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Division of the History of Chemistry of the American Chemical Society

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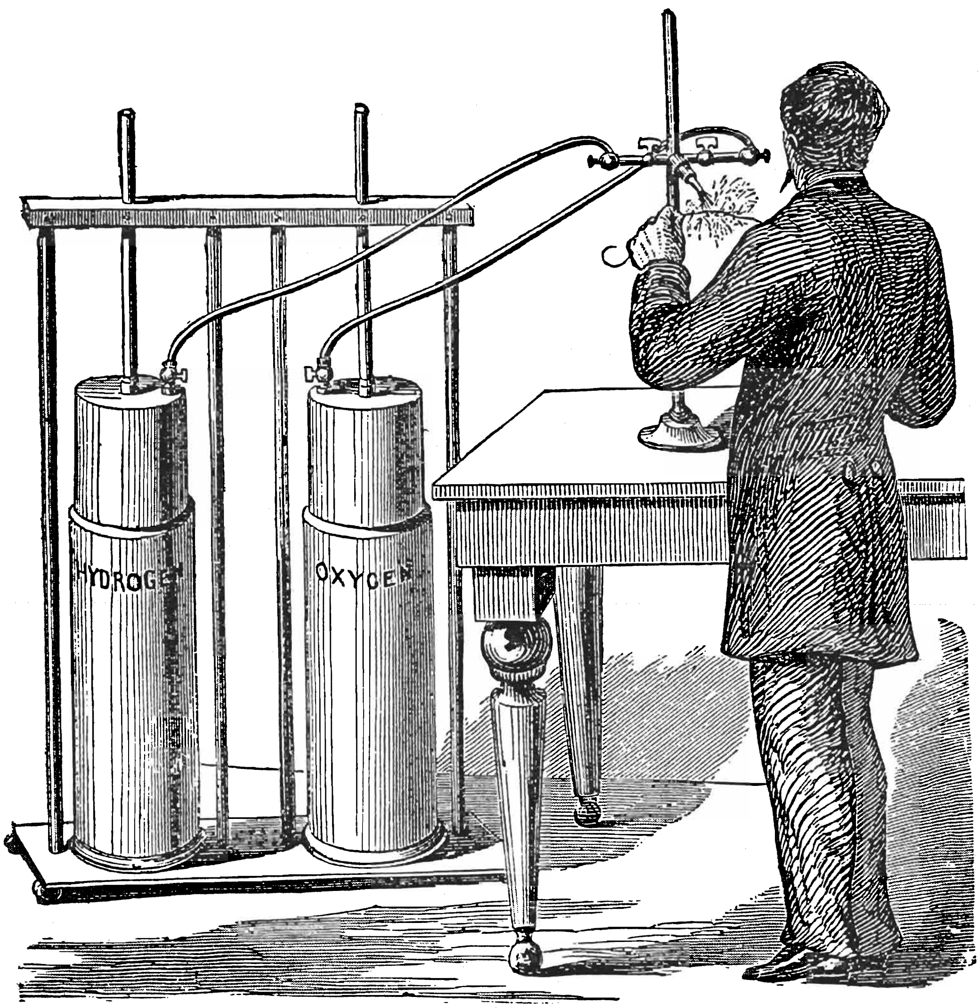

The Origins of the Oxyhydrogen Blowpipe

BULLETIN FOR THE HISTORY OF CHEMISTRY, NO. 4, 1989

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The Cover...

This issue shows a woodcut of an oxy-hydrogen blowpipe taken from the 1868 edition of Joel Dorman Steele's popular textbook, *A Fourteen Weeks Course in Chemistry*. The origins of this instrument and its importance in the history of chemistry are discussed in this issue by Elsa Gonzalez in her article on Jean Baptiste Gaspard Bochard de Saron.

DEADLINES

The deadline for the next issue (Winter 1989) is 30 November 1989. All materials should be sent to Dr. William B. Jensen, Department of Chemistry, University of Cincinnati, Cincinnati, OH 45221, (513) 556-9308.

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THE 1989 OESPER LECTURE

The Strong German Influence on Chemistry in Britain and America

Paul R. Jones, University of New Hampshire

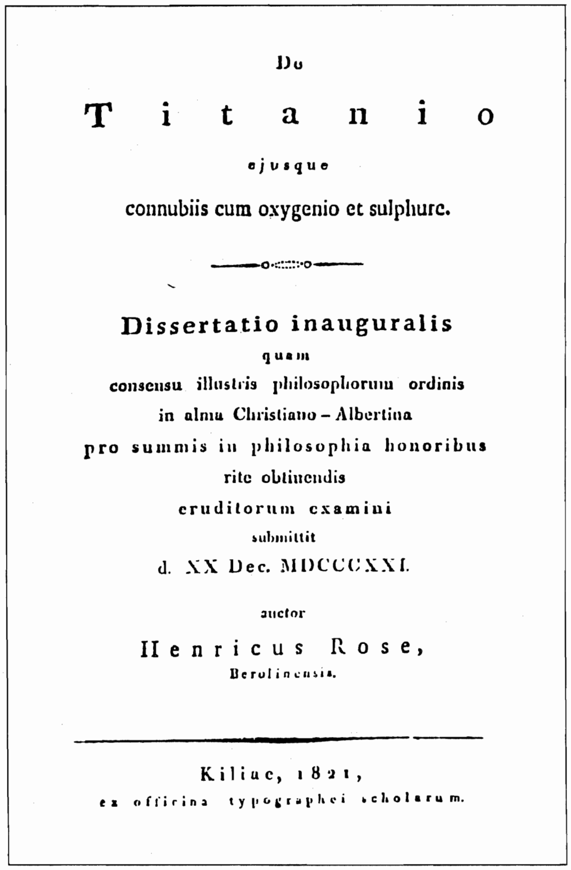
Around the middle of the 19th century, Germany became the recognized center for the training of chemists. Prior to that, students seeking specialized instruction found it necessary to travel to either Paris or Stockholm. Among the students who sought out J. J. Berzelius in Stockholm were Mitscherlich, Henrich Rose (1819-1821) and, shortly thereafter, Wöhler (1823-1825). About the same time (1822-1824), Liebig began his studies with Gay-Lussac in Paris, as did Bunsen ten years later. Gay-Lussac had, in turn, been a pupil of Lavoisier's collaborator, C. L. Berthollet. Indeed, most chemists today can trace their chemical genealogies back to either Berzelius, Berthollet, or to Berthollet's Parisian contemporary, A. F. Fourcroy.

J. W. Döbereiner, self-educated at Jena, did not venture from his homeland. Other Germans who developed careers in chemistry originally studied medicine: for example, O. L. Erdmann, editor of *Journal für praktische Chemie*; O. B. Kühn at Leipzig; N. W. Fischer at Breslau, and F. Stromeyer at Göttingen. L. Gmelin was trained by his father at Göttingen, and the father had been trained, in turn, by *his* father at Tübingen - a case of three generations of self-trained chemists within the same family.

The first German doctoral degree in modern experimental science was awarded to Gustav Rose by the University of Berlin in 1821, where he had studied mineralogy. The following year, his brother, Heinrich Rose, was granted the first doctorate in chemistry at Kiel. His dissertation, based upon work which must have been conducted in Berzelius' laboratory, was entitled *De Titanio ejusque connubiis cum oxygenio et sulphure.*

In the next ten years or so these newly trained chemists assumed professorships at many of the German universities: Mitscherlich and H. Rose at Berlin; Erdmann and Kühn at Leipzig; Stromeyer and Wöhler in Göttingen; Liebig at Giessen and L. Gmelin at Heidelberg. So began the "golden age" of chemistry in the German university and, by the 1830's, only two of the 22 existing universities - Braunsberg and Münster - were lacking professors of chemistry.

In America and Great Britain the situation was quite different. Students were instructed only in lecture halls, without any direct access to laboratory facilities or research opportunities. Those enrolled at Harvard, Yale, Oxford, and Cambridge attended lectures presented by professors who were, for the most part, self-taught and who had not ventured from their home institutions. Consequently, those students who were interested in advanced study in chemistry began, with increasing frequency, to turn their attention toward Germany.


De

Titanio

ejusque

connubiis cum oxygenio et sulphure.

Dissertatio inauguralis

quam

consensu illustris philosophorum ordinis

in almu Christiano - Albertina

pro summis in philosophia honoribus

rite obtinendis

eruditorum examini

submittit

d. XX Dec. MDCCCXXI.

auctor

Henricus Rose,

Berolinensis.

Kiliae, 1821,

ex officina typographei scholarum.

Title page of the first doctoral thesis in chemistry.

Who were these students from America and Great Britain who ventured abroad to immerse themselves in an academic atmosphere where instruction was carried out in a foreign tongue? From what home institutions did they originate? Where did they choose to study? What sort of professional lives did they ultimately lead? Although information of this sort is well known in a few famous cases, such as Ira Remsen (Baltimore) and Henry Roscoe (Manchester) - to name one from each country - the challenge of trying to answer some of these questions for the less famous as well was the motivation behind the present study. Because much of the information on "German-trained" individuals has originated from secondary sources or from anecdotal accounts, it was decided that identification of these individuals would be confined to those students earning a German doctorate in chemistry in the period between 1840 and 1914. Documentation would be limited to matriculation records, doctoral dissertations, and registries of dissertations at German universities.

The search was carried out in Munich, from September 1982, until August 1983, with the Deutsches Museum (DM) as headquarters. The library in the Research Institute of the DM, specializing in the history of science and technology, was a rich source of secondary literature, including tabulations of dissertations published in all existing German universities from 1886 (1). Although this source was invaluable for providing information for the later period of study, it did not provide a lead to dissertations written earlier than that time. Complete registries of dissertations for seven universities (of the total of 22 existing in the late 19th century) from their beginning were available and could be used to identify a limited number of dissertation authors (2-8). In most instances, the listing of authors in the registries included their geographical origin, which was either their birthplace or the location from which they traveled to Germany to undertake their studies. The listing of dissertations in chemistry compiled by Bolton (9) and published in 1890 was useful for confirmation of names but could not serve as an initial identification, because no distinction was made between nationalities of the authors. The recent biographical dictionary by Elliott (10) served to identify a few additional American chemistry doctoral students. From examination of these secondary sources a considerable number of individuals were identified, in some cases with the information about their place and dates of study and the title of their dissertations.

However, the most fruitful source of information came from direct examination of original dissertations, housed in three libraries in Munich: those in the DM, in the Universitätbibliothek (UB), and in the Bayerische Staatsbibliothek (BSB). At both the DM and the UB libraries, I was allowed to examine the dissertation collections and thereby sort out those written by non-German students. Although the holdings at the DM are limited, the number of dissertations in the UB library in chemistry alone approaches 13,000, written over the time period from 1820 until about 1920; and, not suprisingly, most of the dissertations which I identified were found in the UB holdings. Still others were eventually located through the catalog in the library of the BSB.

By examining individually the 14,000 dissertations, I was able to identify those written by English-speaking individuals. Pertinent pages of dissertations, once located, were photocopied, including the title page, acknowledgment page, and biographical sketch of the author, the latter two usually, but not always, having been included in the document.

The outcome of this library search was the identification of almost 800 dissertations written by English-speaking individuals, equally divided between Americans and British (Table 1). The dissertations usually provided information about the author's name and birthplace (or home residence), university, the year the doctorate was awarded, the title of dissertation and the research director ("Doktorvater"). Some of this information, if missing from the dissertation, could be pieced together through valuable secondary sources (11-20), which were particularly useful for students at Giessen (14,19-20), Göttingen (16,17), and Leipzig (15). With few exceptions, early doctoral students at Giessen and Heidelberg did not write dissertations but rather published their results, usually in Liebig's *Annalen der Chemie*. Because no registry of doctorates at Heidelberg has yet been published, it was necessary to seek confirmation from the Archives. I am grateful to Dr. Weisert, University Archivist at Heidelberg, for verifying the granting of doctoral degrees without dissertations between 1854 and 1886. The results of this work have been published in the form of a bibliography by the DM (21) and are stored in file form on microcomputer disk. An English edition of the bibliography is also currently being prepared as part of the new series, *Data Sources in the History of Chemistry*, to be published by the Division of the History of Chemistry of the American Chemical Society.

Table 1. British and American Doctoral Students in Chemistry at German Universities, 1840-1914.

University	*American*	*British*	*Total*
Berlin	51	18	69
Bonn	3	9	12
Breslau	8	6	14
Erlangen	9	10	19
Freiburg	27	16	43
Giessen	4	33	37
Göttingen	106	41	147
Greifswald	0	1	1
Halle	1	4	5
Heidelberg	46	53	99
Jena	4	24	28
Kiel	3	4	7
Königsberg	1	0	1
Leipzig	52	48	100
Marburg	8	14	22
München	23	31	54
Rostock	6	2	8
Strassburg	17	18	35
Tübingen	10	17	27
Würzburg	7	49	56
TU (1)	2	2	4
TOTAL	388	400	788

(1) Technical Universities in Aachen, Darmstadt, Karlsruhe, and München.

An examination of the resulting data provides an interesting perspective on foreign students studying chemistry in Germany in the 19th century and offers tentative answers to some of the questions posed earlier. It is particularly interesting to note both the similarities and differences between the American and British students.

