

# Physical Chemistry Before Ostwald:

## The Textbooks of Josiah Parsons Cooke

### 1. Introduction

In keeping with the theme of this meeting's Bolton Symposium on the Great Books of Chemistry, my task this afternoon is to review for you the textbooks of the 19th-century American chemist, Josiah Parsons Cooke, of Harvard University (1). Before doing so, however, it is of interest to preface my review with a brief overview of Cooke's life and career.

### 2. Josiah Parsons Cooke Jr.

Josiah Parsons Cooke Jr. (figures 1-3) 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 (2). 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 soon constructed a "rudimentary" laboratory in the woodshed behind the family house at Winthrop Place in Boston, where he taught himself chemistry by working through Edward Turner's massive (666 pages) text, *Elements of Chemistry* (3). 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 (38).

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 which 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 (4). However, it was not until the founding of the Harvard Medical School in 1782 and



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

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 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 (5).

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

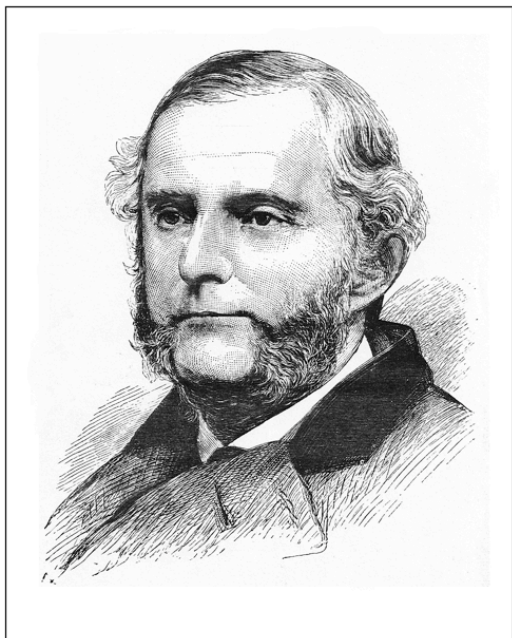


Figure 2. Josiah Parsons Cooke, circa 1877.

– 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

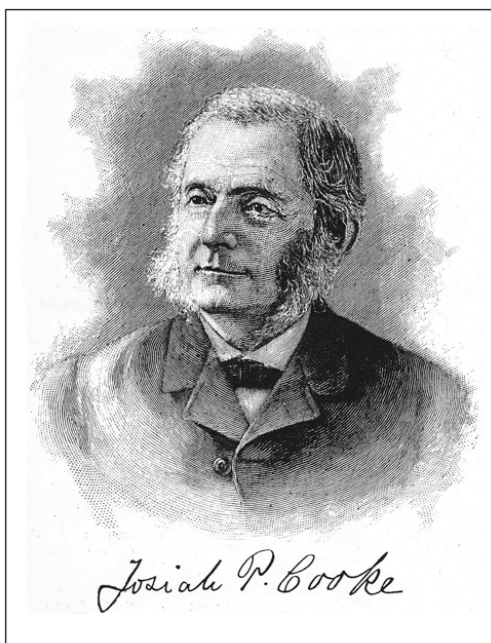


Figure 3. Josiah Parsons Cooke, circa 1887.

the funds to build in 1857 a new chemistry building (figure 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 (2):

*I might simply say in eleven words – “Professor Cooke created the Chemical and Mineralogical Department of Harvard University.”*



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.

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 (6):

*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 rather cruelly suggest that Cooke had made the not infrequent mistake of failing to retire before his powers began to wane (6):





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

*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.*



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

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 (7). 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, though, given Adams' later confusions concerning the application of both the phase rule and the second law of thermodynamics to the study of history, one is inclined to the second interpretation (8).

During his career Cooke also published eight books and 41 research papers, as well as 32 popular essays and lectures (9). 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 (figure 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. And, of course, Richards' most famous student was, in turn, none other than G. N. Lewis.

