BOOKS OF THE CHEMICAL REVOLUTION

Part II: Élémens d'Histoire Naturelle et de Chimie

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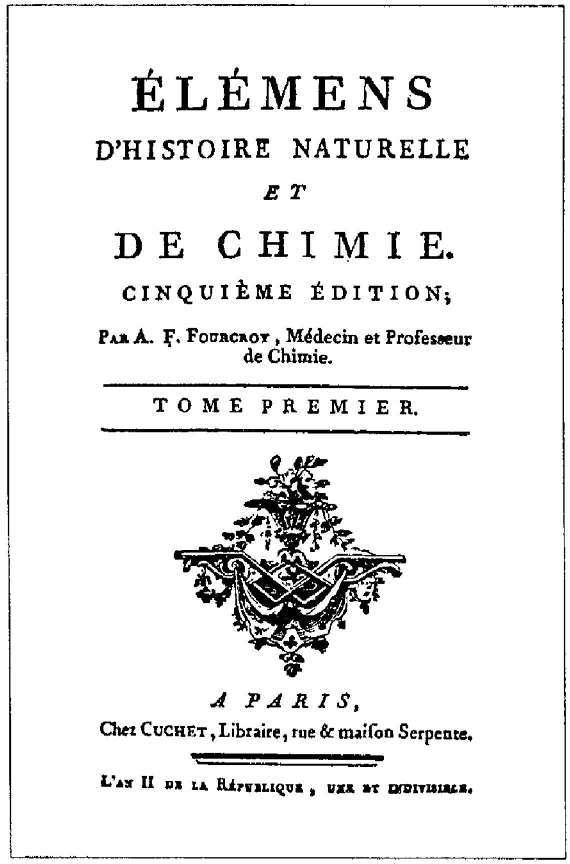

ÉLÉMENS

D'HISTOIRE NATURELLE

ET

DE CHIMIE.

CINQUIÈME ÉDITION;

PAR A. F. FOURCROY, Médecin et Professeur de Chimie.

TOME PREMIER.

A PARIS,

Chez CUCHET, Libraire, rue & maiſon Serpente.

L'AN II DE LA RÉPUBLIQUE, UNE ET INDIVISIBLE.

The first paper in this series celebrated the 1787 publication of the *Méthode de Nomenclature Chimique*, the book which gave the new chemistry its voice and provided the vocabulary needed to preach the revolution (1). In this second paper, we will look briefly at one of the most eloquent of the preachers and at some of his writings, especially one which might well claim to be the first textbook of the revolution.

Antoine Francois de Fourcroy was born in Paris in 1755 into a once-noble family which had suffered decline (2). His father was an apothecary, and he was raised by an elder sister after the death of his mother in 1762. Fourcroy had about six years of formal schooling and was working as a copying clerk in a government office when a chance meeting with Felix Vicq d'Azyr, a rising star in the field of anatomy, resulted in his becoming a medical student. He proved to be a brilliant student and produced important work in medicine (his first publication was the translation of a Latin work on occupational diseases, with added notes and commentary) but he was most interested in chemistry and natural history. His teacher in these areas was Jean-Baptiste Bucquet, a friend and sometime collaborator of Lavoisier. Indeed, Bucquet may have been the first chemist to adopt the anti-phlogistic theory. According to Fourcroy, Bucquet was teaching the new theory in lectures as early as 1779. While still a student, Fourcroy had an experience similar to those later recorded by Arturo Toscanini, Leonard Bernstein, and Ruby Keeler (in "42nd Street"). As described by Fourcroy's biographer, W. A. Smeaton (3):

Antoine Francois Fourcroy

> Bucquet recognized Fourcroy's outstanding ability, and one day in 1778, when he knew that he was too ill to lecture the next day, he asked Fourcroy to take his place. The lecture was to be on the properties of resins, a difficult part of the subject to teach. After spending most of the night in preparation, Fourcroy explained his presence to the large audience and held their attention for two hours. This was a brilliant beginning to his great career as a lecturer.

During his last two years as a medical student, Fourcroy presented a course of lectures at Bucquet's laboratory. When Bucquet died in 1780, Fourcroy used part of his new bride's dowry to purchase the library and apparatus of his former professor, and established his own laboratory, doing research and giving lecture series. Bucquet had intended to write a new textbook, but his illness made that impossible and he asked Fourcroy to take up the task. So it was that 1782 saw the publication of the first edition of *Lecons Élémentaires d'Histoire Naturelle et de Chimie*, a two-volume work which summarized his course of 71 lectures - one chapter for each lecture. The order of topics followed that established by Bucquet, but Fourcroy's treatment of many areas was longer and more detailed. The number of lectures devoted to each topic is summarized in Table 1.

