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Division of the History of Chemistry of the American Chemical Society

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BULLETIN FOR THE HISTORY OF CHEMISTRY

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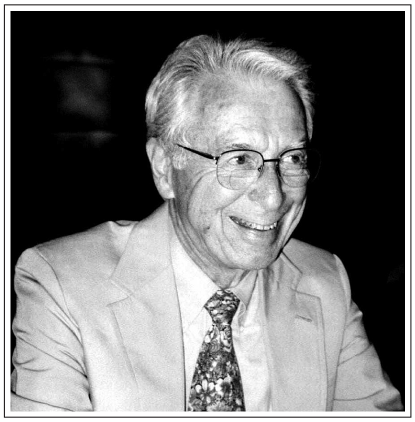
NUMBER 1

BOOK REVIEWS

CHAIRS' LETTER



Dear Fellow HIST Members, Readers, and Friends of the *Bulletin for the History of Chemistry,*

We, the undersigned Chairs, past and current, of the Division of History of Chemistry of the American Chemical Society, along with our Secretary-Treasurer for the last 16 years, join our entire community in acknowledging our gratitude to Paul R. Jones for his 16 years of editorship of the *Bulletin for the History of Chemistry*. During this time, 30 issues of the *Bulletin* were published, which have included a wide diversity of topics while maintaining an extremely high quality of content. Furthermore, Paul has been as scrupulous in creating and sustaining high production values as in preserving scholarly standards. And the issues of the *Bulletin* have arrived regularly and routinely, as if all the hard work to produce such a stream of high quality publications is a matter of course.

Each of us, as authors and reviewers of articles in the *Bulletin*, knows firsthand how detailed, thorough and active an editor Paul has been. Each of us has known how very special it is to be able to rely completely on Paul. Year by year, issue by issue, without fail, he produced the *Bulletin* for HIST's members and for the history of chemistry.

Paul leaves behind a legacy at the *Bulletin* that is eloquent testimony to his enduring impact on our discipline. All those who will read and value so many years of historical documentation, now and in the future, will be grateful for Paul's steadfast commitment.

We raise our glasses in toast to the health and well-being of Paul R. Jones. *Vale*!

Martin D. Saltzman, Chair 1995
Joseph B. Lambert, Chair 1996
Harold Goldwhite, Chair 1997–1998
Stephen J. Weininger, Chair 1999–2000
Richard E. Rice, Chair 2001–2002
David E. Lewis, Chair 2003–2004
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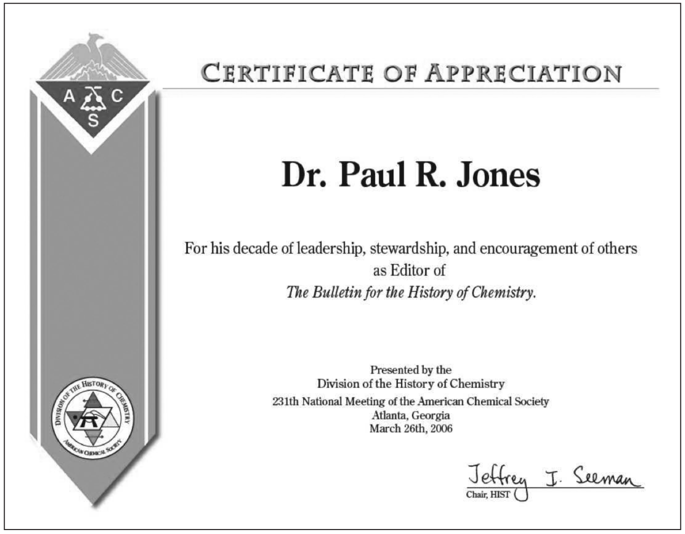


CERTIFICATE OF APPRECIATION

Dr. Paul R. Jones

For his decade of leadership, stewardship, and encouragement of others
as Editor of
The Bulletin for the History of Chemistry.

Presented by the
Division of the History of Chemistry
231th National Meeting of the American Chemical Society
Atlanta, Georgia
March 26th, 2006

Jeffrey I. Seeman
Chair, HIST

EDITOR'S LETTER

Dear Readers,

As the new editor of the *Bulletin*, I would like introduce myself, to thank my predecessors, and to ask you for your assistance.

I am a professor of chemistry at Le Moyne College, a fairly small, undergraduate-oriented university in Syracuse, New York. I have been at Le Moyne for 20 years, teaching at every undergraduate level, from energy and environment for non-science majors to physical chemistry for upper-level chemistry majors. My undergraduate education in chemistry was at the University of Scranton, which, like Le Moyne, is part of the Jesuit network of higher education. My doctoral degree is in chemical physics from Harvard University.

I've been active with the Division of the History of Chemistry (HIST) since about 1997. I first came into contact with the *Bulletin* that year when Paul Jones asked me to referee a manuscript. Later that year I made my first presentation at a HIST symposium. Before too long, I was on the other side of the review process, and my first article in the *Bulletin* appeared in 1999. Since then, I've served HIST as Alternate Councilor and Councilor and as Associate Editor of the Bulletin.

It has been my pleasure and privilege to work with Paul Jones over the last decade or so, first on the HIST Executive Committee, then as associate editor, and most recently in arranging for the editorial transition. Dr. Jones deserves much of the credit for the current issue (and none of the blame!). Most of the content of this issue was received, reviewed, and edited by him, and he has unhesitatingly helped me learn the ropes. I thank him for his stewardship of the *Bulletin*, and for his warm and gracious dealings with me. I wish him many more years as a reader of the *Bulletin* (and author and reviewer, I hope), and I will strive to maintain the quality that the journal has enjoyed to this point.

I have also enjoyed working with the *Bulletin*'s founding editor, William Jensen, on several HIST symposia. I thank him on this occasion for initiating the *Bulletin* and for his many contributions to it since Number 1 in 1988. Dr. Jensen has contributed articles, columns, and book reviews to the *Bulletin* under Dr. Jones's tenure and I hope he will continue far into the future—well beyond his articles in this issue.

Finally, I thank all who have contributed to the *Bulletin* in the past, and I encourage all readers to participate in its future. Authors, editors, and book reviewers are, of course, the most visible contributors. Referees also have an essential role behind the pages of peer-reviewed journals such as the *Bulletin*. Subscribers provide the financial support for the journal, whether through membership in HIST or by individual or institutional subscription. And readers, whether subscribers or not, provide the audience without which authors would be merely talking to themselves. I invite all readers to take an active part in the future of the *Bulletin*. My email-box is open for submissions and for suggestions.

Carmen Giunta

"NOTITIA CŒRULEI BEROLINENSIS NUPER INVENTI"
ON THE 300th ANNIVERSARY OF THE FIRST PUBLICATION ON PRUSSIAN BLUE

Alexander Kraft, Gesimat GmbH, Berlin

Introduction

Prussian Blue (ferric hexacyanoferrate (II)), discovered accidentally in 1706 in Berlin by Johann Jacob Diesbach (1) and Johann Konrad Dippel (2), remains an intensively investigated material. Currently, more than 200 scientific publications with Prussian Blue as a research subject are published annually. Johann Leonhard Frisch (see below) and Diesbach produced Prussian Blue in the years following the invention (3).

Three hundred years ago, in 1710, and four years after the discovery of Prussian Blue, the first publication on this new pigment appeared in the *Miscellanea Berolinensia* (4). Here we provide an English translation of this text and report the story of this first publication as it can be traced from the original sources. Following this material is a short biography of the author of that first publication, Johann Leonhard Frisch.

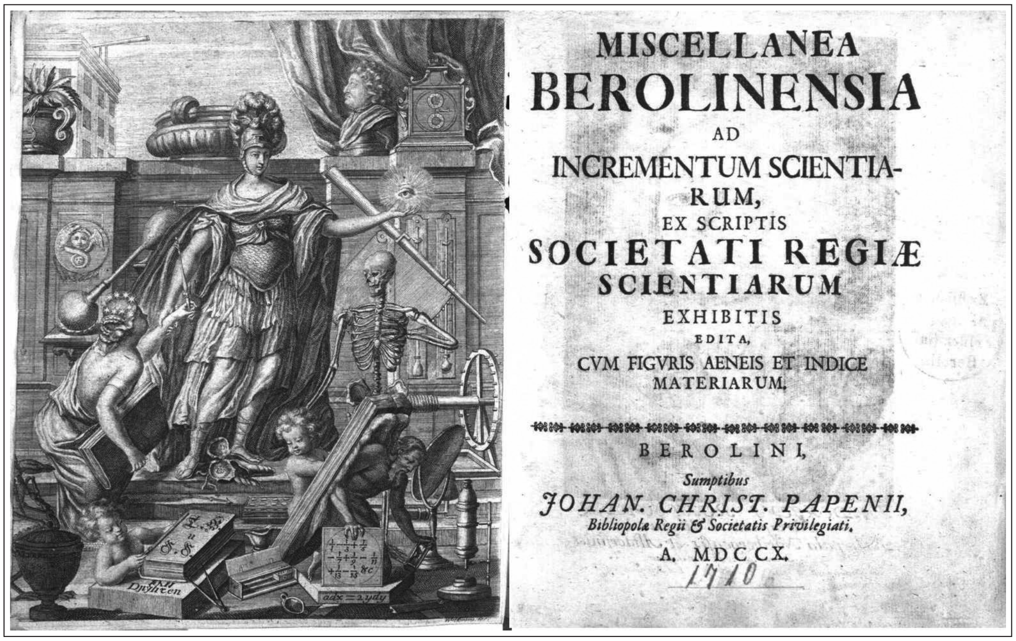
History of the First Publication on Prussian Blue

Published in only seven volumes in 34 years between 1710 and 1744, the *Miscellanea Berolinensia ad incrementum scientiarum—Miscellanea Berolinensia* for short—was the primary journal of the Royal Prussian Society of Sciences up to the reorganization of the Society in 1744. These volumes published in Latin appeared at irregular intervals, in the years 1710, 1723, 1727, 1734, 1737, 1740, and 1743–1744.

The Royal Prussian Society of Sciences was founded on July 11, 1700, in Berlin by the Elector and Margrave of Brandenburg, Friedrich III. One day later, Gottfried Wilhelm Leibniz was appointed as the first president of the Society. In January 1701 Elector Friedrich crowned himself as Friedrich I, the first king in Prussia. The formation of the Society of Sciences was the result of a combined effort of four people: Leibniz in Hannover, the court preacher Daniel Ernst Jablonski (5), the archivist Johann Jacob Chuno (6), and Electress Sophie Charlotte (7) in Berlin. The annual publication of some *Miscellanea* or *Collectanea*, as they were variously called, was an early goal of the Society of Sciences, first mentioned in a "Pro Memoria" Leibniz wrote for the King in the beginning of 1702 (8). However, for some years no action directed toward this goal is recorded. A second mention of the annual publication of Miscellanea occurs as late as December 1706, during a meeting of the Society of Sciences in Berlin headed by Leibniz after a 19-month absence from Berlin (9). During this meeting, plans for publication were affirmed; and from the spring of 1707, the members of the Society submitted texts for the *Miscellanea Berolinensia* to Chuno.

Johann Christoph Hartmann from Frankfurt an der Oder, a town about 80 km east of Berlin, was chosen in June 1707 as publisher of the *Miscellanea*. In October, the Collectanea texts were sent from Berlin to Leibniz in Hannover for proofreading. In March 1708 Leibniz returned the texts to Berlin. When Hartmann then declined to continue the collaboration in April 1708, a new publisher of the *Miscellanea*, Johann Christoph Papen, was found. Printing was finally expected to start but was delayed again in July 1708, because the chosen type set was too worn, and a new set had to be molded. On February 14, 1709, Leibniz headed a conference of the Society in Berlin. Here the final decisions regarding the publication of the *Miscellanea* were made. The printing finally started in May 1709 (10), performed by the printer Johann Wessel. (Printing and publishing were different professions.)

An article on Prussian Blue was not yet among the submitted manuscripts. In fact, this text is first mentioned in a letter dated November 9, 1709, from Frisch in Berlin to Leibniz in Hannover. In this letter, Frisch sent Leibniz a "Latin narrative on a blue dye" (11). He also mentioned that the title could easily be changed to "Berlin Blue [*Berlinisch Blau*]." Thus, it may be that *Preussisch Blau* ("Prussian Blue") was the original name and it was changed to Berlin Blue at the request of Leibniz. In fact, Prussian Blue was usually called *Berliner Blau* in German, whereas in many other languages Prussian Blue (e.g., *Bleu de Prusse* in French, *Azul de Prusia* in Spanish, *Blu di Prussia* in Italian) is more common. Only in recent years has the German Preussisch Blau been used more often, possibly from the literal translation into German of scientific texts that are now primarily in English.



MISCELLANEA
BEROLINENSIA
AD
INCREMENTUM SCIENTIA-
RUM,
EX SCRIPTIS
SOCIETATI REGIÆ
SCIENTIARUM
EXHIBITIS
EDITA,
CVM FIGVRIS AENEIS ET INDICE
MATERIARUM.

BEROLINI,
Sumptibus
JOHAN. CHRIST. PAPENII,
Bibliopolæ Regii & Societatis Privilegiati.
A. MDCCX.
1710

***Figure 1**. Frontispiece and title page of the first volume of the Miscellanea Berolinensia from 1710.*

Johann Theodor Jablonski (12), secretary of the Society of Sciences, also corresponded with Leibniz, the president, in Hannover. In a letter dated January 11, 1710, he reported to Leibniz on the status of the printing process of the *Miscellanea*. He also remarked that the texts Leibniz had ordered to be added at the end would be appended and that among them would also be the *caeruleum* of Frisch (13). On January 30, 1710, Frisch reported to Leibniz in another letter that court councilor Chuno had added the "notitia caerulei Berolinensis" to the pieces that were to be appended to the *Miscellanea* (11). The Frisch text and a second one were later added as "serius exhibita," i.e., addenda.

Finally, after more than two years of preparation and one year of printing, the first volume of the *Miscellanea Berolinensia* was ready in May 1710. (The full name was *Miscellanea Berolinensia ad incrementum scientiarum ex scriptis Societatis Regiae Scientiarum exhibitis edita, cum figura aeneis et indice materiarum.*) Figure 1 shows the frontispiece and title page of the book. The copper engraving of the frontispiece was devised by the Swiss painter and first director of the Berlin Academy of Arts, Joseph Werner (14), and drawn by his son Christoph Joseph Werner (15). Johann Georg Wolfgang (1664–1744) produced the engraving.

In May 1710 the sale of the *Miscellanea Berolinensia* started at the Leipzig *Jubilate* Fair. At this time, the book was still not available in Berlin because in that city a book first had to be presented to the King in an official ceremony. This ceremony did not take place until early June.

This first volume of the *Miscellanea Berolinensia* contains 60 scientific contributions on 425 pages (including the 31 pages with figures at the end), among them 12 articles written by Leibniz. The articles dealt with a wide variety of subjects. The contents of only three are connected with chemistry. Leibniz wrote the first of these, which deals with the solution of a Greek and a German alchemical riddle with some remarks on alchemy (16); a second article, also by Leibniz, reports the history of the discovery of phosphorus (17); and the third article is the one by Frisch on Prussian Blue. Frisch also authored an etymological article (18). The number of printed copies of the *Miscellanea* could not be established. However, of these, the Royal Prussian Society of Sciences bought 50 from the publisher to be distributed at the Royal Court (seven books) and among the members of the Society and in the Prussian government (43 books).

The *Miscellanea Berolinensia* never became an annual publication. In fact, the second volume was not published until 13 years later.

Translation of the "Notitia Cœrulei Berolinensis nuper inventi"

The first page (page 377 of the *Miscellanea*) of Frisch's article on Prussian Blue was displayed as a figure in Ref. 3 The following English translation of the original Latin text is based on two German translations, the first from Mümler (19), published in 1781 (20), and the second, more precise one from Manfred Kraft (21), completed in 2009.

> **Notice of the Newly Invented Berlin Blue**.
>
> Painters who mix their colors with oil have few blue colors at their disposal, and these are of such quality that artists justifiably require better choices. Although one of the commonly used colors can be mixed with oil, it is not stable for a long time and changes to a greenish, pale, rust-colored, or even ugly color. [Au. note: Perhaps this is azurite $Cu_3(CO_3)_2(OH)_2$, a deep-blue mixed copper carbonate-hydroxide mineral that is unstable in the open air and can change to green malachite.] Another choice of blue is stable and beautiful enough, to be sure, but also sandy; this deficiency, so cumbersome in fine artistic work, cannot be avoided, even if it is ground for a year. [Au. note: This may be smalt, a copper oxide-containing glass powder.] The best of all, which is usually called ultramarine or azurinum and is produced from lapis lazuli, discourages many artists because it is high-priced and also does not mix well with other colors. Hence, it can only show its beauty where the artist wants to convey light, and for shadows it is useless. This new blue color, invented some years ago here in Berlin, has undergone careful examination by different painters and now is made public; it is expected to address if not totally satisfy this urgent need of the artists. It possesses none of the disadvantages described above. Even in oil, it shows brilliance. It is durable and a special hue even in water, oil, or other media used in painting. Even *aqua fortis*, as chemists call it, which pits or dissolves everything, does not change or bleach this color but instead makes it more brilliant. [Au. note: Aqua fortis, literally "strong water," is a concentrated solution of nitric acid in water.] Just as some blue pigments can be used for glazing on enamel painting and are not destroyed by what I would describe as a "dry fire," so this new color withstands a "wet fire" (a name which can be properly used for the strong and all-destroying aqua fortis) better than most other colors. Therefore, it gives even less cause for concern with the simpler and more common tests of painters, such as the one involving lemon juice, etc. It is also not affected by changes of location, air, or weather. It is stable in quicklime, decorating the white color as a gemstone decorates gold. [Au. note: This is not the case: Prussian Blue is unstable in alkaline media.] This pigment is made from the finest materials and can be ground to the finest powder. Whatever is not reduced to sufficiently small particles by the first grinding can be pulverized a second or a third time. However, with each grinding the dried powder should be moistened with pure water. This procedure is usually only required for those who want to have it for more convenient use in the smallest kind of painting work, that of miniature painting. Other painters can break it up simply with the small knife they use for mixing the colors on the palette. Because of this fineness, it covers the spots wonderfully on which it is applied with the brush, and it can be spread better than other colors. Additionally, it not only can be applied over the more common blue colors and at elevated spots, but also can be shaded in wrinkles, grooves, and cavities of the painting. There are two varieties of this color: a darker one, more useful for creating shadows, and a lighter one, which is not mixed with white lead or another white color, but emerges during production. Thus, the darker color grade is made from the lighter one by shrinking, or as some say, by concentrating. Ordinary painters, who like this color because of their mixing practices, seldom use the lighter grade; they seek out only the darker grade and mix it with white according to the desired degree of lightness. To the trained eye, it can easily be seen that a color made lighter by mixing the darker grade with a white color lacks the brightness and beauty of

> the one that is naturally lighter. By the way, this pigment is harmless and contains no arsenic or anything unhealthful, but rather medicinal ingredients. Sugary objects painted with this color can be eaten without risk. Painter apprentices can draw their paint brushes with which they apply this paint onto paintings through their mouths without danger. This cannot be done with other paints without endangering life. Finally, because the color is easy to produce, the price hardly reaches the tenth part of that of the very expensive ultramarine. And the quantity of stock of this color, which can be purchased in Berlin from the book dealer of the Royal Society of Sciences, is as large as the lavish artists can demand for their paintings that will be decorated with this color.

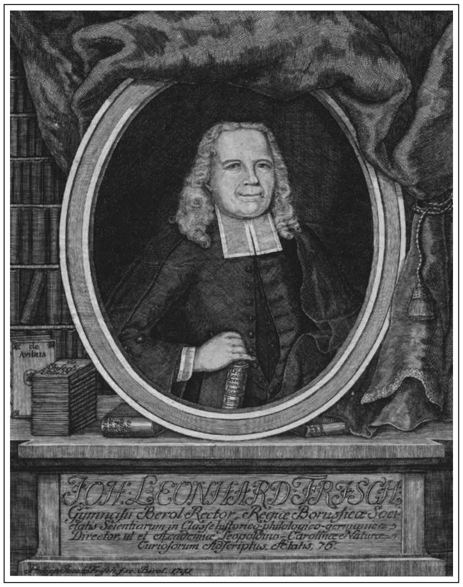


***Figure 2**. Johann Leonhard Frisch, teacher and scientist in Berlin, who in 1710 published the first article on Prussian Blue in the* Miscellanea Berolinensia. *Engraving by his son Philipp Jacob Frisch, 1741 (© Leopoldina, Halle, Germany).*

Some Comments on the Translation

It is remarkable that the name of the color is mentioned only once in the article, i.e., in the title. The book dealer of the Society of Sciences was Johann Christoph Papen (22), a publisher and book dealer who had a shop in Berlin between 1700 and 1723, when he was forced to sell his business. He was also the publisher of the first *Miscellanea* volume of 1710 and of the second one of 1723. Over a longer time, he was factor (i.e., mercantile agent) of the Royal Prussian Society of Sciences. Obviously, he also sold Prussian Blue for Frisch and Diesbach.

Who was Johann Leonhard Frisch?

Biographical information on Frisch, the author of the "Notitia Coerulei Berolinensis," can be found in several sources (e.g., Refs. 23, 24, 25). A short summary of this information is given here, together with some comments on his scientific career and his chemical studies.

Johann Leonhard Frisch was born on March 19, 1666, in Sulzbach in the German region of the Upper Palatinate, which is today part of the German state of Bavaria. At that time, the small town of Sulzbach, lying about 50 km east of Nürnberg, was the capital of the German state Palatinate-Sulzbach, a duchy of the Holy Roman Empire of the German Nation.

