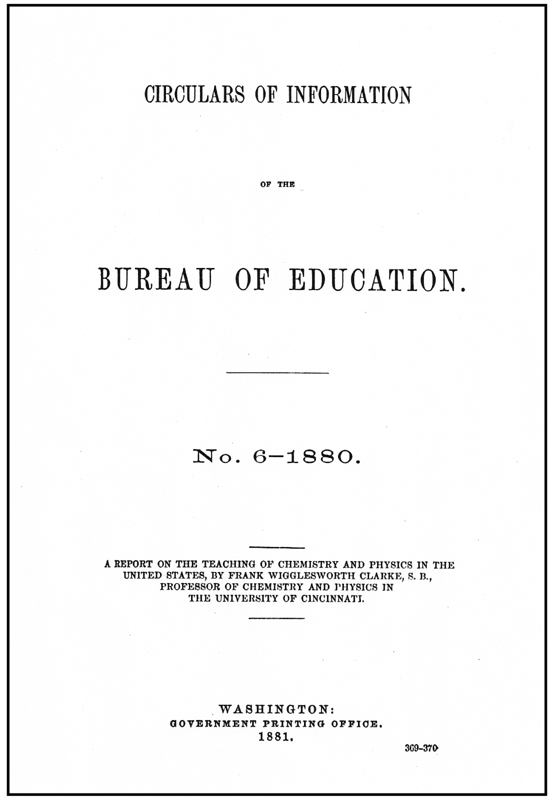
I
F. W. Clarke's 1881 Survey of Chemical Education in the United States

1. Introduction

Perhaps the single most comprehensive source of data relating to the teaching of chemistry and physics in the United States during the last quarter of the 19th century comes from a report (figure 1) prepared for the United States Commissioner of Education in 1881 by the American chemist, Frank Wigglesworth Clarke. However, surprisingly little of the raw data supplied by Clarke has been properly summarized and utilized by historians of chemical education – an oversight which I hope to partially correct with today's lecture (1).



CIRCULARS OF INFORMATION

OF THE

BUREAU OF EDUCATION.

No. 6—1880.

A REPORT ON THE TEACHING OF CHEMISTRY AND PHYSICS IN THE UNITED STATES, BY FRANK WIGGLESWORTH CLARKE, S. B., PROFESSOR OF CHEMISTRY AND PHYSICS IN THE UNIVERSITY OF CINCINNATI.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1881.

369-370

Figure 1. Title page of the Clarke Report on *The Teaching of Chemistry and Physics in the United States*.

2. The Author

Before examining the data in the Clarke report, I should first tell you a little about Clarke himself (figure 2) and about his personal experiences with chemical education in 19th-century America. Born in 1847 in Boston, the son of a hardware dealer, Clarke received his BS degree in chemistry in 1867 from Harvard's Lawrence Scientific School for work done under the supervision of Oliver Wolcott Gibbs. However, graduation was followed by seven years of frustration during which Clarke held a series of temporary teaching jobs at Cornell University, the Boston Dental College, and Howard University, and was even reduced to working as a reporter for several Boston newspapers. Finally, in 1874, at age 27 he was appointed as the first Professor of Chemistry and Physics at the newly-founded University of Cincinnati in Cincinnati, Ohio.

Figure 2. A young Frank Wigglesworth Clarke (1847-1931).

The University of Cincinnati was made possible by an endowment left to the City of Cincinnati by a local miser, real estate speculator, and slum lord named Charles McMicken and by a state law passed in 1870 which allowed tax money to be used for the support of public universities. Though the original architect envisioned an imposing Victorian building for the new university located on a tree-line boulevard in downtown Cincinnati (figure 3), the reality which Clarke found upon his arrival fell a good deal short of this ideal. Funds were available to built only the left wing of the

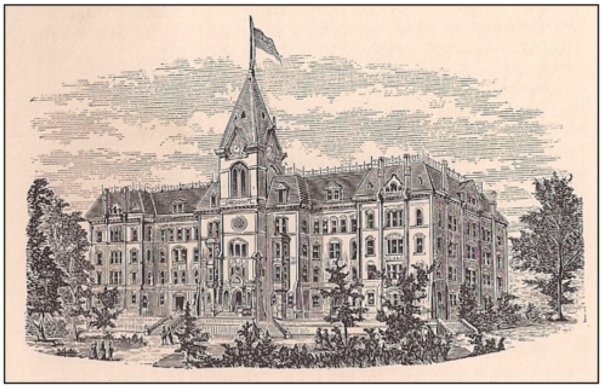


Figure 3. The University of Cincinnati as envisioned by the original architect.

originally projected building and this was not located on a tree-lined boulevard in central Cincinnati, but on the denuded slope of Clifton hill (figure 4) in what was rapidly becoming an industrial slum (figure 5). And to add further insult to injury, one of the city's newly installed elevated street cars or "inclines" ran within 40 yards of the west side of the building (figure 6) causing the windows to rattle and the lectures to become inaudible every ten minutes or so.

Clarke's diary and his letters chronicle his rapid disillusionment with both the quality of the university and the students he was required to teach and reveal that he soon began looking for another job, though he would not have success for another nine years. In the meantime he published a series of articles in *Popular Science Monthly* editorializing on the sad state of science teaching in the United States and the plight of its professors which are little more then thinly disguised extrapolations of the increasing sense of both frustration and despair which he felt over his situation at Cincinnati.