As can be seen, the sections on "natural history" actually contain a lot of chemistry. Each metal (15 were dealt with) included a discussion of the locations and natures of its ores, the extraction and assaying methods used, physical properties of the metal, chemical reactions with earths, saline substances, and flammable substances, and, finally, its uses. Bismuth, nickel, and manganese all fit into the same lecture; three whole lectures were devoted to iron. Most of the time spent on plants and animals was given to the discussion of the liquids and solids derived from them by various means.

The book received good reviews and was quite popular, not only with students but with the general public. It seems hard for us to believe, but in those days many members of the upper layers of society, especially ladies with plenty of time on their hands, attended scientific lectures with great interest. As Smeaton noted (4):

> [Fourcroy's] attitude to the theory of chemistry must have contributed to the popularity of the book. At a time when many important discoveries were being made and Lavoisier was striving to perfect the anti-phlogistic theory, Fourcroy faithfully recorded these discoveries and gave fair and impartial accounts of the rival theories ... This unbiased approach was unusual in 18th-century textbooks (and, indeed, in the textbooks of any century) and would appeal to the intelligent reader who wanted to understand the latest developments in chemistry.

In this 1782 text there is some evidence that Fourcroy was leaning toward Lavoisier's theory (in the section on acids, for instance) but he was essentially a "fair and impartial" recorder. No revolution here - yet.

A year later, Fourcroy received his first public appointment; he joined the faculty of the Royal Veterinary School. This position was eliminated four years later because of "financial exigencies" but by that time he had been made Professor of Chemistry at the Jardin du Roi. His most important duty was to give lectures in chemistry, which would be followed by demonstrations (given by the official demonstrator in chemistry). His first series began in April 1784; it was given in the old, noisy amphitheatre which seated about 600, and was usually overcrowded. By 1788, a new building had been constructed, containing laboratories, a 1200-seat auditorium, and apartments for the professor and the demonstrator. It was in this building that Fourcroy became a superstar - parallels today are few; perhaps Carl Sagan?

A second edition of the *Lecons Élémentaire*, enlarged and restructured into more normal chapters, rather than individual lectures, was apparently ready by the middle of 1784, but final publication did not come until the summer of 1786. The work was retitled *Élémens d'Histoire Naturelle et de Chimie* and appeared in four volumes. The delay in publication is of historic interest, for while the main body of the text still presented both the phlogistic and anti-phlogistic theories, a long preliminary discourse was added in which Fourcroy discussed gases from the point of view of Lavoisier's theory, and showed how most chemical phenomena could be explained in terms of this new approach. At some time between mid-1784 and mid-1786, Fourcroy had become convinced that Lavoisier was right.

Now Cuchet, the publisher of *Élémens*, also produced a series of little volumes for the previously mentioned ladies who attended courses on scientific and literary subjects. The set was called *Bibliotheque Universelle des Dames*, and to this "Ladies Universal Library" Fourcroy contributed, in 1787, two small volumes entitled *Principes de Chimie*. Designed for the complete beginner (Fourcroy says he had found that ladies did not take kindly to abstract ideas), this work discussed chemistry in fairly simple and general terms. But it used the new nomenclature throughout, and phlogiston was not even mentioned. This book was really the first chemistry text to be written entirely in terms of the "new chemistry"; only its elementary level and its limited circulation prevent it from being the main subject of this paper - the first textbook of the revolution. Incidentally, some copies of this book were issued in 1788 with a new title page and preface, and called *Principles of Chemistry, Following the New Discoveries, for the Use of*

Table 1. Topics Covered in the First Edition of the *Élémens*.

Topic	*Lectures*
History of chemistry	1
Laws of affinity	1
Chemical principles (fire, air, water, earth)	5
Mineral kingdom	37
Stones and earths (mineralogy)	5
Saline substances (acids, bases, salts)	12
Combustibles (carbon, sulfur, metals, bitumens)	19
Mineral waters (analysis)	1
Vegetable kingdom	13
Structure and functions of plants	1
Analysis by expression or solvents	6
Analysis by dry distillation	1
Spirituous, acidic, and putrid fermentations	5
Animal kingdom	14
Classification schemes	4
Physiology	2
Analysis of various fluids and solids	6
Animal substances useful in medicine and the arts	2

Students of the Royal Veterinary School. Apparently veterinary students did not take kindly to abstract ideas either.