Yet a second important student of Cooke was the chemist, Charles William Eliot (figure 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 (figure 7), and then, upon his resignation in 1863, by Oliver Wolcott Gibbs (figure 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 assumed that he would succeed Horsford as the

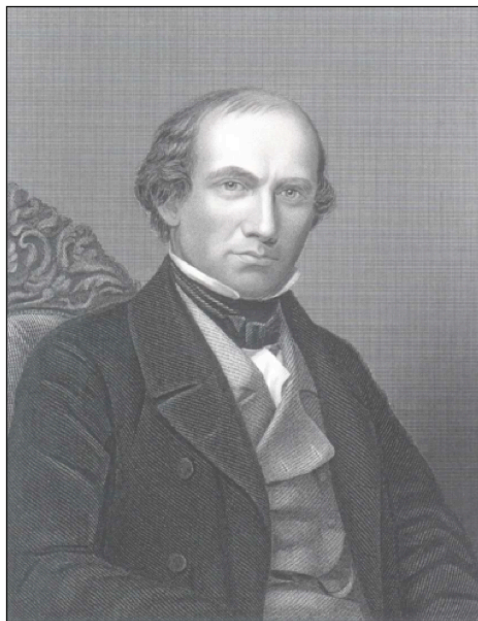


Figure 7. Eben Norton Horsford (1818-1893).

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 (10).

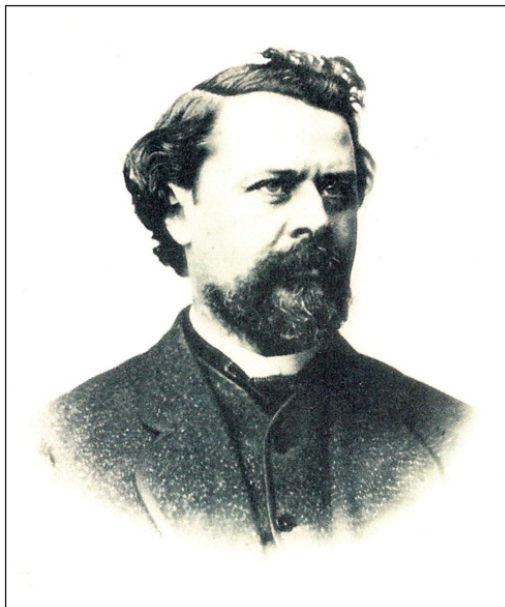


Figure 8. Oliver Wolcott Gibbs (1822-1908).

Lest I leave you 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.

### 3. Chemical Problems and Reactions

The first of Cooke's eight books was a slim 128-page booklet (figure 9) published in 1857 under the title, *Chemical Problems and Reactions To Accompany Stockhardt's Elements of Chemistry* (11). The textbook in question was written by the German chemist, Julius Stöckhardt (figure 10), in 1846 under the title, *Die Schule der Chemie* (The School of Chemistry) (12) and was translated into English in 1850 by C. H. Pierce, who was an assistant to Horsford (13). Horsford had directed Pierce to translate the book and had also contributed an introduction to the final product. The title

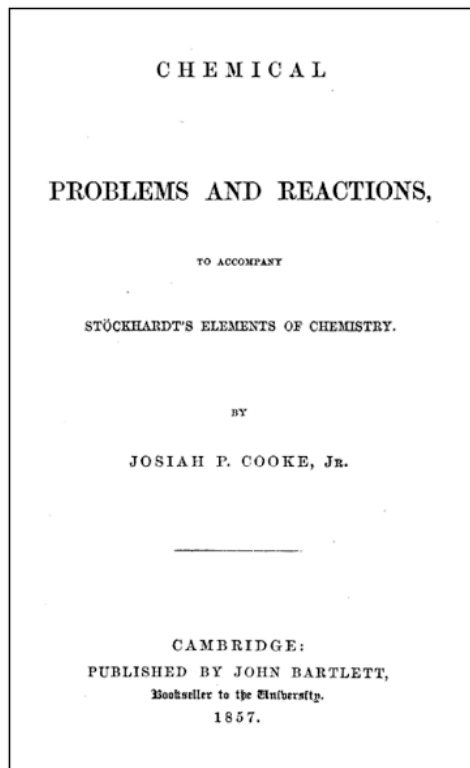


Figure 9. The title page of Cooke's first book.