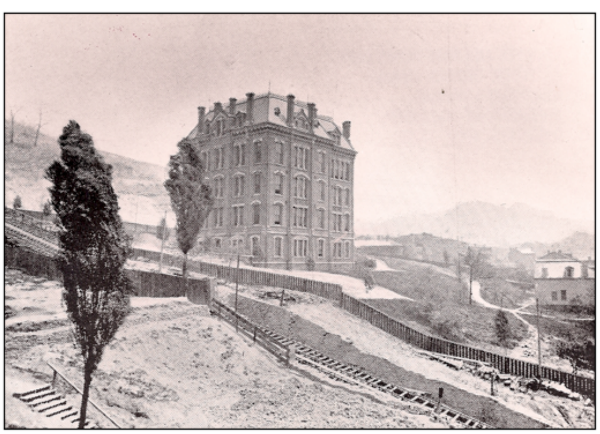


Figure 4. The University of Cincinnati as Clarke actually found it.

Thus, in an article entitled "American Colleges versus American Science," published in 1876, or a mere two years after his arrival in Cincinnati, he provided the following evaluation of his employers – the "he" referring to the typical Professor of Science (3):

To begin with, he encounters a board of trustees among whom not one has the remotest idea of what science is or what is essential to its growth. He is called upon by these gentlemen to teach chemistry, physics, astronomy, botany, zoology, mineralogy, geology, physiology, and perhaps Paley's evidences on top of it all. For study and research he has neither time nor apparatus. For study, indeed, he is not supposed to need any time, and if he should press this necessity upon his employers, he would probably be told he ought to know his lessons before attempting to teach.

Figure 5. The industrial neighborhood immediately below the university building, which can be seen in the upper left-hand corner.

Nor was the situation with respect to students much better:

His students come to him miserably prepared, caring little for what he considers important and regarding his instruction as so much of an impediment between them and their degrees. And for all this he may receive less than a thousand dollars a year, and that with a feeling of precariousness and uncertainty.

In the end, Clarke felt that only one of three things could happen to an individual caught in such a situation:

Figure 6. The tracks to the incline that ran along the west side of the original university building.

At last one of three things happens: he is either called to a chair in some respectable institution, gives up teaching for some less annoying occupation, or else, his enthusiasm quenched, and his aspirations gone, he settles down into a dreary rut to rust out the remainder of his days.

Nor had things improved by 1878, when he published his article on "Scientific Courses of Study" (4):

Students come to the professor of chemistry much as they would go to see a conjurer; expecting to be stunned, dazzled, and delighted but dreaming of no real study except an occasional recitation and the cram for examinations at the end of a term.

Given these experiences, it is perhaps not surprising that Clarke was interested in evaluating the state of chemical education at other institutions, not to mention happy to be given an opportunity to supplement his meager income as a teacher with a special outside commission.

4. The Report

Before leaving Howard University in Washington DC for Cincinnati, Clarke had contracted with the Smithsonian Institution to prepare a series of publications known as *The Constants of Nature*, which consisted of tables of various physical properties of interest to chemists, such as melting points, boiling points, densities, coefficients of thermal expansion, and atomic weights (5). No doubt as a result of these governmental contacts, Clarke was able to further contract with the United States Bureau of Education in 1878 to write a report on the state of the teaching of chemistry and physics in the schools and universities of the United States. The Bureau first sent out survey forms to various academies, high schools, colleges, universities, normal schools, and professional schools (e.g., medical and dental schools) requesting information about the nature of their chemistry and physics curriculums, their teaching facilities, and their faculty. The completed survey forms were then sent to Clarke, who summarized their contents and supplemented them with information obtained by studying a large collection of college catalogs.

The final report, which was published in 1881 under the title *Report on the Teaching of Chemistry and Physics in the United States* (6), was 219 pages in length and consisted of a 33-page general introduction, 122 pages of detailed descriptions of the curriculum and facilities at selected colleges and universities, and 49 pages of dense data tables (figure 7) for all schools which listed:

1. The name and address of the institution in question.
2. The level of the course being taught.
3. The length of the course.
4. The number of teachers.
5. The number of students.
6. The amount of apparatus owned.
7. The textbook being used.
8. The year chemistry and physics were first taught.

Though it is these dense data tables that are of most interest to us today, for some unknown reason Clarke himself never provided a statistical summary of their contents – a fact which no doubt accounts for why they have been overlooked by so many subsequent historians.

5. Sample Size and Quality

The first point of interest is, of course, the size and quality of Clarke's data set. As may be seen from Table 1, Clarke's survey included 1205 schools, ranging from high schools and academies through normal schools to colleges and universities and various kinds of professional schools. In the case of the secondary schools surveyed, the data given in Cubberly (figure 8) indicate that by 1880 there were approximately 2000 private academies and 2000 public high schools operating in the United States (7). Thus Clarke's sample represented 26% of the academies but only 9% of the public

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TABLE II.—*Statistics of instruction in chemistry and physics in secondary schools, &c.*—Continued.