Johann Leonhard's father, Johann Christoph Frisch (1631–1679), was a lawyer employed as a secret *Secretarius* of the government of Palatinate-Sulzbach. His mother Sabina was the daughter of the goldsmith Fecher from Strassburg (present-day Strasbourg). The family moved from Sulzbach to Nürnberg in Franconia because Johann Christoph Frisch became registrar of the government of that city. From 1670, beginning at the age of only four years, Johann Leonhard attended the Lorenz school in Nürnberg and was instructed in Greek by his grandfather (also named Johann Leonhard Frisch, 1604–1673), a clergyman in Nürnberg. Then for some years, Johann Leonhard's father was inspector in Schnabelwaid in the Margraviate of Brandenburg-Bayreuth, also located in the region of Franconia. In this very small town, Johann Leonhard received only private teaching. From 1680 he studied at the gymnasium in Nürnberg and started his university studies in theology in Altdorf near Nürnberg in 1683.

Around 1686 he began his travels through Europe. First he moved to Jena in the German region of Thuringia to continue his studies, which he completed in Strasbourg (by this time annexed by France) in Alsace in 1688. After traveling through France and Switzerland, he returned to Nürnberg. There he received a candidate degree in theology. From 1691 on he traveled again, this time first via Vienna to Hungary. He stayed for a short time as a preacher in Banská Bystrica in Upper Hungary in a region which is now roughly Slovakia. After leaving this area, he moved south to the border region between Hungary and Turkey and served as a translator for the imperial army during the War of the Holy League (1683–1698), a part of the Great Turkish War. By way of Italy, he made his way back to his home region in 1693.

In the following years, he was manager of several agricultural enterprises in Germany and a private teacher of young noblemen. By 1696 Frisch was similarly employed in the town of Blankenburg in the Harz Mountains. His last brief travel period led him in 1698 to the Netherlands. Finally, in the same year, Frisch came via Hamburg to Berlin were he stayed for the remaining 45 years of his life. Shortly after his arrival in Berlin, he became employed as a teacher in the Berlin gymnasium located in the former Grey Monastery of the Franciscans. Soon afterwards, in 1699, he married Sophie Elisabeth Darnmann, daughter of a pastor from Blankenburg. Frisch now had a steady career at the gymnasium, a job that allowed him enough time to follow his scientific interests. From 1725 on, he was rector of the school.

In December 1706 he became a member of the Royal Prussian Society of Sciences. For the next six years or so, he was responsible for the silk production efforts of the Society, with mixed success. In his early years in Berlin, he was also interested in alchemy and chemistry and performed some experimental work of his own, as can be deduced from some of his letters to Leibniz (11) from the years 1708 to 1712. This experimental work addressed, for example, the alchemical production of gold and the production of different colored pigments or dyes. The alchemical experiments were directed mainly on the testing of processes and "powders" of alchemical gold makers, who were active in Berlin at that time, and on the extraction of gold from copper.

His other chemical experiments focused on the preparation of new colors. In addition to his work on the improvement of Prussian Blue (3), Frisch also mentioned a dark red lake color, a blood-red iron solution, and a green copper solution. He tried to use this last one for producing a green-colored paper. At least some of this experimental work was performed together with Diesbach. Frisch also tried to convince the Prussian Society of Sciences to perform "chymical work," but with no real success. However, after 1712 there is no longer mention of chemical experiments in Frisch's letters to Leibniz. He only mentions his Prussian Blue from time to time in a business context. There is also only one further scientific article from Frisch with a chemistry focus after the *Miscellanea* article of 1710. This short article in the third *Miscellanea* volume of 1727 (26) gives a different solution to one of Leibniz's alchemical riddles from the first *Miscellanea* volume (16).

Frisch concentrated his scientific efforts on other fields in which he excelled. These fields included linguistic studies, culminating in several dictionaries, and the study of insects and birds. These latter studies resulted in two encyclopedic books published in several volumes. His work on insects in 13 volumes was completed in 1738, and his voluminous work with illustrations of German birds in 12 volumes was completed in 1763 by three of his sons and a grandson, 20 years after his death. In further volumes of the *Miscellanea Berolinensia*, after his two contributions to the first volume from 1710, Frisch authored as many as 49 articles in which he made, among other things, important early contributions in parasitology. In May 1725 Frisch was elected as the 380th member of the German Leopoldina science academy with the surname (cognomen) Vegetius.

Frisch, who died March 21, 1743, at the age of 77, had three daughters and five sons. Among them were two engravers, Philipp Jacob (1704–1753) and Ferdinand Helfreich (1707–1758), and the preacher and scientist Jodocus Leopold (1714–1787). A well-known grandson was Johann Christoph Frisch (1738–1815), son of Ferdinand Helfreich. Johann Christoph was a famous painter and member of the Academy of Arts in Berlin. From 1805 to 1815, he was director of that academy.

Even in historical sources, Frisch is only very seldom mentioned in connection with Prussian Blue. In a book with his biography and several memorial poems (23), a connection between Frisch and Prussian Blue occurs in only one instance. A translation of the corresponding verse ends this biography of Frisch:

> "Who was it who enhanced the colors bright
> By such a heavenly blue?
> Who could show by his own might
> In silk production great samples, too?
> Who was it who could show creature
> To God's honor after death as if alive
> It was Frisch! If I would be silent, nature would not."

Conclusions

In this paper, we have provided an English translation of the first article on Prussian Blue, together with a short history of the founding of the corresponding journal and a biography of the author Johann Leonhard Frisch.

An enormous number of scientific articles on Prussian Blue have been published in the scientific literature in the last 300 years. According to *Chemical Abstracts* (27) and the author's bibliography of earlier papers, this aggregate amounts to more than 5,500 publications up to 2009. Indeed Prussian Blue remains an interesting and still modern research subject.

ACKNOWLEDGMENTS

I thank Dr. Norbert Kummer from Chemical Abstracts Service and Stephan Fölske from the archive of the Berlin-Brandenburg Academy of Sciences (successor to the Royal Prussian Society of Sciences) for their help in sourcing information. I also thank my father Manfred Kraft for his assistance in literature searches and access, translations of several Latin texts into German, and many discussions on the subject of the history of Prussian Blue.

REFERENCES AND NOTES

1. Johann Jacob Diesbach was a Swiss pigment and dye producer living in Berlin at least between 1701 and 1716. Further information on him has yet to be discovered.
2. Johann Konrad Dippel (1673-1734) was a German pietist theologian, physician, and alchemist. Between 1704 and 1707 he lived in Berlin and between 1707 and 1714 in Maarsen, Netherlands.
3. A. Kraft, "On the Discovery and History of Prussian Blue," *Bull. Hist. Chem.*, **2008**, *33*, 61-67.
4. J. L. Frisch, "Notitia Coerulei Berolinensis nuper inventi," *Miscellanea Berolinensia ad incrementum scientiarum*, **1710**, *1*, 377-378.
5. Daniel Ernst Jablonski (1660-1741), court preacher in Berlin from 1693, one of the initiators of the foundation of the Royal Prussian Society of the Sciences and from 1733 until his death president of the Society. His scientific interests focused on theology and oriental languages.
6. Johann Jacob Chuno (1661-1715), of French Huguenot origin (his name was also written as Cuneau), Royal Court Councilor and first *Archivarius* of the secret states archive in Berlin. He was one of the initiators of the founding of the Royal Prussian Society of the Sciences. His scientific interest focused on mathematics.
7. Sophie Charlotte von Braunschweig-Lüneburg (1668-1705), married in 1684 to Friedrich von Hohenzollern (1657-1713), Electress of Brandenburg from 1688, first Queen in Prussia from 1701. Her friendship with Leibniz and her involvement in the foundation of the Royal Prussian Society of the Sciences are remarkable.
8. A. Harnack, *Geschichte der Königlich Preussischen Akademie der Wissenschaften zu Berlin*, Reichsdruckerei, Berlin, 1900, 129.
9. Ref. 8, p 145.
10. Ref. 8, p 157.
11. L. H. Fischer, Ed., *Joh. Leonh. Frisch's Briefwechsel mit G. W. Leibniz*, Georg Olms Verlag, Hildesheim, New York, 1976 (reprint of the book from 1896).
12. Johann Theodor Jablonski (1654-1731), brother of D. E. Jablonski (5), lived in Berlin from 1700 and was secretary of the Society of Sciences and taught a Prussian prince. He published a French-German dictionary and an encyclopedic dictionary.
13. A. Harnack, Ed., *Berichte des Secretärs der Brandenburgischen Societät der Wissenschaften J. Th. Jablonski an den Präsidenten G. W. Leibniz (1700-1715), nebst einigen Antworten von Leibniz,* Verl. d. König. Akad. D. Wiss., Berlin, 1897.
14. Joseph Werner (1637-1710), a Swiss painter, lived in Berlin from 1696. He was the first director of the Berlin Academy of Arts. In several biographies it is mentioned that he returned to Switzerland in 1706 or 1707. However, letters of J. T. Jablonski to Leibniz (13) prove that he still lived in Berlin in January 1710.
15. Christoph Joseph Werner (1670-1750), son of Joseph Werner. He came to Berlin with his father in 1696. After 1713 he was court painter in Dresden, the capital of the German State of Saxony.
16. G. W. Leibniz, "Oedipus Chymicus aenigmatis Graeci & Germanici," *Miscellanea Berolinensia ad incrementum scientiarum*, **1710**, *1*, 16-22.
17. G. W. Leibniz, "Historia inventionis Phosphori," *Miscellanea Berolinensia ad incrementum scientiarum*, **1710**, *1*, 91-98.
18. J. L. Frisch, "Origo quorundam vocabulorum Germanicorum et cum aliis linguis affinitas," *Miscellanea Berolinensia ad incrementum scientiarum*, **1710**, *1*, 60-83.
19. Johann Ludwig Conrad Mümler (1753-1787), a physician in Wolfenbüttel, translated several scientific publications from books and journals into German from Latin or French.
20. J. L. C. Mümler, Ed., "Nachricht von dem vor kurzem erfundenen Berlinerblau," *Physicalische und medicinische Abhandlungen der Königlichen Akademie der Wissenschaften zu Berlin*, **1781**, *1*, 95-97.
21. Manfred Kraft (born 1936) is a retired chemist living in Leipzig and father of the author. He worked as a research chemist at the precursor companies of today's KataLeuna GmbH for more than 30 years. He is interested in the history of chemistry and among other works translated several 18th-century chemical texts from Latin into German.
22. Johann Christoph Papen (?-?), book dealer and publisher in Berlin between 1700 and 1723. In 1723 he was forced to sell his business to Ambrosius Haude (1690-1748) because of economic difficulties. Later this business would become the important Haude & Spener Publishing Company. Between 1702 and 1722 Papen was also factor (i.e., mercantile agent) of the Royal Prussian Society of Sciences.
23. J. J. Wippel, *Das Leben des Weiland berühmten Rectors an dem Gymnasio zum grauen Kloster in Berlin, Johann Leonhard Frisch: nebst beygefügten Stand- und Lob-Reden, auch einigen Trauer-Gedichten*, Nicolai, Berlin, 1744.
24. "Johann Leonhard Frisch," *Allgemeine Deutsche Biographie*, **1878**, *8*, 93-95.
25. "Johann Leonhard Frisch," *Neue Deutsche Biographie*, **1961**, *5*, 616.
26. J. L. Frisch, "Alia ratio solvendi quatuor posteriores versus aenigmatis Basilii Valentini, cujus Tomo I. Miscell. Berol. p. 21, mentio facta est," *Miscellanea Berolinensia ad incrementum scientiarum*, **1727**, *3*, 25-26.
27. CAplus with SciFinder (Chemical Abstracts Service of the American Chemical Society).

ABOUT THE AUTHOR

Alexander Kraft, Ph.D. in Physical Chemistry (semiconductor electrochemistry) from Humboldt University in Berlin, 1994, is co-founder and one of the managing directors of Gesimat GmbH, Berlin, Germany, a company that developed a smart switchable glazing incorporating a thin electrochromic Prussian Blue film. Before starting with Gesimat in 1998, he developed electrochemical water-treatment technologies and devices. He continued working in this field as a scientific adviser until 2006.

8th International Conference on History of Chemistry "Pathways of Knowledge"

September 14 - 16, 2011 in Rostock, Germany

The Working Party (WP) on History of Chemistry of the European Association for Chemical and Molecular Sciences (EuCheMS) will hold its bi-annual International Conference on History of Chemistry (8th ICHC) in Rostock, Germany, from 14 to 16 September 2011.

From 12 to 14 September 2011 the National Conference of the Working division on History of Chemistry of the German Chemical Society will be held in Rostock, too. At this conference historians of science and technology and chemists will meet around several themes in history of chemistry. Everybody has the interesting option of visiting both events in Rostock.

The 8th ICHC will focus on the theme "Pathways of Knowledge".

This theme is in direct connection to the general aim of the conferences organised by the WP, namely to facilitate communication between historically interested chemists and historians of chemistry from all over Europe. Previous conferences organised by the WP were held in Lisbon 2005 (Chemistry, Technology and Society), Leuven 2007 (Neighbours and Territories: The Evolving Identity in Chemistry) and Sopron 2009 (Consumers and Experts: The Use of Chemistry and Alchemy).

http://www.gdch.de/vas/tagungen/tg/5511__e.htm

PHYSICAL CHEMISTRY BEFORE OSTWALD: THE TEXTBOOKS OF JOSIAH PARSONS COOKE

William B. Jensen, University of Cincinnati

Introduction

In keeping with the Bolton Society's commitment to the study and preservation of the Great Books of Chemistry, the purpose of this paper is to provide an overview of the textbooks of the 19th-century American chemist, Josiah Parsons Cooke, of Harvard University (1). But before doing so, it is of interest to preface the purely bibliographic aspects with a brief summary of Cooke's life and career.

Josiah Parsons Cooke Jr.

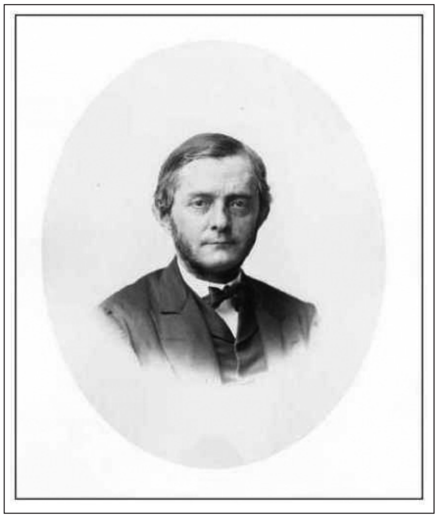


***Figure 1**. Josiah Parsons Cooke Jr. (1827-1894), circa 1868.*

Josiah Parsons Cooke Jr. (Fig. 1-3) (2) was born in 1827 in Boston, the son of a wealthy lawyer of the same name, and was educated at the Boston Latin School and Harvard University, from which he received his A.B. degree in 1848 (3). He was attracted to chemistry as a young teenager, after attending a series of Lowell Lectures on the subject given in Boston by Benjamin Silliman the elder of Yale University, and he soon constructed a "rudimentary" laboratory in the woodshed behind the family house at Winthrop Place in Boston. Here he taught himself chemistry by working through Edward Turner's massive (666 pages) text, *Elements of Chemistry* (4). He later reported being particularly interested in the chemistry of three recently reported discoveries: friction matches, guncotton, and photography, and would pursue the latter as a hobby his entire life (5).

Following graduation, Cooke spent a year in Europe to recover his health, which was never robust. (He suffered from poor eyesight and tremors in the hands). Upon his return in July of 1849 he was appointed as a tutor in mathematics at Harvard and, that November, as an instructor in chemistry and mineralogy, followed by promotion at the end of 1850, at age 23, to the Erving Professorship of Chemistry and Mineralogy—a position he would hold for the remainder of his life. The reasons for this rapid change in status, despite Cooke's lack of formal training in chemistry, was that by 1850 the teaching of chemistry at Harvard had all but collapsed.

Some chemistry had been taught in Harvard College since the late 17th century as part of the course in natural philosophy (6). However, it was not until the founding of the Harvard Medical School in 1782 and the appointment of Aaron Dexter as its first Professor of Chemistry and Materia Medica in 1783, that it received explicit recognition as an independent subject. In 1790 Dexter's position was officially endowed by William Erving and

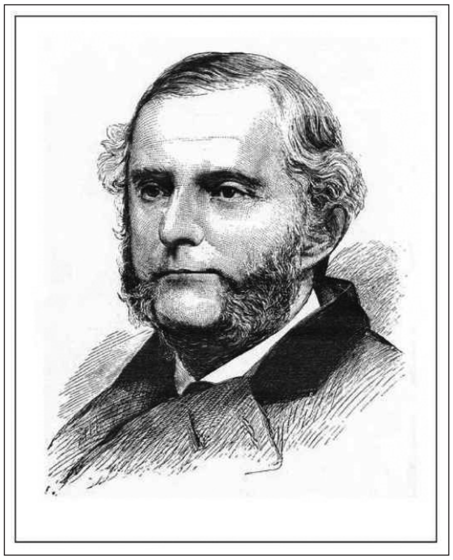


***Figure 2**. Josiah Parsons Cooke, circa 1877.*

became known thereafter as the Erving Professorship of Chemistry and Mineralogy.

After Dexter's retirement in 1816, he was succeeded by his pupil and assistant, John Gorham; and when, in turn, Gorham resigned in 1827, he was likewise replaced by his own student and assistant, John White Webster. It was Webster's sudden departure from Harvard in 1850—not through death from natural causes, resignation, or retirement—but through death by hanging for the murder of a fellow faculty member in the Medical School, that had precipitated the desperate search for a replacement and had resulted in Cooke's rapid rise (7).

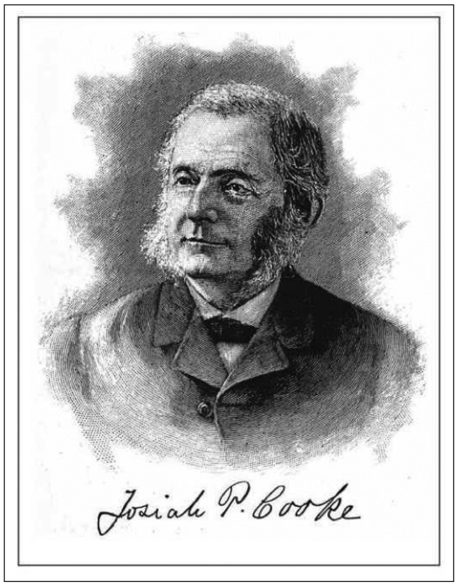


***Figure 3**. Josiah Parsons Cooke, circa 1887.*

Cooke lost no time in reorganizing the teaching facilities and in revising the curriculum. His first step was to obtain an eight-month leave of absence to visit Europe, where he purchased, largely at his own expense, new chemicals and apparatus for the college and also attended the lectures of Jean-Baptiste Dumas and Henri Victor Regnault in Paris. After his return in 1851, he began his life-long struggle to ensure science—and chemistry in particular—a position of equal status with the humanities in the college curriculum. Over the next few years he would succeed in transferring the Erving Chair of Chemistry from the Medical School to Harvard College, in making introductory courses in chemistry mandatory for sophomores and juniors, in introducing a student laboratory course in qualitative analysis, and in playing a key role in raising the funds to build in 1857 a new chemistry building (Fig. 4). By the time of his death in 1894, there was no longer just a single professor of chemistry at Harvard, but rather a chemistry department servicing over 315 students and boasting of three full professors, three instructors, eight assistants, more than 16 course offerings, and a graduate program. As President Eliot of Harvard recalled after Cooke's death (3), "I might simply say in eleven words—'Professor Cooke created the Chemical and Mineralogical Department of Harvard University.'"

Known as "Joby" to the undergraduates, Cooke was a popular teacher and highly successful lecturer, despite having a Boston nasal twang that became "particularly pronounced whenever he attempted to emphasize a phrase." As reported in his obituary in the *New York Times*, he was also known for his exciting lecture demonstrations (8):

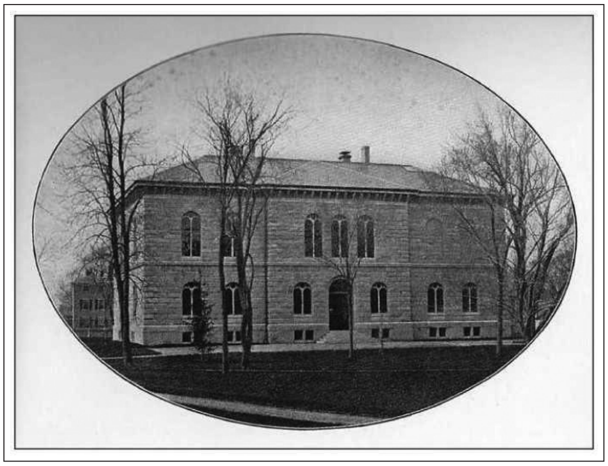


***Figure 4**. Cooke's new chemical laboratory, Boylston Hall, as it appeared in 1860. Chemistry originally occupied half of the space but eventually the entire building, as well as an additional third story added in 1871.*

> In order to interest the students, the old professor used to teach more through the eye than the ear, and his dazzling experiments in electricity, made before a crowded classroom, formed the chief delight in an otherwise dull freshman year.

Given his tremulous hands and the fact that at least one biographical account claims that by 1889 he was partially blind, the adjective "exciting" is probably something of an understatement. Unfortunately, the obituary also went on to suggest rather cruelly that Cooke had made the not infrequent mistake of failing to retire before his powers began to wane (8):

> Lately the course had been less attractive than formerly on account of Professor Cooke's age. It has been kept in the college curriculum more as a tribute to its honored conductor than for its value. Now that the professor is dead, the course will be dropped.

An earlier student assessment of Cooke's lectures occurs in the famous third-person autobiography of the American historian, Henry Adams, who was a member of the Harvard class of 1858 (9). While not mentioning Cooke by name, Adams, during a thoroughly negative retrospect of his student experiences at Harvard, took note of "the course in chemistry, which taught him a number of theories that befogged his mind for a lifetime." Given Adams' tendency to self-deprecation, it is difficult to determine whether this remark is a criticism of Cooke or a comment on Adams' own intellectual shortcomings. Given Adams' later confusions concerning the application of both the phase rule and the second law of thermodynamics to the study of history, however, one is inclined to the second interpretation (10).