Lyon Playfair, later Lord Playfair, a graduate of St. Andrews, was the first English-speaking student to earn a

German doctoral degree in chemistry, which was granted in 1840 at Giessen under the direction of Liebig - roughly 20 years after the first German doctoral degree in chemistry had been granted to Heinrich Rose. The first American to complete a chemistry doctorate in Germany was Jose Vincente Ortigiosa, a native of Mexico. A student of Liebig at Giessen, he is depicted in the famous lithograph of Liebig's laboratory made by Trautschold in 1842 (22), the year that he received his degree (5). Charles Mayer Wetherill, a native of Philadelphia, was the first U.S. citizen to complete a degree in Germany, having received his doctorate at Giessen in 1848.

As with most of Liebig's students, neither Playfair, Ortigiosa nor Wetherill wrote dissertations, but rather published the results of their work in Liebig's *Annalen*. Two American students of Wöhler at Göttingen, William Smith Clark and Newton Spaulding Manross, were the first to write dissertations, in 1852, as part of the fulfillment of the requirements for the doctorate. Incidentally, both of these dissertations were written in English, a privilege extended to only a few (about 9%) of the nearly 800 American and British doctoral students during the 70-year period covered.

For every year, except two, in the period from 1842-1914, doctoral degrees were awarded to one or more English-speaking students. The number completing degrees increased regularly until the 1890's, when it began to taper off, a trend which undoubtedly reflects the development by this period of opportunities for advanced training in the U.S. and Britain. Of the 22 German universities in existence in the middle of the 19th century, 19 of them conferred doctoral degrees on English-speaking chemistry students, although to varying extents, ranging from a high of 147 degrees at Göttingen to just one degree each at Greifswald and Königsberg (Table 1).

The choice of institution varied considerably with the time period, and American and British students had their own preferences. Giessen, Göttingen, Heidelberg, and Marburg were favorite choices in the 1840's and 1850's. Only in the 1870's were degrees awarded for the first time at Berlin, Freiburg, Leipzig, Rostock, Strassburg, Tübingen, and Würzburg; and in the 1880's at Bonn, Breslau, Erlangen, Halle, Jena, Kiel, and Munich. Of the nearly 800 English-speaking chemistry students who completed doctoral degrees, over half studied at one of four universities: Göttingen, Leipzig, Heidelberg, and Berlin. In some cases, American and British students showed strong preferences for certain institutions, with the Americans generally preferring Göttingen, Berlin, and Freiburg and the British preferring Giessen, Jena, and Würzburg (Table 2).

It has been possible to identify the research director for 95% of the doctoral students, mainly from acknowledgment pages in the dissertations. Some of the secondary sources mentioned earlier have also been helpful in this regard. A few German chemistry faculty stand out as dominant mentors of the American students. Several of these were at Göttingen, where such a large number of Americans earned their degrees. Wöhler served as research director for 20 Americans over a 30-year career. Less well-recognized is Hübner, Wöhler's colleague and successor, who, in a brief 15-year period, also directed the dissertations of some 20 Americans. Wallach served as mentor for another 20 American students over a 25-year career and Tollens directed doctoral dissertations of 11 Americans in a 20-year period. An account of the experiences of one American under Tollens' tutelage was published in 1942 (23). Fittig and V. Meyer also directed research for another nine Americans during their rather brief careers at Göttingen.

Liebig's doctoral students at Giessen were overwhelmingly British: 21, as compared to three Americans, in the short span of 13 years. Although Bunsen served as Doktorvater for only five students (of whom four were British) during his long career at Heidelberg, he and Kopp jointly directed dissertations by eight students, six of whom were Americans. The English-speaking doctoral students trained by Fittig in Tübingen and Strassburg and by V. Meyer in Heidelberg were about equally divided between Americans and British. A. W. Hofmann's English-speaking students at Berlin were predominantly American (18 of 23), as were Ostwald's at Leipzig (17 of 23). Emil Fischer directed predominantly British students at Würzburg (12 of 15 in seven years) but mainly Americans at Berlin (12 of 16 in 22 years). Hantzsch, during relatively brief careers at Würzburg and Leipzig, directed dissertations of 29 English-speaking foreigners, 27 being British. However, the record for total number of English-speaking doctoral students goes to J. Wislicenus, who was mentor to ten American and 23 British students at Würzburg and Leipzig. Perhaps his experience as a private assistant to Horsford at Harvard, during the years 1853-1856, made him sympathetic to other young men in a foreign land (24).

The impact on the chemistry profession in America and Britain exerted by these German-trained students can be assessed by following their careers after they returned home. The

Table 2. Distribution of American and British Chemistry Students Among the Top Ten German Universities, 1840-1914.

University	*% American*	*% British*
Göttingen	72	28
Leipzig	51	49
Heidelberg	47	53
Berlin	71	29
Würzburg	12	88
München	43	57
Freiburg	65	35
Giessen	11	89
Strassburg	49	51
Jena	14	86

professional lives of many of them have been gleaned from the secondary sources already cited, as well as from *American Men of Science, Appleton's Cyclopedia, Poggendorff*, and individual biographies and obituaries. Unfortunately, it has not been possible to trace the subsequent lives of all of them. Several of the Americans trained in the 1850's and 1860's were killed during the Civil War. Others became active in educational institutions, often those from which they had received their undergraduate degrees. Specific examples are provided by the University of Pennsylvania, where Samuel P. Sadtler (Göttingen, 1871) and Edgar Fahs Smith (Göttingen, 1876) were faculty members; Columbia, with Charles A. Joy (Göttingen, 1853) and Charles F. Chandler (Göttingen, 1856); Amherst College, with William S. Clark (Göttingen, 1852) and Elijah R. Harris (Göttingen, 1859); and MIT, with Augustus H. Gill (Leipzig, 1890), Arthur A. Noyes (Leipzig, 1890), Lewis M. Norton (Göttingen, 1879), Samuel P. Mulliken (Leipzig, 1890), and Benjamin E. Talbott (Frieburg, 1900). At Johns Hopkins University, founded in 1876, Ira Remsen (Göttingen, 1870) and his assistant, Harmon N. Morse (Göttingen, 1875), developed the chemistry instructional program, and Remsen later served as president of the University.

Liebig's laboratory at Giessen was a favorite among British students.

A conservative estimate of the institutions being served by these early generation, German-trained Americans numbers well over 50, and they vary from early, well-established schools, such as the University of Pennsylvania, to liberal arts colleges, such as Amherst, Williams, and Beloit, to newly founded technical schools, such as the Columbia School of Mines and MIT, to the land-grant institutions founded after the Civil War. Several also served as presidents of the American Chemical Society (25).

In contrast to the multitude and variety of schools in the United States, centers for higher learning in Great Britain were few in number. In 1840, in England, only three institutions were active sites for chemistry instruction: Cambridge, Oxford, and University College, London. Other students learning chemistry did so as part of their medical training at one of the hospitals. In Scotland, there were four universities, all founded in the late 15th and early 16th centuries. Benjamin C. Brodie, one of Liebig's doctoral students (Giessen, 1850), assumed the professorship in chemistry at Oxford, which he held until 1873. At University College, another Liebig student, Alexander Williamson (Giessen, 1845), occupied the professorship from 1855-1887, being the successor to George Fownes, also a Liebig student (Giessen, 1841), who had died at an early age. Edward Frankland, a student of Bunsen at Marburg (1849), first filled the professorship at Owens College (later University of Manchester) and eventually succeeded Hofmann at the Royal College. Frankland's successor at Manchester, Henry Roscoe, was one of Bunsen's students at Heidelberg (1854), and was very influential in developing the doctoral program in chemistry, modeled after the research teaching of Bunsen and Liebig (26). This, in turn, became the model for graduate programs throughout Britain. All of the these chemists, except Fownes, also served terms as President of the Chemical Society of London.

Meanwhile in Scotland, the German training was noticeable as well. Serving as professor at Edinburgh from 1858-1868 was Lyon Playfair, also a student of Liebig (Giessen, 1840). He resigned to enter public life, serving as advisor to Prince Albert, an organizer of the Royal College of Chemistry and, eventually, as a member of Parliament. For 30 years, beginning in 1839, Frederick Penny held the professorship at Glasgow. Penny had visited Liebig in Giessen and was awarded the doctorate in 1842 on the basis of research published in the *Annalen*, but apparently carried out at Glasgow.

These returning chemists in America and Britain, undoubtedly enthusiastic over their stimulating training in the laboratories of Germany, were anxious to pass on their professional heritage. As they helped found new departments of chemistry and new institutions, they also encouraged their own students to continue the cycle by studying in Germany. Elijah Harris, a doctoral student of Wöhler's at Göttingen (1859), returned to Amherst College as professor from 1868-1907. During this tenure, he sent 28 students abroad, all of them to Göttingen - more than half of whom earned doctoral degrees. Many other examples could be cited of this trend, which took place in Britain as well. In some instances, the family influence was strong, as with William Henry Perkin, Jr. (Würzburg, 1882), whose younger brother, Frederick, studied under him at Owens College and then earned a doctoral degree at Würzburg with

Hantzsch in 1897. Three generations of Franklands were German-trained doctoral students. Besides Edward Frankland, already mentioned, both his son Percy and grandson Edward P. earned doctorates at Würzburg, the son under Wislicenus in 1880 and the grandson under Tafel in 1908.

This discussion has been limited largely to the influence of first-generation American and British students of the German tradition. As the chemical industry began to develop, first in Britain and later in America, it was natural that its leadership was assumed by many of these chemists, often second or later generation. Thus, Irving Langmuir, a doctoral student of Nernst at Göttingen, and future Nobel Prize winner, was a strong influence in the development of research at General Electric.

Not only did the returning Americans and British exert significant influence on the development of chemistry in their homelands, but some native Germans, emigrating at a time when the economic and social conditions were unfavorable in their native country, became prominent chemists abroad, including Charles Goessmann at the Massachusetts Agricultural Station; John Maisch at the Philadelphia College of Pharmacy; Frederick Genth at the University of Pennsylvania; William Elderhorst at RPI, and Hermann Endemann, a student of Kolbe at Marburg and the first editor of *JACS*. In England, the name of August W. Hofmann, the first director of the Royal College of Chemistry, (1845-1864), comes immediately to mind, along with that of Carl Schorlemmer, who was hired by Roscoe as the first Professor of Organic Chemistry at Owens College, a position he held from 1874-1892 (26).

If one could eventually learn about all 800 of the American and British students who completed doctoral degrees in Germany before 1914, a demonstration of the strong impact on chemistry communities in their native lands would be even more impressive than that gleaned by looking only at the first generation. Furthermore, it must not be forgotten that these ambassadors of chemistry, through their "Doktorväter", owed their professional success indirectly to that original trio of influential tutors in Stockholm and Paris.

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BOOKS OF THE CHEMICAL REVOLUTION

Part II: Élémens d'Histoire Naturelle et de Chimie

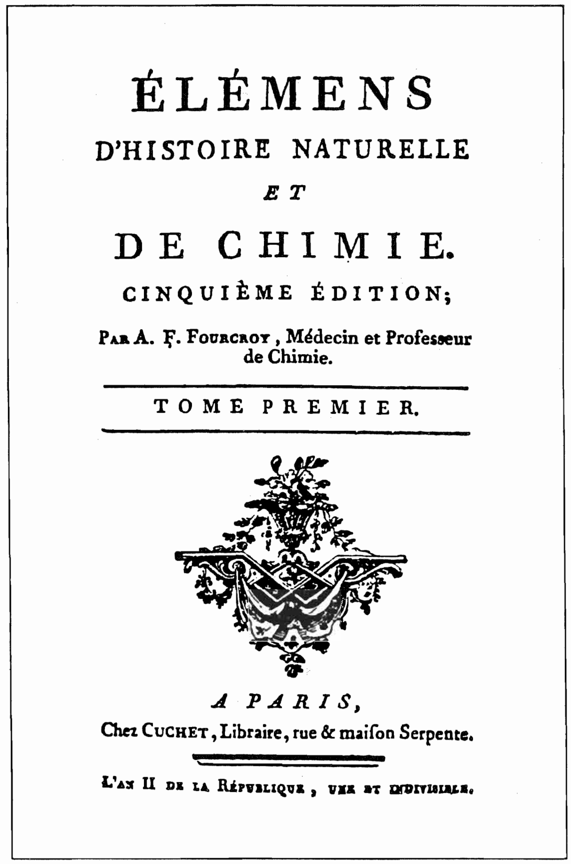
Ben B. Chastain, Samford University

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):

> 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


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

Antoine Francois Fourcroy

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.

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7. Ibid., p. xiii-xiv.

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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.