Name of institution.	Post-office address.	No. of teachers: Number in chemistry.	No. of teachers: Number in physics.	No. of teachers: Total number for both branches.	Do these teachers instruct in other subjects?	Grade of the course in which these studies are begun: Chemistry.	Grade of the course in which these studies are begun: Physics.	Course of study: Chemistry.	Course of study: Physics.	Average age of pupils beginning these studies.	Approximate value of chemical and physical apparatus.	Text books used: In chemistry.	Text books used: In physics.	Instruction began: Chemistry.	Instruction began: Physics.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
UNIVERSITIES AND COLLEGES—Continued.															
Lehigh University	South Bethlehem, Pa.	2	1	3	No.	Freshman	Freshman	B. 2, 3 t.	H. 3 t.	16–17	$20, 000	143, 211, 212, 239, 260, 265, 266, 268, 270, 280.	9, 67, 94	1866	1866
Swarthmore College	Swarthmore, Pa.	2	1	2		Freshman	Freshman	B. 6	G.			212, 252, 266			
Augustinian College of St. Thomas of Villanova.	Villanova, Pa	1	2	3				E.	E.					*1855	*1855
Washington and Jefferson College.	Washington, Pa	1	1	1		Junior	Senior	H. 7 t.	I.			183, 235	13		
Waynesburg College	Waynesburg, Pa	1	1	2	Yes.			9	4		500	204	3, 7, 35, 55	1851	1851
Brown University	Providence, R. I.	2	1	3	No.	Freshman	Sophomore	A. 6 t.	G. 3 t.	20–21		120, 192, 219, 222, 223, 257	9, 13, 44, 63	1811	
College of Charleston	Charleston, S. C	1	1	1	Yes.	Senior	Senior				800–1, 000	183	35	1838	1838
University of South Carolina	Columbia, S. C	1	1	2	Yes.	Junior	Freshman	I. 8	E. 7			140, 212	35		
Erskine College	Due West, S. C	1	1	1	Yes.	Senior	Junior	L.	I.			191	35		
Furman University	Greenville, S. C	1	1	1		Junior	Junior	7				124, 171	1, 63		
Newberry College	Newberry, S. C	1	1	1	Yes	Junior	Junior	9	4		100	204	35	1858	1858
Wofford College	Spartanburg, S. C	1	1	2	Yes.	Junior	Junior	9	7	19	600	124	13	1855	1855
East Tennessee Wesleyan University.	Athens, Tenn					Junior	Sophomore	L	L.			204	32		
Beech Grove College	Beech Grove, Tenn.	1	1	1	Yes.	Junior	Junior	11	11	15	None	124	35	1869	1869
King College	Bristol, Tenn	1	1	2	Yes	Junior	Junior	L.	L.			204			
Southwestern Presbyterian University.	Clarksville, Tenn	1	1	1	No.	Sophomore	Sophomore			17	2, 000	140	44	1850	1850
Hiwassee College	Hiwassee College, Tenn.	1	1	2	Yes.	Freshman	Freshman	11	9	18	None	197	53	1849	1849
Southwestern Baptist University	Jackson, Tenn	1	1	1	No.	2d year	3d year			18		183	35, 47	1877	1877
East Tennessee University	Knoxville, Tenn	2	2	3	Yes.	Freshman	Freshman	A. 4, 6 t.	E. 7, 11	16–18	2, 000	183, 238, 260, 312	47, 71	1839	1839
Cumberland University	Lebanon, Tenn	1	1	2	Yes.	Junior	Junior	6 t.	7	16–20	1, 500	124, 209, 238, 260, 266, 276	9	1842	1842
Bethel College	McKenzie, Tenn	1	1	1	Yes.	Senior	Senior	I. 11	I. 9	18–25		124, 204	38	1847	1847
Manchester College	Manchester, Tenn.	1	1	1	Yes.	Freshman	Freshman	11	9	18–20	None	161, 190	35, 37, 45	1866	
Maryville College	Maryville, Tenn			3	Yes.	Junior	Junior	9	7		2, 000–2, 300	141	35	*1849	1849
Christian Brothers' College	Memphis, Tenn	2	3	4	Yes	Sophomore	Preparatory	9	7	13–14	1, 500	143	39	1874	
Mosheim Institute	Mosheim, Tenn	1	1	1	Yes			11	9	16	None	204	39	1870	1870
Mossy Creek College	Mossy Creek, Tenn.	1	1	2	Yes.	Junior	Senior	L.	L.			197	35		
Central Tennessee College	Nashville, Tenn	1	2	2	Yes	Sophomore	Preparatory	9	7	20	350	190	35, 45	1874	1870
Fisk University	Nashville, Tenn	1	1	1	Yes.			7 t.	7	20	2, 000	141	32	1874	1873
Vanderbilt University	Nashville, Tenn	3	1	4	1 does	Junior	Junior	E. 6 t.	E. 4	19	30, 000	183, 235, 238, 260, 270, 273, 303, 311, 313,	13, 63	1875	1875
University of the South	Sewanee, Tenn	1	1	2	Yes.			E. 7 t.	E. 4			143, 238	9, 13, 63		
Tusculum College	Tusculum, Tenn	1	1	1	Yes.	Senior	Junior	L.	K.	20	150	124	35	1827	1827
Texas Military Institute	Austin, Tex	1	1	1	Yes.	Next to highest	Next to highest	9	7	17	300	204	47		
Southwestern University	Georgetown, Tex	1	1	1	No.	Preparatory	Preparatory	8	6	14		183, 184, 212	13, 47, 48		
Baylor University	Independence, Tex.	1	1	2	Yes.	Academic	Academic	9	7	14	700	204	35, 38, 325	1846	1846
Salado College	Salado, Tex	1	1	1	Yes.	Junior	Freshman	I.	I.						
Trinity University	Tehuacana, Tex	1	1	2	Yes	Sophomore	Junior	I.	I.						
Waco University	Waco, Tex	1	1	1	Yes.	Sophomore	Sophomore	L.	L.			122	35		
University of Vermont and State Agricultural College.	Burlington, Vt	1	1	2	Yes.	Freshman	Freshman	4, 6 t.	4	18	6, 000	124, 141, 238, 260	13, 47	1830	1830
Middlebury College	Middlebury, Vt	1	1	2	Yes.	Junior	Junior	K.	K.			140	35		
Norwich University	Northfield, Vt	1	1	1	Yes	Sophomore	Junior	9	4	18–20		204	3, 55	1834	1834
Randolph Macon College	Ashland, Va	1	1	1	Yes.	3d year	2d year	I. 9	G. 7, 11	18	800	183, 204	38, 63	1832	1832
Emory and Henry College	Emory, Va	1	1	1	Yes.	Common sch'ls	Common sch'ls	9	7	16	4, 000	124, 141, 204	35, 45	*1839	*1839
Hampden Sidney College	Hampden Sidney, Va.	1	1	1		Junior	Senior	G. 9, 20	L. 7			183, 204, 316	1		
Washington and Lee University	Lexington, Va	1	1	2				E. t.	E. 4			183, 204	47, 55, 91		
Richmond College	Richmond, Va	1	1	2	Yes.			9	E. 4			143	13, 32, 52, 62		
Roanoke College	Salem, Va	1	1	1	Yes	Junior	Junior	L.	L			204	35		
University of Virginia	Charlottesville, Va	2	1	3	No.	Ungraded	Ungraded	1 t.	E. 3 t.	19–21	26, 000	143, 238, 260, 311	13, 103, 116, 117	1825	1825
Bethany College	Bethany, W. Va	1	1	1	Yes			L. 6 t.	L. 7	22	5, 000	124, 223, 260, 266	13		
West Virginia College	Flemington, W. Va.	1	1	1	Yes.	Preparatory	Preparatory			16	100	124, 140	33, 35	1869	1869
West Virginia University	Morgantown, W. Va	1	1	1		Freshman	Sophomore	H. 7	F. 7			140	63		
Lawrence University	Appleton, Wis	1	1	1	Yes	Senior	Junior	L. 9	I. 4	20	600		9	1849	1849
Beloit College	Beloit, Wis	1	1		Yes.	Sophomore	Junior	I. 7 t.	K. 4.	18	1, 000	183, 212, 234	13	1847	1847