During his career Cooke also published eight books and 41 research papers, as well as 32 popular essays and lectures (11). Of particular note was his early work on the classification of the chemical elements, which is referred to in most historical accounts of the development of the periodic law; his work on nonstoichiometric compounds; and his accurate determination of the atomic weight of antimony and of the combining ratio of hydrogen and oxygen in water. This latter work would become an inspiration for his most famous student, Theodore Richards (Fig. 5), who would go on to become the first American chemist to receive a Nobel Prize in Chemistry (1914) for his own work on the accurate determination of atomic weights. Richards' most famous student was, in turn, none other than G. N. Lewis.

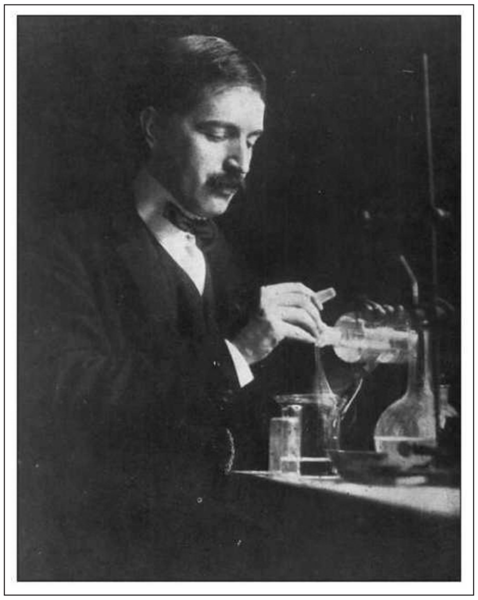


***Figure 5**. Theodore William Richards (1868-1928).*

Yet a second important student of Cooke was the chemist, Charles William Eliot (Fig. 6). Indeed, Eliot was Cooke's first and, at the time, only student and worked closely with him in his personal laboratory, which, prior to the building of Boylston Hall, was located in the north end of the basement of University Hall next to the college bakery and was lacking both running water and gas. He would go on to become one of Harvard's most innovative presidents—a connection which no doubt helped to facilitate Cooke's ambitions for both the chemistry curriculum and the college's chemistry department, though these were also complicated by competition with the Rumford Chair of Chemistry in the Lawrence Scientific School. The Rumford Chair was first occupied in 1847 by Eben Horsford (Fig. 7) and then, upon his resignation in 1863, by Oliver Wolcott Gibbs (Fig. 8).

In 1861 Eliot was appointed as Horsford's assistant and, during the next two years, essentially ran the teaching laboratories, since Horsford had become increasingly preoccupied with his baking powder factory in Providence, Rhode Island. There is no doubt that Eliot

***Figure 6**. Charles William Eliot (1834-1926).*

assumed he would succeed Horsford as the Rumford Professor and that the appointment of Gibbs instead came as a great disappointment. In light of this, one cannot help but wonder whether bitterness over this affair may have played some role in the decision, made during Eliot's subsequent presidency of Harvard, to transfer both the chemistry students and chemical laboratories of the Lawrence Scientific School to Cooke's domain within Harvard College and to consign Gibbs to the Department of Physics (12).

Lest the reader be left with the impression that Eliot's presidency always guaranteed the success of Cooke's plans, it should be noted that Cooke had a bitter parting of the ways with Harvard shortly before his death. He and his wife were childless, and they had taken his wife's nephew, Oliver W. Huntington, under their wing as something of a substitute son. Huntington also became Cooke's personal assistant and long-time collaborator—a role of increasing importance as Cooke's eyesight began to fail. However, Harvard's refusal to promote Huntington led, in the end, to Cooke's cancelling of a large bequest that he and his wife were intending to leave to the college upon their deaths.

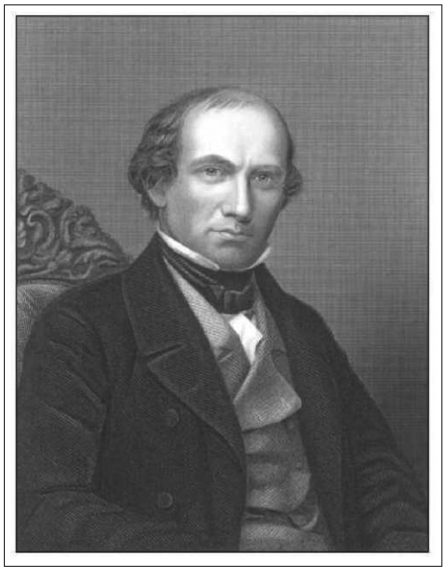


***Figure 7**. Eben Norton Horsford (1818-1893).*

Chemical Problems and Reactions

The first of Cooke's eight books was a slim 128-page booklet (Fig. 9), published in 1857 under the title *Chemical Problems and Reactions to Accompany Stockhardt's Elements of Chemistry* (13). The textbook in question was written by the German chemist, Julius Stöckhardt (Fig. 10) in 1846 under the title, *Die Schule der Chemie* (The School of Chemistry) (14) and was translated into English in 1850 by C. H. Pierce, who was an assistant to Horsford (15). Horsford had directed Pierce to translate the book and had also contributed an introduction to the final product. The title used in the translation was *The Principles of Chemistry Illustrated by Simple Experiments* and not *The Elements of Chemistry,* as incorrectly stated in the title of Cooke's small supplement.

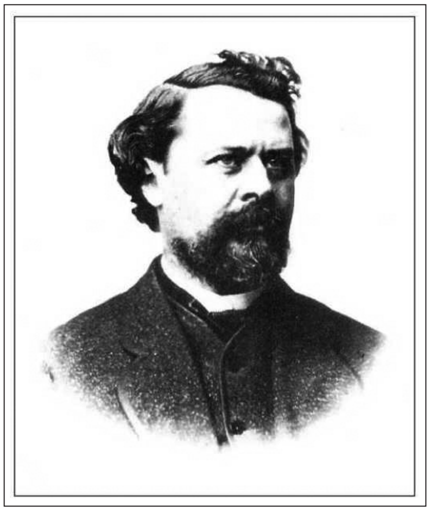
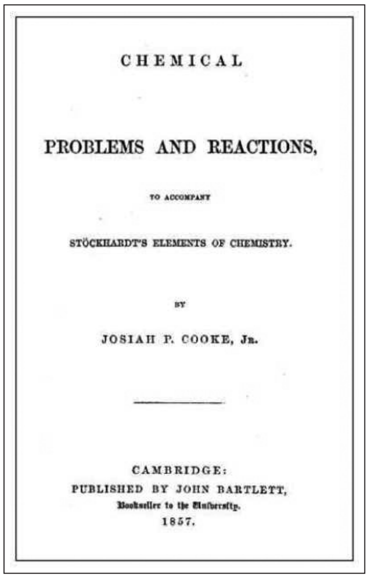


***Figure 8**. Oliver Wolcott Gibbs (1822-1908).*

Stöckhardt's book was obviously the textbook that was being used by both Horsford in the Lawrence Scientific School and by Cooke in Harvard College for the introductory chemistry course. Like all introductory chemical texts of the period, it contained no mathemati-



CHEMICAL

PROBLEMS AND REACTIONS,

TO ACCOMPANY

STÖCKHARDT'S ELEMENTS OF CHEMISTRY.

BY

JOSIAH P. COOKE, Jr.

CAMBRIDGE:
PUBLISHED BY JOHN BARTLETT,
Bookseller to the University.
1857.

***Figure 9**. The title page of Cooke's first book.*

cal equations or numerical calculations. It was Cooke's dissatisfaction with this state of affairs and his belief that the Stöckhardt text by itself was "unsuitable for college instruction" that had led to his small supplement and which gives us our first glimpse of the emphasis on the physical and mathematical foundations of chemistry that would come to characterize Cooke's future publications.

Cooke's booklet contained chapters and exercises on chemical nomenclature, chemical symbolism, balancing chemical equations, stoichiometric weight-weight calculations, and both density and gas-law problems, as well as tables of atomic weights, solubilities, conversion factors, specific gravities, and logarithms. As such it was, to the best of my knowledge, the first specialized English-language book to deal specifically with the subject of chemical calculations, though, as indicated in Table 1, there were several German predecessors, some of which dated back to the 1820s (16).

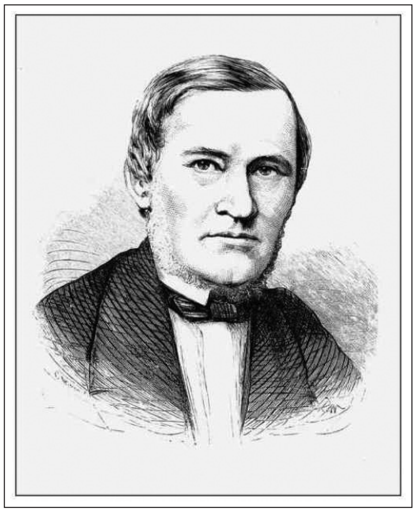


***Figure 10**. Julius Adolf Stöckhardt (1809-1886).*

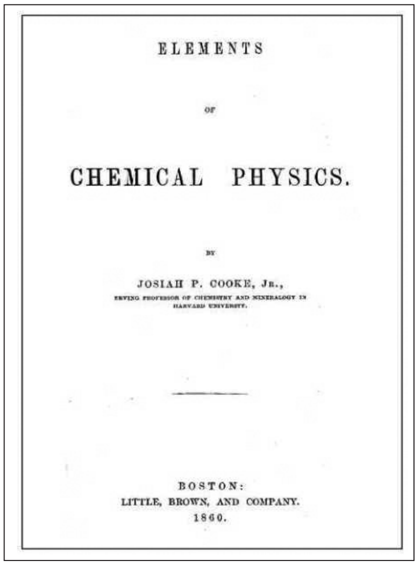
***Table 1**.* Early monographs on chemical calculations

Date	Author	Title
1829	Ehrmann	*Die Stöichiometrie*
1829	Buff	*Versuch eines Lehrbuch der Stöichiometrie*
1837	Kühn	*Lehrbuch der Stöichiometrie*
1843	Frickhinger	*Katechismus der Stöichiometrie*

Elements of Chemical Physics

If Cooke's first book had provided evidence of the importance he attached to quantitative calculations in chemistry, his second book, *Elements of Chemical Physics* (Fig. 11), revealed his belief in the importance of having a sound background in physics (17). Despite its title, this massive 739-page tome was in fact a textbook of physics rather than a textbook of physical chemistry, as the term is now understood. Indeed the terms "chemistry" and "chemical change" appeared only three times in the index. Even when viewed as a textbook of physics or natural philosophy, its focus was unusually narrow, since it dealt almost exclusively with the mechanical and thermal properties of the three states of matter and covered nothing of their optical, electrical, or magnetic properties. The reason for these rather glaring omissions was that the book was intended to be the first of a three-volume set, the second of which was to deal with the interaction of matter with light and electricity and the third with chemical stoichiometry and classification.

It is almost certain that Cooke's projected three-volume series, as well as his use of the unusual title "chemical physics," rather than the more conventional "chemical philosophy" popular at the time to describe works on theoretical chemistry, were both directly inspired by Volume 1 of the three-volume treatise, *Elements of Chemistry, Theoretical and Practical*, by the British chemist, William Allen Miller, first published in 1855 (18). Whereas Volumes 2 and 3 of Miller's work dealt with descriptive inorganic and organic chemistry, respectively, Volume 1, which dealt with chemical philosophy or theoretical chemistry, carried the subtitle *Chemical Physics,* as in the title of Cooke's own book.



ELEMENTS

OF

CHEMICAL PHYSICS.

BY

JOSIAH P. COOKE, JR.,
ERVING PROFESSOR OF CHEMISTRY AND MINERALOGY IN
HARVARD UNIVERSITY.

BOSTON:
LITTLE, BROWN, AND COMPANY.
1860.

***Figure 11**. The title page of Cooke's second book.*

Likewise, there is little doubt that Miller's treatise was, in turn, inspired by John Frederic Daniell's 1839 text, *An Introduction to the Study of Chemical Philosophy: Being A Preparatory View of the Forces which Concur to the Production of Chemical Phenomena* (19). Daniell was Professor of Chemistry at King's College London and a close associate of Michael Faraday (Fig. 12). Inspired by Faraday's view (20) that chemistry was but one aspect of the general study of the forces of nature—a view which Faraday would later articulate in his famous juvenile lectures of 1859 on *The Various Forces of Nature* (21)—Daniell devoted nearly 70% of his 565-page treatise to the physics of the mechanical, thermal, optical, and electrical properties of matter and to their "concurrence" with chemical affinity, and also dedicated his book to Faraday.

This attempt to correlate chemical affinity with various other forces is reminiscent of the view later taken in the 1890s by Wilhelm Ostwald that the new discipline of physical chemistry was nothing other than the study of the chemical aspects of various energy forms, with well-defined branches dealing, for example, with thermochemistry, electrochemistry, photochemistry, surface chemistry, and mechanico-chemistry.

Miller, who was a student and collaborator of Daniell, as well as his successor as Professor of Chemistry at King's College (Fig. 13), freely admitted that his own massive three-volume treatise was inspired by Daniell's earlier work. Whereas Daniell had devoted only 30% of his book to the descriptive chemistry of a few select nonmetallic elements and had said nothing of organic chemistry, Miller, as already noted, devoted an entire volume to each (884 pages for inorganic and 976 pages for organic chemistry) and expanded the 396 pages of chemical physics in Daniell's treatise into a separate volume of 643 pages. Had Cooke completed his projected treatise on *Chemical Physics*, he would have, in turn, expanded Miller's single volume into a massive three-volume work.

***Figure 12**. (Left): John Frederic Daniell (1790-1845). (Right): Michael Faraday (1791-1867).*

Thus, in the Cooke-Miller-Daniel sequence we have uncovered an earlier pre-Ostwaldian tradition of attempting to base chemical theory on a firm foundation of physics—a view which would also heavily color William Whewell's treatment of chemistry in both his *History of the Inductive Sciences* of 1837 and his *Philosophy of the Inductive Sciences* of 1840, in which chemistry was closely linked with electrical phenomena and the concept of molecular polarity (22).

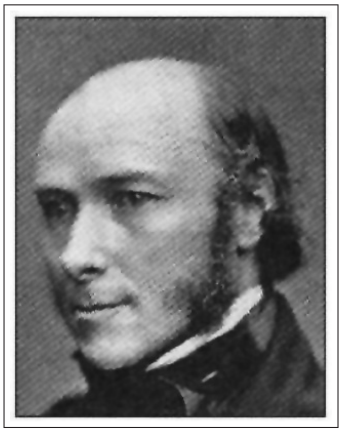


***Figure 13**. William Allen Miller (1817-1870).*

Indeed, it is not even necessary to go to the specialized treatises of the above authors for evidence of this tradition, since, as shown in Table 2, authors of many elementary introductions to chemistry written during this period also saw fit to devote the first quarter or so of their text to a preliminary qualitative review of basic physics and chemical theory. Rather than organizing this material around various types of energy, as suggested by Ostwald, or various kinds of forces, as done by Daniell and Miller, the material in many of these older texts was organized in terms of various kinds of "imponderable fluids"—thus linking it to a tradition that may be traced back to Lavoisier at the end of the 18th century.

Table 2. Space devoted to "chemical physics" in introductory chemistry textbooks.

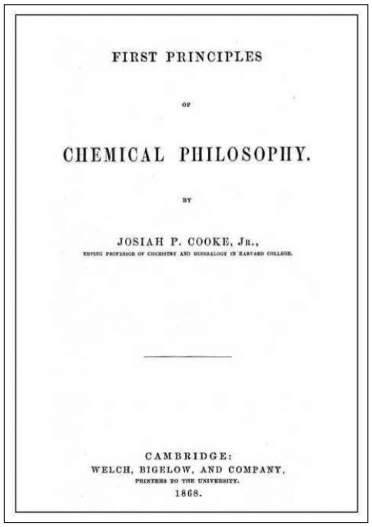
Date	Percent	Author
1830	22%	Edward Turner
1830	22%	Benjamin Silliman Sr.
1850	37%	John Johnson
1852	29%	Benjamin Silliman Jr.
1858	34%	David Wells

In making these comparisons, however, there is one very important difference that should be emphasized. In sharp contrast to the books by Daniell and Miller and the preliminary surveys of natural philosophy found in the typical introductory chemistry text of the period, Cooke's book actually contained a fair number of mathematical equations and was, in the words of Benjamin Silliman, "an elaborate treatise in advance of anything before attempted in this country or, in fact, in our language."

First Principles of Chemical Philosophy

As already stated, Volumes 2 and 3 of Cooke's projected three-volume treatise on chemical physics never materialized. Instead, in 1868 he published a slim 138-page text (Fig. 14) titled *First Principles of Chemical Philosophy* (23). This was slightly expanded in 1870 to include a chapter on chemistry and light and combined, as Part I, with an even larger quantity of material dealing with descriptive chemistry, and labeled as Part II, to create the final version of a 544-page book (24). In this form it became the text that Cooke would use for the remainder of his teaching career. Reprinted several times over the next decade, Cooke would not revise it until 1884, when a second edition was finally published.

The striking discrepancy between Cooke's projected three-volume treatise of 1860—which, if we are to judge from the size of the first volume, might well have been expected to approximate 1,800 pages or more—and the 138-page booklet of 1868 immediately raises a number of questions: Why the long delay? Why the change in title? Why the radical shrinkage? As for the first of these questions, the intervention of the Civil War and duties associated with the rapid expansion of the chemistry department in Boylston Hall may account for at least some of the delay. As for the second and third questions, time and a more realistic appraisal of what was or was not practical in a teaching situation seem to have played the crucial role. Given its size and narrow focus, as well as its atypical title, it is difficult to imagine what the market would have been for the *Chemical Physics* text of 1860. Its failure to cover such topics as electricity, optics, and magnetism precluded its use in a conventional physics course; and its failure to cover anything explicitly chemical precluded its use in an introductory chemistry course. Nevertheless, it was reprinted in 1866 and 1877. My own guess is that it was probably used internally within the Harvard Chemistry Department for some sort of "physics for chemists" course.


FIRST PRINCIPLES
OF
CHEMICAL PHILOSOPHY.
BY
JOSIAH P. COOKE, JR.,
ERVING PROFESSOR OF CHEMISTRY AND MINERALOGY IN HARVARD COLLEGE.

CAMBRIDGE:
WELCH, BIGELOW, AND COMPANY,
PRINTERS TO THE UNIVERSITY.
1868.

***Figure 14**. Title page of the rare first edition of Cooke's* First Principles of Chemical Philosophy.

But the most important reasons for the radical shrinkage in size had less to do with market considerations than with a change in emphasis brought on by Cooke's teaching experiences during these years—reasons which he explicitly described in his preface (23):

> This book is intended to supplement ... a course of lectures; and it deals solely with those principles which can only be acquired by study and application, while it leaves the facts to be stated, and the experiments to be shown, in the lecture-room. The author has been led to make such a division in his own course of instruction, because he has found, by long experience, that a recitation on mere facts or descriptions of experiments is, to the great mass of college undergraduates, all but worthless; although he is convinced that the study of chemical philosophy may be made an important means of mental discipline.

Indeed, when one examines the massive volumes by Daniell and Miller, or the earlier volume by Cooke, one quickly discovers that their unwieldy size is, in fact, largely due to the lengthy and detailed descriptions of apparatus and demonstrations which they contain. Once this was stripped away—or rather consigned to the lecture room rather than the textbook—Cooke discovered that the necessary theoretical and classificatory principles quickly reduced to a series of short and concise chapters.

In the final format of the 1870 edition, one not only finds the mathematical formulas and numerical examples given in Cooke's earlier books, but also a series of numerical and verbal problems at the end of each chapter and an appendix containing tables of data and logarithms. Essentially the entire contents of his first book on chemical calculations were integrated into the new book, as well as the pertinent theoretical content of his second book. Thus, in addition to problems related to chemical nomenclature and symbolism, the balancing of chemical equations, weight-weight calculations, and specific gravity and gas law problems, one also finds problems related to Graham's law of diffusion, Ohm's law, and to heats of combustion.

Over the years I have read many historical chemistry texts and I can verify that Cooke's textbook is by far the most quantitative and scientifically sophisticated ever produced by an American chemist during the 19th-century—a view that was also shared by his contemporaries. Thus the influential British journal, *The Chemical News*, stated that (25):

> So far as our recollection goes, we do not think that there exists in any language a book on so difficult a subject as this so carefully, clearly, and lucidly written.

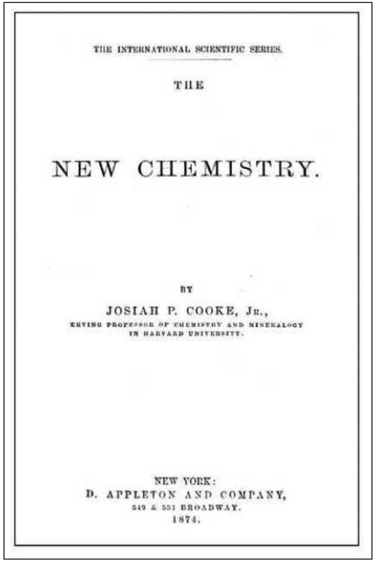
and *The American Journal of Science* noted that (26):

> To Professor Cooke, more than to any American, is due the credit of having made chemistry an exact and disciplinary study in our colleges ... Its logical analysis and deduction of the subject will command the careful attention of chemists whose duties required them to instruct in this difficult department.

The New Chemistry

While there is no doubt of the excellence of Cooke's text, there is more doubt, given its mathematical demands, as to whether it was widely adopted by other colleges and academies. These doubts are further reinforced by the fact that it was published by a local Cambridge printer and that, aside from a few reprintings, only one revision was called for in the 24 years separating its initial publication in its complete form and Cooke's death.

But if there are possible doubts concerning the popularity of Cooke's formal textbook, there are none whatsoever concerning the popularity of his next book (Fig. 15), *The New Chemistry* of 1874 (27). This book, based on a series of public lectures Cooke gave at the Lowell Institute in Boston in the fall of 1872, was published by the Appleton Company of New York as part of its highly popular International Scientific Series.



THE INTERNATIONAL SCIENTIFIC SERIES.

THE

NEW CHEMISTRY.

BY

JOSIAH P. COOKE, Jr.,

ERVING PROFESSOR OF CHEMISTRY AND MINERALOGY
IN HARVARD UNIVERSITY.

NEW YORK:
D. APPLETON AND COMPANY,
549 & 551 BROADWAY.
1874.