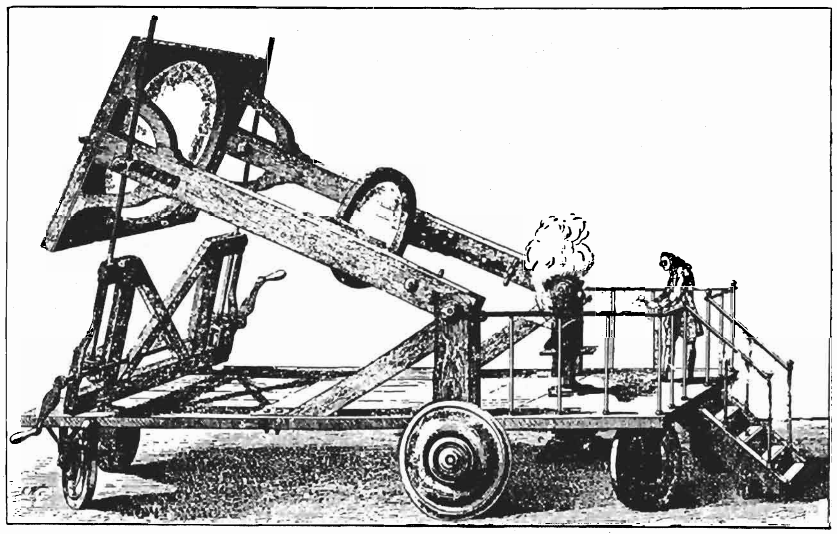
Attempts at capturing the heat of the sun's rays are apparently quite ancient. Myth tells us that Prometheus caught the heat of the sun to light the Vestal Fire and, when the Olympic Games started, the heat of the sun was used to light the Olympic flame, as it still is today (4). Likewise, Aristophanes 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 sources was already well established by the 17th century (7) and descriptions of their use can be found in the writings of such scientists as Robert Boyle, Robert Hooke and John Mayow. Even Galileo mentioned them, noting, in passing, that lead could be "melted instantly by means of a concave mirror only three hands in diameter" (8).

17th century burning lenses and mirrors came in all sizes, ranging from the hand-held magnifying glass used by Mayow to ignite antimony and sulfur in sealed vessels (9), to the large burning mirrors made by Francois De La Villette (1621-1698) of Lyon for the use of the Hessen family of Kassel (10). An example of a Villette mirror, built around 1670, is still preserved in the Staatliche Kunstsammlungen in Kassel, Germany. It has a diameter of 1.5 meters and a focal depth of 3.45 meters and was bought by Landgraf Wilhelm VIII about 1713 in Brabant as a gift for his father, Landgraf Carl, for use in his alchemical and metallurgical experiments. The same museum also houses two Tschirnhausen burning mirrors.

The efficiency of a typical Villette instrument was described by Henri Justel in a letter sent to Henry Oldenburg, the Corresponding Secretary of the Royal Society, on 18 July 1665 (11):



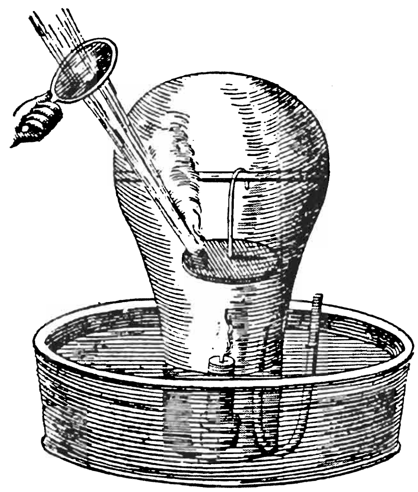
An example of a large 18th century burning glass described by Lavoisier.

We examined its effects several times, in the morning, at noon, and in the afternoon. It always burned things most effectively, melting and liquefying any object with very few exceptions. In our presence it melted silver (a 15 sous coin), copper (a liard), brass, bits of a cast iron kettle, small bits of steel, heads of small iron nails ... it calcines glass and building stone (which it turns into glass by melting, and so it does the bones of animals); and it melted glass polished on both sides ... It lighted a candle very quickly, and thick sticks of wood which it set afire in a moment made a pretty sight. The radius of the mirror is four feet eight inches, and the focus is at two feet four inches. The diameter is two feet six inches and about two lines; the mirror was also found to be polished on the convex side ... The mirror itself is now finished on its stand; it is valued at 150 Louis d'or.

Though burning mirrors and lenses continued to be used as high temperature heat sources throughout the 18th century, the discovery of oxygen (or vital air) and its ability to support combustion resulted in a number of attempts in the 1780's to employ it to enhance the heating efficiency of conventional laboratory heat sources. The most common approach was to direct a stream of oxygen, rather than common air, through a conventional laboratory blowpipe onto a candle or oil flame and, in turn, to direct the resulting oxygen-enhanced flame onto the object to be fused (12). Experiments with devices of this type, which were in essence a kind of "oxygen blowpipe", were made by, among others, the German chemists, Friedrich Ehrmann (1741-1800) (13-14) and Franz Achard (1753-1821) (15), the Swedish chemist, B. R. Geijer (16), and by Lavoisier himself (17). Lavoisier's interest in high temperature fusion was, in part, related to his growing realization that solids, liquids and gases were actually three interconvertable states of matter. Materials were not inherently solid, liquid or gaseous but, depending on their temperatures, only relatively so. To thoroughly test this assumption required a high temperature source which could potentially melt even the most recalcitrant counterexamples. In his 1782 memoir on the subject, entitled "A Method of Greatly Augmenting the Action of Fire and Heat in Chemical Operations", he first summarized the results that had been obtained to date by the use of burning mirrors and lenses (17):

The great burning lenses of Tschirnhausen have provided chemists with an agent much stronger than the fire of the furnace, by which they have discovered that a large number of bodies, regarded as infusable or as fixed, will yield to the action of very strong heat. The trials done by M. de Count Lauraguais and M. D'Arcet with a porcelain furnace have confirmed the same truth and the great lens of M. Trudaine, built by M. de Berniéres, under the inspection of the Commissaires de l'Academie Royale des Sciences, has completed the proof that the quality of being fixed or refractory, attributed to certain bodies, is relative to the degree of fire used.

However, despite these successes, Lavoisier was quick to point out that the use of lenses and mirrors was apparently limited, since attempts at increasing their size did not produce



John Mayow's use of a small magnifying glass to heat materials confined over water, circa 1674 (9).

a proportionate increase in temperature, but did make them correspondingly more expensive and difficult to work with. Consequently it was necessary to find some alternative based on the ability of the recently discovered gas, oxygen or vital air, to enhance combustion. The rest of the memoir is largely taken up in describing an elaborate system, developed by Lavoisier and J. Meusnier, for directing a stream of oxygen through a blowpipe and their unsuccessful attempts to use it to fuse platinum metal.

Only near the end of the memoir does Lavoisier mention yet another suggestion, based on the work of Bochard de Saron (17):

> President de Saron has told me of another very ingenious idea, to apply on bodies that cannot be placed in contact with charcoal. It consists of using a converging assembly of two blowpipes, one supplied with vital air and the other with inflammable air. One obtains a pointed flame, very white, very luminous, and very hot with which one can easily fuse iron but with which, nevertheless, it is not possible to fuse platinum. The manner of operation is so convenient and so rapid as to remove all objections and I prefer it to all others ...

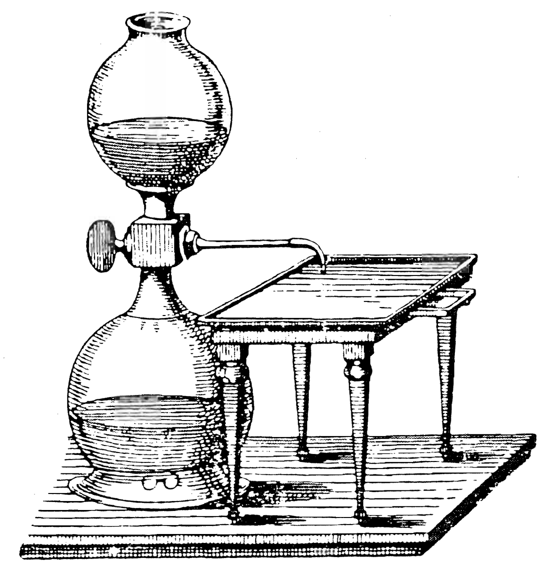
In short, like Priestley before him, Bochard had suggested an oxyhydrogen blowpipe but, unlike Priestley, had apparently actually built one. Regrettably, we have only second hand descriptions of Bochard's apparatus and procedure (17, 18-19). We do know that he and his laboratory assistant, M. Tillet, used leather bags to store each gas separately, and that, in contrast to Lavoisier's negative result, Bochard claimed to have successfully fused platinum. Nevertheless, Lavoisier was enthusiastic about Bochard's device, and in closing, outlined both a way of improving it and his intention to pursue the matter further (17):

> ... imagine an apparatus in which vital air could be made to surround the inflammable air on all sides, so that the latter in some way burns in an atmosphere of vital air. Perhaps a more considerable effect will obtained. With the help of M' le Président de Saron's inspiration, I hope to further pursue the benefits of this new method.

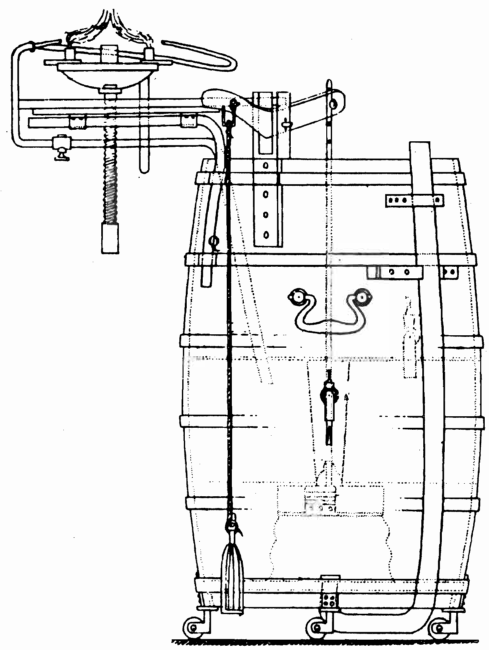
Here Lavoisier is, in effect, suggesting a premixing of the oxygen and hydrogen prior to combustion, a suggestion which he apparently did not develop, though 20 years later an inverted form of his proposal, with oxygen on the inside and hydrogen on the outside, was perfected by the American chemist, Robert Hare (20).

Jean Baptiste Gaspard Bochard de Saron was born in Paris in 1730 (21). The son of a wealthy family, he was best known for his work in astronomy, but he also dabbled in mathematics, natural philosophy, chemistry, art, music and book publishing. He served as President of the Parliament of Paris (hence Lavoisier's reference to his title), and as both Vice-President and President of the Academie Royal de Sciences. His development of the oxyhydrogen blowpipe stemmed from his interest in making corrosion resistant metal telescope mirrors from platinum and the consequent necessity of finding some means of melting the metal.

Both of Bochard's biographers (18-19) state that the first fusion of platinum took place in Bochard's secret laboratory, which he had installed in his home in the Rue de l'Université (22). He had inherited the house from his uncle, Canon Elie de Bochard, and had remodeled it in order to accommodate his large family, his observatory and astronomical instruments, his printing press and, of course, his metallurgical laboratory. The laboratory is referred to as "secret" because its entrance was disguised in the woodwork of Bochard's library. Interest-



Ehrmann's oxygen blowpipe of 1785 (13).



Part of Robert Hare's original oxyhydrogen blowpipe (1802). The double compartment barrel stores the two gases and the blowpipe itself is attached to the side at the upper left (24).

ingly, this house is still standing and is presently occupied by offices of Editorial Gallimard. The present occupants have indicated that the leather bags used by Bochard to collect oxygen and hydrogen are still hanging behind the woodwork of the library, which is now used by the firm's President as an office (23).

Like Lavoisier, Bochard came to grief at the hands of the French revolution. Accused of being a counterrevolutionary, he was arrested on 18 December 1793 and guillotined on 20 April 1794, the same year as Lavoisier, after first being allowed to make an inventory of his laboratory apparatus and astronomical instruments.

Most likely, because of his failure to write a memoir on the subject, posterity lost track of Bochard's contribution and several 19th century investigators, apparently unaware of his work, laid claim to having invented the first workable oxyhydrogen torch. The most notable of these was the American chemist, Robert Hare, mentioned earlier, who published an account of his oxyhydrogen blowpipe in 1802 (24) and whose claims to priority were vigorously defended in American textbooks against European claims for more than half a century (25).

The blowpipe was gradually improved throughout the 19th century, largely by refining the premixing of the gases. By 1852 the Johnson-Matthey Company of London was able to display a large nugget of fused platinum at the Great Exhibition at the Crystal Palace, and by 1859, the French chemists, Henri Sainte-Claire Deville and Henri Debray, were able, with their improved instrument, to reach temperatures of over 2000°C, or nearly 300°C above the melting point of platinum, (26).

References and Notes

1. Based on a paper given at the 197th National Meeting of the American Chemical Society in Dallas, TX, 9-14 April 1989. The author wishes to express her thanks to Dr. William B. Jensen for his help in extensively revising and expanding the original manuscript.

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6. E. Gibbon, *Decline and Fall of the Roman Empire*, Methuen, London, 1898.

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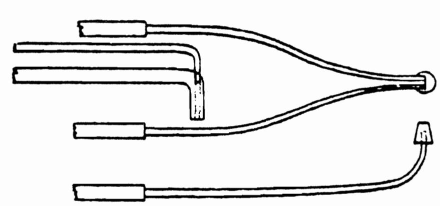
12. For background on the development of the conventional laboratory blowpipe, see W. B. Jensen, "The Development of Blow-



Some of the tips used by Hare in his compound blowpipe. Of particular interest is the second from the top in which the oxygen delivery tube is contained within the hydrogen delivery tube (24).

pipe Analysis", in J. T. Stock and M. V. Orna, Eds., *The History and Preservation of Chemical Instrumentation*, Reidel, Boston, 1986, pp. 123-149.

