was the *matter* of heat, all gases contained it).
2. Acidifiable bases - the principles of acids; four which had been decomposed (azot, carbon, sulfur, phosphorus), 22 others which had not yet been decomposed, including muriatic, succinic, acetic, tartaric, oxalic, lactic, formic, boracic.
3. Metals - 17, including gold, silver, mercury, copper, iron, molybdenum, tungsten, manganese, platinum.
4. Earths - silica, alumina, lime, magnesia, barytes.
5. Alkalis - potash, soda, ammoniac.

It is of interest to note that, as Fourcroy says: "ammoniac has been decomposed; M. Berthollet has determined with precision the nature and proportion of its principles" but it was placed with the other "fixed alkalis" so as "not to interrupt the order and relation of these substances, which in many respects appear as indecomposable substances in chemistry".

As an example of how these were combined, consider sulfur: there were two acids known, containing different amounts of oxygen; the one considered saturated was "acide sulfurique", the one with less oxygen was "acide sulfureux". Salts of the former were "sulfates", of the latter "sulfites". Similarly, "carbone" produced "acide carbonique", "carbonates", and "carbures". Azot lead to two acids which were called "nitrique" and "nitreux" (in the second English edition in 1794 the translator, George Pearson, chose "nitrogen" rather than "azot", to be consistent with hydrogen and oxygen).

There followed two dictionaries, the first listing old names alphabetically and "translating" them into the new, the second reversing the process. This second was twice the length of the first, reflecting the large number of new substances recently investigated, for which no old names existed.

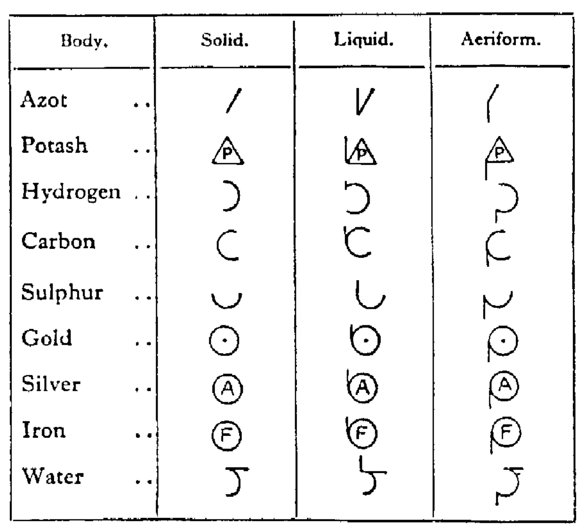
And what of the symbols of Messrs. Hassenfratz and Adet mentioned on the title page and "adapted to this nomenclature"? Suffice it to say they never really caught on. One or two examples may demonstrate why. The simple substances were divided into six classes, not five - the sixth being "inflammables". Each class had a characteristic symbol:

1. Simplest substances - a straight line
2. Alkalis and earths - a triangle
3. Inflammable substances - a semi-circle
4. Metals - a circle
5. Acid radicals - a square
6. Compounds of unknown nature - a diamond

Inside the triangles, circles, and squares were letters; usually the first letter of the Latin name of the substance. When symbols were combined, their relative positions implied relative degrees of saturation. In the case of organic acids, letters had to be used again. Liquids and gases were indicated by adding the vertical stroke which stood for caloric, either above or below (see figure).

Though the authors of the *Méthode* praised the system of symbols and referred to it as "very ingenious", neither they nor many other writers incorporated them into textbooks. The major problem was typographical; printers had to construct special type which could be inserted into a regular printed page. The result was that the symbols were printed in some dictionaries and books, but always as separate plates or special tables. One of the reasons Berzelius chose ordinary letters for his symbol system (the one still used) was that they could be easily printed. Hassenfratz and Adet just never caught on.

What was the reception of the rest of the volume? Even though it was only on nomenclature, most scientists saw no way to separate it from the rest of Lavoisier's ideas on chemistry, and so it was sharply criticized by the phlogistonists in the Academy, and that body in effect remained neutral, playing no part in the acceptance of the new names. The hostility of the editor of the *Observations sur la Physique* led to the formation in 1789 of the *Annales de Chimie*, most of whose articles used the new nomenclature. Perhaps of more importance in the long run were the several new textbooks of chemistry which used the new ideas, including those by Jean Chaptal of Montpellier, Fourcroy at the *Jardin du Roy*, and, of course, Lavoisier with his 1789 *Treatise* (Chaptal, incidentally, argued for the use of nitrogene instead of azote). These texts were translated into the major European languages over the following years and widely



Some examples of the symbols of Hassenfratz and Adet (2) used. Lavoisier was the only one of the four authors who did not survive the French Revolution; and Guyton, as one of the editors of *Annales de Chimie*, and Fourcroy, as a noted and popular teacher, had great influence on the general adoption of the new system in France.

The first English translation was made by James St. John in 1788. It was he who decided to spell oxygen and hydrogen with a "y" rather than the French "i"; he also used "ph" in words like sulphur, instead of the French "f". Thomas Jefferson, who was in France at this time, wrote a letter in July 1788 in which he states that Lavoisier's new theories are not yet sufficiently established by experiment, and therefore it is too early to reform nomenclature. However, when Samuel Mitchill became a professor at Columbia in 1792, he used the new system in all his lectures, and in 1794 published a volume entitled *Nomenclature of the New Chemistry*. At least two other books on the new nomenclature had been published in America by 1800, and the system was in almost universal use in this country by that time (7).

The *Méthode de nomenclature chimique* was the lexicon of the chemical revolution; it furnished the vocabulary with which the new ideas could be proclaimed and discussed. The spread of the revolution, however, was accomplished by other books, especially those by Fourcroy and Lavoisier. These will be discussed in subsequent papers in this series.

References and Notes

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5. W. A. Smeaton, *Fourcroy, Chemist and Revolutionary, 1755-1809*, Heffer, Cambridge, U.K., 1962, p. 12.
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THE HISTORY OF THE DEXTER AWARD

Part III: The Second Decade

Aaron J. Ihde, University of Wisconsin

Earle Caley (1900-1983), the recipient of the 1966 award, was born in Cleveland, Ohio, where a high school teacher developed in him a lifelong interest in chemistry. After taking a doctorate in analytical chemistry at Ohio State University, he taught at Princeton, where a friend in classics inspired a further interest in archeology. These two interests were finally combined during a sabbatical spent in Athens, where Caley began to analyze coins and other archeological artifacts. This became his specialty as an analytical chemist. After working in industry during World War II, he joined the Ohio State faculty as an analytical chemist, where he published numerous papers and books on analytical chemistry and on his archeological studies.

Earle Caley

The 1967 award was given to Mary Elvira Weeks (1892-1975). Born in Lyons, Wisconsin, she attended Ripon College, where she became interested in chemistry. This led to a M.S. degree in chemistry at the University of Wisconsin and to a Ph.D. at the University of Kansas, where she became a faculty member in 1921. At Kansas she encountered Frank Dains' collection of pictures of famous chemists. This, in turn, led to the publication of a long series of papers in the *Journal of Chemical Education* in the early 1930's dealing with the discovery of the chemical elements and illustrated with pictures from the Dains' collection. This series proved so popular that it was reprinted in 1934 as a book entitled *Discovery of the Elements*. By the time of Miss Weeks' death in 1975, the book had gone through seven editions, the last two done in collaboration with Henry Leicester. In 1944 Weeks took a position as