Figure 15. *Cooke's highly popular New Chemistry of 1874.*

Cooke had in fact given an earlier series of lectures "On the Chemistry of the Nonmetallic Elements" at the Lowell Institute back in 1855, at the conclusion of which he acknowledged the debt he owed to the series of Lowell Lectures given many years earlier by Benjamin Silliman Sr., which he had attended as a young teenager (28):

> I should be suppressing a generous emotion, were I not, in concluding, to allude to the very peculiar circumstances under which I have filled this place. With one exception, the only course of lectures on chemistry before this Institution, previous to the one just concluded, were delivered by Professor Silliman of New Haven, in the years 1839-1843. At those lectures I was an attentive listener. Although a mere boy—one of the youngest of those present—I then acquired my taste for science which has since become the business of my life.

The subject of the lectures of 1872 was—as suggested by the title of Cooke's book—an overview of the recent revolution in chemistry brought on by the establishment of a new set of self-consistent atomic and molecular weights based on an explicit revival of Avogadro's hypothesis, the introduction of the valence concept, and the rise of structure theory (29). This book is even more readable than Cooke's formal textbook and was something of an international success, having been translated into German, Italian, and Russian and kept in print long after Cooke's death. Indeed, there is indirect evidence that the book was used as a textbook in certain high schools, since, in 1891, Cooke also wrote a detailed laboratory manual to accompany it, which was being reprinted as late as 1901 (30).

Whereas *First Principles of Chemical Philosophy* had received sterling reviews in the chemical literature, *The New Chemistry* was praised in the nonchemical press as well. Thus, the British medical journal, *The Lancet,* wrote (31):

> The science which it contains is popular science in the best sense of the term. The great ideas of chemistry are presented with singular clearness and with very varied illustration.

Likewise, *The Standard* raved that (31):

> Mr. Cooke's style is clear, his matter weighty, and his method intelligible. He bases his theories on the law of Avogadro respecting molecules, and thence leads his hearers or readers on through various easy steps to the very heights of the science of chemistry.

Science and Religion

In addition to his textbooks, Cooke also wrote two books dealing with science and religion: *Religion and Chemistry* of 1864 (32) and *The Credentials of Science: The Warrant of Faith* of 1888 (33). The first of these evolved from a series of lectures given at the Brooklyn and Lowell Institutes and the second from the Ely Lectures, which Cooke had been invited to give at the Union Theological Seminary of New York City in 1887.

The use of science to support religion based on arguments from design is usually referred to as natural theology and has a long history extending back to Robert Boyle and the establishment of the first Boyle Lecture in 1692. Previous attempts to exploit chemistry for this purpose had been made by the British chemists William Prout in 1834 (34), George Fownes in 1840 (35), and George Wilson in 1862 (36). They also abounded in the Lowell Lectures given by Benjamin Silliman that Cooke had attended as a teenager. However, these previous attempts were mere pamphlets when compared to the size of the 348-page first edition of Cooke's *Religion and Chemistry* of 1864. As indicated by its original subtitle, *Proofs of God's Plan in the Atmosphere and its Elements*, most of this book dealt with the chemistry of the atmosphere and its bearing on the origins and preservation of life.

Not everyone admired Cooke's forays into theology. These were apparently not confined to his books but also frequently found their way into his introductory chemistry lectures as well (37):

> Professor Cooke was a deeply religious man, and his lectures were permeated with a sincere desire so to interpret the principles of chemical and physical science that they should appear as but confirmations of Christian theology.

Thus the historian and philosopher, John Fiske, who took chemistry from Cooke in 1861 during his sophomore year at Harvard, felt that Cooke "mixed too much theology with his science for the good of either his science or theology," though his true opinion, as expressed in his private correspondence, was a good deal more blunt (38):

> I am thinking of writing an excoriating notice of Joby Cooke's new work "Religion and Chemistry" for the Atlantic Monthly ... The book is as disgusting a mess of twaddle as ever was croaked.

Of course, Fiske may have been biased, since he had been caught as a sophomore reading a book by the French positivist and rationalist philosopher, August Comte, during chapel. Fiske was taken before the faculty and charged with "disseminating infidelity among the students and with gross misconduct at church by reading during the service." Cooke and several other faculty, who insisted that Fiske be suspended for a year, were reportedly "very bitter" when he was let off with nothing more than a public admonition (37).

Essays and Collected Papers

To the modern reader the greatest value of Cooke's two volumes on natural theology lies in the insights they provide concerning Cooke's personal views on the nature, function, and limitations of science. Yet additional insights concerning his views on the teaching of science and its relation to education and culture in general can be had by examining his 1881 collection, *Scientific Culture and Other Essays* (39). Several of these essays were also reprinted in his collected *Chemical and Physical Researches* of the same year (11) and also issued as separate pamphlets (30). Unfortunately both considerations of space and the specific focus of this paper preclude any detailed discussion of these otherwise interesting views.

Influences and Impact

Given that Cooke (Fig. 16) was totally self-educated as a chemist, his accomplishments and career are truly

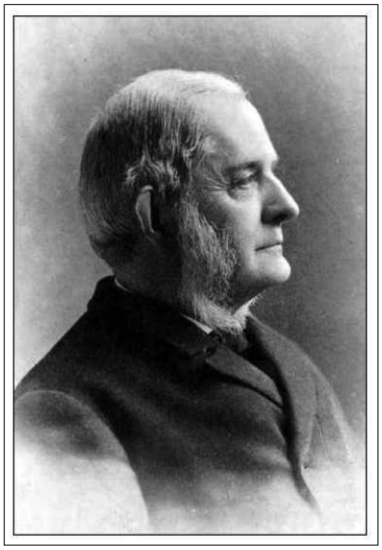


***Figure 16**. Josiah Parsons Cooke, circa 1890.*

extraordinary. Indeed, the fact that he did not come out of the usual medical-pharmaceutical background typical of most chemists of his day may well account for his atypical emphasis on the mathematical and physical foundations of chemistry. The fact that his mathematical training was apparently rigorous enough to result in his initial appointment at Harvard as a tutor in mathematics is certainly of great significance, as is his later disappointment at the failure of most students to maintain a similar standard of mathematical competence. Thus, in his opening address to the high school chemistry teachers attending the 1875 Summer Course of Instruction in Chemistry at Harvard, he complained (31):

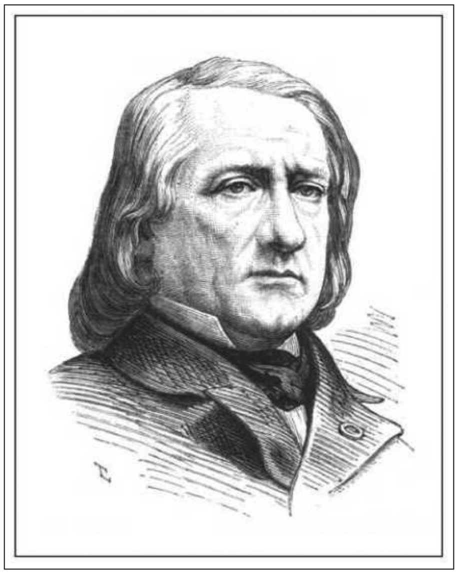


***Figure 17**. Henri Victor Regnault (1810-1878).*

> The great difficulty against which the teachers of natural science have to contend in the colleges is the wretched tread-mill habits the students bring with them from the schools. Allow our students to memorize their lessons, and they will appear respectably well, but you might as easily remove a mountain as to make many of them think. They will solve an involved equation of algebra readily enough so long as they can do it by turning their mental crank, when they will break down on the simplest practical problem of arithmetic which requires of them only thought enough to decide whether they should multiply or divide.

Surely many teachers of today would concur with Cooke's complaint.

This mathematical orientation also probably accounts for why Cooke decided to spend six of his eight months in Europe in 1851 attending the lectures in Paris of Regnault (Fig. 17), since this chemist was unusual in having specialized in the study of the thermal and mechanical properties of gases and liquids. Coming out of an engineering background, he held professorships in both chemistry and physics. Cooke later stated that he was strongly influenced by Regnault, and the contents of Cooke's 1860 text on chemical physics are in many ways a summary of the kinds of research in which Regnault specialized.

There is still much to learn about Cooke, whether concerning the influences that molded his personal vision of chemistry or his own influence on 19th-century chemical education in the United States. Thus, for example, nothing has been said about Cooke's later attempts to upgrade the teaching of high school chemistry, his work in electrical measurements, or his contributions to Harvard's mineral collections. In short, Cooke is deserving of a much more detailed study than can be provided in one overview lecture.

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Alchemy and Medicine from Antiquity to the Enlightenment

CRASSH and the Department of History and Philosophy of Science, University of Cambridge

22-24 September 2011

Call for papers (deadline 1 May 2011):

Alchemists pursued many goals, from the transmutation of metals to the preservation of health and life. These pursuits were continually informed and modified by medical knowledge, while alchemical debates about nature, generation, and the achievability of perfection in turn impacted on medicine and natural philosophy. Alchemical texts circulated in print and manuscript; in courts, in households, and in the marketplace, both reflecting and contributing to debates about the body and the natural world. Alchemy was studied by physicians, clerics, natural philosophers, merchants, artisans, and aristocrats; some drawn toward theoretical speculation, others towards empirical practice.

This three-day international conference, held at Peterhouse, Cambridge, will investigate these interactions, from alchemy's development in late antiquity to its decline throughout the eighteenth century. It will ask how alchemical and medical ideas changed over time, how they reflected the experience of individual readers and practitioners, and the extent to which they responded to significant currents in intellectual, political, religious, and social life.

Proposals for 20 minute papers are welcomed, and the participation of postgraduate students and junior researchers is particularly encouraged (with student bursaries available). The language of the conference is English. Abstracts of 200-300 words, accompanied by a one-page CV, should be sent to Jennifer Rampling (jmr82@cam.ac.uk) by 1 May 2011.

Organised by Jennifer Rampling, Peter M. Jones and Lauren Kassell (Department of History and Philosophy of Science, Cambridge), and supported by the Centre for Research in the Arts, Humanities, and Social Sciences (CRASSH).

BENJAMIN SILLIMAN JR.'S 1874 PAPERS: AMERICAN CONTRIBUTIONS TO CHEMISTRY

Martin D. Saltzman, Providence College

To mark the centennial of the discovery of oxygen by Joseph Priestley (1733-1804) on August 1, 1774, H. Carrington Bolton of the Columbia College School of Mines suggested a gathering of American chemists be held to celebrate this event. A suggestion was made by Rachel Bodley of the Women's Medical College of Pennsylvania that an appropriate place would be Northumberland, Pennsylvania, where Priestley had settled in 1794 after being hounded out of England for his radical views. Organizing the event was a group of New York chemists. About 70 chemists attended for the daylong event, which featured a series of four papers and visits to the Priestley house and grave site (1).

The papers read at the meeting were "The Life and Labors of Priestley," by H. H. Craft of the University of Toronto; "The Century's Progress in Theoretical Chemistry," by T. Sterry Hunt of MIT; "A Review of Industrial Chemistry," by J. Lawrence Smith of the University of Louisville; and "American Contributions to Chemistry," by Benjamin Silliman Jr. of Yale University.

Silliman's two 1874 papers, totaling 57 pages and covering the content of his address in Northumberland, are the subject of this analysis, which it is hoped will enlighten readers on the state of American chemistry on the eve of the centennial of the founding of the United States and the birth of the American Chemical Society (2). Thackray and coworkers have produced an extensive study of American chemistry from 1876-1976 (3). The current paper is a modest attempt to fill in the period prior to 1876 as viewed by Silliman. Silliman's papers appeared in two installments with different titles (August/September and December (4, 5) in the *American Chemist*, the journal founded and edited by the brothers Charles F. Chandler and William H. Chandler (6, 7).

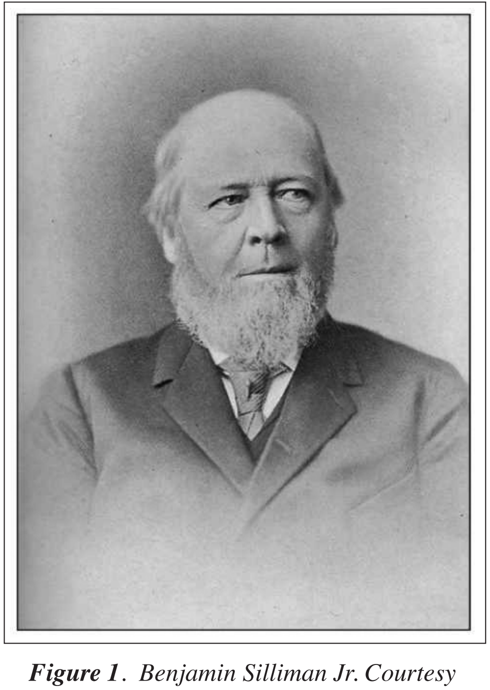

***Figure 1**. Benjamin Silliman Jr. Courtesy Oesper Collection, University of Cincinnati.*

Few people were as qualified as Benjamin Silliman Jr. (1816-1885) (Fig. 1) to survey the history of chemistry in America. Silliman Sr. and Jr. had served as Professors of Chemistry at Yale College from 1806 to 1870 (8). Benjamin Silliman Sr. founded the *American Journal of Science* in 1818 (9), and his son began almost immediately assisting him in the editing of the journal. He assumed the editorship of the journal in 1841 and continued his association with it until his death in 1885. The committee could not have picked a more able person to discuss the development of American chemistry.

The title of Silliman's first paper has an asterisk and the following qualifying statement by the author (10):

> In attempting to comply with the invitation of the committee in charge of the Chemical Centennial at Northumberland to prepare an "Essay upon American Contributions to Chemistry" in an address to be delivered on that occasion, I found the "Essay" insensibly and almost unavoidably assuming the historical form, and taking a wider range than may seem consistent with a strict rendering of its title. But such as it became it is now presented as a slight contribution toward a more elaborate historical discourse which yet remains to be prepared.

Silliman indicates the importance of the centennial of the discovery of oxygen to the development of modern chemistry as follows (10):

> The emancipation of our science from the dominion of phlogiston, with its seductive but false philosophy, may be likened to the overthrow of aristocratic traditions, and monarchial supremacy, under which our ancestors were held, and the building up of the American system of self-government in their place.

In the view of Silliman there were two important periods in American chemistry, those that occurred before 1845 and those that occurred afterwards. By 1845 it had been almost two decades since Liebig "threw open wide the doors of access to the laboratory at Giessen and welcomed cordially all students without distinction of nationality to his scientific hospitality" (11). This was a seminal event in the history of American chemistry, according to Silliman.

In 1846 the Smithsonian Institution was organized in Washington, DC, "opening wider and yet more freely the various paths of scientific research" (11). The American Association for the Advancement of Science in 1848 began publishing its own journal *Proceedings* which offered another venue for publication and according to Silliman was another landmark for American science.

The establishment of several scientific schools at some of the oldest and most prestigious American colleges was also a major event that took place in the late 1840s. Among the most important was the Sheffield Scientific School (1847) at Yale College, in which Silliman played a major role (12), and the Lawrence Scientific School (1847) at Harvard in which Liebig's student Eben Horsford was a major force (13).

The names in Table 1 are arranged in the order as presented by Silliman in his paper. Silliman does not provide any rationale for his listing as it is not strictly chronological or alphabetical. Several others have been omitted because their contribution or connection with chemistry seemed marginal at best. I have provided background material on the chemists mentioned by Silliman prior to 1845. Biographical information was gathered from Silliman's paper, internet searches, and the compilations of Miles and Gould (14) and various other sources such as the Chemical Heritage Foundation. Where a doctoral degree was earned, this is listed with the institution, year, and mentor when possible (14).

Table 1. Leading American chemists active before 1845.

NAME	DATES	CHEMICAL TRAINING	PROFESSIONAL CAREER	RESEARCH INTERESTS AND OTHER PROFESSIONAL DISTINCTIONS	OTHER ACCOMPLISHMENTS
Joseph Priestley	1733-1804	Self-educated	Tutor and Unitarian minister	Inorganic and physical chemistry	Discoverer of more new gases then any of his contemporaries
Benjamin Thompson (Count Rumford)	1753-1814	Self-educated	Inventor and government official	Physical chemistry and thermodynamics	Cofounded Royal Institution in 1799; endowed Rumford professorships at Harvard

NAME	**DATES**	**TRAINING**	**CAREER**	**INTERESTS**	**OTHER**
John Maclean	1771-1814	Glasgow	Princeton (1796-1812), William and Mary (1812-1813)		Opposed phlogiston theory; foremost proponent of the new chemistry in US
Parker Cleaveland	1780-1858	Harvard	Bowdoin College (1805-1853)	Mineralogy	
Benjamin Rush	1745-1813	Princeton, Edinburgh Medical School	Penn. Medical School		Produced the first chemistry textbook in America
James Hutchinson	1752-1793	Penn. Medical School	Penn. Medical School (1789-1793)		Revolutionary War Surgeon
James Woodhouse	1770-1809	Penn. and Penn. Medical School	Penn. Medical School (1796-1809)		
Aaron Dexter	1750-1829	Harvard Medical School	Harvard Medical School (1783-1816)		
Samuel Latham Mitchill	1764-1831	Columbia, Edinburgh Medical School	Columbia (1792-1820)		Congressman and Senator (1804-1813); first to teach Lavoisier's new chemistry in US; editor of *Medical Repository*
Robert Hare	1781-1858	Penn.	Penn. Medical School (1847)	Inorganic and physical chemistry	Developed the improved blow pipe for analysis
Archibald Bruce	1777-1818	Columbia, Edinburgh Medical School	College of Physicians and Surgeons, Columbia (1807-1812); Rutgers Medical School (1812-1818)	Mineralogy	
Benjamin Silliman Sr.	1779-1865	Yale	Yale (1804-1853)		One of the most eminent of American teachers of natural science; founder of *American Journal of Science* (1818)
Adam Seybert	1773-1825	Penn. Medical School; studied in Paris, Edinburgh, Göttingen	Operated a laboratory for drug preparation; seller of chemicals and equipment	Eudiometric analysis of air	Congressman (1809-1815, 1817-1819)
William James McNevin	1763-1841	Vienna Medical School	Professor of Medicine and Chemistry at College of Physicians, Columbia (1808-1826) and Rutgers Medical School (1829-1829)	Toxicology	First person to offer laboratory instruction in chemistry as part of curriculum

NAME	**DATES**	**TRAINING**	**CAREER**	**INTERESTS**	**OTHER**
John Gorham	1783-1829	Harvard and Harvard Medical School; studied in Paris, London, Edinburgh	Harvard (1809-1827)		One of the founders of *New England Journal of Medicine*
James Freeman Dana	1793-1827	Harvard and Harvard Medical School	Harvard, Dartmouth (1816-1827)	Analytical chemistry	Considered by his contemporaries to be unrivalled in his experimental abilities
Samuel Luther Dana	1795-1868	Harvard	Chemical manufacturer	Agricultural chemistry	"Muck Manual of Manures;" one of the first writers in the US to present an approach to agriculture based on chemistry
John Griscom	1774-1852		Private school teacher; also Rutgers Medical School		For 30 years he was acknowledged to be one of the best teachers of chemistry; popularized view of state-supported higher education
Thomas Cooper	1759-1839		Dickinson College, Penn., Univ. South Carolina		
Thomas Clemson	1807-1888	Sorbonne, École des Mines	Manufacturing chemist, mining engineer	Agricultural chemistry	Driving force in establishing USDA; his bequest led to founding of Clemson Univ.
John Redman Coxe	1773-1864	Penn. Medical School	Professor of chemistry Penn. Medical School, professor of pharmacy		Helped establish first college of pharmacy in US
James Cutbush	1788-1823	Penn.	Chemical manufacturer and lecturer		
Julius Ducatel	1796-1849	St. Mary's College (Baltimore), Paris	Maryland and Maryland Medical School		
Lardner Vanuxen	1792-1848	École des Mines (Paris)	Columbia College (SC) (1819-1826), consultant geologist (1826-1848), West Point (1824-1828)	Mineralogy	
John Patton Emmet	1796-1842	College of Physicians and Surgeons, Columbia			
John Torrey	1796-1873	College of Physicians and Surgeons, Columbia	College of Physicians and Surgeons (1827-1855), Princeton (1830-1854)	Mineralogy, botany	Prolific writer and investigator of the flora of America

NAME	**DATES**	**TRAINING**	**CAREER**	**INTERESTS**	**OTHER**
Samuel Guthrie	1782-1848	College of Physicians and Surgeons, Penn. Medical School	Manufacturer of alcohol, vinegar, potassium, chlorate, mercury fulminate		First to make chloroform
George T. Bowen	1803-1828	Yale, Penn. Medical School	Univ. Nashville (1826-1828, 1829-1850), chemical manufacturer	Mineralogy	
Gerard Troost	1776-1850	Leiden, Amsterdam		Mineralogy	
Denison Olmsted	1791-1859	Yale	North Carolina (1817-1825), Yale (1825-1859)	Mineralogy, meteorology, astronomy	One of the earliest to study meteors
William Williams Mather	1804-1859	West Point	West Point (1829-1835), Ohio Univ. (1842-1859)	Geology, mineralogy	First American to determine an atomic weight of an element
Lewis C. Beck	1798-1853	Union College, College of Physicians and Surgeons, Columbia	Rensselaer Polytechnic Inst. (1824-1829), Rutgers (1831-1853), New York Univ. (1836-1838), Albany Medical College (1840-1853)	Industrial chemistry, mineralogy	
Jacob W. Bailey	1811-1857	West Point	West Point (1838-1857)	Botany	First professor of chemistry at West Point
Alexander Dallas Bache	1806-1867	West Point	Penn. (1828-1843), US Coastal Survey (1843-1867)		First president of National Academy of Sciences; great grandson of Benjamin Franklin
J. E. Teschmacher	1791-1863	Privately educated in England	Self-employed entrepreneur in Boston	Mineralogy	
John Pitkin Norton	1822-1852	Yale, Agricultural Chemical Association laboratory (Scotland)	Yale	Agricultural chemistry	Influenced the founding of the agricultural experimental station system
Evan Pugh	1828-1864	D.Phil. under Wöhler, Göttingen 1856	Penn. State College (1859-1864)	Agricultural chemistry	President, Penn. State
Charles M. Wetherill	1825-1871	Penn., Paris, D.Phil. under Liebig, Giessen 1848	USDA (1862-1863), Smithsonian (1863-1865), Lehigh (1866-1871)	Agricultural chemistry; mineralogy	First chemist to serve in USDA

Analysis of American Chemistry, Pre-1845

In this period we find many American chemists who are purely homegrown products, and the study of chemistry abroad is the exception rather than the rule as it will be later. Instruction in chemistry was provided in undergraduate institutions beginning in 1767 at Columbia and amounting to about 50 in total by 1839 according L. C. Newell (16). This instruction varied greatly in quality and continuity. The medical schools were the most prominent chemical centers and produced the vast bulk of American chemists. The most important of these were the College of Physicians and Surgeons at Columbia University in New York and University of Pennsylvania Medical School. Approximately 25% of those listed attended one or the other. Among collegiate institutions the choice was fairly narrow with Harvard, Yale, Pennsylvania, and West Point the dominant ones, 38% of the group having attended one of these. Laboratory instruction was the exception and not the rule; often it was obtained by the eager young student through private instruction at additional expense.