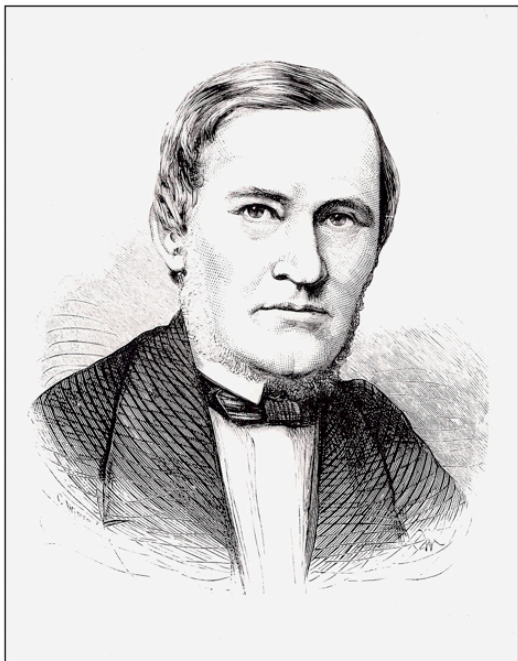


Figure 10. Julius Adolf Stöckhardt (1809-1886).

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.

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 mathematical 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 founda-

tions 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 containing 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, it had several German predecessors, some of which dated back to the 1820s (14).

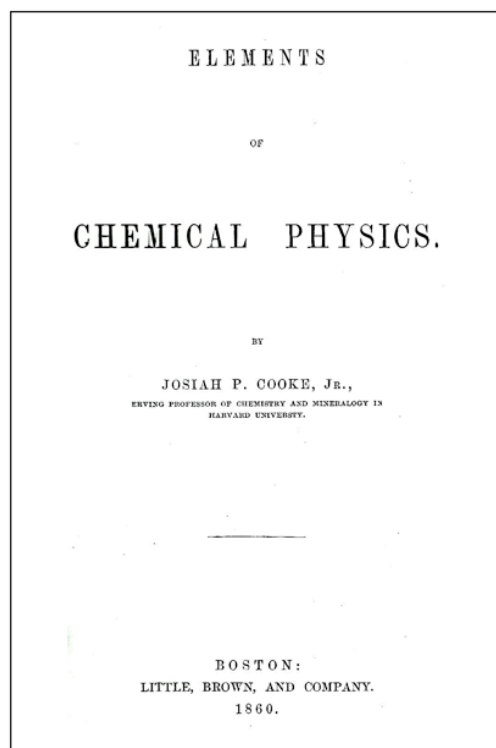


Figure 11. The title page of Cooke's second book.

Table 1. Early Monographs on Chemical Calculations.

Date	Author	Title
1829	Ehrmann	<i>Die Stöchiometrie</i>
1829	Buff	<i>Versuch eines Lehrbuch der Stöchiometrie</i>
1837	Kühn	<i>Lehrbuch der Stöchiometrie</i>
1843	Frickhinger	<i>Katechismus der Stöchiometrie</i>

#### 4. Elements of Chemical Physics

If Cooke's first book had provided evidence of the importance that he attached to quantitative calculations in chemistry, his second book, *Elements of Chemical Physics*, published in 1860, revealed his belief in the importance of having a sound background in physics (15). 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





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

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 said 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



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

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 a three-volume treatise, *Elements of Chemistry, Theoretical and Practical*, by the British chemist, William Allen Miller, first published in 1855 (16). 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.

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* (17). Daniell was Professor of Chemistry at King's College-London and a close associate of Michael Faraday (figure 12). Inspired by Faraday's view (18) 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* (19) – 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 (figure 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

**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

would have, in turn, expanded, Miller’s single volume into a massive three-volume work.

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 (20).

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, 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, many of these older texts organized this material 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.

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.”