* About.

578 579

Figure 7. A Typical example of the densely packed data tables in Clarke's report.

high schools. Likewise Cubberly reports that roughly 366 colleges and universities were operating in the United States by 1880 (Table 2), so Clarke's sample included an astounding 85%. Unfortunately, I was unable to find the data required to provide a similar evaluation of the quality of Clarke's sample for either the normal schools or the professional schools.

5. Curriculum

As may be seen from Table 3, between 87% and 100% of the schools surveyed reported that they were currently teaching an introductory chemistry course, so one may confidently conclude from Clarke's data that, by the last quarter of the 19th century, the teaching of elementary chemistry had become a standard feature of the curriculum at nearly all secondary and university-

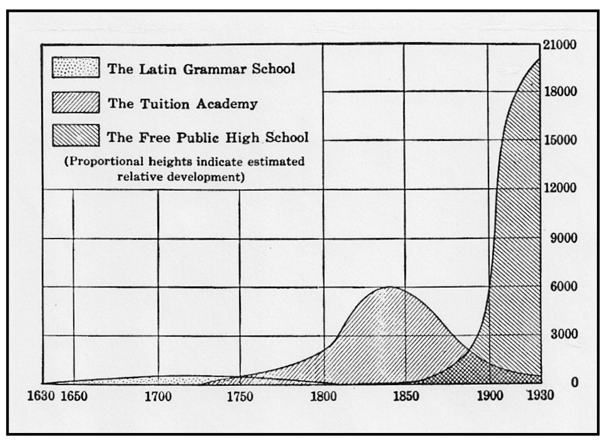


Figure 8. Number and kinds of American secondary educational institutions over time.

Table 1. The Number and Types of Schools Surveyed by Clarke.

TYPE OF SCHOOL	RESPONSES
Public High Schools	176
Private Academies	431
Normal Schools	79
Women's Colleges and Academies	89
Universities and Colleges	312
Scientific and Agricultural Schools	33
Medical Schools	64
Dental Schools	10
Pharmacy Schools	11
Total	1205

Table 2. Founding Dates of American Colleges and Universities by Decade.