Some American chemists chose to study abroad in this time period, with Paris being the most likely destination. A few Americans in the early 1840s started the trend to go to German universities, particularly Göttingen and Giessen, where, respectively, Wöhler and Liebig welcomed American students. These graduates who returned with their D. Phil. degrees were among the best trained in the United States in both theory and practice (17).

Research was generally not expected of academic chemists. One of the reasons for this was that laboratory space was either nonexistent or extremely limited if it was available. Institutional support for research was minimal at best; and given the high cost of equipment and chemicals which for the main part had to be imported from Europe, one can see why it required Herculean effort to begin and sustain a research program. Lecturers were paid on the basis of the number of students they taught. Many chemists of this period, in order to support themselves, held two or three positions, which often involved considerable travel and absence from their families for months at a time. This was particularly true of those teachers of chemistry in medical schools with only a four-month academic term. This very likely led to an uneven quality of instruction.

There was not much prestige associated with fundamental research and thus most of the chemical work that was done was centered on practical applications. Public service was also performed by many of these early chemists, mainly in the form of analysis of materials associated with public health.

One of the most significant aspects of this period according to Silliman was the large number of inspiring teachers who set the stage for a vast expansion of American chemistry in the post-1845 period. Among this elite group were John Maclean (Princeton); James Woodhouse and Robert Hare (Penn); Benjamin Silliman (Yale); and Samuel Latham Mitchill (Columbia).

Table 2. Leading American chemists post-1845.

NAME	DATES	CHEMICAL TRAINING	PROFESSIONAL CAREER	RESEARCH INTERESTS AND PROFESSIONAL DISTINCTIONS	SIGNIFICANT ACCOMPLISHMENTS
Charles Upham Shepard	1842-1915	Yale, Göttingen	South Carolina Medical School (1867-1885), South Carolina private analytical laboratory	Analytical and industrial chemistry	First person in US to grow tea as a commodity
Augustus Hayes	1886-1882	Dartmouth	Consultant and analyst	Industrial chemistry	
Lewis Feuchtwanger	1805-1876	Jena D.Phil. (1829)	Pharmacist and metallurgist	Mineralogy	First to suggest using nickel alloys in minting small coins
Robert Peter	1805-1894	Rensselaer Polytechnic, Transylvania Medical College	Transylvania Medical College (1838-1857)	Analytical chemistry	
John William Draper	1811-1882	Penn. Medical School	Hampden Sydney (1836-1838), New York Univ. (1838-1882)	Physical chemistry	Made some of the first Daguerreotypes in US; first president of the ACS

NAME	DATES	TRAINING	CAREER	INTERESTS	OTHER
Robert E. Rogers	1813-1884	Penn. Medical School	Virginia (1842-1852), Penn. Medical School (1852-1877), Treasury Department consultant (1877-1884)	Physiological chemistry	Introduced student laboratory instruction in medical school
John Johnston	1806-1879	Bowdoin	Wesleyan (1835-1873)	Physical chemistry	Prolific author of textbooks in chemistry and physics
James C. Booth	1810-1888	Penn., Göttingen	Private consulting chemist, chemical teaching laboratory, ran refiner for US mint (1849-1887)	Industrial chemistry	Founder of oldest chemical consulting business in US
Charles T. Jackson	1805-1880	Harvard Medical School	Analytical consulting laboratory in Boston	Industrial chemistry, mineralogy	Suggested ether as an anesthetic in 1846
James Blake	1815-1893	Univ. College London, Medical School	Univ. California Medical School	Analytical and inorganic chemistry	Studied periodic relationships based on physiological effects of elements
O. Wolcott Gibbs	1822-1908	Columbia and Columbia Medical School, Berlin, Giessen, Paris	City College of NY (1849-1863), Harvard (1863-1887)	Inorganic and physical chemistry	One of the founders of the National Academy of Sciences.
John Lawrence Smith	1818-1883	Medical College of South Carolina, Paris, Giessen	LSU (1850-1852), Virginia (1852-1854), Univ. Louisville (1854-1866)	Analytical chemistry	First American student of Liebig
Traill Green	1813-1897	Penn. Medical School	Lafayette College (1837-1841, 1849-1891), Marshall College (1841-1848)		
Martin H. Boyé	1812-1909	Copenhagen, Polytechnic Univ., Penn. Medical School	Assistant to Robert Hare, Penn. Central High School	Geology, mineralogy, inorganic and organic chemistry	Synthesis of ethyl perchlorate
Benjamin Silliman Jr.	1816-1885	Yale	Yale	Analytical and industrial chemistry	Helped establish American oil industry by analysis of Pennsylvania rock oil; one of the first members of National Academy of Sciences
Fredrick A. Genth	1820-1893	Heidelberg, Giessen, Marburg (D.Phil. 1845 under Bunsen)	Private chemical consultant, Penn. (1872-1888)	Analytical and inorganic chemistry	One of the most respected analytical chemists in America in his time
Eben Horsford	1818-1893	Rensselaer Polytechnic, Giessen	Rumford Prof. at Harvard (1847-1863); chemical manufacturer (1863-1893)	Agricultural and food chemistry	Developed the baking powder industry in America; student of Liebig but did not earn degree
Thomas Sterry Hunt	1826-1892	Yale	Geological Survey of Canada (1847-1872), MIT (1872-1878)	Mineralogy, organic chemistry	First to propose climate change due to carbon dioxide concentration changes
John W. Mallet	1832-1912	Trinity College (Dublin)	Univ. Louisiana Medical School (1865-1868), Virginia (1868-1912)	Atomic weights, toxicology	Superintendent of the Confederate States ordnance laboratory

NAME	**DATES**	**TRAINING**	**CAREER**	**INTERESTS**	**OTHER**
William P. Blake	1826-1910	Yale	Professional geologist; professor of geology School of Mines, Univ. Arizona (1896-1905)	Mineralogy	First to introduce western mining technology in Japan (1861)
William H. Brewer	1828-1910	Yale, Heidelberg, Munich	Washington College (1858-1860); Geological Survey of California (1860-1864); Sheffield Scientific School, Yale (1864-1903)	Agricultural chemistry, botany	One of the persons to recommend the purchase of Alaska in 1867
John M. Ordway	1823-1909	Dartmouth		Mineralogy	
George J. Brush	1831-1912	Yale, Munich, Freiberg School of Mines, Royal School of Mines (London)	Industrial chemist, MIT, Tulane (1884-1904)	Civil engineering, biology	
Henry Wurtz	1828-1910	Princeton	George Washington Univ. (1858-1861), private laboratory for consulting (1856-1900)	Metallurgy, petroleum technology	
Samuel Johnson	1830-1909	Yale, Leipzig, Munich, London	Yale (1856-1900)	Agricultural chemistry	Father of American agricultural research
John L. Leconte	1818-1891	Georgia, New York College of Physicians and Surgeons	Georgia (1846-1855), South Carolina (1856-1869), Univ. California (1869-1891)	Physics	President of Univ. California (1876-1881); measured speed of sound and showed that flames are sensitive to sound
Charles A. Joy	1823-1891	Union College, Göttingen (D.Phil. 1852 under Wöhler), Berlin, Paris	Union College (1854-1857), Columbia (1857-1877)	Mineralogy	
Charles A. Goessmann	1827-1910	Göttingen (D.Phil. 1852 under Wöhler)	Industrial chemist (1857-1861), Rensselaer Polytechnic (1862-1864), Univ. Massachusetts (1868-1907)	Inorganic and agricultural chemistry	"Not a better practical chemist in the United States," in opinion of his contemporaries
Eugene W. Hilgard	1833-1916	Heidelberg, Royal School of Mines (Freiberg), Zürich, Heidelberg (D.Phil. 1854 under Bunsen)	Smithsonian Institution, Mississippi, Michigan, Univ. California	Soil science	
John M. Maisch	1831-1893	Hanau	Pharmacist (1850-1859), New York College of Pharmacy (1859-1866), Philadelphia College of Pharmacy (1866-1893)	Pharmaceutical chemistry	Editor of *American Journal of Pharmacy* (1871-1893); assay of adulterants in food and medicine; participant at Priestley celebration
Theodore G. Wormley	1826-1897	Dickinson College, Philadelphia College of Medicine (M.D.)	Starling Medical College; Penn. Medical School (1877-1897)	Toxicology	

NAME	DATES	TRAINING	CAREER	INTERESTS	OTHER
John C. Draper	1835-1885	New York Univ.	New York Univ (1858-1871), City College of NY (1863-1885)		
Alexander Means	1801-1883	Transylvania Univ.	Emory (1838-1848), Medical College of Georgia (1840-1853), Atlanta Medical School (1855-1867)	Medicinal chemistry	President of Emory(1854-1855); first person to demonstrate an electric light in America
Josiah P. Cooke Jr.	1827-1894	Harvard	Harvard (1850-1894)	Atomic weight measurements	Physical chemistry textbook
John Addison Porter	1822-1866	Yale, Giessen	Delaware (1844-1847), Brown (1850-1852), Yale (1852-1864)	Agricultural chemistry	Helped in founding of Sheffield Scientific School at Yale, which awarded the first Ph.D. degree in America
Newton Spaulding Manross	1825-1862	Yale, Göttingen (D.Phil. 1852 under Wöhler)	Self-employed mining engineer and inventor (1853-1861), Amherst College (1862)		Died at Battle of Antietam, 1862
Matthew Carey Lea	1823-1897	Self-educated	Private laboratory	Photochemistry, analytical chemistry	
Charles F. Chandler	1836-1925	Harvard, Göttingen (D.Phil. 1853 under Wöhler and Rose)	Union College (1854-1857), Columbia (1857-1877)	Industrial chemistry	Chairman of the Priestley Centennial Celebration and publisher of *The American Chemist*
Henry Bradford Nason	1831-1895	Amherst College, Göttingen (D.Phil. 1857 under Wöhler)	Rensselaer Polytechnic (1858-1895)	Mineralogy	
Frank H. Storer	1832-1914	Harvard, Heidelberg, Freiberg, Paris	Industrial chemist (1857-1871), MIT (1865-1870), Harvard (1870)	Industrial and agricultural chemistry	
Charles Gilbert Wheeler	1836-1912	Nuremberg	Chicago, Chicago Medical College (1868)	Organic and physiological chemistry	
Cyrus Moors Warren	1824-1891	Harvard, Paris, Heidelberg, Munich, Berlin, London	Chemical manufacturer, MIT (1866-1868), private laboratory (1868-1891)	Petroleum chemistry	
Frederick Hoffmann	1832-1904	Berlin, Jena (D.Phil. 1859)	Pharmacy owner, publisher of the *Pharmaceutical Review*	Dye chemistry, analytical chemistry	
Maurice Perkins	1836-1901	Columbia College of Physicians and Surgeons, Heidelberg, Göttingen, Tübingen	College of Physicians and Surgeons (1862-1864), Harvard (1864-1865), Union College (1870-1901)		Founding member of the ACS
James M. Crafts	1839-1917	Harvard, Freiberg, Heidelberg, Paris	Cornell (1867-1870), MIT (1870-1874, 1891-1907), Paris (1879-1891)	Inorganic and organic chemistry	Friedel-Crafts reaction discovered in 1877; President of MIT (1898-1900)

NAME	DATES	TRAINING	CAREER	INTERESTS	OTHER
Samuel P. Duffield	1833-1916	Michigan, Munich, Giessen (D.Phil. 1858)	Founder of Parke, Davis, and Co. (1866), Detroit Medical School (1868-1881)	Pharmaceutical chemistry	Received M.D. in 1872 and practiced medicine along with teaching and running a pharmaceutical business
Gideon E. Moore	1842-1895	Yale, Wiesbaden, Leipzig, Heidelberg (D.Phil. 1870 under Bunsen, Kirchhoff, Kopp)	Consultant in New York City		Editor, *J. Am. Chem. Soc*., Vol. 2 (1880)
H. Carrington Bolton	1843-1903	Columbia, Paris, Heidelberg, Göttingen (D.Phil.1866 under Wöhler), Berlin	Columbia (1872-1877), Trinity College (1877-1887)	History of chemistry, bibliography of chemistry	Driving force behind Priestley Centennial and one of the first lecturers on the history of chemistry in the US
Le Roy C. Colley	1833-1916	Union College	New York State Normal School (1861-1874), Vassar (1874-1907)		Leading writer of text books in chemistry and physics for secondary schools in the 19th century
Samuel T. H. Endemann	1842-1909	Marburg (D.Phil. 1866 under Kolbe)	New York City Board of Health (1867-1880), consultant (1880-1909)	Medicinal chemistry, sanitary chemistry	Founding member of the ACS, Editor, *J. Am. Chem. Soc.,* 1879, 1881
Stephen P. Sharples	1842-1923	Penn. State College, Harvard	Consultant	Analytical chemistry	
George F. Barker	1835-1910	Yale, Albany Medical School	Wheaton College, Albany Medical School, Pittsburgh, Yale Medical School, Williams College, Penn.	Physical chemistry, toxicology	Expert on chemical patents and witness in criminal trials involving poisons
Samuel F. Peckham	1839-1918	Brown	Brown, Washington and Jefferson, Maine, Minnesota	Petroleum chemistry	
Paul Casamajor	1831-1887	École centrale, Paris	Chemist, American Sugar Co. (1867-1887)	Carbohydrate chemistry	
Frank W. Clarke	1847-1931	Harvard	Boston Dental College (1867-1873), Howard Univ. (1873-1874), Univ. Cincinnati (1874-1883), US Geological Survey (1883-1924)	Mineralogy, geochemistry, atomic weight determination	Analysis of minerals; determination of atomic weights
William H. Chandler	1841-1906	Union College, Columbia	Lehigh (1871-1906)		Co-publisher of *The American Chemist*.
Henry Morton	1836-1902	Penn.	Philadelphia Dental College (1863-1870), Stevens Institute (1871-1901)	Spectroscopy	President, Stevens Institute (1870-1902)
Albert B. Prescott	1832-1905	Michigan (M.D.)	Michigan (1865-1895)	Toxicology, organic chemistry	Founder and Dean of the College of Pharmacy at Univ. Michigan

NAME	DATES	TRAINING	CAREER	INTERESTS	OTHER
Samuel Sadtler	1847-1923	Gettysburg, Harvard, Heidelberg, Göttingen (D.Phil. 1871 under Wöhler)	Gettysburg, Penn.	Industrial chemistry	Established oldest continual industrial research and consulting business in US
Charles E. Munroe	1849-1938	Harvard	Harvard (1871-1874), US Naval Academy (1874-1886), Naval Torpedo Station (1886-1892), George Washing Univ. (1892-1918)	Analytical chemistry, explosives	Developed the shape charged explosive
Albert R. Leeds	1843-1902	Haverford, Harvard, Berlin, Columbia; College of Physicians and Surgeons, Munich	Stevens Institute (1871-1902)	Mineralogy, photochemistry, sanitary chemistry	Founding member of the ACS
Ira Remsen	1846-1927	Göttingen (D.Phil. 1870 under Fittig), Tübingen	Williams College (1872-1875), Johns Hopkins (1876-1913)	Organic chemistry	Established the German model of graduate education in the US; editor of the *American Journal of Chemistry*
Edward Morley	1838-1923	Amherst College	Western Reserve Univ.	Physical chemistry, atomic weights of oxygen and hydrogen	Michelson-Morley experiment of 1887; completed theological studies at Andover Theological Seminary (1860-1863)

The Post-1845 Period

In Table 2 are listed those American chemists Silliman viewed as noteworthy in the post-1845 period. This list follows the order in which they are mentioned by Silliman and is as complete as possible. Of the 47 chemists for which I have been able to gather information, one can see a quantum leap in their formal training in chemistry and the beginnings of a tradition of original chemical research. Study abroad now became more the norm rather than the rare exception. Germany was the prime destination and almost half of the listed chemists studied there for some period of time. Depending upon their financial and personal circumstances, many were able to stay long enough to complete the doctoral degree. By visiting and working at several universities, they succeeded in gaining a diversity of research experience. In the pre-1845 group of 37 only 12 had studied abroad and only two obtained a degree. The universities chosen for study were Giessen, where Liebig welcomed American students, as well as Göttingen, where Wöhler offered similar hospitality. Bunsen in Marburg and later in Heidelberg also had many American students.

After 1845 chemistry moved increasingly from medical schools to institutions devoted to instruction in the natural sciences. In the pre-1845 group 16 of 38 received their chemical training in medical schools followed in four cases by study abroad.

In the 19th century Americans were drawn to the study of mining at the École des Mines in Paris and the Royal School of Mines in Freiberg, Germany. Given the vast natural resources of the United States this seemed to be a logical choice. Schools of mines were only established in the 1850s in the United States. This wealth of natural resources and the interest in knowing the content of minerals contained shows up in the recurring research interests by many of the chemists that Silliman listed.

One of the accomplishments of Silliman in preparing this paper was to assemble a bibliography of the papers published by the persons he cited. One can see the spectacular growth in American chemistry by the sheer increase in volume of papers published. Forty-two of the persons listed in Table 2 published at least 10 papers, and several had as many as 40 or more. Among this elite group were J. W. Draper (46 papers); Wolcott Gibbs (47); B. Silliman (48); J. M. Maisch (52); and M. C. Lea (43). What is remarkable is that most of these papers were authored without collaborators. Although for the most part the work appeared in American journals, some were published abroad—notably in German journals. While many American chemists individually were highly productive, there was a lack of continuity as contrasted with the German model of the chemical institute and the emphasis on research. Eventually the German system was adopted in America, through the efforts of German-trained chemists such as Ira Remsen at Johns Hopkins in the late 1870s (18).

Silliman's review of American chemistry has been described by E. H. Thomson in the *Dictionary of Scientific Biography* as an "important publication not supplanted to this day" (19).

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THE RISE AND FALL OF DOMESTIC CHEMISTRY IN HIGHER EDUCATION IN ENGLAND DURING THE EARLY 20TH CENTURY

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Introduction

In Britain, during the 1880s and 1890s, there had been an increasing interest in the teaching of domestic subjects to girls (1). Initially, it was domestic economy—cooking, laundry work, and so on. Educators thought such mandatory instruction was important for two reasons: first, it was believed that the squalor and drunkenness that prevailed among the lower classes could be prevented by education in "home-thrift" and economic cookery; and second, there was a fear of a shortage of domestic servants for upper-middle-class homes. Two subsequent reports, the Interim Report on Housecraft in Girls' Secondary Schools in 1911 and the Consultative Committee on Practical Work in Secondary Schools in 1913, both contended that, in the new "scientific age," the teaching of domestic subjects should have a strong foundation in science and become domestic or household science. At the core of domestic science was chemistry—especially the chemistry of foodstuffs and household cleaners.

Women had only a few years earlier gained admission to university to take academic chemistry. As a result, a fierce debate arose in England among the first generation of women chemists and their supporters as to the type of chemical education most appropriate for young women. That is, should the next generation of girls learn "real" chemistry, which would continue to give them access to the same opportunities as men? Or should they learn domestic chemistry as a component of domestic science, which would enable them to undertake their role as wives and mothers in a scientific manner? A leading proponent of domestic science for girls was Arthur Smithells, Professor of Chemistry at the University of Leeds. Smithells, who had given lectures at Manchester High School for Girls, was a strong champion of education for girls (2). He saw domestic science as a means of bringing an applied aspect that would, in particular, be beneficial for women's roles in society.

Having fought so hard for getting girls an academic education equal to that of boys, many women scientists saw domestic science as a reversal of those gains, limiting girls' aspirations and opportunities to that of domesticity. Ida Freund, Lecturer in Chemistry at Newnham College (3), was one of the most vociferous opponents of the teaching of science to girls through the context of domestic science. In particular, she authored a lengthy denunciation in the feminist publication, *The Englishwoman* (4):

> It was erroneous to think that through the study of the scientific processes underlying housecraft and especially cookery, you can teach science, that is, give a valuable mental training which should enable the pupils in after life to judge whether an alleged connection between effect and cause has been established or not.

Most of the influential headmistresses of girls' schools similarly opposed the introduction of domestic science. For example, Lilian Faithfull, Principal of the prestigious Cheltenham Ladies College concurred (5):

> The foundations of a knowledge of chemistry and physics should be built up on a well-ordered system which must not be subordinated from the outset to the requirements of home science. The teaching of science during the school years should be such as to prove equally useful to the pupil who elects to take at a later stage a university course in science and to the pupil who enters upon the home science course.

In terms of the chemistry component, there were two parallel threads to the debate: the type of chemistry taught at girls' secondary schools, and the offering of courses in domestic chemistry at colleges, polytechnics, and universities. Manthorpe has provided a detailed discussion of the former (6), but the latter, in particular, the chemistry content of domestic science programs in higher education, has not previously been researched.