## 5. 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 (figure 14) entitled *First Principles of Chemical Philosophy* (21). 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 (22). 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 revised 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 1800 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

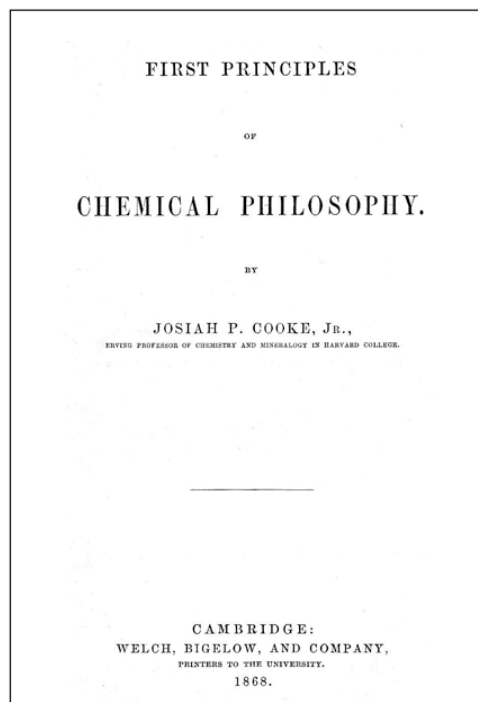


Figure 14. Title page of the rare first edition of Cooke’s *First Principles of Chemical Philosophy*.

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.

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 (21):

*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

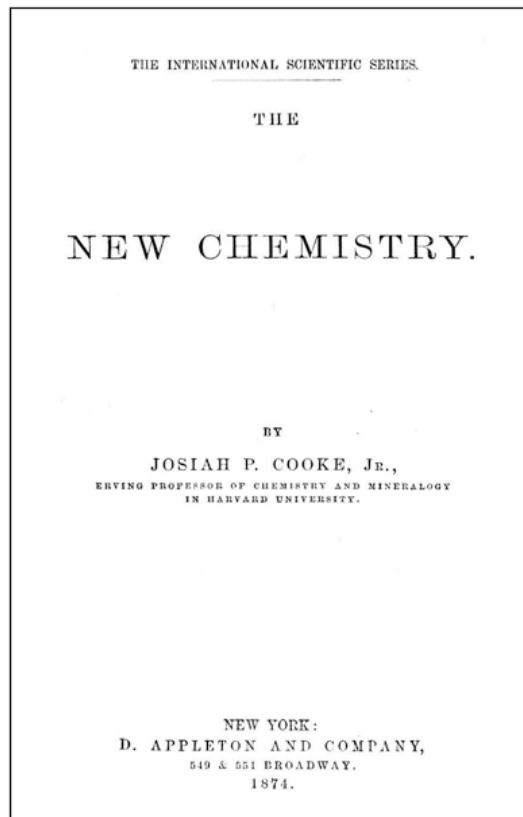


Figure 15. Cooke’s highly popular *New Chemistry* of 1874.

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 (23):

*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 (24):

*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.*

## 6. 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 rein-



forced 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 (figure 15) – *The New Chemistry* of 1874 (25). This book was based on a series of public lectures which Cooke gave at the Lowell Institute in Boston in the fall of 1872 and was published by the Appleton Company of New York as part of its highly popular International Scientific Series.

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 which he owed to the series of Lowell Lectures given many years earlier by Benjamin Silliman Sr. that he had attended as a young teenager (26):

*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 (27). 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 (28).

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 (29):

*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 (29):

*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.*

## 7. Science and Religion

In addition to his textbooks, Cooke also wrote two books dealing with science and religion – his *Religion and Chemistry* of 1864 (30) and his *The Credentials of Science: The Warrant of Faith* of 1888 (31). 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 (32), George Fownes in 1840 (33) and George Wilson in 1862 (34), and 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 the 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 (35):

*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 sopho-



Figure 16. Josiah Parsons Cooke, circa 1890.

more 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 (36):

*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 insisted that he be suspended for a year, and were reportedly “very bitter” when he was let off with nothing more than a public admonition (35).

## 8. Essays and Collected Papers

To the modern reader the greatest value of Cooke’s two volumes on natural theology lies in the insights which 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 gen-

eral can be had by examining his 1881 collection, *Scientific Culture and Other Essays* (37). Several of these essays were also reprinted in his collected *Chemical and Physical Researches* of the same year (9) and also issued as separate pamphlets (29). Unfortunately time considerations and the focus of this symposium preclude any detailed discussion of these otherwise interesting views.

## 9. Influences and Impact

Given that Cooke (figure 16) was totally self-educated as a chemist, his accomplishments and career are truly 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 (29):

*The great difficulty against which the teachers of natural science have to contend in the colleges are 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.*

I am sure many teachers in the audience 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 of Regnault (figure 17) in Paris, 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 way a summary of the kinds of research in which Regnault specialized.