DECADE	NUMBER FOUNDED
Before 1780	10
1780-1789	7
1790-1799	7
1800-1809	9
1810-1819	5
1820-1829	22
1830-1839	38
1840-1849	42
1850-1859	92
1860-1869	73
1870-1879	61
Total	366

level educational institutions in the United States. However, Clarke's data not only allows us to evaluate how many schools were teaching chemistry in 1880, it also allows us to trace the gradual introduction of chemistry into the curriculum over time since Clarke also reported the date at which each school first began teaching chemistry.

As may be seen from figure 8, the private academy first came into existence in Great Britain in the 1730s and rapidly spread to America, where the number of such institutions slowly increased, eventually reaching a maximum of roughly 6000 by the 1840s. As revealed by Table 4, 205 academies, or roughly 48% of Clarke's sample, reported the date at which they first began to teach chemistry. Only one academy reported that it had begun teaching chemistry in the 18th century, otherwise it is not until the 1810s that we begin to see a gradual increase in the number offering chemistry, followed in the 1840s by a significant surge, due in part to the large number of new academies founded during this decade.

Table 3. Percentage of Schools Teaching Chemistry in 1880.

TYPE OF SCHOOL	PERCENT TEACHING CHEMISTRY
Public High Schools	87
Private Academies	92
Normal Schools	88
Women's Colleges and Academies	99
Universities and Colleges	98
Scientific and Agricultural Schools	100
Medical Schools	100
Dental Schools	100
Pharmacy Schools	100

The first free public high school in the United States was founded in Boston in 1821. As shown in figure 8, as the number of these free public institutions began to increase, the number of private tuition-based academies began to slowly decrease, with the crossover point occurring roughly about the time that Clarke's report was published, when Cubberly estimated that there were approximately 2000 high schools

Table 4. Date by Decade at which Chemistry was First Taught in American Academies.

DECADE	NUMBER TEACHING CHEMISTRY
Before 1780	0
1780-1789	0
1790-1799	1
1800-1809	0
1810-1819	4
1820-1829	6
1830-1839	7
1840-1849	23
1850-1859	41
1860-1869	54
1870-1879	70
Total	206

Table 5. Date by Decade at which Chemistry was First Taught in American Public High Schools.

DECADE	NUMBER TEACHING CHEMISTRY
1820-1829	2
1830-1839	2
1840-1849	9
1850-1859	35
1860-1869	40
1870-1879	35
Total	123

and 2000 academies in the United States. As indicated in Table 5 roughly 70% of Clarke's sample for the high schools reported the date at which chemistry was first taught. Starting in the 1820s there is a gradual increase, with the most significant surge occurring in the 1850s or roughly a decade after the surge for private academies.

The parallel data for universities and professional schools is summarized in Table 6. In this case roughly 54% of the survey sample reported this information. Not surprisingly the teaching of chemistry at the university level began much earlier than at the secondary level, with three schools claiming courses dating back to the 18th century, and a steady increase from 1800 onwards, with the first conspicuous surge occurring in the 1820s or nearly two decades before the corresponding surge for the private academies and three decades before the surge for public high schools.

Table 6. Date by Decade at which Chemistry was First Taught in American Colleges, Universities, and Professional Schools.

DECADE	NUMBER TEACHING CHEMISTRY
Before 1780	1
1780-1789	2
1790-1799	0
1800-1809	4
1810-1819	6
1820-1829	12
1830-1839	18
1840-1849	17
1850-1859	36
1860-1869	45
1870-1879	47
Total	188

6. Professional Training, Equipment and Faculty

As may be seen from Tables 7 and 8, only 38, or roughly 11% of the colleges, universities and scientific schools reported that they offered more than an introductory course in chemistry or, in other words, reported that they were offering a degree program designed to train professional chemists. As summarized in Table 7, 22 of these schools, or roughly 6% of all colleges and universities, were offering a three-year

Table 7. Universities and Colleges Offering a Three-Year Curriculum in Chemistry.

SCHOOL	MAJORS	EQUIP.
University of California	18	$20,000
Wesleyan University (CT)	19-20	....
University of Chicago	18	$5,300
Jefferson College (LA)	15	$10,000
Smith College (MA)	......	$8,000
University of Minnesota	18-20	$5,000
Cornell (NY)	18	$19,000
Haverford (PA)	18-19	$4,500
Washington University (MO)	16-18	$4.500
Lake Forest University (IL)	18	$2,000
Lehigh University (PA)	16-17	$20,000
Swarthmore College	......	....
State Agr & Mech. College (AL)	17-19	$5,000
Sheffield Scientific School (Yale)	......	....
Purdue University (IN)	19	$5,000
Iowa State Agricultural College	18	$8,500
Maine State College of Agr & Mech.	19	....
University of Missouri	......	....
Pennsylvania State College	19	$3,500
Worchester (MA)	17	$18,000
Stephens Institute of Technology	18	$20,000
Princeton School of Sciences	......	....

degree program and were doing so using laboratory and equipment investments ranging from a high of $20,000 at several schools to a low of $3500 at Pennsylvania State College. Likewise, another 16 institutions (Table 8), or roughly 5%, reported offering a four-year program (including the University of Cincinnati) and were doing so using laboratory and equipment investments ranging in value from a high of $40,000 at the University of Pennsylvania to a low of $1000 at the Maryland Agricultural College. Far less variable was the number of students taking chemistry at these schools, which fluctuated between 15 and 21 or about the size of a single recitation section in our present day course. Whether this represented the number of chemistry majors or the total number of students taking general chemistry is unclear, though one strongly suspects that the latter interpretation is the correct one.