The debate about the college teaching of domestic chemistry is illustrated by the exchange in 1911 initiated by Hall and Grünbaum, science lecturers at Avery Hill [Teachers] Training College, Eltham. They contended that incoming women students in domestic science programs required only very basic chemistry before being taught household chemistry (7):

> Before "domestic" chemistry can be introduced with profit, they [college students] must understand the composition of air and water and the nature and reactions of acids, bases, and salts. In the short time at our disposal we do not think that chemical formulæ and equations can be explained with any advantage, nor do we consider such explanation absolutely necessary. When the effects of air and of water on ordinary substances have been grasped, the methods of cleaning such substances can be deduced and practiced on all the available household appliances. The lessons on natural waters teach the methods of softening and make an introduction to the chemistry of laundry work.

Among the respondents was Hilda J. Hartle of Homerton College, Cambridge, another teachers' training college. Hartle was opposed to the whole concept of domestic science, contending that it did not have a basis in science. She pointed out (8)

> The science of cookery and of laundry work is yet in its infancy. No literature of the subject exists. Not even the most brilliant organic chemist can be said to "know" the chemistry of foods, still less can such a subject be within the grasp of students in training.

Nevertheless, the teaching of domestic science thrived in some English institutions of higher education for many decades. Bird has compared the Gloucestershire School of Cookery and Domestic Economy and the Bristol University B.Sc. in Domestic Science (9) but without a comparison of the science component. Here we will contrast the rise and fall of the chemistry content of domestic science programs at four well respected institutions of higher education in the London area: those at Berridge House, a college for working-class girls; two polytechnics with very different programs, the chemistry-weak program at South-Western Polytechnic and the chemistry-strong program at Battersea Polytechnic, both aimed at middle-class young women; and that at King's College for Women, designed for upper-middle-class women students.

Domestic Chemistry at Berridge House, Hampstead

In the 1890s and 1900s, some colleges were established specifically to teach domestic subjects to girls (10). The women students were primarily recruited from the lower classes of society and many, upon graduation, obtained employment as maids with "fine families." The emphasis at these institutions was less on science than on domestic training in a "scientific manner." For example, Elizabeth Atkinson, teacher at the Manchester Municipal Training College of Domestic Economy, described in her book, *The Teaching of Domestic Science* (11), that a course of laundry-work should contain theoretical and practical studies on the laundry roles of starch, bran, water, soap, soda, salt, bleaching, patent cleaners, stain-removing, and paraffin wash.

The most renowned institution of this type was the Training College of Domestic Subjects, Berridge House, Hampstead (Fig. 1), opened in 1909 by the National Society for Promoting Religious Education. Berridge House was proud of its well-equipped Science Laboratory, and it was the first Domestic Science Training College in Britain to appoint a lecturer with a science degree.

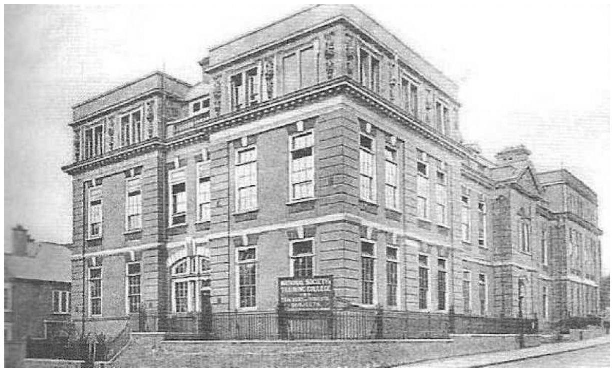


***Figure 1**. Berridge House.*

In 1910 the girls' magazine, *The Girls' Realm*, devoted a whole article to the Domestic Science program at Berridge House. Besides the more traditional domestic science topics of cookery, needlework, and housewifery, the magazine lauded the chemistry component of the program (12):

> Specially interesting is the laboratory, where the students actually make their own tests, classify foodstuffs, ascertain the chemistry of bread-making, the composition of soap, the properties of starch, borax, soda, etc., as applied in washing and naturally manufacture for themselves such household commodities as baking powder and furniture polish according to their own tried formulæ.

From 1911 onwards, the science lecturer at Berridge House, Miss Marshall, took the students annually to a soap manufacturing company. The students watched each of the steps involved in producing the different types of soap. One of the students added (13), "In the Chemistry Lab we saw the experiments for testing the purity of soaps, and also saw growth of disease germs and action of disinfectants..."

In 1964 Berridge House was merged with St. Katherine's, Tottenham, to form the College of All-Saints, Tottenham. The Berridge House site was closed. The combined institution became a teachers' training college offering home economics and general science, the domestic science program never surviving the merger (14).

Domestic Chemistry at South-Western Polytechnic and Battersea Polytechnic Institute

The undefined nature of "domestic science" meant that the chemistry component at each polytechnic differed considerably and also varied over time at any particular institution. We have chosen to contrast the domestic chemistry content at South-Western Polytechnic (Chelsea College, as of 1922) and at Battersea Polytechnic Institute, the former being chemistry-poor and the latter being chemistry-rich.

The offering of domestic science at South-Western Polytechnic was noted in *Nature* in 1899 in the context of new diploma offerings aimed at middle-class women (15). It reflected the growing scarcity of domestic workers as a result of the increasing opportunities for the employment of working-class women in other areas: "In this connection may be cited the work now being done on the women's side of the institute in the direction of offering ladies of the middle classes such instruction in domestic science as will make them independent of servants." Whatever the views of the author, such training also opened up new opportunities for the employment of middle-class women as supervisors in domestic and catering organizations.

The diploma program at South-Western Polytechnic became the autonomous School of Home Training in Domestic Science in the 1903-04 academic year (16). In its second year of existence, the program included a course titled "Household Chemistry" consisting of 25 lectures. By 1909-10, the chemistry content had decreased and the course had been renamed "Household Science." During the 1920s, that course disappeared to be replaced by one titled "Applied Electricity" later renamed "Domestic Electricity."

In the 1913-14 year, the school had changed its name to the School of Training in Housecraft and Household Management. Nevertheless, the near science-less Domestic Science Department continued on until the 1940s, when there was increasing pressure for the college to discontinue nondegree programs. As the anonymous biographer of Chelsea College (formerly South-Western Polytechnic) noted (17):

> The domestic science department was the first to go, in 1949, to provide space for pharmacy; vocational work was transferred to Battersea [Polytechnic], and non-vocational work to a women's institute.

By contrast, the chemistry component at Battersea Polytechnic Institute was much stronger. Battersea introduced a School of Domestic Economy in the early 1890s (18); and from its very inception, the chemistry of food and cookery was a significant part of the syllabus (19). The *Battersea Polytechnic Magazine* reprinted an article from the British women's weekly, the *Gentlewoman*, lauding their domestic science program (20):

> One of the most thorough and up-to-date establishments for training in the science of domesticity is the Women's Department of the Battersea Polytechnic, Battersea Park Road, which is staffed by highly trained teachers under the control of Miss M. E. Marsden. Thither flock girls from all parts of the world, even from South Africa and Japan, and many of them, especially those who intend to follow domestic science as a profession, take the three-year course. … Special stress is laid on the scientific principles underlying household processes, and the work of the kitchen and laundry is co-ordinated with that of the scientific laboratory and the lecture-rooms.

The School subsequently became the Department of Domestic Science and, by 1919-20, in addition to traditional general and organic chemistry courses, a course "Chemistry as Applied to Household Processes" appears, containing the following topics:

> Air. Water. Chemical theory. Acids, alkalis and salts. Carbon and its oxides; fuels. Soaps. Textile fabrics. Water softeners. Sugars, starch, alcohol, acetic acid. Proteins. Fats. Vitamines. Yeasts, moulds, and bacteria. Study of certain foods. Preservation and sterilisation of food stuffs. The practical work will be partly illustrative of the lectures and partly experimental craft work, i.e.:-
>
> *Experimental Housewifery*. – Study of metals, causes of tarnish, metal polishes and preservers, stainless cutlery. Study of woods, dry rot, furniture polishes, stains, paints and varnishes. French polish. Lacquers. Care of leather. Materials used in making floor coverings, and scientific reasons for methods of cleaning and preserving them. Household disinfection.
>
> *Experimental Laundrywork*. – Comparative value of methods of softening water for laundry purposes. Study of detergents and their action on textile fabrics. Methods of testing fabrics, and the reactions of laundry reagents on them. Experimental removal of stains; bleaching and dyeing. Laundry blues. Microscopic and chemical examination of starches. Disinfection of clothing.
>
> *Experimental Cookery*. – Examination of the chemical and physical natures of various foodstuffs, e.g., flour, fat, fish, meat, eggs, vegetables, pulses, milk. The effects of heat, and of different methods of cooking on these food stuffs. Study of yeast and its action on bread making. Examination of sugar substitutes. Experiments to attempt the solution of problems encountered in the kitchen.

The continued strength of the chemistry content at Battersea from 1919 until 1948 seems to have been the exception among domestic science programs. It is of note that all the chemistry staff at Battersea throughout the program's history were women. Claudia McPherson was the senior chemistry instructor from 1915 until 1948 and every year the junior instructor or instructors were also women. In addition, from 1926 until 1948, the Head of the Department of Domestic Science was a woman chemist, Helen Masters. Both Masters and McPherson retired in 1948, and it seems quite probable that the survival of a strong component of domestic chemistry until that year was the result of their influence.

***Figure 2**. Battersea Polytechnic.*

In 1948 the Department of Domestic Science became a separate entity: the Battersea College of Domestic Science. Thereafter, the syllabus no longer included any specific mention of chemistry; instead there was a course "Science, Physiology, and Nutrition." In 1963 the College was transformed into the Battersea Training College for Primary Teachers, offering courses leading to a Teachers' Certificate with special reference to domestic subjects.

Domestic Chemistry at the Women's Department of King's College

Located in Kensington, the Women's Department of King's College, University of London, opened a Home Science and Economics Department in 1908. The Department offered a three-year program, initially as a College Certificate, and it was aimed to attract upper-middle-class women who would become high school teachers of domestic science. In the interwar period, there was also a steady demand for the graduates in hospital dietetics. There were three mandatory areas of study: applied chemistry, sanitary science, and economics (21). The chemistry instructor of the time, Margaret McKillop, wrote an enthusiastic account of the program and of its possible conversion to full degree status (which occurred in 1921) (22):

> There is no doubt that the idea of the possible new degree, with as good a standing as that to which engineering and agriculture have now established their claim, is gaining ground with most people. Meanwhile headmistresses have begun to ask, much too early for our present achievements, for the "new sort of domestic science teacher." They mean, or ought to mean, someone who teaches science with constant reference to home life, a practical-minded woman who can also be a good form mistress and bring a little college atmosphere; but at present, it is true, they are a little inclined to expect a first class chemist combined with a first class cook, who can also take odd sciences and other subjects throughout the school! There is no doubt that many girls' schools are going to

> have Domestic Science now put right into the ordinary curriculum instead of being left as a top-dressing for a possible (but unusual) last year.

This enthusiasm was not totally shared. In addition to contesting the teaching of domestic science as a science at secondary schools, Freund strongly opposed the offering of a degree in domestic science. In a 1911 rebuttal of Freund's views, Sir Arthur Rücker, past Principal of the University of London, contended that domestic science degrees and their associated research programs could pave the way for new discoveries in academic science (23):

> ... it must be remembered that great outbursts of technical activity have frequently been accompanied by a rapid development of the sciences concerned. ... The ordinary text-book proof of the second law of Thermodynamics is evidently based on a knowledge of the steam engine. It will be the same with Domestic Science.

The chemistry content of the program was very strong, as exemplified by the requirements in the *1912-13 King's College, Women's Department Calendar*: First Year General Chemistry (60 lectures and 120 hours of practical work); Second Year Organic Chemistry (60 lectures and 150 hours of practical work); and Third Year Applied Chemistry (60 lectures and 180 hours of practical work). The Applied Chemistry course consisted of the following (24):

> The constituents of the atmosphere and methods of estimation – water analysis with special reference to its use for drinking purposes, cooking, and in the laundry – the constituents of foods, adulterants, and preservatives, with a value to determining their wholesomeness – the chemistry of cooking and of the materials used in cooking – the chemical changes caused by organized and unorganized ferments, applied to the preparation, preservation, and deterioration of foods and to digestion – the chemistry of laundry work and other cleansing processes – the nature and quality of textile fabrics in common use; the physical and chemical properties of their constituent fibres – disinfectants and antiseptics – scientific principles underlying the care and preservation of the chief materials used in the structure and equipment of a house.

Christina Bremner, famed advocate of female education (25), contended that graduates from this program would have excellent employment possibilities in hospitals, schools, and other public organizations; and, of course, such graduates would excel at scientific homemaking.

Figure 3. *Student in domestic chemistry laboratory of King's College.*

She described the chemistry component (26):

> Students of chemistry must learn to perform simple analyses, to study hydrocarbons, alcohols, acids, and so forth, so that in the final year they may deal effectively with water analysis, constituents and relative values of different foods, the chemical changes of ferments, preservation and deterioration of food, purity of milk, and so forth.

She assailed those who argued that only "pure" or "men's" chemistry should be taught to women students (26):

> It would be interesting to know precisely how far feminism and opposition to a Domestic Science course in a University coincide. I cannot think the lines of demarcation correspond perfectly, for I have known advanced feminists, and count myself amongst them, who for years have bitterly complained that so little of the money devoted to technical training has been spent on women, and also how very lacking in thoroughness have been many domestic science courses carried on all over the country.

Bremner was correct in that the pro and con divide did not correspond perfectly to the division among women in society. Some feminist chemists, such as Ida Smedley Maclean, supported the teaching of domestic studies on a scientific basis (27).

Bremner's optimistic view of the program was challenged by Rona Robinson. Robinson, a chemistry graduate, and at the time a Gilchrist Post-Graduate Scholarship holder at King's College for Women, wrote a fierce rebuttal, first of all noting that Bremner's rosy description of the program was based on a one-day visit. In particular, Robinson took the College to task for claiming that the first- and second-year chemistry was strong enough to provide sufficient theory for the third-year Applied Chemistry (28):

> Such "applied Chemistry" is far beyond the reach of beginners in science, and it is nothing short of charlatanry and deception on the part of the authorities to state that they teach anything of this nature. To talk of the students *applying* the knowledge of such matters in the third year is to apply knowledge which they do not possess. The student who is going to work on the *chemistry of foodstuffs* would have first to do an amount of pure chemistry that would shatter the whole curriculum of this course...

Smithells was a particularly outspoken supporter of the domestic science program at King's College (29). He responded to Robinson's attack on the program (30):

> I think it is hardly necessary to assure your readers that the somewhat elementary educational questions raised by Miss Robinson have not escaped the notice of those who are responsible for the course. We have had many difficulties to face and still have problems to solve; we shall, no doubt, continually mend our ways. But the suggestion that the courses at King's College for Women are superficial or unsound scientifically is one that I am sure would not have been made had Miss Robinson continued her studies.

Despite the criticisms of Freund and Robinson, the program prospered. We have an account of the experiences of a domestic science student, Lucy Smart, taking the first-year chemistry course (31):

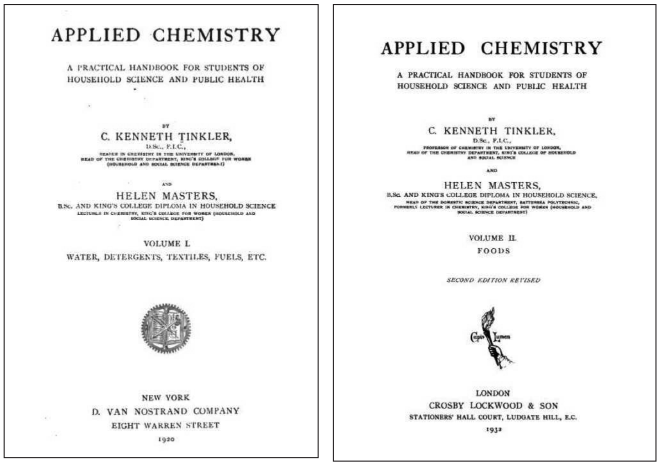
> ... On other days we are startled by flames of burning ether and explosions in treacle tins – during the so-called Chemistry lecture. After spending several hours staining our hands in trying to detect arsenic, we are allowed to go to the "Workhouse," where we learn how to remove the same stains and how to wash woollens.

Another student, Susan Lovell, commented (32):

> There is far more Science attached to the Household than one would think. Physics, Chemistry and Biology take a far more prominent place during the first year than Household Arts.

In 1915, the arts and science departments of King's College for Women were transferred to the Strand, the location of the main (men's) campus of King's College. The surviving portion, the Household and Social Science Department of King's College for Women, became completely independent on a new site at Camden Hill Road, Kensington. This orphan unit became the King's College of Household and Social Science (KCHSS). The two Chemistry Department staff at this time, Charles Tinkler and Helen Masters (prior to her move to Battersea), collaborated on a text for the domestic chemistry course, *Applied Chemistry* (33). The book, published in 1926 as a two-volume set, became the standard reference work on analytical procedures for chemistry related to the home. It was still being reprinted into the 1950s.

In 1953 King's College of Household and Social Science was renamed Queen Elizabeth College. Along with a change in name came a broadening of mandate, including the formation of departments in each of the pure sciences. That same year, the B.Sc. (Household and Social Science) was replaced by two separate degrees: B.Sc. (Household Science) and B.Sc. (Nutrition). The Department of Household Science only survived until 1966, the nutrition degree finding much more favor among incoming students. In that year, the Household Science Department was renamed the Department of Food and Management Science. Domestic science—and domestic chemistry in particular—was no more.



APPLIED CHEMISTRY

A PRACTICAL HANDBOOK FOR STUDENTS OF
HOUSEHOLD SCIENCE AND PUBLIC HEALTH

BY
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Figure 4. Applied Chemistry*, the commonly used text for domestic chemistry.*

Commentary

In the late nineteenth and the first half of the twentieth century, domestic chemistry was taught in some English institutions of higher education as part of domestic science programs. Women chemists were divided about the validity of "domestic chemistry." Nevertheless, for that period of time the subject of domestic chemistry, usually taught by women chemists, existed. Domestic science never did become defined as a science, and contrary to the grand vision of Sir Arthur Rücker, research into the chemistry of domestic technology never did flourish.

Over time, some of the domestic science departments tended to become orphaned from their parent institutions. Blakestad summed up the cause of the decline in household science (34):

> Household science had sought to work within modern scientific paradigms and to develop a new type of scientific expert, yet its interdisciplinary approach to social problems, based on a similar holistic notion of women's domestic roles, was equally subject to displacement by specialist experts as the twentieth century progressed.

It was as if domestic science as a claimed science had become an embarrassment. Thus by the end of the 1960s, this chapter in the history of chemistry for women had come to an end.

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DENISON-HACKH STRUCTURE SYMBOLS: A FORGOTTEN EPISODE IN THE TEACHING OF ORGANIC CHEMISTRY

William B. Jensen, University of Cincinnati

Introduction

The history of chemical nomenclature and symbolism is resplendent not only with proposals that were once widely used in the chemical literature, but which have since been displaced by more modern developments, but also with those which, however logical, were doomed to oblivion almost from their inception and which now survive as historical relics to be found only in the papers and books of their originators (1). Some of these latter proposals (Fig. 1) (2), such as the geometric symbolism of Hassenfratz and Adet, which was designed to encode the nomenclature reforms of Lavoisier and his collaborators, or the circle symbols of Dalton and Loschmidt, have at least managed, despite having never been widely adopted, to make it into the history books, whereas others remain forgotten in the dusty back issues of unread journals (3). This latter scenario was unfortunately the fate of the Denison-Hackh proposals for organic symbolism, despite the fact that certain aspects of these symbols have since been independently rediscovered and are currently widely used in the chemical literature. It is this latter irony which provides both a philosophical and a sociological justification for indulging in a brief historical retrospect of this forgotten symbolism.

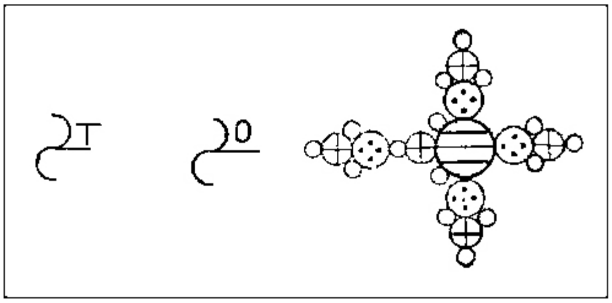

***Figure 1**. Chemical symbols which have made the history books despite never having been widely adopted by chemists. (Left): Hassenfratz and Adet symbols for tartaric and oxalic acid; (Right): Dalton's circle symbolism for alum.*

Denison-Hackh Structure Symbols

In the October 4, 1918 issue of *Science*, Mr. Ingo W. D. Hackh, an assistant in the Department of Chemistry at the University of California-Berkeley, published a short article entitled "Organic Symbols," in which he proposed replacing the conventional structural formulas of organic chemistry with pure topological bonding or framework formulas in which the conventional letter symbols of Berzelius for H, O, N and C were eliminated and replaced instead by bond nodes corresponding to their common valence connectivities of one, two, three and four, respectively (Fig. 2) (4). Only when less common elements, such as S, P, or the halogens, were present in an organic compound was it necessary to explicitly use the corresponding letter symbols. Just as a single bond was a straight line, so a double bond was represented as a loop and a triple bond as a circle with a line through the center (Fig. 3). When these proposals were consistently followed, the result, according to Hackh, was a unique and distinctive "structure symbol" for each of the more than 100,000 organic compounds known at the time (Fig. 4)—a symbol that was both compact and easy to write and that, as an additional bonus, also facilitated the taking of lecture notes.

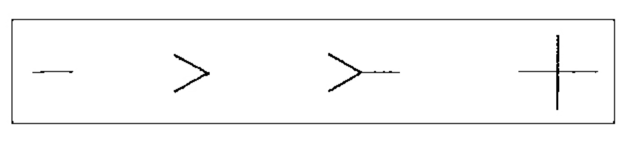

Figure 2. *(Left to Right): Bond nodes for hydrogen, oxygen, nitrogen, and carbon.*

The brief article in *Science* was not Hackh's first attempt at publicizing his symbolism, as he had already published a short paper on this subject in the spring of 1918 in the soon to be defunct *Canadian Chemical Journal* (5). Nor was this symbolism completely original with Hackh, since he also acknowledged having gotten the basic idea from a suggestion published by a certain Dr. Henry S. Denison in *The Denver Medical Times* four years earlier (6). But what had been merely a passing interest for Denison soon became an abiding obsession for Hackh, who would continue to refine and apply the symbols over the next two decades in a variety of papers and books (7-24).