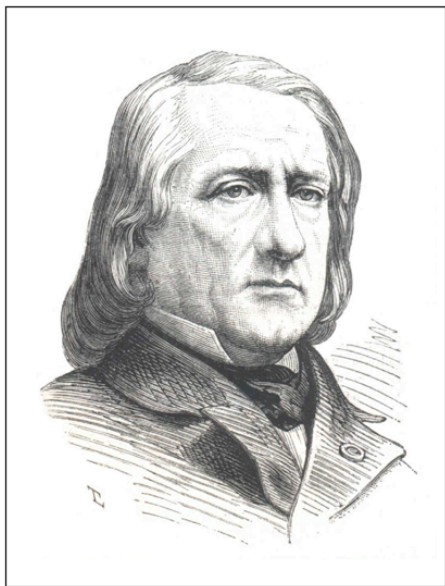


Figure 17. Henri Victor Regnault (1810-1878).

There is still much to learn about Cooke, whether concerning the influences which molded his personal vision of chemistry or his own influence on 19th-century chemical education in the United States. Thus, for example, I have said nothing 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 I can hope to provide in this brief overview lecture.

## 10. References and Notes

1. An invited lecture given as part of the symposium, *Physical Chemistry Books From New England*, held as part of the 240th National Meeting of the American Chemical Society in Boston, MA, 23 August, 2010.
2. The most comprehensive biographical source is still the booklet, C. L. Jackson et al, *Addresses in Commemoration of Josiah Parsons Cooke*, American Academy of Arts and Sciences: Washington, DC, 1895, reprinted from *Proc. Amer. Acad. Arts Sci.*, **1895**, 30, 513-543. See also C. L. Jackson, "Memoir of Josiah Parsons Cooke, 1827-1894," *Biogr. Mem. Nat. Acad. Sci.*, **1902**, 4, 175-183; Anon., "Sketch of Professor J. P. Cooke Jr.," *Pop. Sci.*, **1877**, 6, 1-6; Anon., "Josiah Parsons, Cooke," *Sci. Amer.* **1887**, 57, 377; C. S. Forbes, "Josiah Parsons Cooke, Jr." in C. C. Gillispie, *Dictionary of Scientific Biography*, Vol. 3, Scribners: New York, NY, 1971, pp. 397-399; S. Rosen, "Josiah Parsons Cooke of Harvard," *J. Chem. Educ.*, **1982**, 59, 525. Additional interesting information may be found in reference 10.
3. E. Turner, *Elements of Chemistry, Including the Recent Discoveries and Doctrines of the Science*, 6th ed., Thomas, Cowperthwait & Co: Philadelphia, PA, 1840.
4. For background on the early history of chemistry at Harvard, see I. B. Cohen, *Some Early Tools of Science*, Harvard University Press: Cambridge, MA, 1950, Chapter 4, "The Beginnings of Chemistry at Harvard." and C. A. Elliott, M. W. Rossiter, Eds., *Science at Harvard University: Historical Perspectives*, Lehigh University Press: Bethlehem, PA, 1992.
5. There are many books dealing with the Webster murder and trial. See, for example, J. W. Webster, *The Trial of Professor John White Webster*, Scribner: New York, NY, 1928; H. Thomson, *Murder at Harvard*, Houghton Mifflin: Boston, 1971; R. Sullivan, *The Disappearance of Dr. Parkman*, Little Brown: Boston, 1971; and, most recently, the semi-fictionalized account "Death of a Harvard Man" in S. Schama, *Dead Certainties*, Knopf: New York, NY, 1991.
6. Anon., "Prof. Cooke Mourned at Harvard," *New York Times*, **1894** (9 Sept.), 13. For the nickname "Joby," see reference 35, pp. 72, 134.
7. H. Adams, *The Education of Henry Adams: A Centennial Version*, Massachusetts Historical Society, Boston, 2007, p. 47. I wish to thank Roger Egolf for bringing this quote to my attention. Though Cooke and Adams were fellow faculty members at Harvard from 1870-1877, not only is Cooke not mentioned by name in the autobiography, he is also not mentioned in the five volumes of Adams' collected correspondence.
8. H. Adams, *The Degradation of Democratic Dogma* Macmillian: New York, NY, 1919.
9. In 1881 Cooke bound together reprints of his most important publications in the form of a limited number of presentation volumes. See J. P. Cooke, *Chemical and Physical Researches*, Cambridge, 1881.
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24. Anon., "Review of First Principles of Chemical Philosophy by Josiah P. Cooke," *Amer. J. Sci.*, **1869**, 47, 435.