In keeping with these trends, Table 9 reveals that over 75% of the schools reported having only one faculty position devoted to the teaching of chemistry, with another 18% reporting two positions. Only 6% reported having three or more positions and therefore qualified as having what we would today consider to be a proper department of chemistry.

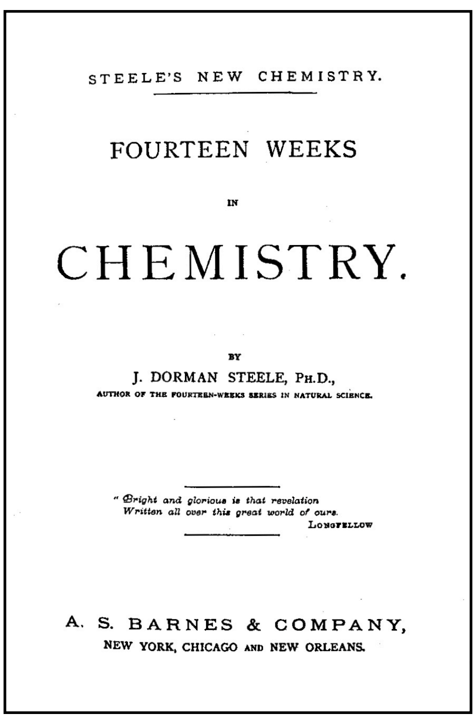
Table 8. Universities and Colleges Offering a Four-Year Curriculum in Chemistry.

SCHOOL	MAJORS	EQUIP.
Johns Hopkins	18	....
Harvard	21	....
University of Michigan	21	....
University of Cincinnati	17-18	$8,000
Lafayette College (PA)	16-18	$12,000
La Salle College (PA)	16-17	$2,000
University of Pennsylvania	15-16	$40,000
Brown University	20-21	....
Eastern Tennessee University	15-18	$2,000
Racine College (WI)	17-19	$10,000
Illinois Industrial University	18	$18,000
Maryland Agricultural College	16	$1,000
MIT	18	$15,000
Lawrence Scientific School	....	....
Polytechnic School (Washington University)	17-18	$3,200
Columbia School of Mines	....	....

Table 9. Number of Chemistry Faculty for Universities and Professional Schools.

FACULTY	NUMBER	PERCENT
No faculty	5	1%
One faculty member	241	75%
Two faculty members	59	18%
Three or more faculty	18	6%
Total	323	100%

Clarke reported no information on graduate programs in chemistry, though we know from other sources that at least two American schools (Harvard and Yale) were offering advanced degrees in chemistry by the late 1860s. At least another dozen schools, including Johns Hopkins, the University of Cincinnati, and the University of Tennessee, were offering this option by the 1870s, though the latter two schools apparently had no takers until the early 20th century. Most 19th-century American chemists seeking advanced chemical training during this period went instead to Germany, where it has been estimated that roughly 600 received graduate degrees of some sort (8, 9).


STEELE'S NEW CHEMISTRY.

FOURTEEN WEEKS

IN

CHEMISTRY.

BY

J. DORMAN STEELE, PH.D.,

AUTHOR OF THE FOURTEEN-WEEKS SERIES IN NATURAL SCIENCE.

"Bright and glorious is that revelation
Written all over this great world of ours.
LONGFELLOW

A. S. BARNES & COMPANY,

NEW YORK, CHICAGO AND NEW ORLEANS.

Figure 11. The 1873 edition of Steele's popular textbook.

It should also be noted that, despite its prestige, German training was not always the best. Thus Clarke's eventual successor at Cincinnati, Thomas Norton, received his B.A. in 1873 from Hamilton College in New York State after having taken a single course in chemistry his senior year. He then traveled to Germany to study chemistry under Bunsen at Heidelberg, from whom he received a Ph.D. in chemistry after two years without having to submit a thesis. Likewise, Alfred Springer, a local Cincinnati industrial chemist and friend of both Clarke and Norton, graduated from high school in Cincinnati in 1870 at age 16 and immediately left for Germany to also study chemistry under Bunsen at Heidelberg, from whom he received a Ph.D. in chemistry two years later, again without having to submit a thesis. These rather slapdash scenarios contrast sharply with the four-year B.S. chemistry degree program used to train Clarke at Harvard, and are also reflected in the subsequent scientific reputations of these three men, of whom only Clarke attained any degree of eminence.