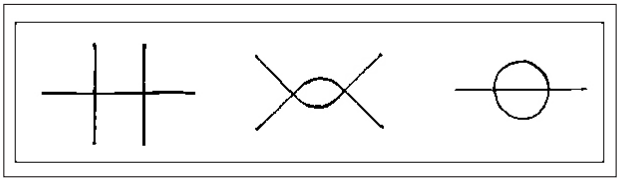

Figure 3. *Structure symbols for single, double, and triple bonds. (Left to Right): ethane, ethene, and ethyne.*

The end product of this refinement process was described in a paper published in the *Journal of Chemical Education* in 1930 (21) and in a small booklet for students and teachers published the next year under the title *Structure Symbols for Organic Chemistry* (24). This consisted of 38 pages of text followed by 29 hand drawn plates giving the structure symbols for over 1,000 organic compounds. These two publications reveal refinements designed to indicate both the presence of chiral carbon centers (Fig. 5) and, if desired, the presence of various bonding and nonbonding electron pairs (Fig. 6). But perhaps the best known and most influential of Hackh's various publications was the highly illustrated *Dictionary of Chemistry*, which he produced for the Blakiston Company of Philadelphia in 1929 and which he soon filled with many examples of his structure symbols (20).

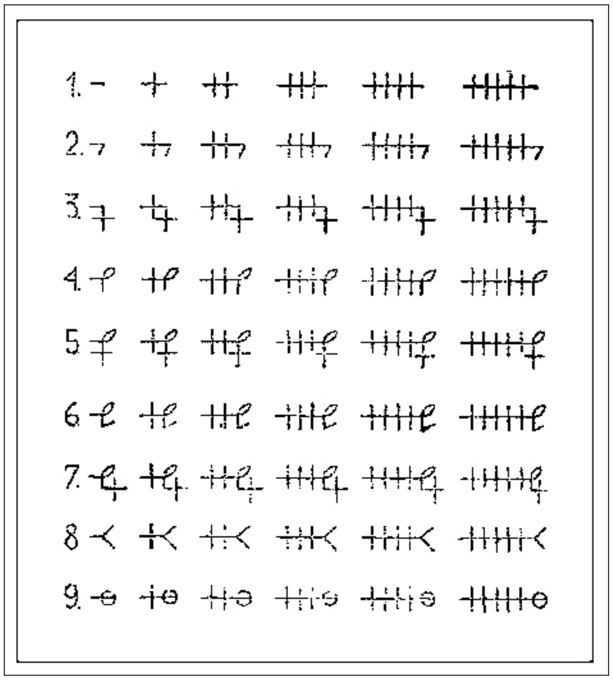

***Figure 4**. Structure symbols for various homologous series: 1) alkanes, 2) alcohols, 3) methyl ethers, 4) aldehydes, 5) methyl ketones, 6) carboxylic acids, 7) methyl esters, 8) primary amines, 9) nitriles.*

Failure

So how successful was Hackh in convincing his fellow chemists of the merits of his new "structure symbols," as he came to call them? The answer, as far as I can determine, is that his efforts ended in failure. Though J. J. Sudborough, the British translator of the popular organic textbook by the German chemist, August Bernthsen, noted Hackh's 1918 article in Science and incorporated a brief mention of the symbolism in the 1922 and subsequent editions of the text (25), Hackh's efforts to interest American chemical educators were largely unsuccessful. Over the years, his 1930 article in the Journal of Chemical Education elicited a single reader response, which largely dealt with the reader's own eccentric proposals for a "chemical shorthand" (26); and a review of Hackh's subsequent booklet in the same journal by C. A. Buehler of the University of Tennessee-Knoxville provided only a lukewarm endorsement (27):

> The present structural formula seems so well established that it is not likely to be replaced unless a much more desirable method of representation is devised. Any such method will have to overcome custom, and to do this its advantages must outweigh decidedly its disadvantages. The structure symbol does have the advantage of compactness and simplicity, but is that

> sufficient to overcome the inconvenience of having the chemical symbols omitted? Is it not desirable to make our representations intelligible to, at least, the scientifically interested public? Taking everything into consideration, the reviewer does not feel that the structure symbol is an improvement over the structural formula.

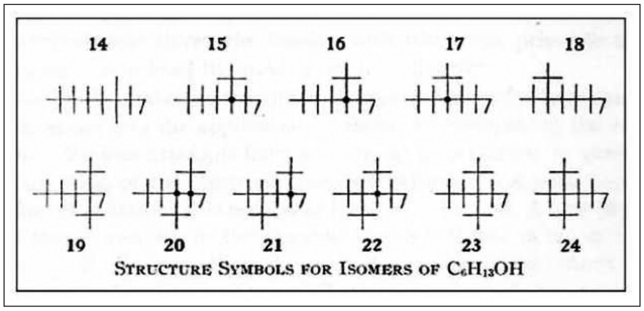

Figure 5. *Hackh's method of indicating chiral carbon centers (black dots) illustrated using the various isomers of hexanol.*

L. I. Smith, who reviewed the booklet for the *Journal of Physical Chemistry*, was even more harsh in his assessment of the possible uses of the symbols in undergraduate teaching (28):

> As a teaching device, the reviewer doubts very much if these symbols would have the value claimed for them, namely, that they make it possible to include a larger amount of organic chemistry in the usual courses; and it would appear that the new symbols might have the definite disadvantage of getting the student even further away from reality than the usual structural formulas do, since in the new symbols no symbols for carbon, hydrogen, nitrogen, or oxygen appear.

However, this criticism was offset by Smith's enthusiastic endorsement of the symbolism for advanced students and research workers (28):

> But as a tool for advanced students and research workers, these new symbols appear highly advantageous, for they amount to a shorthand way of representing the structural formulas and can be written in much less time than even the most abbreviated structural formulas. This, it seems to the reviewer, is the field in which these symbols have their greatest advantage, and this advantage is a considerable one.

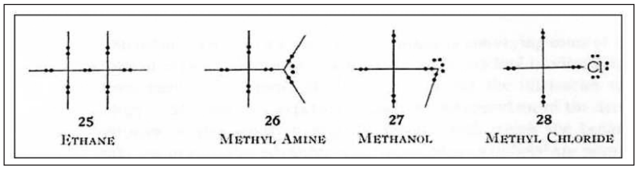

Figure 6. *Structure symbols with bonding and nonbonding electron pairs superimposed.*

Likewise, though Hackh's chemical dictionary would go through many subsequent editions—some as late as the 1980s—Julius Grant, who took over editorship of the dictionary after Hackh's death in 1938, began to eliminate progressively most of the references to Hackh's structure symbols, starting with the 3rd edition of 1944 (29).

Some Historical Ironies

By the late 1940s it is safe to say that essentially all traces of Hackh's original proposals had disappeared from the chemical literature, though ironically the following decades would see several independent applications of their underlying premises, albeit without any mention of Hackh or his original proposals. The first of these occurred in the late 1950s and early 1960s with the rise of framework molecular models (30), the most popular of which were the versions devised by Fieser (31) and by Prentice-Hall (32) for the use of students taking sophomore organic chemistry, both of which were, in turn, based on the more expensive precision metal Dreiding models used by research chemists (33).

These framework models were literally 3D versions of Hackh's 2D structure symbols, though their application in teaching organic chemistry during these decades was never coupled, to the best of my knowledge, to proposals, similar to those of Hackh, for drawing 2D topological projections of the resulting 3D models. Indeed, this development was doubly ironic since, 22 years before these developments, Hackh himself had constructed a series of 3D framework models from heavy gauge wire that were identical in appearance to the much later plastic FMM Prentice-Hall models (Fig. 7) and had explicitly noted that his structural symbols were nothing more than 2D topological bonding maps or "graphs" of these models.

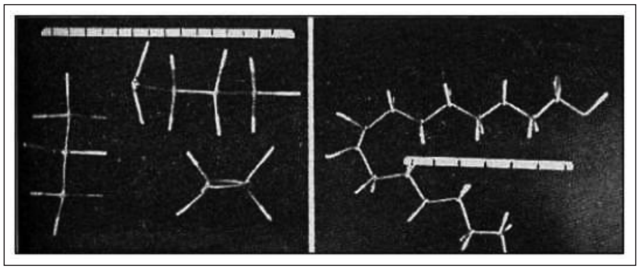

Figure 7. *Wire framework molecular models introduced by Hachk in the second edition (1937) of his chemical dictionary more than two decades before they came into common use by students and research workers in the field of organic chemistry.*

A second irony occurred in 1970, when an article was published by G. W. Evans in *Chemistry*—the ACS sponsored publication designed for high school chemistry teachers—entitled "A Proposed Structural Shorthand for Organic Chemistry," in which Hackh's structural symbols were once again described but represented as an original suggestion on the part of the author and without any reference to Hackh whatsoever (34). This oversight was caught by readers of the journal, and a few months later Evans published a letter properly crediting Hackh but claiming to have had no prior knowledge of his work (35).

Yet a third and final irony lies in the fact that, since the 1970s, a type of highly abbreviated organic structural symbolism closely related to Hackh's original proposals, but even more minimalist in content, has come into general use in the chemical literature (Fig. 8). Already in the late 19th century it was commonplace to represent the benzene ring as an abstract hexagon in which not only the C and H atoms were implicit but the C–H bonds as well. In the case of substituted benzene compounds only the functional groups and nonhydrogenic substituents were explicitly indicated with atomic symbols. By the early 20th century this type of abbreviated symbolism was also being extended to other ring systems, including polycycles, such as naphthalene and anthracene, and heterocycles, such as pyridine and dioxane; and by mid-century its was being widely used in the literature dealing with natural products and biochemistry. The final stage in the evolution of this symbolism—its logical extension to chain hydrocarbons and their derivatives—appears, for reasons which will be discussed in a later section, to have been largely stimulated by the development of explicit retrosynthetic strategies for the synthesis of complex natural products in the late 1960s (36).

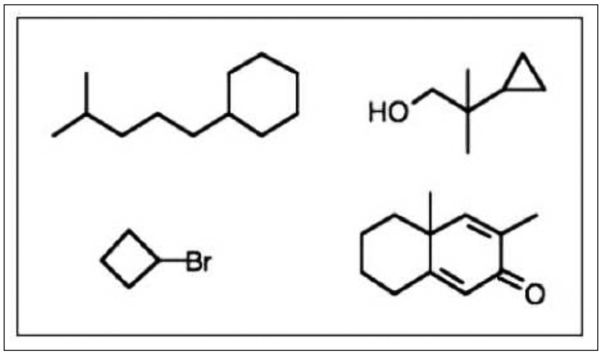

Figure 8. Examples of modern skeletal structure symbols.

While similar in spirit to Hackh's original proposals, there are, of course, some important differences between Hackh's symbols and modern skeletal formulas. Whereas all bonds are explicitly articulated in Hackh's symbols, C–H bonds and bonds within functional groups are often left implicit in the modern symbolism. Whereas the symbols for H, O, N, and C are implicit in Hackh's symbolism, only the symbols for H and C are implicit in the modern symbolism and then only if they are not part of a functional group. In keeping with their purely topological significance, carbon chains were written in a straight line or as branched at right angles in Hackh's symbols, whereas they are written in a zigzag fashion in modern symbolism, since suppression of the C–H bonds now requires the presence of kinks in the chain to indicate the locations of secondary carbon centers. Likewise, terminal points now indicate the locations of primary carbon centers rather than hydrogen atoms, and the convergence of three bonds at a common junction now indicates the location of a tertiary carbon center rather than a nitrogen atom.

Who was Ingo Hackh?

Before speculating on the reasons for Hackh's failure to win widespread support for his symbolism, it is necessary to say a little about his life and career, since both are relevant to our final conclusions. Born Ingo Waldemar Dagobert Hackh (Fig. 9 and 10) in Stuttgart, Germany, on March 25, 1890, Hackh received a Ph.G. degree at

Figure 9. *A young 29-year old Ingo Hackh around the time he first proposed his system of structure symbols as he appeared in the 1919 issue of* Chips*, the student yearbook for the College of Physicians and Surgeons in San Francisco. (Courtesy of the Institute of Dental History and Craniofacial Study, University of the Pacific.)*

age 19 from the Technische Universität Braunschweig. For readers unfamiliar with this degree, it stands for pharmacy (Ph) graduate (G) and was generally awarded for having completed a two- or three-year undergraduate program of course work. Graduation was followed by employment as a chemist for the firm of E. DeHaen in Seelze, Germany, and immigration to the United States in July of 1912. From 1912 to 1915 Hackh was employed as a pharmaceutical chemist, first by the Abbott Alkaloid Company of Chicago and San Francisco (now Abbott Laboratories) and then by the Von Ruck Research Laboratories. In 1915 he entered the chemistry program at the University of California, Berkeley, from which he received an A.B. degree in chemistry in 1917. Staying on for another year at Berkeley as an assistant in the Chemistry Department, Hackh was appointed in late 1918, at age 28, as Professor of Biochemistry at the College of Physicians and Surgeons in San Francisco, a position he held until his premature death in 1938 at age 48.

***Figure 10**. Hackh as he appeared in 1929 at age 39, the year the first edition of his chemical dictionary was published. (Courtesy of the Institute of Dental History and Craniofacial Study, University of the Pacific.)*

In addition to his short booklet on organic symbolism, his highly successful chemical dictionary, and over two dozen published papers in a wide variety of chemical and pharmaceutical journals, Hackh also published a speculative monograph in German on atomic structure and the periodic table titled *Das synthetisches System der Atom* (1914), a popular account of the discovery of the chemical elements titled *The Romance of the Chemical Elements: Their History and Etymology* (1918), and a second short study booklet for students titled *Chemical Reactions and their Equations: A Guide for Students of Chemistry* (1928) (37-40). Though initially favoring a spiral form of the periodic table in his 1914 monograph, Hackh later opted for a rather eclectic rectangular table, which he advocated in numerous published papers and also incorporated into his later books and dictionary (41-42). Unlike his structure symbols, his proposals concerning the periodic table are still mentioned in most histories of the subject and on the websites of those who are currently obsessed with this topic (43-44).

Why was Hackh Unsuccessful?

The answer to this question will come in two stages—the first sociological in nature and the second scientific. Though most scientists wish to deny it, repeated studies by sociologists of science have convincingly shown that the ability of a scientist to successfully market his or her scientific ideas depends as much on their personal prestige within the scientific community as on the intrinsic merits of their ideas (45). Hackh not only lacked such prestige within the chemical community—having come out of a pharmacy background and having spent most of his career teaching organic chemistry and biochemistry to students of dentistry; he actually operated at the fringes of the chemical community. This fringe status was also reflected in the fact that all of his books were published by the Blakiston Company of Philadelphia, a publisher that specialized in textbooks and monographs targeted at medical, pharmacy, and dentistry schools rather than at university chemistry departments.

Despite his obvious competence, Hackh was not a practicing research organic chemist in the laboratory sense, and he appears to have had no contact with those at the center of the organic chemistry research community. Unfortunately, his attempts to circumvent this problem by publishing in the chemical education literature overlooked a depressing truth about curriculum innovation: namely, that significant changes in subject content, notation, and symbolism essentially occur by a one-way process which flows from the research literature into the chemical education literature but almost never in the reverse direction. In other words, innovations prompted by pedagogical considerations, however cogent, almost never have a significant impact on the research literature.

This latter truth is illustrated by the fact, mentioned earlier, that the minimalist, skeletal, organic symbolism used today, not only in the research literature but, to an increasing extent, in the textbook literature, appears to have originated in the research literature dealing with the chemistry of complex natural products rather than in an explicit attempt to streamline the teaching of organic chemistry. As the natural products being studied became increasingly complex and the required synthetic routes ever more lengthy and challenging, there was increasing pressure to move beyond the personal intuition or *chemisches Gefühl* approach of earlier workers in the field to an explicit articulation of the assumptions underlying the various synthetic strategies. The resulting "retrosynthesis" methodology soon came to focus on two key issues: techniques for the manipulation of the underlying carbon framework (e.g., extension, ring formation, stereospecificity, etc.) and techniques for the insertion, exploitation, and/or masking of key functional groups—the two essential features of an organic structure that are retained in our modern minimalist, skeletal formulas.

This then provides us with the scientific reasons for Hackh's ultimate failure. His own structure symbols failed to properly identify and focus on these two essential parameters of modern synthetic organic chemistry. By retaining the H–C bonds, his symbols became too cluttered and confusing when applied to very complex structures. By selectively treating those functionalities containing oxygen and nitrogen in the same manner as the carbon framework, he failed to properly highlight what was in fact the most important determinant of reactivity for most organic compounds. In short, his symbols, however internally logical and self-consistent, both failed to make explicit those features (i.e., certain functional groups) which should have been emphasized and to make implicit those (i.e., the C–H bonds) which could be safely deemphasized.


Figure 11. *Two late 18th-century pharmacy jars illustrating traditional pharmaceutical symbolism.*

In closing, I cannot resist making one final speculative observation. In reading Hackh's various publications on this subject, I was struck by an increasing tendency on his part to make the resulting formulas evermore stylized and abstract in appearance, so that in the end they look almost like mystical symbols or hieroglyphs, as well as by his repeated attempts to eliminate as many explicit atomic symbols and other letter abbreviations (such as R for generalized alkyl groups) as possible, as though they were so many would-be blemishes on the geometric purity of the final symbols. Given Hackh's European pharmacy background, in which abstract symbolism was once a commonplace in the labeling of pharmacy bottles (Fig. 11), I cannot help but wonder whether a knowledge of this ancient pharmaceutical tradition might have played a subconscious role in shaping these two tendencies (46).

ACKNOWLEDGMENTS

I would like to thank Dr. Dorothy Dechant, Museum Curator of the Institute of Dental History and Craniofacial Study, University of the Pacific, for her assistance in providing portraits of Hackh (Fig. 9 and 10) and for her help in verifying certain biographical details. Thanks also to Dr. Theodor Benfey, former editor of *Chemistry*, for his help with regard to the Evans affair.

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Renewing the Heritage of Chemistry in the 21st Century

Conversations on the Preservation, Presentation and Utilization of Sources, Sites and Artefacts

A Symposium of the Commission on the History of Modern Chemistry (CHMC)

Paris, 21-24 June 2011

A century on from the award of the Nobel Prize for chemistry to Marie Curie, it is appropriate that this symposium should be taking place in Paris. The discussions we propose are also timely, since in our 21st century new scientific ideas and new technologies have changed the face of chemistry itself and the nature of the sources for its future history. Along with the paper documents, oral histories, instruments, and other artefacts that have previously embodied the heritage of chemistry, we now need to include source-materials and artefacts of a quite different nature, including electronic documents, images, videos, databases, software, and the hardware necessary for the preservation of this enlarged range of resources.

The preservation of key locations associated with the heritage of chemistry is another matter in which historians, curators, and industrial archaeologists have a common interest. Such sites include academic and industrial research laboratories and sites of technological innovation which allow scholars to see apparatus and equipment in their original settings, while informing the general public in ways that highlight key developments and advanced understanding.

Historians, chemists, archivists, museum curators, librarians, and industrial archaeologists and all those interested in the heritage of chemistry in the 20th and 21st centuries, are invited to meet in Paris on 21-24 June 2011 for a symposium to share their ideas. Our intention is to present the fruits of historical research based on the sources, sites and artefacts of chemistry and the views on the technical problems related to the preservation and presentation of these resources for both historians and the general public.

For further information, see http://chmc2011.fr/ or http://chmc2011.fr/?lang=en

LETTER: Vedic Hinduism and the Four Elements

In his articles on the theory of four elements—water, air, earth, and fire—Habashi mentions that this theory was known by ancient civilizations in the East long before the Greeks (1,2). I would like to confirm that this theory was actually mentioned in the Indian book *Alchemy: Soma in the Veda*, in which the Vedic Hindus of 3000 BC made alloys of gold and silver (3). Vedas are the books of knowledge created by ancient Hindus. In the Vedas, Vayu is air, Agni is fire, Varuna is water, and Prithvi is earth. The powerful Surya, or the Sun, was at the center, surrounded by eight planets: Mars (Angaraka), Mercury (Budha), Jupiter (Guru), Venus (Sukra), Saturn (Sani), Moon (Chandra), and two nodes (Rahu and Kethu). These nine (excepting Prithvi) were considered Nava Graha (nine houses). The astrological relationship of these four elements with the planets is also discussed in the Vedas (4). In addition to these four elements, Vedas and Upanishads (interpretations of Vedas) also mention other material elements which form the basis of intelligence and consciousness in describing life (5). This has been one of the pursuits of the scientific community besides developing and understanding of material things. Such knowledge has been kept up over the millennia by transferring by word of mouth from generation to generation. They have been transcribed to the printed form only recently.

Vedic Hinduism preceded the later religions such as Buddhism and Jainism springing out of Hinduism to overcome some of the interim fallen knowledge in the 6th century BC. Thanks to Habashi for the Cambodian Temple reference (2)—which was actually a Hindu Temple at the time mentioned in the article. Knowledge of the Vedic period was not known to many in the West.

—Neale R Neelameggham, South Jordan, Utah, neelameggham@yahoo.com.

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BOOK REVIEWS

Pharmacy and Drug Lore in Antiquity: Greece, Rome, Byzantium. John Scarborough. Variorum Collected Studies Series. Burlington, VT, Ashgate Publishing Company, 2009, xxviii + 354 pp, ISBN 978-0-7546-5954-9, $165.

In his preface to this erudite and engaging collection of essays John Scarborough laments the divide that grew up between classicists, on the one side, and scientists and medical doctors, on the other, as the classics receded as a component of liberal education in the twentieth century. One of the consequences of this divergence, he points out, was loss of attention to the place of medicine, and of drugs in particular, in ancient life and literature.

Scarborough's own scholarship represents a historian's response to this challenge. The fourteen articles and chapters here included span more than a millennium of Greek, Roman, and Byzantine history, and range in subject from the pharmacology of sacred plants, roots, and herbs, through drugs in Pliny's *Natural History*, to herbs of the field and garden in Byzantine medicinal pharmacy.