13. F. L. Ehrmann, *Versuch einer Schmelzkunst mit Behülfe der Feuerluft*, Strasbourg, 1785.

14. F. L. Ehrmann, *Essai d'un Art de Fusion a l'Aide de l'Air du Feu ou Air Vital*, Treutel, Strasbourg, 1787. This is a French translation of reference 13, to which two memoirs by Lavoisier are added.

15. See *Crell's Neueste Entdeckungen*, **1783**, *8*, 79 and reference 16, pp. 592-594.

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17. A. L. Lavoisier, "Sur un moyen d'augmenter considérablement l'action du feu et de la chaleur, dans les opérations chimiques", *Mem. Acad. Sci.*, **1782**, 457, published 1785. Also reprinted in *Oeuvres de Lavoisier*, Vol. 2, Imprimerie Imperiale, Paris, 1867, pp. 423-432. For an English summary, see reference 16, p. 458.

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19. J. D. Cassini, "Eloge de M. Le President de Saron", *Memoires Pour Servir A L'Histoire Des Sciences*, Colas, Paris, 1810.

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21. For further details of the life of Bochard, see E. L. Gonzalez, "Jean Baptiste Gaspard Bochard de Saron: Nobleman, Mathematician, Astronomer, Physicist, Chemist, Printer, Publisher, Artist and Musician", presented at the Midwest Junto in the History of Science, Iowa State University, Ames, Iowa, 28 April 1989.

22. The building is located at 17 Rue de l'Université, Paris, France, 75007.

23. Personal communication from M. Lucien Boyer, Editorial Gallimard, Paris.

24. R. Hare, *Memoir of the Supply and Application of the Blowpipe*, Chemical Society of Philadelphia, Philadelphia, 1802. Reprinted in *Phil. Mag*., **1802**, *14*, 238, 288 and *Ann. Chim*., **1802**, *45*, 113.

25. See, for example, T. D. Mitchell, *Elements of Chemical Philosophy*, Correy and Fairbank, Cincinnati, OH, 1832, footnote on p. 69.

26. For a brief summary of the early history of the oxyhydrogen blowpipe, see J. R. Partington, *A History of Chemistry*, Vol. 3, Macmillan, London, 1962, pp. 724-725.

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KASIMIR FAJANS (1887-1975): THE MAN AND HIS WORK

Part I: Europe

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To some, the name of Kasimir Fajans calls to mind a man whose early achievements in radiochemistry secured for him a place in the history of chemistry. A very few may recall one of those blue volumes published under the aegis of the Baker Lectures at Cornell University and which evolved from lectures given by Fajans during his visit to the United States in 1930. Some may even have been contemporaneous with his teaching years at the University of Michigan, beginning in 1936. If so, his name may conjure up recollections of an outspoken critic of instruction in chemistry, particularly of the dominant qualitative approach to chemical bonding. To yet another group, those who were fortunate to have heard one or more lectures by him, the name recalls a person who left an indelible mark on his listeners.

None of these recollections, however, really gives much insight into what made this man "tick" or into the genesis of his major contributions to the progress of chemistry in our century. In this account I will try, among other things, to reduce this void by recounting some of the events said by him to have had a profound influence on the development and direction of his career (1).

Kasimir Fajans, the centennial of whose birth was celebrated in 1987 (2), was born in Warsaw, Poland, on 27 May 1887. He was the second child and the elder son of five children born to Herman and Wanda (Wolberg) Fajans. Both parents' families had members who had distinguished themselves at some period during the 18th, 19th, or 20th centuries: whether in science, medicine, music, photography, government, or in Polish patriotic movements. The Fajans family was part of the highly emancipated and "polonized" Jewish population. Polish, not Yiddish, was the daily language. Not surprisingly, as the elder son, Kasimir served as a role model for his younger siblings in what was reported to have been a loving and respectful family environment.

For the first years, private teachers taught Fajans at home. He later moved on to the Real-Gymnasium, a school where natural sciences, rather than Latin and Greek, were stressed. Nevertheless, the Russian dominance throughout the schools mandated that Russian be the official language. Polish was not allowed in the school building. The clash between Fajans' interests and that of the teacher's showed up in another way. In a Russian language class, Fajans was once given a poor grade for writing on "Climate" as an essay subject. Fortunately the director of the school was a scientist and responded favorably to Fajans' complaint about the grade. Beyond his early interest in science, Fajans was also a sports lover. He played tennis (something he kept up until retirement), rode a bicycle (a novelty then), and often hiked in the countryside and mountains.

The first event identifiably associated with the specific direction of his eventual career came when he was nine years old, vacationing with the family at a summer resort. His father, on a customary biweekly visit from the city, had brought a newly published book about the recently discovered Röntgen rays. This account, which included the first pictures of the bones within the human hand, aroused the boy's interest. In passing, it is also of interest to note that, many years earlier, Fajans' father had had the father of Marie Sklodowska Curie as his high school physics teacher.

Fajans' father, handsome, benevolent and well-liked, was a successful businessman representing Geiers, a large textile firm. This connection made the father aware of the contributions of chemistry to dye technology. Understandably, he very much wanted his son to go on to study dye chemistry and to take employment in the textile plant. Fajans, however, was more interested in pure science than in technology.

Furthermore, the political situation in Poland was bad. Even at the university level all subjects had to be taught in Russian and the admission of Jewish students was restricted. So, following the example of many who could afford it, Fajans opted to leave Poland. With his father's blessing, he chose to go to the University of Leipzig, intending to study biology. This objective changed during the first year, for he soon became interested in chemistry. The famed Wilhelm Ostwald was the Professor of Chemistry. Along with Arrhenius, Van't Hoff, and (later) Nernst, he had been one of the founding fathers of the new discipline of physical chemistry in the 1880's and 1890's.

The faculty at Leipzig seemed to be an ideal one. The scientific atmosphere proved to be very stimulating and Fajans attended as many seminars as possible. Even though he did not understand much of the subject matter, he valued the chance to hear and meet distinguished scientists. Unfortunately, Ostwald had decided to retire at the early age of 52 in order to pursue his many other interests, such as the development of an international language, color theory, and painting. A visiting professorship at Harvard took him away for most of the school year, and he returned only in time for Fajans to hear his last course lecture. Ostwald left in 1907 and his successor turned out to be incapable. This, in turn, led to the departure of the other notable faculty members, including M. Bodenstein, H. Freundlich (who was Laboratory Assistant for the course in Qualitative Analysis and had just completed his work on the adsorption isotherm), and R. Luther (Assistant Laboratory Director and co-author of the Ostwald-Luther laboratory text of physical chemistry).

This unforeseen and unfavorable development also caused young Fajans to leave for Heidelberg the same year. There he opted to study under Georg Bredig, who had recently left Leipzig as well, and who was still an "Associate Professor" at the time (German practice allowed only one full professor; Fritz Haber was *the* Professor of Chemistry). Bredig was interested in catalysis, a new field on the borderline between physical and organic chemistry. This appealed to Fajans' dual interests. Several chemists (A. Rothmann, for example) had observed that stereo-directed reactions could be catalyzed by naturally occurring enzymes, and Fajans' work with Bredig dealt with the use of an asymmetric base, such as nicotine, to preferentially catalyze the formation of one isomeric reaction product over another. His doctoral thesis was entitled *Partial Separation of Stereochemical Isomers by Asymmetrical Catalysis* (3). His discovery during this work of the directed decarboxylation of camphor carboxylic acid was the first use of a synthetic compound to mimic the stereospecific catalytic properties of enzymes. For this he earned the degree of *Dr. phil. nat.* and was awarded the Victor Meyer prize in October of 1909. It was during his last term at Heidelburg that Fajans also had the good fortune to meet Salomea Kaplan, a medical student and his future wife.

Kasimir Fajans. circa 1925.

Because of the prevailing undemocratic rules, the doctoral examination prior to the awarding of the degree was conducted without Bredig. Only full professors were allowed on the committee, which consisted of Philipp Lenard, Nobel Prize winner and Professor of Physics, Ludwig Königsberger, the Professor of Mathematics, and Theodor Curtius, who had succeeded Victor Meyer as Professor of Organic Chemistry ("Pure organic with a few inorganic byproducts," related Fajans). Curtius, not wishing to embarrass Fajans, asked a few simple questions about organic chemistry, but did not dare to challenge him on physical chemistry. Then, having finished his cursory examination, Curtius proceeded to spend the next hour talking about *his own work.*

As Fajans later told it, one of these stories dealt with Curtius' isolation of hydrazoic acid, HN_3. Having just discovered a hydrate of hydrazine, H_2N_2, he and his students were searching for a nitrogen compound having an even higher nitrogen content. When quite confident that they had succeeded, they did the analysis via decomposition, measuring the evolved nitrogen volumetrically over water. Curtius, with a perfectly straight face, recalled that after the volume was equivalent to two nitrogens "we counted the bubbles and we drank a bottle of champagne after each additional bubble!" Fajans remarked that, "Knowing Curtius, this was almost believable." (Fajans' moderation was in contrast to the drinking habits of some of his German contemporaries, who frequently accused him of "drinking beer through a straw.")

Because he still felt deficient in the subject, Fajans initially decided to continue working in the field of organic chemistry, with the hope of eventually using his knowledge of physical chemistry to clarify some of its mysteries. In order to strengthen his organic background, he applied for a post-doctoral position with Emil Fischer. However, Fischer had no vacancies in his laboratory and Fajans ended up working with Richard Willstätter at Zürich instead. Fajans later characterized the experience at Zürich as frustrating. He quickly discovered that he did not feel comfortable with the high degree of empiricism prevalent in the presentation and practice of organic chemistry at that time and he had to admit that the laboratory skills necessary for a successful "organiker" were not his. This led Fajans to the conclusion that physics, rather than organic chemistry, should be his field of study. Though this decision was to lead to a highly successful research career, he continued to harbor a certain ambivalence towards organic chemistry and, some 50 years later, in 1959, he proudly confessed that "I began to understand organic chemistry only recently - only on the basis of the Quanticule Theory."

It so happened that during his earlier stay at Heidelberg, Fajans was asked to give a report at a physics colloquium supervised by Lenard. He was directed by Lenard to a 1908 paper by Rutherford and Geiger on counting alpha particles and determining their charge. In preparing his report, Fajans also read the 1907 German translation of Rutherford's Silliman Lectures, *Radioactive Transformations*, delivered at Yale University in 1905. Having decided to desert organic chemistry, Fajans now remembered his backround reading for the physics colloquium and decided to apply for a postgraduate position in Rutherford's laboratory at Manchester. About ten years later, Fajans was reminded of the events behind his decision to take up the study of radiochemistry. Having been invited to Heidelberg to give a lecture on radioactive displacement laws and isotopes, he was met after the lecture by his former physics professor, Lenard, who remarked that, "It was good that you gave in 1909 the report in the colloquium."

Before leaving for England, Fajans and Salomea Kaplan were married. This was fortunate, for more than the usual reasons, as Mrs. Fajans was fairly fluent in English. This skill enabled the couple to get along in everyday contacts outside the laboratory until Fajans' command of English had developed sufficiently. They frequently went to the theater in Manchester, in part, as a means of improving their knowledge of English and, in part, because of the excellent performances. They also enjoyed concerts. In the laboratory, Hans Geiger acted as an interpreter for Fajans and Rutherford during this learning period. Several years later Fajans sent Geiger a copy of his newly published book, *Radioactivity* (4). A short time later the two of them met at a meeting of the Berlin Physical Society, where Geiger remarked, "Fajans, your book is very well written ... I married recently and I read your book to my wife on our honeymoon!" Other contemporaries at Manchester included J. Chadwick, C. G. Darwin, G. von Hevesy, G. N. Antonoff, W. Makower, and H. G. Moseley.

Fajans' work at Manchester included the discovery of branching in radioelement transformations and the measurement of half-lives on the order of 10^{-1} and 10^{-3} seconds and resulted in collaborative publications with both Moseley and Makower (5-7).

Fajans greatly admired Rutherford and declared that he undoubtedly belonged with Faraday in the "Chemists' Hall of Fame". Rutherford had an ability to use very simple experiments to achieve important, far-reaching results. Fajans remarked that Lenard also possessed this trait to some degree. Without a doubt, Fajans' admiration for these outstanding scientists and their methods influenced his own future methodology in the study of atoms, molecules, liquids and solids.

It was intended that Fajans should return to Heidelberg when he was finished at Manchester. However, his doctoral mentor, Bredig, had followed Fritz Haber to Karlsruhe and in 1911 extended Fajans an invitation to join him there as Chief Assistant, with early promotion to Privatdozent (similar to our "Assistant Professor"). The invitation was accepted even though the situation was far from ideal. Karlsruhe had no medical school at which Salomea, who had begun work on an M.D. degree, could finish her training. She would have to take their baby son, Edgar, who had been born during the stay in Manchester, with her to Strassburg, the site of the nearest medical school, and for two years would have to be content with visits from Kasimir, who would live at Karlsruhe.