But let us return to our main subject, the *Élémens*. The crucial parts of the story will be told in the author's own words, from his preface (in the 1799 translation of John Thomson of Edinburgh) (5):

The rapid sale of the second edition, which was almost entirely disposed of in less than eighteen months, did not leave me so much time to bestow upon the third edition, as I had to improve and enlarge the first; the whole additions, therefore, made to the third edition did not amount to a single volume, while two additional volumes have been given along with the second. [*The constant enlargement of textbooks today - Morrison and Boyd comes readily to mind - seems to have historic precedents*.] In the successive editions of an elementary treatise, which men of science, and an enlightened public, have sanctioned with their approbation, there must indeed be a period when further additions become improper, and when nothing remains but to review and correct it with care. To this state my work was brought, in my own opinion, in the third edition.

It is this third edition, which appeared in December 1788, which merits the label "first textbook of the revolution". Again from the preface (6):

I may observe, that the theory laid down in the third edition of these elements, differed essentially from that in the two former. In them, I acted merely as the historian of the different opinions which had hitherto prevailed among chemists. In the third, though I did not entirely quit this character, and although I explained the principal theories which had been proposed, yet I took a decided part, and adopted completely the doctrine which some philosophers have called the "pneumatic" or "antiphlogistic".

In fact, not only had he rewritten large sections in terms of the "new chemistry", but what occupied the major portion of the fifth volume of this edition was the explanation of the new nomenclature, the catalog of synonyms of the old and new names of substances, and the large table of nomenclature, reprinted from the *Méthode de Nomenclature Chimique* of 1787. (These are the parts which Fourcroy had contributed to the *Méthode*.)

His new stance in this third edition was emphatically taken (7):

I hope that those who shall study these elements attentively, and without prejudice, will find that this [antiphlogistic] doctrine differs from all the chemical theories which have succeeded each other in framing no suppositions, in admitting no hypothetical principles, and in consisting merely in a simple relation of facts. I think I may venture to assert, that the philosophers who have not yet entirely adopted this doctrine, and particularly those who have opposed it with undue warmth, have not completely understood our opinions. They do not seem to be aware that the basis of our opinions, the foundation upon which our principles rest, is not to be compared with what has been termed theory in physics; that in our system we do nothing but deduce obvious conclusions from a great variety of facts; that we admit nothing which has not been demonstrated by experiment, and that as we reject every hypothesis, it is impossible we can commit mistakes similar to those into which the learned authors of different systems of physics have fallen. Either I am much deceived, as well as those modern chemists to whom we owe so many ingenious discoveries, or the rising generation who are now employed in studying the sciences will renounce, as we have done, those hypotheses which have been so long agitated in the schools, and [will] confine themselves entirely to the results of experiments.

So much for the unbiased approach of the previous editions.

The preliminary discourse which he had added to the second edition was modified for the third, shifted to the new fifth volume, and renamed "Discours sur les Principes et l'Ensemble de la Chimie Moderne" (Discourse on Modern Chemistry in General, and on its Basic Principles). In the discourse, after another affirmation of the superiority of the new doctrine of Lavoisier (who, Fourcroy says "first laid the foundations, and who invented almost the whole of this system") over that of Stahl and the phlogistonists, Fourcroy explains the reason for its inclusion (8):

This doctrine [i.e., Lavoisier's] has been exposed at large in all the parts of this elementary work. But as it may be of advantage to exhibit a short and condensed view of the subject, I thought that, by uniting, in a discourse of no great length, the principles on which it is founded, it would become more striking and clear to those who devote themselves to the study of this science ...

His thesis is this: "There is not a single experiment in chemistry in which one or the other of the two following phenomena does not happen. 1. Caloric is disengaged or fixed. 2. An elastic fluid is formed, or absorbed, or its base passes from one fluid into another" (8). Therefore, he concludes, "the foundation of chemical theory depends on the properties and the action of heat [and] the formation and fixation of elastic fluids. It is therefore upon these two objects that our whole attention ought to be fixed" (8). After a brief summary of the properties of the known gases (he lists 16), Fourcroy presents as a proposal for further study and discussion a list of 14 phenomena or classes into which the whole of chemical knowledge may be organized. In order of increasing complexity, these are:

1. The absorption or disengagement of caloric, and the production or diminution of heat, with the effects of both.
2. The influence of air in combustion, and the general nature of combustible bodies.
3. The effects of light on bodies.