At first sight the chronological scope and variety of topics in this collection suggest a lack of unity and coherence. Reading quickly dispels this impression, however, as several general themes and issues emerge from the detailed and focused individual studies.

One of these has to do with the relations between empirical and magico-religious elements in Greek and Roman perceptions of the causes of the properties of drugs. Scarborough makes clear that these elements were often fused in popular beliefs and practices from the time of Homer on. This fusion is reflected, for example, in the writings of Theophrastus, who drew extensively on the lore of "root-cutters" and other popular sources for his knowledge of the uses of plants.

Closely related to this theme is Scarborough's insistence on the insufficiency of trying to understand ancient drug ideas and practices in terms of modern ideas of drug action and efficacy. In some cases he provides much modern botanical and chemical-pharmacological information about plants and drugs, as in his analysis of Theophrastus. Although some ancient drugs, or their constituents, survive in modern medicine, Scarborough shows that even in these cases it is not always possible to establish a one-to-one correlation between ancient and modern use. He rightly emphasizes, and shows with many examples, that we do not understand ancient drug practices simply by applying criteria of modern pharmacology, because there are many magical or religious meanings and rituals associated with drugs that we cannot now reconstruct. Such a finding points to the need for an anthropological model, or models, of the place of drugs in the beliefs and practices of ancient societies. While acknowledging the need, Scarborough does not claim to supply these models, and we are left with tantalizing glimpses of particulars for which they might provide interpretation.

Juxtaposed with this anthropological tendency, and somewhat in tension with it, is Scarborough's insistence that ancient knowledge and practice involving drugs changed significantly over time. Change could take the form of the evolution of medical doctrines, as in the Hippocratic writings from the fifth century BC to the first century AD. It could also take the form of incremental accumulation of empirical formulas derived from observation and trial and error, and ultimately sifted and organized by writers such as Dioscorides in the first century AD or Paul of Aegina in the seventh century. In some passages this comes across as a kind of progress, although as the case of the second century BC poet Nicander indicates, at least in its written embodiments drug knowledge could undergo degradation as well as improvement.

Writers on drugs provide most of our sources for ideas and practices in antiquity, and Scarborough proceeds on the view that the written record represents the place of drugs in Greco-Roman and Byzantine medicine in general. Popular beliefs and usages are visible, at least in partial ways, through the medium of the major writings. Dioscorides' *Materia Medica*, for example, is the basis of Scarborough's analysis of the place of the opium poppy in Hellenistic and Roman medicine. Scarborough shows that in the chapters of Theophrastus' *Inquiry into Plants* in which he discusses drugs, he relies on knowledge of root-cutters and drug venders, which he treats in a critical way. Pliny's *Natural History* shows familiarity with Greek writings on drugs, but also incorporates widespread popular practical knowledge of drugs and an associated folkloric tradition in Roman Italy. The examples of two kinds of incense found in a collection of Greek and Coptic papyri illustrate connections between expert and popular drug knowledge in Roman and Byzantine Egypt.

The popular sources of drug lore as refracted through medical writings on occasion suggest the social location of drug practices. Galen's commentary on Hippocratic writings on drugs, for example, suggests that the richest information in this literature came from midwifery, not formal medicine. Elsewhere Scarborough points out that a significant number of ancient drugs were used as contraceptives or abortifacients, suggesting use by prostitutes as well as by other women wishing to avoid pregnancy.

Taken together, these essays document an extensive, variegated, and evolving knowledge of drugs in both the medical writings and the popular beliefs and practices of Greek, Roman, and Byzantine antiquity. Scholars will find in them a valuable resource, enhanced by an index that enables study of single topics across the separately paginated chapters. They should also appeal to anyone with a serious interest in the long and multifaceted human experience with drugs.

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Errata

Two captions of two figures are incorrect in James J. Bohning, "History of HIST. II. On Probation," **2010**, *35(2)*, 66-80. The correct captions follow:

Figure 4. *Lyman C. Newell, Boston University, first Secretary of HIST. Edgar Fahs Smith Collection, University of Pennsylvania Libraries.*

Figure 5. *Charles A. Browne, first Chair of HIST, with his wife Louise and daughter Caroline, Christmas 1937. Edgar Fahs Smith Collection, University of Pennsylvania Libraries.*

Materials and Expertise in Early Modern Europe, Ursula Klein and E. C. Spary, Eds., University of Chicago Press, Chicago, IL, 2010, 408 pp, ISBN 978-0-226-43968-6, $50.

This interesting collection of papers, from two workshops held in Berlin in 2004 and 2006, is edited by Ursula Klein, a researcher in the history and philosophy of chemistry at the Max Planck Institute for History of Science in Berlin, and Emma Spary, a lecturer in the history of science at Cambridge University. The book includes twelve contributions from twelve different authors, which are divided into three parts, "The Production of Materials," "Materials in the Market Sphere," and "State Interventions." The editors have provided a general introduction to the volume and a separate introduction for each individual part, offering themes that unite an otherwise quite diverse group of papers. While each contribution treats a different material—or group of materials—they do so in very different ways. In favor of the coherence of the whole, most of the contributions do have something to say about the relationship between craft skills and academic science in the period from 1600-1800, which the editors propose as the overarching *leitmotif* for the book.

Following an introduction that offers an interesting perspective on the long-running historical debate over the origins of modern science in the head (the history of science as the history of ideas) or in the hand (a history of science as the formalization of mechanical and chemical knowledge), the book opens with a chapter on vermilion by Pamela Smith. This historian of the commerce of alchemy presents a number of interesting reflections on this red pigment and its association with other alchemically significant objects such as mercury, blood, and lizards. The next paper, by Hanna Rose Shell is more biographical, exploring the work of Bernard Palissy in the 16th century. This extraordinary artist and natural philosopher is best known for his ceramic reproductions of amphibians, fish, seashells, and fossils in elaborate basins and platters. As the aptly named author explains, Palissy's casting and creations—his 'biomorphic earthenware'—were linked to a profound interest in natural history and the nature of life. Christoph Bartels next offers a chapter on early mining and metallurgy in the Harz Mountains, focusing in on a 17th-century debate about the use of gunpowder for rock-blasting, showing the increasing significance of scientifically trained administrators like Heinrich Albert von dem Busch. Adrian Johns' chapter on ink is the most literary in the book; and in it he rightly points out that while there has been a great deal of interest in the history of printing technology, there has been little study of the technology of ink. Nevertheless, he offers only very general indications as to what such a history would look like. Ursula Klein's own paper on ethers closes the first part, and she traces the interest that 18th-century pharmacists displayed in this innovative and evocative substance, both as a medicine and as a subject of experimental investigation.

The second part opens with Barbara Orlan's essay on milk in 18th-century France. Here the author shows how chemists such as Parmentier and Déyeux took an interest in the chemical analysis of milk in a context where milk was both commercially and culturally important. While the results of the analyses were far from decisive, they still enabled the two to offer chemical reflections on the relationship between milk, butter, and cheese. The following paper on the virtues of the spa water at Peterhead in Scotland is more oriented towards an investigation of the status of the experts promoting the therapeutic qualities of spa water at the end of the 18th century. Here, Matthew Eddy focuses on Rev. William Laing, a keen amateur in chemistry and medicine, who earned an M.D. without attending medical school and became a diligent promoter of the therapeutic virtues of Peterhead water. In Chapter 9, Emma Spary takes us into the world of liqueurs in 18th-century Paris. She places this luxury good at the heart of competing guilds—apothecaries, *limonadiers*, and distillers—and brings to light a debate over the status of liqueurs as medicines or intoxicating drugs.

The last part of this collection titled "State Interventions" covers agriculture, gunpowder, and dyeing. Marcus Popplow proposes an analysis of agriculture in 18th-century Germany with a marked orientation toward economic theory. He is particularly interested in the strategies of "economic improvers" in the agricultural sphere who attempted to amass useful natural, historical, meteorological, and other relevant information in order to improve the agricultural economies of the German lands. In the next chapter Seymour Mauskopf treats the quality of gunpowder in 18th-century England, presenting an outline of how it was manufactured and how this manufacture was organized between public and private powder mills at the time. He is especially interested in the efforts of William Congreve to improve the quality of gunpowder at the end of the 18th century, and in particular to make the testing of gunpowder more reliable. The message conveyed by Mauskopf is that the domain of ballistics, artillery, and gunpowder was much more complex than one might suppose and that relevant advances in the chemistry involved (the chemistry of gases) contributed much less than empirical trial and error to the improvement of this military resource.

The book closes with a chapter by Augustí Nieto-Galan on the art of dyeing in France, which underlines the importance of a move in the 18th century from domestic production in small workshops to the large "manufactures" that implied a more stringent division of labor and a consequent multiplication of specialists within the industry. Dyeing and printing were complex crafts involving the use of many chemical agents, and like most crafts they were perpetuated by oral traditions within guild structures. The author closes the chapter with the example of Berthollet's introduction of chlorine bleaching, showing how rather than being held up as a triumph of the new chemistry, it was simply integrated into the range of practical techniques already available to the dyers for achieving the same end. Here, Nieto-Galan challenges the gloss that the editors want to give to these histories. In the general introduction, the editors suggest that the whole book consists of an "inquiry into the interconnectedness of the sciences, technology, and society in the early modern period, through particular sorts of material objects and practices;" but their particular approach is to stress the importance of "experts" who move between the world of "learned inquiry" and the nonacademic world of the arts and crafts. While it is a good idea to have a central theme around which to unite the diverse contributions to a collected volume, I am not sure that this one is the best one for examining the place of materials in 18th-century culture. Be that as it may, I suspect that most readers will search out the chapter on the material that is of particular interest to them rather than reading the whole for a coherent sustained argument that they would be more likely to find in a monograph.

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Sites of Chemistry, 1600-2000

The Sites of Chemistry, 1600-2000 is a four-year project to investigate the multitude of sites, spaces and places where chemistry has been practiced since 1600. These will be explored over the next four years in a series of annual conferences, each devoted to a particular century. A final conference in early 2015 will explore themes and developments over the whole period and on a broader comparative scale. The first conference, on the "Sites of Chemistry in the 18th Century," will be held in Oxford at the Maison Française on 4-5 July 2011 and proposals for papers are invited.

For further details on the project, topics and themes, programme, planned publications, funding, and organization, see http://www.sitesofchemistry.org.

For further information contact the co-ordinators of the project, John Perkins, jperkins@brookes.ac.uk, and Antonio Belmar, belmar@ua.es.

The Historiography of the Chemical Revolution: Patterns of Interpretation in the History of Science, John G. McEvoy, Pickering and Chatto, London, 2010, 352 pp, ISBN 978-1-84893-030-8, £60/$99

As the author points out in his preface, "the Chemical Revolution is generally regarded as the birth of modern chemistry and as the very paradigm of a scientific revolution." Given the significance of the changes in chemistry between 1770 and 1840, the extent of the attention of historians of chemistry paid to this period is not surprising. John McEvoy's book is an in-depth examination of that attention. It is a scholarly and analytical work that requires and deserves close reading.

McEvoy's credentials for undertaking such an enterprise are impressive; a series of at least a dozen substantial articles published between 1988 and 2000, references to which are included in the comprehensive bibliography of this volume, provide some of the background research. The author's aims are spelled out: "Addressing the needs and concerns of the scholarly practitioner, it is designed to provide the neophyte with a useful guide through the intricate labyrinth of fascinating philosophical and historiographical issues associated with past and present interpretations of the Chemical Revolution …"

The Introduction to the book covers the philosophical and historiographical terrain and prepares the reader for the chapters that follow. The Chemical Revolution can be regarded as "the Cinderella of 'scientific revolutions'" compared with the scientific revolution of the seventeenth century and the Darwinian revolution of the nineteenth. But even this Cinderella has drawn a substantial amount of description and commentary, and one aim of this book is to analyze the patterns of interpretation that historians of chemistry have applied. In McEvoy's judgment there is a relatively small number of such patterns.

The titles of the seven chapters give clear descriptions of the scope of each. Chapter 1 on positivism, whiggism, and the Chemical Revolution discusses the hold that these perhaps earlier views of the Chemical Revolution had on historians of science, and the difficulties more recent historians have had on escaping from the constraints of these views. Chapter 2 discusses postpositivism and historiography taking as its starting point the 1950s and 1960s, and giving pride of place in the reinterpretation to Henry Guerlac's 1961 book *Lavoisier–The Crucial Year*.

Postpositivist interpretations of the chemical revolution occupy Chapter 3, which includes attempts to separate the social from the conceptual backgrounds of Lavoisier's work. Chapter 4 looks at the transition from modernism to postmodernism, and reviews changing philosophical images of science; it looks at David Bloor's "Strong Programme" (1976) which founded the current discipline of the sociology of scientific knowledge and rejects earlier views of Robert Merton and Karl Mannheim. Chapter 5 on the sociology of scientific knowledge and the history of science continues this theme examining how the social environment of knowledge may shape what we might consider as the essentials of science including discoveries, inferences, and even objectivity and credibility.

Postmodernist and sociological interpretations of the Chemical Revolution are the themes of Chapter 6. These approaches stress the local rather than global cultures of chemistry, rejecting Kuhn's paradigmatic shift view of the Chemical Revolution in favor of "geographically distributed and culturally differentiated sites of local knowledge production."

The final chapter (Chapter 7) on the Chemical Revolution as history returns to the complexity and nuances of the revolution, suggesting that rather than focusing on the narrower views of philosophical and sociological interpretations of the revolution, future historians should be looking at integrative solutions that incorporate the complexity of the events and conditions that make up the Chemical Revolution.

This book is a major contribution to the history of chemistry. It includes extensive chapter notes, a comprehensive bibliography, and a full index. I recommend it highly.

Harold Goldwhite, California State University, Los Angeles

Much Ado about (Practically) Nothing: A History of the Noble Gases. David E. Fisher, Oxford University Press, Oxford, UK, and New York, 2010, x + 259 pp, ISBN 978-0-19-539396-5, $24.95.

In the first chapter, David Fisher explains that his "book is an attempt to portray the most important aspects of the story" of the noble gases, " along with an account of my fifty years with the gases and people met along the way." He also emphasizes that the account is "readable (i.e., jargonless)." This is no way prepares the reader for the quirky mix that follows.

For one thing, the dominant story line is really Fisher's work with the noble gases, with an emphasis on how this work shaped a somewhat erratic career that began at Brookhaven National Laboratory and ended up at the University of Miami with stops at Oak Ridge and Cornell University along the way. The focus here is at least as much on Fisher and the ups and down of his career as it is on the history of the noble gases.

I hasten to say that the focus on a scientist's research career adds a useful dimension to the narrative. As a historian of science I was particularly interested in Fisher's initial attempts in the late 1950s to explore the nuclear structure of a wide variety of noble gas isotopes. First he tried using Brookhaven's Cosmotron to irradiate targets and a mass spectrometer to make the measurements. When that did not work, he decided to "turn it around and use meteorites to study the nuclear reactors I was interested in: instead of putting an iron target in the Cosmotron, we could use the iron meteorites that had been irradiated out in space." (p 16) Although that did not work, he ended up being able to use what was known about the nuclear reactions to discover something about the history of the meteorites. In the course of this story, Fisher provides many details about what it is really like to work in a lab, the fact that equipment does not work as advertised, that there is a pecking order for who gets to use a large instrument, that nature is tricky, and the research life full of disappointment as well as exhilaration.

I initially thought this might be a good book for use in the classroom, especially since the personal narrative is broken by a collection of witty and entertaining historical anecdotes about various discoveries related to the noble gases. These stories echo the theme that research life is unpredictable and do a good job of illustrating how understanding comes thanks to happenstance as well as persistence, intelligence, and hard work. But as I read on I began to wonder whether this was really a book for students. For one thing, the narrative shifts back and forth from subject to subject and between tales of the noble gases and Fisher's career in a manner that I fear would be confusing to them. In addition, the somewhat disjointed narrative tends to let out Fisher's inner smart-aleck. For example, in the midst of telling the story of argon, he notes the initial contributions made by Joseph Priestley, who contradicted Aristotle's notion of air. This prompts the aside that Aristotle "was wrong in just about everything, from the movements of the stars to the seat of human consciousness, but two thousand years later he was still The Man." (p 19) In fact, Fisher, though not wrong about everything, is frequently wrong about episodes in the history of noble gases not directly connected to his own experience. For example, Fisher incorrectly states that Priestley was not controversial in England before the French Revolution and that Joseph Black conducted experiments "on Priestley's fixed air" (p 22) when in fact Black isolated and named fixed air before Priestley worked on it. Some of the descriptions of Fisher's career are also unsuitable for students; for example his ugly tenure fight at Cornell that included a slur on his wife (which he is quick to dispel), an account that names names and seems to be aimed at settling scores.

On the other hand, who says every book has to be a textbook? All in all I think this book will appeal to historians of science, chemists, and others interested in learning a bit about the noble gases and a lot about Fisher's eventful career and eccentric but entertaining view of research and the research life.

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The Poisoner's Handbook: Murder and the Birth of Forensic Medicine in Jazz Age New York. Deborah Blum, Penguin Press, New York, 2010, 336 pp, ISBN 978-1-59420-243-8, $25.95 hardcover, $16.00 paper (978-0143118824).

The Poisoner's Handbook is about chemistry *in* history rather than history *of* chemistry. It is a rare example of a narrative that gives chemistry—or rather forensic science more broadly—as prominent a role in its pages as politics and law enforcement. The intersection of chemistry with history is what makes the book suitable for a review in the *Bulletin*. The topics of poison and murder allow it to tap into the broad audience for mystery fiction and true crime. And the interaction of forensic science with the legal system makes the book relevant to those interested in science and society and useful to those who wish to illustrate such connections. I recommend this book to readers attracted to any of the aforementioned topics. It is well written and, although aimed at a popular audience, well documented.

Deborah Blum brings her formidable story-telling skills to the topic of forensic science in New York city during the 1920s and 1930s. The book's overarching subject is the emergence of an effective and professional medical examiner's office in New York, largely through the efforts of chief medical examiner Charles Norris and forensic toxicologist Alexander Gettler. Blum, a Pulitzer Prize winning journalist who teaches science writing at the University of Wisconsin-Madison, constructs her narrative from building blocks of poison-related murders, suicides, and accidents. These incidents have the immediacy of scenes from crime fiction or reporting. They give the reader the sense that they were "ripped from the headlines" of their day, and indeed, Blum's notes are replete with references to accounts in contemporary newspapers.

The organization of the book is primarily chronological, although the chapters are named for toxic substances. In the table of contents, each chapter is designated by a name and formula; however, the heading at the start of each chapter also includes a time period of a year or two. At least one poisoning involving the title element or compound has a featured role in each chapter, but it would be misleading to say that the chapter is primarily "about" that material. In between "Chloroform ($CHCl_3$), 1915" and "Thallium (Tl), 1935-1936," cyanides, carbon monoxide, methyl alcohol, and more are featured—and, of course, arsenic.

The chapters may be named after chemicals, but the real protagonists are Norris and especially Gettler, both of whom are well characterized as individuals. Norris was the first professional medical examiner of New York city after state law and pressure from the governor abolished a system in which the coroner was a political appointee, often unqualified, of Tammany Hall. Norris is described principally as a dedicated and able administrator, but he continued to perform autopsies throughout his career. He was not afraid to write to the press or to complain to the mayor or other officials for the resources his office needed to do its job.

Gettler, the principal scientist in the story, was an extremely hard worker, combining his job as forensic toxicologist in the medical examiner's office with a pathology position at Bellevue Hospital and a faculty appointment at New York University. Blum describes several analytical procedures he developed to detect poisons in various tissues. She also explains experiments he conducted to determine how long certain toxins remained in tissue post-mortem and whether they could be produced by decomposition. Blum tells us that Gettler enjoyed gambling and cigars, but to reporters interested in his cases, he appeared to be dull. (In one contemporary account, he was said to have "a personality as colorless as the sodium chloride that he works with.")

Prohibition has as pervasive a role in this tale as that of the principal actors, Gettler and Norris. The Eighteenth amendment of the US Constitution, which would prohibit making, selling, or transporting "intoxicating liquors" for "beverage purposes," passed the Congress in December 1917, near the beginning of the period treated in the book. It was ratified in January 1919 and went into legal effect a year later. Until December 1933, Prohibition was the law of the land, albeit a law much ignored, despised, and circumvented. For this reason, ethyl alcohol gets a chapter in the book, including some discussion of its relatively low-grade toxicity. Methyl alcohol gets two chapters (one under the heading of wood alcohol) because of its widespread use as an adulterant of or substitute for ethyl alcohol. How bootleggers and owners of speakeasies filled the demand for intoxicating beverages with industrial denatured alcohol redistilled to a greater or (too often) lesser extent is a recurrent motif among the tales of poison in these pages.

Another important theme in the book, although more understated, is the *laissez faire* attitude toward public and occupational health and safety that prevailed at the time. Many supporters of Prohibition were unconcerned with the public health consequences of adulterated liquor, because liquor was illegal. Acute poisoning by tetraethyl lead and chronic poisoning by radium are among the hazards faced by workers near New York and described by Blum. The household use of gas produced from coal and comprised mainly of carbon monoxide and hydrogen was apparently tolerated as a matter of course, despite the predictable tragic consequences of accident, suicide, or murder.

Chemists will notice occasional turns of phrase to remind them that the author is not a chemist. There are even rare lapses, such as calling DDT an organophosphate. But *The Poisoner's Handbook* is to be commended for illustrating how individuals like Gettler and Norris applied science to help the legal system hold murderers to account and protect the innocent and for communicating the hazards attendant on injudicious use of many materials.

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International Society for the Philosophy of Chemistry

The International Society for the Philosophy of Chemistry—Summer symposium 2011, will be held during August 9-11, 2011, in Bogota, Colombia, at the campus of the Universidad de los Andes. The conference is being sponsored by the Universidad de los Andes (Colombia).

This event is the continuation of the International Society for the Philosophy of Chemistry—Summer symposium 2010, organised in Oxford at the University College during August 9-11, 2010.

For further information see https://sites.google.com/site/intsocphilchem2011/

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