Along with his students at Karlsruhe, Fajans was to spawn some much needed advances in the development and understanding of radiochemistry. He had read in Soddy's book the reference to the Lucas-Lerch Rule about radioactive decay (8). This rule stated that all elements emitting radiation became more noble. Fajans recognized that this could not be right. One day in late 1912, feeling fatigued, he and a graduate student, Oswald Göhring, decided to take time off to go to a performance of the opera, "Tristan and Isolde". Although Fajans did not play a musical instrument, he was very fond of music and opera. While sitting there with eyes closed, enjoying the music, he suddenly opened them, took a paper from his pocket and wrote down an equation. The true decay route had suddenly dawned on him: *Only beta decay leads to a more noble element.* This led, in turn, to his enunciation of his famous displacement laws for radioactive decay (9-10). Frederick Soddy published similar rules (11), but not until after the appearance of Fajans' paper, leading some to doubt the originality of Soddy's conclusions (12-14).

Closely following the displacement laws was the discovery (with Göhring) of element 91 in the form of one of its short-lived isotopes, which they appropriately named Brevium (15). Regrettably, based on their study of its longest lived isotope, Hahn and Meitner are usually given the credit for having discovered element 91 (protactinium) five years later.

A comic opera by Lortzig entitled "The Czar and the Carpenter" provided the inspiration for another important rule. This was the relationship between the atomic weight and stability of radioactive isotopes (or the members of a *pleiad*, as Fajans originally named such groups). In summary, the rule states that, as the atomic weight decreases, the half-life decreases for isotopic alpha-radiators but increases for beta-radiators, and that, consequently, in a given pleiad, the beta-radiators have higher atomic weights than the alpha-radiators, and the longest lived is of shorter life than the longest lived isotopic alpha-radiator. Little was made of this rule at the time. However, with the rise of nuclear physics in the 1940's it became of increasing importance, though Swinne eventually found some exceptions (16).

Atomic Weight	0 (VIII)	I a b	II a b	III a b	IV a b	V a b	VI a b	VII a b	Atomic Weight
197		Au							197
200			Hg						200
204				Tl					204
206					RaG				206
(207)				βAcC″ 4.7^m	(AcD)				(207)
207					Pb				207
208				βThC″ 3.2^m	ThD	Bi			208
210				βRaC″ 1.3^m	βRaD 16^y	βRaE 5^d	αRaF 136^d		210
(211)					βAcB 36^m	$\alpha\beta$AcC 2.15^m	αAcC′ (0.005^s)		(211)
212					βThB 10.6^h	$\alpha\beta$ThC 61^m	αThC′ (10^{-11s})		212
214					βRaB 27^m	$\alpha\beta$RaC 19.5^m	αRaC′ (10^{-6s})		214
(215)							αAcA 0.002^s		(215)
216							αThA 0.14^s	—	216
218							αRaA 3^m		218
(219)	αAn 3.9^s								(219)
220	αTn 54^s								220
222	αRn 3.82^d								222
(223)			αAcX 11.2^d						(223)
224		—	αThX 3.7^d						224
226			αRa 1600^y						226
(227)				βAc 20^y	αRdAc 19^d				(227)
228			(β)MsTh$_1$ 6.7^y	βMsTh$_2$ 6.2^h	αRdTh 1.9^y				228
230					αIo 10^{5y}				230
(231)					βUY 25^h	αPa 3×10^{4y}			(231)
232					αTh 1.5×10^{10y}				232
234					βUX$_1$ 24^d	{βUZ 6.7^h / βUX$_2$ 1.17^m}	αU$_{II}$ (2×10^{6y})		234
238							αU$_I$ 4.5×10^{9y}		238

Placement of the known radioelements in the periodic table, circa 1930 (16). Used by Fajans to illustrate his famous displacement laws for radioactive decay.

Meanwhile, Fajans, along with some others, came to a growing conviction that the atomic weight of an element was not the fundamental constant which many others believed it to be. He also realized his lack of experience in atomic weight determination handicapped him in carrying out experimental work convincing to his peers. As a result, he wrote to T. W. Richards at Harvard requesting permission to send a graduate student, Max Lembert, to work there. The objective was to determine the atomic weight of lead obtained from radioactive minerals, for comparison with that of ordinary lead. The results obtained by Lembert and Richards were as Fajans had predicted - the lead from the new ore sample had a lower atomic weight, 206.5 vs. 207.2 for ordinary lead. Richards, who was skeptical about the existence of isotopes, had difficulty in shedding his original belief that impurities or errors were the cause of the differences in the determined atomic weights. However, the evidence obtained by Lembert was not easily dismissed and Richards and Lembert eventually published the results (17). Nevertheless, Richards continued to think of the subject as a "problem area" for several more years (18-19)! Otto Hönigschmid, working in Prague after earlier training at Harvard, also obtained similar, though less striking, experimental results at about the same time, as did Soddy and Maurice Curie (20). The term isotope, by the way, had been introduced by Soddy in 1913 and was suggested to him by an English physician, Margaret Todd, at a dinner party at the home of his father-in-law.

The rules for co-precipitation of minute concentrations of radio-elements were also enunciated by Fajans and P. Beer during this period. They were confirmed by Fritz Paneth, and extended by Fajans and co-workers and by Otto Hahn in the period between 1913 and 1926 (21-24).

A view of the difference in formalities observed by Fajans and his doctoral mentor, Bredig, has been given by one who knew both during the Karlsruhe days. Elizabeth Rona, in her delightful little book, *How It Came About*, tells how, in her early graduate school days, she changed her plan to work under Bredig, known as the "Shreckliche," and chose to work under Fajans "in a new and exciting field" (25). She adds that Fajans (apparently ahead of his time) did not discriminate against women at his frequently held laboratory parties. A dinner invitation to Bredig's home, in spite of the fine food and hospitality, meant that Rona would have to join the ladies in family talk rather than to talk shop with her laboratory associates, as she so longed to do.

A sidelight, possibly foreshadowed by Fajans' frustration with organic chemical research at Zürich, is also mentioned by

Rona. She remarks that, in contrast to his great ingenuity, foresight and courage, Fajans was not a skilled experimentalist. "We feared his handling our instruments." Yet Fajans insisted that "there are no experimental difficulties" too great to overcome. This assertion appeared as the caption on a caricature presented to him by his students on his 26th birthday and reproduced here. This shows him working away in apparent determination, despite one arm in a sling, blood from one hand dripping into a broken jar, and broken glass and equipment flying about!

With the start of World War I in 1914, things at Karlsruhe changed for the worse. Most of the students had to leave. Fajans, a Russian subject, was not allowed to teach, only to work in the laboratory. Each day he was required to identify himself at the police station. Of this duty, his little son, Edgar, would frequently remind him by asking, "Have you said Fajans already?"

Before the end of the war, Poland became an independent country and Fajans had some hope of getting a position at the University of Warsaw. This, however, fell through. Nernst, at Berlin, had indicated his interest in having Fajans join him, but another offer appeared before Nernst could make a definite proposal and, by a somewhat fortuitous route, Fajans was called to the University of Munich instead. Adolf von Baeyer, who looked with utter contempt upon physics and physical chemistry, had just retired. His former student, Richard Willstätter, who had arrived to replace him, recognized the need for physical chemistry but found there was no laboratory for it. He could not get Haber, who now was at the Kaiser Wilhelm Institute in Berlin and unavailable. It was then that Willstätter remembered Fajans and his work in Rutherford's laboratory. The result was that in 1917 Fajans was offered a position in physical chemistry, as he once wryly remarked, "in spite of my time at Zürich."

Life in this beautiful city was very pleasant. Vacations often were spent in the nearby Bavarian and Austrian Alps. Fajans and both sons (Stefan was born in 1918) came to enjoy skiing. There was an excellent opera, and the symphony orchestra, conducted by Bruno Walter, provided an added attraction. Among his colleagues at Munich were W. Röntgen, Professor of Experimental Physics; A. Sommerfeld, Professor of Theoretical Physics; P. Groth, Professor of Mineralogy and Crystallography; and O. Hönigschmid, Professor of Analytical Chemistry.

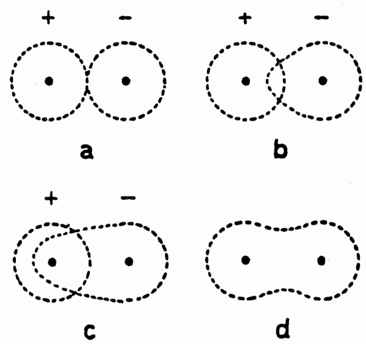
Upon arriving in Munich, Fajans dropped his work in radiochemistry and embarked instead upon the investigation of the factors governing chemical bonding and the properties of atoms and molecules in the solid, liquid and gaseous states. One could say that a new career began here. He was not to return to active work in radiochemistry until almost 20 years later, after leaving Germany.

One of the first fruits of this shift in interest was Fajans' experimental proof of what should properly be called the Born-

"Experimentelle Schwierigkeiten Gibt Es Nicht" Student commentary on Fajans' lab technique at Karlsruhe (25).

Fajans-Haber Themochemical Cycle (26). Each of the three parties involved in the development of this concept eventually agreed to simultaneously publish his own paper in the 5 December 1919 issue of the *Verhandlungen der Deutschen Physikalischen Gesellschaft*. Fajans' thermochemical investigations also extended to diamond, graphite, and to aliphatic and aromatic compounds (27-29).

As early as 1920, Fajans and H. Grimm, as a result of studying the halides of sodium and potassium, recognized the fallacy of assigning constant radii to ions (30-31). By 1923, based on further work with Georg Joos (in the first of some 50 publications by Fajans and co-workers dealing with refractometry), he proposed the dependence of anionic size on the polarizing (deforming) effect of the cation (32-33). It may be noted that Fajans was expounding and practicing a form of "crystal field theory" decades before it was applied to the problem of d-d spectroscopic transitions. Billiard-ball concepts in chemistry were ushered out - yet this reality was ignored by many in the following years. One can still find recent statements by physicists and chemists warning of the dangers of assuming spherical ions, written as though the concept of ion deformation were only recently developed! Already in 1925, Fajans predicted that NaF (not CsF, as Coulson later wrote) would be found to be the most polar of the



Fajans' picture of the transition from ideal ionic bonding (a), through polar covalent bonding (b and c) to ideal covalent bonding (d) via progressive anion polarization (16).

alkali metal halides, and 38 years later this was borne out experimentally by Canadian researchers (34-35).

At about this time, Willstätter resigned from the chairmanship of the department, and Heinrich Wieland, from the University of Freiburg, succeeded him. Wieland used his influence to get Freiburg to offer Fajans a Chair (full Professorship) in Physical Chemistry. However, the University of Munich and its Board did not want him to leave. They countered with a similar offer, with the proviso that all agreements had to be made with the approval of Wieland. Apparently Wieland had feared difficulties at Munich because of Fajans' influence and popularity in the department, which was why he had arranged for the offer from Freiburg. Long negotiations followed, Fajans stayed at Munich, and eventually the two developed a close rapport and a solid friendship.

It was also around this time, roughly halfway through the Munich period, that Fajans and Linus Pauling first met. It is no secret that their views on the nature of chemical bonding and its effect on structure developed along differing paths. In 1987 Dr. Pauling graciously took time out from busy preparations for an extended speaking tour to dictate and send to me some reminiscences of this period (36):

My wife and I arrived in Munich about the end of April 1926. I had received a Guggenheim Fellowship, and I worked with Professor Arnold Sommerfeld in his Institute for Theoretical Physics, University of Munich. Fajans' laboratory was some distance away, about one mile from the main university building, but I soon went to see him, to tell him that I was interested in working on some problems in which he also had interest. He had been working on the electric polarizability of atoms and ions. His students had carried out many experimental determinations of the index of refraction [using] light at different wavelengths, in order to obtain values of the electric polarizability. He was also interested in the structure of crystals, a field in which I had been working during the preceding four years.

Fajans and his wife immediately invited us to have lunch with them, in their home. I remember that on one occasion we came to lunch, continued talking, and finally also stayed for dinner. We met the Fajans children [Edgar and Stefan], who were amused by the rather odd German that we spoke. Later in the year we were planning to go skiing in the Bavarian Alps. My wife was small, just the right size to use a pair of skis belonging to one of the Fajans children, so that these skis were loaned to us.

Although we were interested in the same scientific topics, there did not arise any occasion when Fajans and I found it desirable to work together on a problem. One reason was that Fajans was very busy. He had a large Division of Physical Chemistry, with many students, and was kept busy with its administration and with his teaching duties, as well as his supervision of research programs. He told me at one time that the research results of many investigations had piled up on his desk, because he could not find time to write up the results for publication. He also regretted that he was so busy that he could not take the time to study the new theory of quantum mechanics. I think that this inability to get a good grasp of quantum mechanics was a problem that bothered him all the rest of his life.

I did not see very much of him in later years. However, my wife and I continued to feel grateful to him and his wife for their kindness to us, when we appeared in a foreign land as young people just beginning their careers.