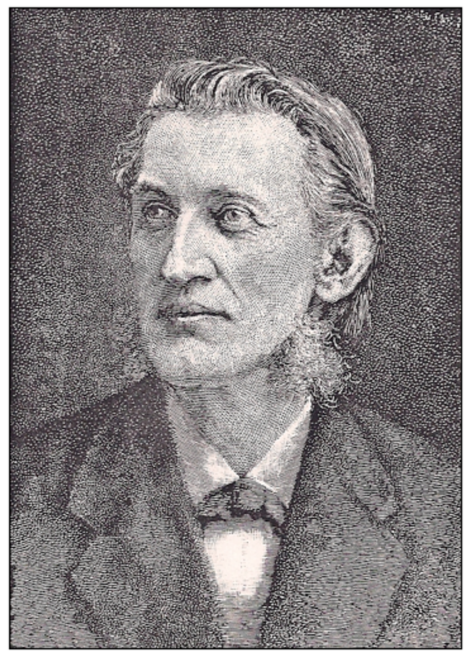
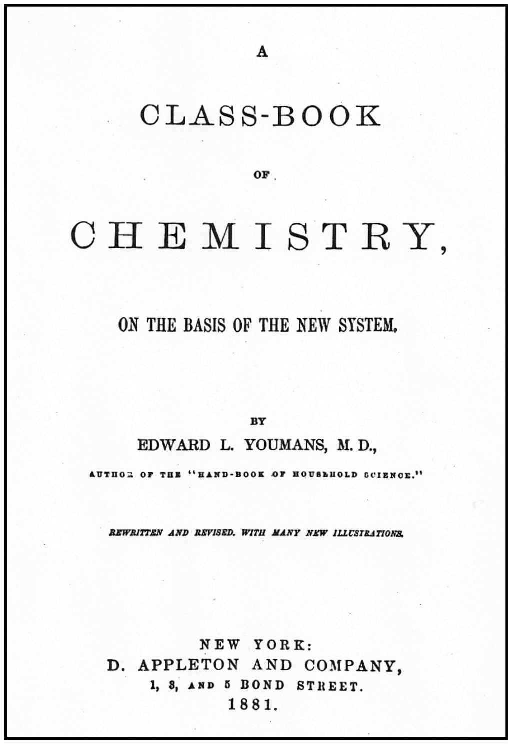


Figure 10. Joel Dorman Steele (1836-1886).

7. Textbooks

Any one familiar with the current market in introductory chemistry textbooks knows that, although roughly two-dozen different textbooks are in print at any given time, only two or three of these texts tend to dominate the market. Interestingly, Clarke's data shows that this was also the situation in the 1880s, as his survey re-



A

CLASS-BOOK

OF

CHEMISTRY,

ON THE BASIS OF THE NEW SYSTEM.

BY

EDWARD L. YOUMANS, M. D.,

AUTHOR OF THE "HAND-BOOK OF HOUSEHOLD SCIENCE."

REWRITTEN AND REVISED, WITH MANY NEW ILLUSTRATIONS.

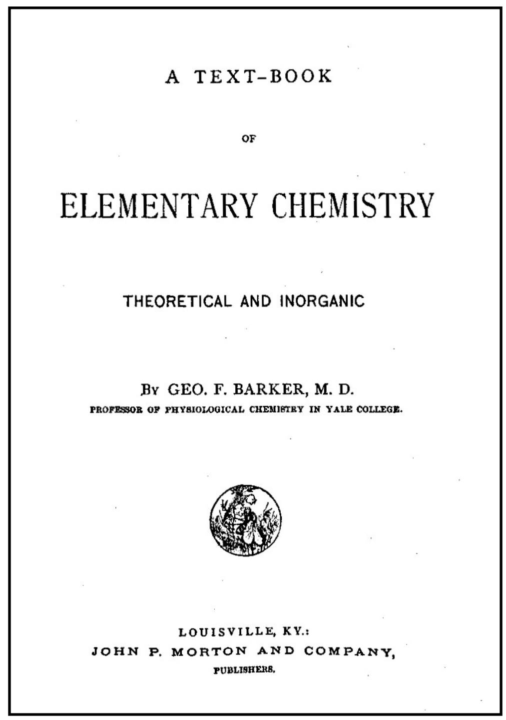
NEW YORK:
D. APPLETON AND COMPANY,
1, 3, AND 5 BOND STREET.
1881.

Figure 11. The 1881 printing of Youmans' *Classbook of Chemistry.*

veals that 41% of the secondary schools reporting were using the 1873 revised edition of the textbook *Fourteen Weeks in Chemistry* (figure 9) by Joel Dorman Steele (figure 10), which was first published in 1868, and another 15% were using the 1877 revised edition of the text *Class-book of Chemistry* (figure 11) by Edward Livingston Youmans (figure 12), first published in 1851. Reflecting the not always too clear line separating the smaller colleges and the academies, 20% of the colleges and universities reported that they were also using Youmans' textbook, whereas another 15% reported that they were using *A Textbook of Elementary Chemistry: Theoretical and Inorganic* (figure 13) by George Frederick Barker (figure 14).

Figure 12. Edward Livingston Youmans (1821-1887).

It should be noted that neither Steele nor Youmans were trained chemists. Steele was a former high school principal who became a highly successful textbook author of the "cut and paste" variety, publishing textbooks not only in chemistry, but in physics, astronomy, zoology, botany, and physiology, as well as in history – several of which were still in active use as late as the 1920s, whereas Youmans began his career in the 1850s as a self-taught itinerant lecturer in chemistry. Eventually he became the editor of the journal, *Popular Scientific Monthly,* and of a highly successful series of popular science monographs published by the firm of D. Appleton and Company of New York, as well as the major American proponent of the British philosopher, Herbert Spencer.