25. J. P. Cooke, *The New Chemistry*, Appleton: New York, 1874.

26. Quoted in G. P. Fisher, *Life of Benjamin Silliman*, Vol. 2, Scribner: New York, NY, 1866, p. 325.

27. On the concept of three, rather than just one, chemical revolution, see W. B. Jensen, "Logic, History, and the Chemistry Textbook. III. One Chemical Revolution or Three?," *J. Chem. Educ.*, **1998**, 75, 961-969.

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31. J. P. Cooke, *The Credentials of Science: The Warrant of Faith*, Carter: New York, NY, 1888.

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34. G. Wilson, *Religio Chemici*, Macmillan: London, 1862.

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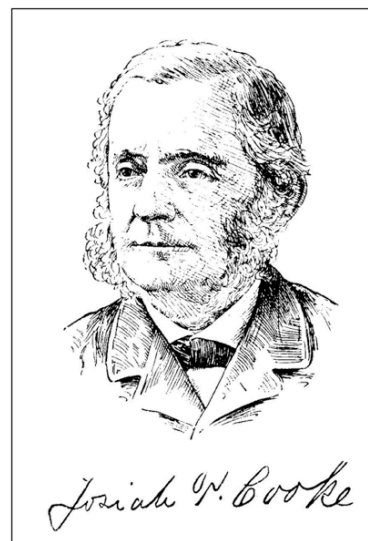
38. The Weissman Center for Photographic Preservation at Harvard contains a set of calotypes of the Harvard Yard taken by Cooke his freshman year (1844) from the window of his dormitory.

## Publication History

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## 2011 Update

Since giving this talk two additional images of Cooke have come to my attention, the first a photograph showing him in 1860 at age 33 and the second a drawing, probably based on figure 3, which appeared in an early 20th-century dictionary of American biography:



I have also come across an interesting period characterization of the Daniel - Miller - Cooke tradition of chemical physics. This appears in the 1869 volume, *Habit and Intelligence in their Connection with the Laws of Matter and Force: A Series of Scientific Essays*, by John Joseph Murphy (Macmillan: London). In his essay on "Scientific Classification," Murphy assigns the study of force and energy to the dynamical sciences and the study of the properties of matter to the chemical sciences, further dividing the latter into three subsciences:

*The chemical group of sciences may be enumerated as molecular physics, chemistry, and crystallography. The names of the two latter need no explanation. Molecular physics has till now been usually regarded as a part of chemistry and has been treated of in the introductory chapters of works on that subject; but I think it is now time to raise it to the rank of a distinct science. It maybe defined as the science of the various states of molecular aggregation: it includes the theory of the gaseous or vaporous, the liquid, and the solid states of substances, and consequently of evaporation and freezing; of cohesion and capillary, of solution, of gaseous*

*and liquid diffusion, of osmose, and of various kindred subjects. In strictness of definition, crystallography is a branch of molecular physics but the facts of crystallography are so distinct and peculiar that it is much better to treat it as a separate science.*

*It is sufficiently obvious that molecular physics comes before chemistry in the series, because the simplest facts of chemistry would be unintelligible without some knowledge of molecular physics – enough, at least, to understand what is meant by solution or evaporation. Crystallography comes after chemistry, because every crystalline species is a distinct substance having its own particular chemical constitution, which is equally characteristic of it with its "crystallographic elements;" and this, of course, can only be learned from chemistry; while it is possible to understand chemistry as the science of combinations and decompositions without reference to the facts of crystallization which are indeed referred to in chemical writings only occasionally.*

This is an almost perfect characterization of Cooke's book on *Chemical Physics*, as well as of a sizable portion of what eventually came to be viewed as classical physical chemistry.