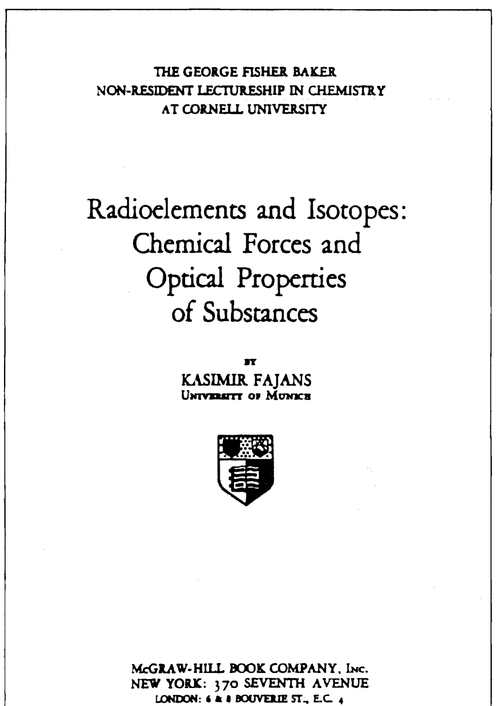
It was in 1928 that Fajans published his ideas on the importance of the mutual polarization of anions and cations (37-38). This became a continuing theme throughout his career. His frequently expressed disdain for the popular acceptance of the additivity of ionic radii may best be illustrated by his reply to a fellow attendee at the International Symposium in Trieste in June 1959. The man told Fajans how he used values from certain named sources, "for they are the best radii." Fajans replied, "There are no good ionic radii." Recounting this in October 1959, he added with a smile, "God did not make ionic radii."

Other activities during the Munich years dealt with photochemistry (39-41), dye absorption (which led to the development of adsorption indicators for argentometry) (42-44), extensive refractometric studies (carried out for all three states of matter and at temperatures as high as 1000° C) (45), a book of popular lectures on radioactivity (4), and the publication of a well-known laboratory manual for physical chemistry (46).

His Baker Non-Resident Lectureship at Cornell University in 1930, and the subsequent publication of these lectures, gave American audiences a firsthand exposure to his work and views (47). His popularity as a lecturer also resulted in invitations to lecture at, among others, Columbia, Harvard, Yale, Princeton, Michigan, Chicago, Northwestern, McGill, and Wisconsin. These obligations were squeezed between the weekly three days of lectures and seminars at Cornell. This busy schedule worried Professor L. M. Dennis, the Department Head at Cornell, since Fajans was supposed to deliver the manuscript of a book based on his lectures at the end of the term. While at Cornell the family also learned something of inherited school pride. A professor who had shown no previous interest in attending Fajans' lectures suddenly became friendly when he learned of Fajans' difficulties with Dennis. One day he confided to Mrs. Fajans, "I am a third generation graduate of Harvard. The first word my children are taught to speak is not 'mommy' or 'daddy' but 'Harvard'!" Fajans finally did complete the required manuscript, though it is interesting to note that the resulting volume is probably the thinnest of the entire Baker Lecture Series. Indeed, his preface suggests that he was not unaware of this possibility.

It was also during this visit that Fajans received the happy news that the Rockefeller Foundation had decided to finance a new Institute of Physical Chemistry in Munich with Fajans as the director. This was completed in 1932 and consisted of a wonderfully equipped three-story building, complete with a roof terrace for entertaining guests and holding afternoon laboratory teas.

Unfortunately, Fajans was not to enjoy his new Institute for very long. Gathering clouds on the political horizon and the ascendancy of Hitler left little doubt that he and his family would have to leave Munich. The Rockefeller Foundation optimistically thought that the Fascist Regime would soon fall and asked Fajans to wait patiently. No doubt, because of their influence, the Fascist government exercised some restraint in handling the affairs of both Fajans and the Institute. Yet, no new pupils came. His wife had to help in the laboratory. Acquaintances were being tagged and sent to concentration camps.


THE GEORGE FISHER BAKER
NON-RESIDENT LECTURESHIP IN CHEMISTRY
AT CORNELL UNIVERSITY

Radioelements and Isotopes:
Chemical Forces and
Optical Properties
of Substances

BY
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It was in 1934, in the *Zeitschrift für physikalische Chemie*, that Fajans published one of his last papers to be written in Germany, a long discussion of refraction and dispersion, with references to papers in the same volume by his co-workers at the Institute (48). Also included were critical comments on the work of other investigators, which foreshadowed the increasingly divergent nature of his own views on the subject.

The next year Fajans was finally forced to leave Germany and his Institute. Because Edgar, the oldest son, had been born in Manchester, he could claim English citizenship. He had just acquired his Ph.D. at Frankfurt, and fortunately was able to go to London to work with F. G. Donnan. Young Stefan, born in Munich, was sent to a private boarding school in Cambridge. The remaining task was to find congenial employment for Fajans. Tendered professorships in Poland and in Turkey and a possibility of industrial research in Poland presented problems only too obvious. A one-year fellowship appointment at Cambridge opened an opportunity not only to finish some work which he had planned, but also to prepare for a more permanent move. Indeed, before leaving Munich, he had been offered, through messages sent by way of his son in London, a professorship at the University of Michigan. The arrangements were completed during the stay at Cambridge, and in 1936 Fajans, along with his wife and younger son, arrived in Ann Arbor.

Part II of this article, dealing with Fajans' career in the United States, will appear in the Spring 1990 issue of the Bulletin.

References and Notes

1. An earlier version of this account was presented as part of the *Symposium in Commemoration of the Centennial of Kasimir Fajans' Birth*, held at the Fall National ACS Meeting in New Orleans, LA, on 1 September 1987. Parts derive from my past conversations and correspondence with Kasimir Fajans, also from seminars which he presented, particularly the historical lectures at 3M Company on 27 June 1956 and on 13 October 1959 (the latter during a week of seminars and discussions about his views of chemical bonding). I am particularly indebted to his son, Dr. Stefan Fajans, M.D., for providing a copy of his mother's excellent biographical notes about his father. (She also earlier gave me a copy of the book (25) by E. Rona.) I also wish to thank my former employer, the 3M Company, for its support and encouragement, and for the willing assistance by members of its Technical Libraries Staff. The much needed help of Dr. Mary V. Orna and Dr. Seymour Z. Lewin in setting up the original Symposium is deeply appreciated.

2. Previously published biographical accounts of Fajans include:

a. E. Lange, "Kasimir Fajans zum 70 Geburtstag", *Z. Elektrochem.*, **1957**, *61*, 773-774. (Lange and Fajans were colleagues at Munich).

b. Anon., "Biografia del Prof. Dr. Kasimir Fajans", *Rev. Soc.*

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Dr. Reynold E. Holmen, 2225 Lilac Lane, White Bear Lake, MN 55110, is retired from the 3M Company, where he was employed as an organic chemist. He received his Ph.D. degree from the University of Michigan, where he had the stimulating experience of taking several courses from Fajans.

THE HISTORY OF THE DEXTER AWARD

Part IV: The Third Decade

Aaron J. Ihde, University of Wisconsin

The winner of the 1977 award, Modesto Bargalló (1894-1981), was born in Spain and played an important role in science education in Spanish universities. At the close of the Spanish Civil War, he fled Spain and started a new career in Mexico, where he was a faculty member of the National Polytechnic Institute in Mexico City. Although he had been interested in history of chemistry while still in Spain, that interest flowered in Mexico, where he made extensive studies of the history of metallurgy in Colonial Latin America. He published numerous papers on history of chemistry and of metallurgy and was the author of several works on Latin-American metallurgy.

Modesto Bargalló

George Kauffman (b. 1930), recipient of the 1978 award, was born in Philadelphia and educated at the Universities of Pennsylvania and Florida. He developed a deep interest in coordination compounds, aroused at Penn by a professor who had worked with Alfred Werner at Zürich. Kauffman became a member of the chemistry faculty at California State University in Fresno in 1956 and has taught courses in general and inorganic chemistry, as well as history of chemistry. His interest in the latter subject developed early in his career and came to fruition during a research leave in Zürich where he studied the papers of Werner. He has edited three collections of classical papers in coordination theory and has chaired two symposia on teaching history of chemistry, one of which was published in book form. He has also published a biography of Werner and a symposium volume on the Werner Centennial

George Kauffman

which he organized.

The 1979 award was given to Joseph Needham (b. 1900), the son of a London physician, who abandoned the study of medicine after graduating from Cambridge and turned to biochemistry. He studied in the laboratory of F. G. Hopkins at Cambridge and became a Fellow of Caius College upon appointment to the university faculty. Parallel with a distinguished biochemical career, he had a curiosity about the interrelations between science, religion, and society. He has published or edited numerous works reflecting his interests. He is now best known as the author of the multivolume work *Science and Civilization in China.* Three parts of Volume 5, dealing with chemistry and chemical technology in China, are now in print.

Joseph Needham

The recipient of the 1980 award, Maurice Daumas (b. 1910), was born in France, where he studied chemical engineering. In 1947 he began his long tenure at the National Museum of Arts and Commerce, where he has contributed extensively to the history of scientific apparatus. His best known works are *Les Instruments Scientifique aux XVIIe et XVIIIe Siecles* (1953); *Lavoisier, Théoreticien et Experimentateur* (1955), *l'Encyclopédie de la Pléiade: Histoire de la Science* (editor, 1957), and *Histoire Générale des Techniques* (editor, 5 volumes).

The 25th Dexter Award was given to Cyril Stanley Smith (b. 1903) in 1981. A native of Birmingham, England, Smith came to the United States in 1924, after completing his B.S. at the University of Birmingham, in order to study metallurgy at MIT. From 1927 - 1942 he was a research metallurgist with American Brass Company. During World War II he was a Division Leader in charge of metallurgy at Los Alamos, where his group worked on the metallurgy of plutonium. Following the war, he became Director of the Institute for the Study of Metals at University of Chicago. He returned to MIT in 1961 as Institute Professor and became Emeritus in 1969. Smith developed an early interest in the history of metals, but found the subject very poorly developed. This caused him to investigate the early works in the field and, ultimately, to bring about translation of the classical works of Biringuccio, Ercker, Reaumur, Theophilus, and other early authors. He has not only contributed to the opening of the classical literature but has also effectively applied metallurgical knowledge to the interpretation of archeological and artistic problems relating to metals.

Maurice Daumas

John H. Wotiz (b. 1919), winner of the 1982 award, was born in Ostrava, Czechoslovakia. After studying briefly at the Czech Polytechnicum of Prague, Wotiz came to the United

States, finishing his B.S. in chemistry at Furman University in 1941 and his Ph.D. at Ohio State in 1948. An active organic chemist his entire academic career, Wotiz's major contributions to history of chemistry center on his role in helping to establish the Center for History of Chemistry in Philadelphia and his organization of the European History of Chemistry Tour, which he has conducted since 1971.

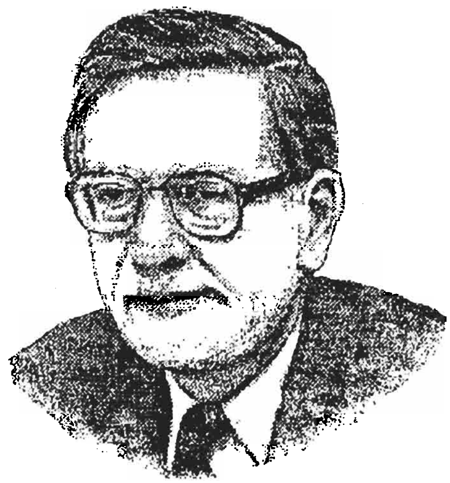
Arnold Thackray (b. 1939), winner of the 1983 award, was born in England, where he read chemistry at Bristol University and worked as a chemical engineer before turning to the history of science (Ph.D. Cambridge). His interests lie in the historiography of science, and in understanding technology, medicine, and science as elements of modern culture. His interests in European intellectual history, the American chemical and chemical engineering community within a context of quantitative history and policy concerns, and the development of the history and sociology of science as a field of scholarly endeavor, have resulted in over 40 papers and six books, including *Atoms and Powers: An Essay on Newtonian Matter-Theory and the Development of Chemistry* (1970), *John Dalton: Critical Assessments of his Life and Science* (1972), *Gentlemen of Science: Early Years of the British Association of Science* (1981, with J. B. Morrell), and *Chemistry in America, 1876-1976: Historical Indicators* (1985, with J. L. Sturchio, P. T. Carroll, and R. F. Bud). He was the founding Chairman of the Department of History and Sociology of Science at the University of Pennsylvania (where he now holds the position of Joseph Priestley Professor), edited *Isis* from 1978 to 1985, and is currently editor of *Osiris*. Active in numerous professional societies, he was President of the Society for Social Studies of Science and is now the Treasurer of the American Council of Learned Societies. He has been the Director of the Beckman Center for the History of Chemistry since its inception in 1982.

Cyril Stanley Smith

John Wotiz

The winner of the 1984 award, Maurice Crosland (b. 1931), studied chemistry at the University of London, before turning to the history of science, receiving his Ph.D. in history of chemistry in 1959. In 1963 he was appointed lecturer in the history of science at the University of Leeds and in 1974 he became Professor of the History of Science at the University of Kent at Canterbury. He has served as honorary editor of the *British Journal for the History of Science*, as President of the British Society for the History of Science, and is a member of the International Academy of the History of Science. Besides numerous papers, he is author of *Historical Studies in the Language of Chemistry* (1962), *The Society of Arcueil* (1967), *Gay-Lussac, Scientist and Bourgeois* (1978), and *The Science of Matter* (1971).

Arnold Thackray



Maurice Crosland

Robert Multhauf (b. 1919), winner of the 1985 award, was born in Sioux Falls, South Dakota. After taking a B.S. degree in chemical technology, he worked for several years as a chemist and chemical engineer in industry and for the U.S. army. In 1948 he returned to school, eventually receiving an M.S. and Ph.D. in history from the University of California-Berkeley. Dr. Multhauf has served as Head Curator of the Department of Science and Technology of the U.S. National Museum, as Director of the Museum of History and Technology of the Smithsonian Institution, and as editor of *Isis*. His book-length contributions include *The Origins of Chemistry* (1967), *Neptune's Gift: A History of Common Salt* (1978) and *The History of Chemical Technology: An Annotated Bibliography* (1984).