A TEXT-BOOK

OF

ELEMENTARY CHEMISTRY

THEORETICAL AND INORGANIC

BY GEO. F. BARKER, M. D.

PROFESSOR OF PHYSIOLOGICAL CHEMISTRY IN YALE COLLEGE.

LOUISVILLE, KY.:
JOHN P. MORTON AND COMPANY,
PUBLISHERS.

Figure 13. The title page of the 1870 edition of Barker's *Textbook of Elementary Chemistry.*

Only Barker received university-level training in chemistry, having studied for two years under Benjamin Silliman Jr. at Yale. This was followed by a series of short-lived teaching appointments at Weaton Col-

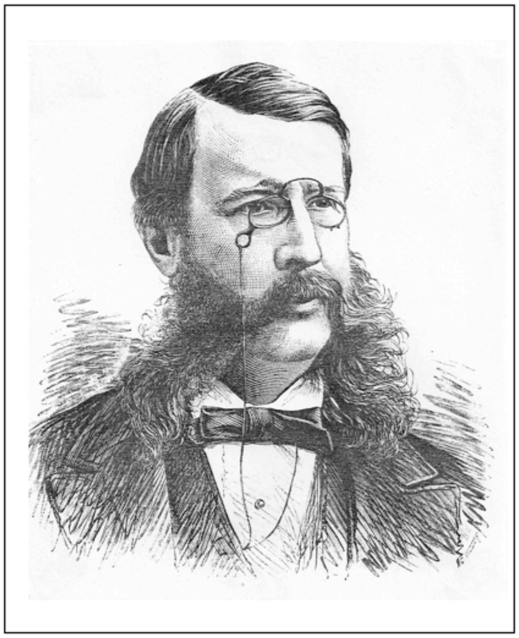


Figure 13. George Frederick Barker (1835–1910).

lege, Albany Medical School, the University of Pittsburgh, Yale, and Williams College, before he finally came to rest as Professor of Physics at the University of Pennsylvania.

Yet a second trend in textbook usage still present today is the selection of an entirely different set of textbooks and publishers by the medical, dental and pharmacy schools. In Clarke's day the publisher of preference was the Henry C. Lea Company of Philadelphia and the book of choice was the text, *A Manual of Chemistry*, by George Fownes, a British textbook first published in 1847 and which was being used by 33% of the dental schools, 53% of the medical schools, and 72% of the pharmacy schools in Clarke's sample.

8. The Escape

Only in 1883 did Clarke finally succeed in escaping from his unhappy situation at the University of Cincinnati. This he did by taking the second of the three routes outlined in his article of 1876 – the selection of a "less annoying occupation" than teaching. That year his persistence and government contacts finally paid off when he was appointed as the Chief Chemist of the United States Geological Survey in Washington DC. Here he would achieve, before his death in 1931, a fair degree of renown, leading both to his election to the National Academy of Sciences and to his election as President of the American Chemical Society in 1901. Today he is best remember for his definitive recalculation of the known atomic weights of the elements (1897) and for his publication in 1908 of the monograph, *The Data of Geochemistry*, now considered to be one the great classics of that science (10). In honor of this latter contribution, the present-day geochemical unit for the relative abundance of the chemical elements is known as the Clarke number.

9. References and Notes

1. A lecture first given to the Division of Chemical Education of the American Chemical Society at the 195th National ACS Meeting in Toronto, Canada, on 05-11 June 1988 and since repeated on numerous occasions.

2. For biographical background, see L. M. Dennis, "Frank Wigglesworth Clarke," *Biographical Memoirs, National Academy of Sciences*, **1932**, *15*, 139-165.

Figure 14. Clarke as he appeared in late 1890s in an etching published in *Popular Science Monthl*y for 1894.

3. F. W. Clarke, "American Colleges versus American Science," *Pop. Sci. Mon.*, **1876**, *9*, 467-479.

4. F. W. Clarke, "Scientific Courses of Study," *Pop. Sci. Mon.*, **1878**, *13*, 187-197.

5. F. W. Clarke, *Specific Gravities, Boiling and Melting Points; and Chemical Formulas*, Smithsonian: Washington, DC, 1873; *Specific Gravities, Boiling and Melting Points, First Supplement*, Smithsonian: Washington, DC, 1876; *A Table of Specific Heats for Solids and Liquids*, Smithsonian: Washington, DC, 1876; *Tables of Expansion by Heat for Solids and Liquids*, Smithsonian: Washington, DC, 1876.

6. F. W. Clarke, *A Report on the Teaching of Chemistry and Physics in the United States*, Bureau of Education, Cir-

cular 6-1880, Government Printing Office: Washington, DC, 1881.

7. E. P. Cubberley, *The History of Education*, Houghton Mifflin: Boston, MA, 1920, pp. 699, 705.

8. E. H. Beardsley, *The Rise of the American Chemical Profession, 1850-1900*, University of Florida: Gainesville: FL, 1964.

9. P. Jones, *Bibliographie der Dissertationen amerikanischer und britischer Chemiker an deutschen Universitäten*, Deutschen Museums: München, 1983.

10. For background on the significance of Clarke's book, see M. Fleischer, "The Abundance and Distribution of the Chemical Elements in the Earth's Crust," *J. Chem. Educ*., **1954**, *31*, 446-455.