4. The decomposition and recomposition of water.
5. The production and the decomposition of earths.
6. The formation and the decomposition of alkalis.
7. Acidification: the formation and decomposition of acids; the nature of these salts, their differences, etc.
8. The combination of acids with earths and alkalis.
9. The oxidation and reduction of metals.
10. The solution of metals by acids.
11. The formation of the immediate principles of vegetables by vegetation.
12. The several species of fermentation.
13. The formation of animal matters by the life of animals.
14. The purefaction and decomposition of animal matters.

Each of these is considered briefly, and the relationship of each to the properties of gases is shown. It is a really beautiful summary of the state of chemical knowledge at the time, expressed in the new system.

A fourth edition of *Élémens* was published in 1791, with only a few minor changes; a fifth edition in 1793 was merely a reprint of the fourth. This fifth edition was reprinted in Switzerland in 1798. English translations of each edition had appeared within a year or two of the French publication. There were also translations into Italian, German, and Spanish. Incidentally, the first publication in America of the new theories came in Philadelphia in 1791 in a pirated edition of the *Encyclopaedia Britannica*, which reproduced a nomenclature table from the English translation of the third edition of Fourcroy's *Élémens*. Thus it can be argued that Fourcroy, with his large audiences in Paris and his very popular textbook circulated throughout Europe, did more to spread the new nomenclature and the new chemistry than anyone else. All I wish to claim is that it is this third edition, published 200 years ago last December, which was the "first textbook of the revolution".

One final word - in Bernard Cohen's marvelous book, *Revolution in Science*, he states that although Bucquet used the word "revolution" in referring to Lavoisier's work as early as 1777, and Lavoisier himself used it in his lab notebook as early as 1773, it was Fourcroy, through his textbook and other writings who "was most effective in canonizing the expression 'the revolution in chemistry'..." (9).

The third paper in this series will look at the most famous book of the chemical revolution, Lavoisier's own *Traité Élémentaire de Chimie*.

References and Notes

1. B. Chastain, "Méthode de Nomenclature Chimique", *Bull. Hist. Chem.*, **1989**, *3*, 7-11.

2. Most of the biographical information in this paper is from W. A. Smeaton, *Fourcroy, Chemist and Revolutionary, 1755-1809*, Heffer, Cambridge, 1962. This excellent book also contains a detailed bibliography of Fourcroy's works and is recommended to all who wish further information.

3. Ibid., p. 7.

4. Ibid., p. 180.

5. The title page of this translation reads, *Elements of Chemistry and Natural History. To which is Prefixed, the Philosophy of Chemistry, Fifth Edition, with Notes, by John Thomson, Surgeon, Edinburgh.* 3 vols., 1799. The quote is from Vol. 1, p. xi.

6. Ibid., p. xiii.

7. Ibid., p. xiii-xiv.

8. Ibid., Vol. 3, pp. 475-76.

9. I. B. Cohen, *Revolution in Science*, Harvard, 1985, p. 234.

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BOCHARD DE SARON AND THE OXYHYDROGEN BLOWPIPE

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It was Joseph Priestley who first noted in 1775 that a mixed flame of dephlogisticated air (oxygen) and inflammable air (hydrogen) exhibited an unusually high temperature, and who first suggested that one might obtain a useful high temperature source by directing a stream of oxygen into a hydrogen flame by means of a bellows (2, 3). However, the practical construction of such a device was first accomplished by the French scientist, Jean Baptiste Gaspard Bochard de Saron, who was also the first to use an oxyhydrogen torch to successfully fuse platinum (1). Prior to Bochard's work, scientists wishing to work at high temperatures had to rely instead on the use of burning mirrors and lenses to concentrate the heat of the sun.

Attempts at capturing the heat of the sun's rays are apparently quite ancient. Myth tells us that Prometheus caught the heat of the sun to light the Vestal Fire and, when the Olympic Games started, the heat of the sun was used to light the Olympic flame, as it still is today (4). Likewise, Aristophanes refers, in *The Clouds*, to "That stone, that splendidly transparent stone, By which they kindle fire?" (5) and Plutarch claims that Archimedes used burning mirrors to set fire to the fleet of Marcellus in the sea off Syracuse (6).

Prior to the introduction of gas and Bunsen burners, only coal-burning furnaces, ventilated with bellows, were available to fuse such materials as metals, minerals, glasses, bones, etc. If one wished to avoid contamination by the combustion products of burning coal, the only alternative was the use of burning glasses and mirrors.

The use of lenses and mirrors as standard laboratory heat