Robert Multhauf

The 1986 award was given to Robert Anderson (b. 1944). Born in London and educated at Oxford as a physical chemist through the doctorate degree, Dr. Anderson became Assistant Keeper of the Department of Technology of the Royal Scottish Museum in Edinburgh in 1970 and Director in 1984. He has also served as Assistant Keeper and Keeper of the Department of Chemistry of the Science Museum of London and as Deputy Keeper of the Wellcome Museum of the History of Medicine. His contributions to the history of chemistry rest largely on his contributions to its preservation in the context of the science museum. Among his many books and catalogs, *The Playfair Collection and the Teaching of Chemistry at the University of Edinburgh* (1978) and his *A Bibliography of Joseph Black* (with G. Fyffe) are of interest to historians of chemistry.

Robert Anderson

The overall statistics for the third decade of the award show a continuation of the trends observed for the second decade, with the recipients becoming progressively younger and the number functioning as professional historians of science gradually increasing. Four of the recipients for this decade were over 70 when they received the award, whereas three were in their 40's. Although all of the recipients received degrees in either chemistry or chemical engineering through at least the B.S. level, over half functioned professionally as historians of science, rather than as chemists, for most of their careers.

Starting with the 1987 award to Allen Debus, short biographical sketches and portraits of the winners can be found in the *Divisional Newsletter* or in earlier issues of the *Bulletin*.

Dr. Aaron J. Ihde is Professor Emeritus in the Department of Chemistry of the University of Wisconsin, Madison, WI 53706. The update from 1982-1986 was provided by the Bulletin staff.

The 1988 Bibliography

With this issue we introduce a new feature to the *Bulletin* - an annual bibliography of books and papers published in the history of chemistry. The bibliography will contain only items for the year in question, though occasionally an earlier item will be included if it has been overlooked in previous bibliographies. The categories are generally self-explanatory. Thus the category on *Disciplinary, Institutional and Social Relations* includes histories of chemistry departments, studies of the development of research traditions and specialties, and histories of chemical education and the popularization of chemistry. Items which fall into more than one category have been placed according to their primary emphasis. If you published a relevant book or article in 1988 which has been inadvertently overlooked, please bring the omission to the attention of the editor for inclusion in a later bibliography. In future issues the bibliography will appear in the Spring issue of the succeeding year. In other words, the *1989 Bibliography* will appear in the Spring 1990 issue (No. 6).

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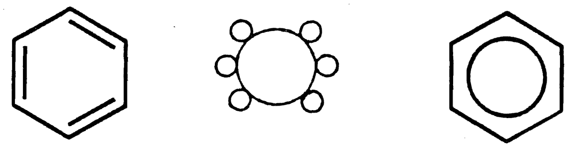
BOOK NOTES

Chemische Studien and *Konstitutions-Formeln der Organischen Chemie in Graphischer Darstellung*, Johann J. Loschmidt, Reproductions of the Original 1861 and 1913 Editions, Aldrich Chemical Company, Milwaukee, WI, 1989. 54 pp. and 152 pp. Paper (Typeset) $12.00 each.

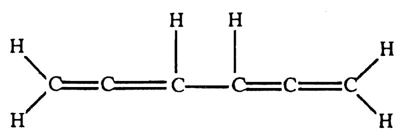
These volumes, issued by the Aldrich Chemical Company, are reproductions of the famous pamphlet published by the Austrian physicist, Johann Josef Loschmidt (1821-1895), in 1861 and of the later annotated edition of the same work, published by Kekulé's biographer, Richard Anschütz, in 1913 as part of Wilhelm Ostwald's famous series, *Klassiker der Exakten Wissenschaften*. Loschmidt's story certainly has all the elements of a romance of the "forgotten genius" genre: born in poverty, forced to privately publish his ideas on chemical structure - many of which appear to have anticipated the work of Kekulé and others, forgotten and then rediscovered after his death by Kekulé's biographer, etc., etc. Indeed, in the article in *Aldrichimica Acta,* in which the republication of these pamphlets is announced, William J. Wiswesser lists a dozen "firsts" in the theory of chemical structure supposedly contained in Loschmidt's masterpiece (1).

Unfortunately, many of Wiswesser's claims involve the exercise of a good deal of historical hindsight and others are simply wrong. The most serious of these is his contention that Loschmidt proposed the first correct cyclic structure for benzene (II) four years before Kekulé (I) and that his structure even anticipated aspects of the delocalized MO structure used today (III), a premise which he illustrates pictorially by comparing the three formulas:

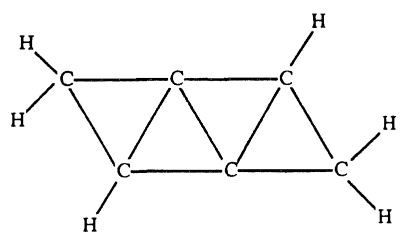


I II III

This assertion suggests that Wiswesser has not carefully read the work he so enthusiastically recommends to others, for though Loschmidt did propose two structures for benzene in his pamphlet, neither correspond to Kekulé's ring formula. Translating Loschmidt's formulas into modern notation, his first proposal corresponds to a chain stucture:



and his second to a polycyclic structure:

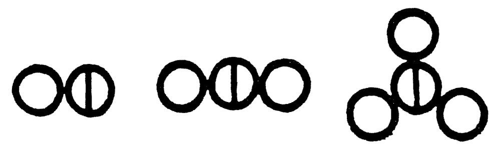


However, he quickly rejected both as inconsistent with the known chemical properties of benzene, and concluded that:

In any case, it is at present impossible to arrive at a definitive result on this [subject], and we can hold our decision *in suspenso*, since our constructions [i.e., formula] are completely independent of it. We take for the C_6^{VI} nucleus the symbol in figure 184 and will treat it as though it were a six-sited [i.e hexavalent] element.

The symbol referred to in the quote is a large circle and, like all the circles in Loschmidt's formulas, it stands for a two-dimensional projection of the spherical domain of influence for the atom in question. In other words, the benzene circle in Loschmidt's formulas does not stand for a ring of six carbon atoms but for the spherical domain of a large, undifferentiated, hexavalent pseudoatom or "element" composed in some unknown manner of six carbon atoms. Because this aromatic pseudoatom persists unchanged in the structures of other aromatic derivatives, there is no reason to speculate on its internal structure, and Loschmidt promptly proceeds to use it to successfully write the formulas for 121 aromatic derivatives.

Also questionable is Wiswesser's claim that the pamphlet is the "first picture book of molecules, containing graphic displays with atomic domains, rather than abstract bond lines." In fact, Loschmidt's symbols are a throwback, with modifications to represent multiple bonding, to the symbolism used by Dalton 50 years earlier:



Like Loschmidt's circles, the circles in Dalton's formulas represent spheres of atomic influence and included not only the material atom itself but its surrounding envelope of repulsive caloric. As Meldrum noted many years ago, Dalton held to a simple and very literal physical picture of atoms and molecules (compound atoms) and there is little doubt that his atomic diagrams were intended to represent not only the composition but the structure (however unjustified this might have been experimentally) of the molecule in question (2). Though this aspect was never emphasized by Dalton, he did use it to physically justify his famous rule of simplicity (3):

When an element A has an affinity for another B, I see no mechanical reason why it should not take as many atoms of B as are presented to it, and can possibly come into contact with it ... except in so far as the repulsion of the atoms of B among themselves [is] more than a match for the attraction of an atom of A. Now this repulsion begins with 2 atoms of B to 1 of A, in which case the 2 atoms of B are diametrically opposed; it increases with 3 atoms of B to 1 of A, in which case the atoms of B are only 120° asunder ... and so on in proportion to the number of atoms. It is evident then from these propositions, that, as far as powers of attraction and repulsion are concerned (and we know of no other in chemistry) ... *binary* compounds must be first formed in the ordinary course of things, then *ternary* and so on, until the repulsion of the atoms of B ... refuse to admit any more.

The drawings of binary, ternary and quaternary molecules given by Dalton in his famous *New System of Chemical Philosophy* are consistent with the predictions of his repulsion model of molecular structure. Indeed, it is tempting to speculate that the inability of Berzelius' atomic symbols to represent this structural aspect with equal clarity was at least partly responsible for Dalton's well-known dislike of Berzelius' proposals, just as it was responsible for the superior clarity of Loschmidt's formulas over those of his contemporaries.

Both pamphlets are attractively reproduced and reasonably priced, though there are some breaks in the thinner print and line drawings, the portrait of Loschmidt in the 1913 edition has the resolution of a poor photocopy, and the glued bindings have a tendency to give out almost immediately. Nevertheless, in spite of these minor physical shortcomings and the questionable historical motives, the Aldrich Company must be enthusiastically applauded for making this classic available again to both chemists and historians.

William B. Jensen, University of Cincinnati

References and Notes

1. W. J. Wiswesser, "Johann Josef Loschmidt (1821-1895): A Forgotten Genius", *Aldrichim. Acta*, **1989**, *22*, 17-19. This article also gives instructions on how to order.
2. A. N. Meldrum, "The Development of the Atomic Theory: Dalton's Chemical Theory", *Manchester Mem.*, **1911**, *55(6)*, 1-18.
3. Quoted in reference 2, p. 9.

TRANSLATIONS

The Answer to Last Issue's Puzzle

The reaction between "cuperous nitre" and tin described by Cavallo was discovered by the British chemist Bryan Higgins in 1773 (1). Though the editor was unable to find mention of an equation describing the reaction in the standard reference books, the most likely representation is:

$$Sn(s) + Cu(NO_3)_2 \cdot 3H_2O(s) \rightarrow SnO(s) + CuO(s) + 3H_2O(l) + 2NO_2(g)$$

Cuperous nitre is, of course, copper dinitrate trihydrate and the observation that "copious nitrous fumes" are emitted, as well as the facts of thermodynamics, make it likely that the nitrate ion, rather than the copper ion, is the primary oxidizing agent. $\Delta H°$ for this reaction is -220.97 kcal/mol, $\Delta S°$ is 189.2 cal/K mol and $\Delta G°$ at 298K is -277.4 kcal/mol. An alternative reaction with $Cu(OH)_2(s)$, $Sn(OH)_2(s)$, $NO_2(g)$ and only 1 mole of H_2O as products is slightly more exothermic but less favorable overall due to a smaller entropy change. The moisture in the copper nitrate is necessary to kinetically initiate the reaction and the folding of the foil minimizes heat loss to the environment, thus helping to make the reaction thermally self-accelerating.

A recent twist on the use of copper nitrate as an oxidizing agent is the development of a new laboratory reagent called *claycop*, which is short for clay-supported copper nitrate (2).

References and Notes

1. B. Higgins, "Actual Fire and Detonation Produced by Contact of Tin Foil with the Salt Composed of Copper and the Nitreous Acid", *Phil. Trans.*, **1773**, *63*, 137.
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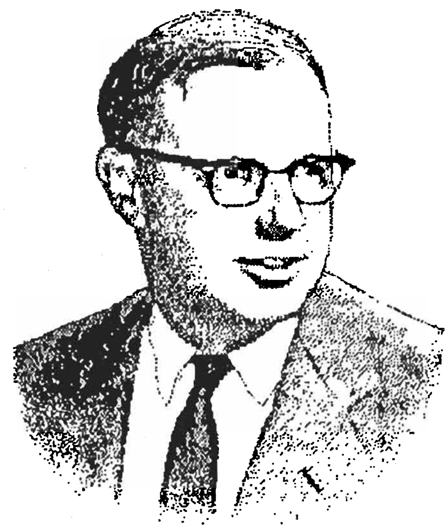
AWARDS

The Dexter Award

The 1989 Dexter Award for outstanding accomplishment in the history of chemistry has been awarded to Dr. Dean Stanley Tarbell of Vanderbilt University. The award, which consists of a cash prize of $2000 and an engraved plaque, was presented to Dr. Tarbell at the Fall National Meeting of the American Chemical Society in Miami Beach.



Dr. Dean Stanley Tarbell

Born in Hancock, New Hampshire, in 1913, Dr. Tarbell received both his undergraduate and graduate training in chemistry from Harvard University, taking a Ph.D. in organic chemistry under Dr. Paul Bartlett in 1937. Most of his academic career (1938-1967) has been spent as an organic chemist at the University of Rochester. In 1967 he became Distinguished Professor at Vanderbilt University and Professor Emeritus in 1981. Dr. Tarbell's work in the history of chemistry, which has been done in collaboration with his wife, Dr. Ann Tracy Tarbell, has largely centered on the development of organic chemistry in the United States, and has resulted in numerous articles and two books: a biography of Roger Adams (*Roger Adams; Scientist and Statesman*), published in 1981, and *Essays on the History of Organic Chemistry in the United States*, published in 1986.

The Division would at this time also like to solicit nominations for the 1990 Dexter award. Nominations should include a complete vita for the nominee, consisting of biographical data, educational background, awards and honors, publications, and presentations and other services to the profession; a nominating letter summarizing the nominee's achievements in the field of the history of chemistry and citing unique contributions which merit a major award; and at least two seconding letters. Copies of no more than three publications may also be included if available. All nominations should be sent to Dr. William B. Jensen, Secretary, The Division of the History of Chemistry - ACS, Department of Chemistry, University of Cincinnati, Cincinnati, OH, 45221 by 1 January 1990. It should be emphasized that, though the award is administered by an American organization, it is international in scope and previous winners have included historians and chemists from Germany, France, Holland, Hungary, and Great Britain.

The Outstanding Paper Award

As of 1990, the Division's Outstanding Paper Award has been changed from the best paper presented at a general session to the best paper published in the *Bulletin for the History of Chemistry*. This change allows members who are unable to attend national meetings to compete. As before, the award will consist of $100, a certificate, and $150 worth of books from the current catalog of the publishing firm of D. Reidel. Papers published up to three years prior to the date of the award are eligible, and the winner will be chosen by a committee which operates independently of the *Bulletin's* editorial staff.

NOTES FROM MEMBERS

Jeffrey L. Sturchio (formerly of AT&T Bell Labs) has been appointed as corporate archivist for Merck & Co., Inc. Dr. Sturchio's new address is Merck & Co., Inc., P.O. Box 2000, Rahway, NJ 07065-0900.

Raymond B. Seymour (University of Southern Mississippi) and Charles H. Fisher have recently published *Profiles of Eminent American Chemists*. The book gives brief biographies of the 154 chemists who have won either the American Institute of Chemists' Gold Medal or its Chemical Pioneers Award.

EVENTS OF INTEREST

* Applications are invited for the 1990-1991 Edelstein International Fellowship in the History of Chemical Sciences and Technology. The fellowship period is from 1 September 1990 to 30 June 1991, and successful applicants are expected to divide their time between the Beckman Center for the History of Chemistry in Philadelphia and the Edelstein Center for History and Philosophy of Science, Technology and Medicine in Jerusalem, Israel. The application deadline is 31 October 1989. For details, applicants in the USA should contact Dr. Arnold Thackray at the Beckman Center and those in Europe should contact Dr. Itamar Pitowsky of the Edelstein Center.

* Mary Virginia Orna and Mary Margaret Grubbs will conduct a winter intersession in the history of science from 4-18 January 1990. The course will take place at London's Science Museum, with side trips to Oxford, Cambridge, Kew Gardens and Greenwich. Cost of the trip, which includes round trip airfare (to and from JFK-New York-London), hotel accommodations, ground transportation in England and some meals, will be approximately $1499. For additional cost, the course may be taken for undergraduate or graduate credit through the College of New Rochelle. For more information, write or call Dr. Mary Virginia Orna, Department of Chemistry, College of New Rochelle, New Rochelle, NY 10801; Phone: (914) 654-5309 (O) or (914) 636-4453 (H).

* The Edelstein Center International Workshop on the History of Chemical Technology will be held in Jerusalem on 28-31 May 1990, rather than 1989, as incorrectly announced in the last issue. For further details, contact Dr. Tony Travis, Deputy Director, Sidney M. Edelstein Center for the History and Philosophy of Science, Technology and Medicine, The Hebrew University of Jerusalem, Jerusalem, Israel.

* Dr. Colin A. Russell, noted British historian of chemistry, will be in the United States in April of 1990 and will be available for university seminars and other speaking engagements. Persons interested in contacting Dr. Russell, or in obtaining a list of potential talks, should contact Dr. John H. Wotiz, Department of Chemistry, Southern Illinois University at Carbondale, Carbondale, IL 62901.

* More detailed information is now available on the new *Mitteilungen* or journal/newsletter of the *Fachgruppe Geschichte der Chemie* of the *Gesellschaft Deutscher Chemiker (GDCh)*. The group, which was established in 1962, is one of 18 subdivisions of the GDCh and has a membership of 233, mostly from academia and industry. The purpose of its publication is to preserve the most interesting of the papers read at the group's biannual meetings and to provide information on current projects and events in the history of chemistry. The journal, which is published in German, appears once a year, and costs DM16 for nonmembers and DM8 for members of the GDCh. Subscriptions should be sent to the Gesellschaft Deutscher Chemiker, Fachgruppen, Postfach 900440, Varrentrappstrasse, D-6000, Frankfurt (Main) 90, West Germany.

* Cornell University has established a cold fusion archive to document the current controversy over cold fusion. Potential contributors should contact Dr. Bruce V. Lewenstein, Cold Fusion Archive Project, STS Program, 632 Clark Hall, Cornell University, Ithaca, NY 14853; Phone: (607) 255-6500.

* A two-day symposium in honor of Dr. O. T. Benfey entitled "The Context of Chemistry: Conceptual, Historical, Social" will be held at the 1989 Southeastern Regional ACS Meeting on 9-11 October 1989 in Winston-Salem, NC. The program

will feature 17 speakers with topics in the areas of chemical education and the history and philosophy of chemistry. For further information, contact Dr. David MacInnes, Department of Chemistry, Guilford College, Greensboro, NC 27410; Phone: (919) 292-5511.

FUTURE MEETINGS

Boston .... 22-27 April 1990

Five copies of 150-word abstract (original on ACS Abstract Form) by 1 December 1989. Title of paper by 1 November 1989.

* *General Papers.* Contact J. L. Sturchio, Corporate Archives, Merck & Co. Inc., P.O. Box 2000, Rahway. NJ, 07065-0900 (215) 997-2832.
* *History of Biotechnology.* Contact J. L. Sturchio, (see address above).
* *The 1890 Benzol Fest 100 Years Later* (Cosponsored by ORGN). Contact J. H. Wotiz, Dept. Chemistry, Southern Illinois University at Carbondale, Carbondale, IL 62901, (618) 453-5721.
* *Wartime Research at RDX and its Political Aftermath.* Contact J. T. Edwards, Dept. Chemistry, McGill University, 801 Sherbrooke St. West, Montreal, PQ, Canada H3A 2K6, (514) 398-6233 or (514) 489-1663.
* *Chemistry in Colonial America* (Cosponored by CHED).
* *True Stories of Small Chemical Businesses* (Cosponsored by SChB).

Washington .... 26-31 August 1990

* *General Papers.* Contact J. L. Sturchio (see address above).
* *History of the Development, Use and Testing of Food Additives* (Cosponsored by CHAL). Contact H. T. McKone, Dept. Chemistry, St. Joseph College, W. Hartford, CT 06117, (203) 232-4571.
* *Chemistry and Crime II.* Contact R. O. Allen, Dept. Chemistry, University of Virginia, Charlottesville, VA 22901, (804) 924-3622.
* *History of Environmental Pollution and Protection in Relation to Federal Regulations.* Contact R. Sarmiento, U.S. Environmental Protection Agency, Analytical Chemistry Section, Bldg. 306, BARC-East, Beltsville, MD 20705, (301) 344-2266.
* *From Newport to the Nation's Capital: A Century of ACS National Meetings.* Contact J. J. Bohning, Dept. Chemistry, Wilkes College, Wilkes-Barre, PA 18766, (717) 824-4651. Ext. 4614.
* *50th Anniversary of the Discovery of the Transuranium Elements* (Cosponsored by INOR and NUCL).
* *True Stories of Small Chemical Businesses* (Cosponsored by SChB).

Atlanta .... 14-19 April 1991

* *General Papers.* Contact J. L. Sturchio (see address above).
* *Michael Faraday - Chemist* (Cosponsored by CHED). Contact D. A. Davenport, Dept. Chemistry, Purdue University, West Lafayette, IN 47907, (317) 494-5465.
* *Chemistry and Science Fiction.* Contact J. H. Stocker, Dept. Chemistry, University of New Orleans, New Orleans, LA 70148, (504) 286-6852.
* *History of Synthetic Fibers.* Contact R. B. Seymour, Dept. Polymer Science, University of Southern Mississippi, Southern Station Box 10076, Hattiesburg, MS 39406, (601) 266-4868.
* *Emil Fischer: One Hundred Years of Carbohydrate Chemistry* (Cosponsored by CARB).
* *True Stories of Small Chemical Businesses* (Cosponsored by SChB).

New York .... 25-30 August 1991

* *General Papers.* Contact J. L. Sturchio (see address above).
* *History of Steroid Synthesis.* Contact L. B. Gortler, Dept. Chemistry, Brooklyn College, Brooklyn, NY 11210, (718) 780-5746 or J. L. Sturchio (see address above).
* *A Century of Chemistry in New York (Commemorating the Local Section Centennial).* Contact J. Sharkey, Dept. Chemistry, Pace University, Pace Plaza, New York, NY 10038, (212) 488-1502.
* *Chemistry and Crime III - Forensic Methods: Past, Present and Future.* Contact S. M. Gerber, 70 Hillcrest Road, Martinsville, NJ 08836, Phone (201) 356-4721; Richard Saferstein, New Jersey Forensic Laboratory, P.O. Box 7068, West Trenton, NJ 08825, (609) 882-2000, Ext. 2692.
* *True Stories of Small Chemical Businesses* (Cosponsored by SChB).

San Francisco .... 5-10 April 1992

* *General Papers.* Contact J. L. Sturchio (see address above).
* *True Stories of Small Chemical Businesses* (Cosponsored by SChB).

Geneva .... (Date to be Announced)

* *100th Anniversary of the Geneva Conference.* Contact J. G. Traynham, Dept. Chemistry, Louisiana State University, Baton Rouge, LA 70803, (504) 388-3459.

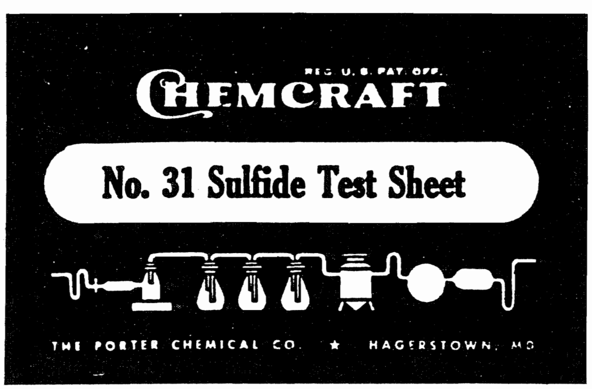
PARTING SHOTS

The World's Largest Hydrogen Sulfide Test

William B. Jensen, University of Cincinnati

Any chemist who ever owned a chemistry set as a kid knows that they often contained some rather bizzare chemicals, such as logwood and azurite, which one has never encountered since in the course of one's professional career. The reasons for this atypical selection are not obvious, though I have always assumed they were related in some way to an index of the (colorful reactions)/(cost) variety. Among the arcane items in my chemistry set was a packet labeled sulfide test paper, a square of filter paper coated with lead acetate and used to detect sulfide via the formation of a black coating of PbS. Again, I confess to having wondered about the precise utility of this item, given the fact that, in the aqueous environment of the home laboratory, sulfide ion is almost always in equilibrium with hydrogen sulfide gas and the characteristic odor of the latter, coupled with the incredible sensitivity of the human nose, seemed, at best, to make the test paper redundant.

Nevertheless, its existence was filed away in my chemical subconscious and, surprisingly, proved useful during the course of my graduate research at the University of Wisconsin. Our work required the use of some rather outdated dry boxes, which were continuously springing leaks in the hot, humid Wisconsin summers. On one occasion, we had been shut down for over a week. Application of soap solution to the joints under a positive nitrogen pressure in the box had failed to find the leak. Filling the box with Freon gas and testing the joints with a flame to detect the tell-tale green of escaping halogenated hydrocarbons was equally futile. Finally, I remembered the reputed sensitivity of the sulfide test paper in my childhood chemistry set. Ignoring the protests of my advisor, we released some hydrogen sulfide in the box, wrapped all the joints in filter paper dampened with lead acetate solution and went to lunch. Upon returning, the guilty joint was quickly detected via a black stain on the test paper. Of course, we then had to spend another day removing the hydrogen sulfide from the



Lyon Playfair

box, a rather curious procedure involving the inflation of an army surplus weather balloon, but nonetheless I felt I had at last found the ultimate use for sulfide test paper - at least, that is, until I read the memoirs of Lyon Playfair (W. Reid, *Memoirs and Correspondence of Lyon Playfair*, Cassell, 1899, p. 94).

Playfair (1818-1898) had studied chemistry under Thomas Graham and was the first Englishman to receive a German Ph.D. in chemistry (from Liebig at Giessen in 1840). Upon returning to England, he became a proponent of Liebig's views on agricultural chemistry and a government consultant on matters of sanitation, agriculture and science education. His increasing involvement in government work eventually resulted in his election to Parliament and to a successful political career, culminating in his receiving the title of Baron Playfair of St. Andrews in 1892.

In 1845 Playfair left his position as Professor of Chemistry at the Royal Institution of Manchester to accept a government post with the Museum of Economic Geology in London, and shortly thereafter was asked to investigate the sanitation of Buckingham Palace. He quickly discovered that it was in a frightful state as "a great main sewer ran through the courtyard, and the whole palace was in untrapped connection with it." To forcefully illustrate this to the government officals, he had a small room in the basement of the palace freshly painted with white lead [$Pb(CO_3){\cdot}Pb(OH)_2$] and closed up for the night. In the morning the entire room was found blackened from the hydrogen sulfide in the sewer gas.

Though not done on filter paper, this surely qualifies as the world's largest hydrogen sulfide test and puts my graduate school innovation to shame - thus doth history humble us all. It is also of interest to note that some things do not change, as Playfair also reported that "the condition of the palace was so bad that the Government never dared to publish my report".

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