12. V. Serrin, *Pour l'application d'un dispositif a chaîne, dit pondérateur, aux instruments de pesage et de mesure de tous genres*, French Brevet 199,701, 20 July 1889.

13. *L'Industrie Francaise des Instruments, 1901-1902*, Syndicat des Constructeurs en Instruments d'Optique et de Precision, 1902, p. 244 (facsimile reprint, Alain Brieux, Paris, 1980).

14. W. Uhink," Zur Theorie und Praxis der Kettenwaage", *Z. Instrum.*, **1926**, *46*, 519.

15. La chaîne se manoeuvre facilement de l'extérieur de la cage a l'aide d'un bouton *ad hoc*, de telle facon que, lorsqu'une pesée a été ebauchée, á 1 mgr près, il n'est plus necessaire d'ouvrir la cage pour la compléter.

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LAURA ALBERTA LINTON (1853-1915): AN AMERICAN CHEMIST

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American women chemists publishing without a male co-author in the years before 1900 form a rather select group, and if we exclude those whose only single-author publication was Ph.D. dissertation research, the number becomes even smaller (1). Of the independent workers who make up this remaining group, a few are well known in the story of women scientists in America: one might name, for instance, Ellen Swallow Richards of MIT, whose early papers in analytical chemistry (2) date back to the mid-1870s, Helen Abbott-Michael, author of several papers on the chemical identification of plant constituents (3), and Ida Keller, another plant chemist (4). However, in the early volumes of the American chemical journals there are also less well-known names, and one of these is Laura Alberta Linton.

Laura Linton published two substantial papers on the analysis of asphalt samples in the *Journal of the American Chemical Society* in 1894 and 1896 (5). The publications appearing in this journal in its early years were somewhat uneven in quality and scientific content, but the two papers by Linton stand out for the amount of careful analytical work they record and the clarity and directness of their presentation. Furthermore, we know that they were received by the chemical community with some interest, and were considered important contributions to the field. Linton says in the introduction to her second (1896) paper that she was encouraged to present more

Laura Alberta Linton

results and to indicate new developments in her analytical methods, because of the favorable reception accorded her 1894 publication. An extensive discussion followed the oral presentation of the 1896 paper at the Cleveland meeting of the American Chemical Society in December 1895, the participants clearly recognizing the commercial importance of asphalt. In 1896 Linton published one other paper (6), jointly with the petroleum chemist Stephen F. Peckham. After that her name disappears from the chemical literature.

Who was Laura Linton? She was born in Mahoning County, Ohio, 8 April 1853, the oldest child in the Quaker family of Joseph and Christiana Linton (7). The Lintons farmed in Ohio, Pennsylvania and New Jersey, and finally settled in Wabash County in southern Minnesota in 1868. Laura graduated from Winona Normal school in 1872, and enrolled at the University of Minnesota in Minneapolis the same year. Chemistry became her major interest.

In her senior year Linton was given the job of analyzing some mineral specimens collected along the northern shore of Lake Superior by two faculty members, Stephen Farnum Peckham and Christopher W. Hall. The small, translucent, green pebbles she investigated were chemically very similar to thomsonite, a silicate of calcium, sodium and aluminum, but Peckham and his co-worker concluded, mainly from differences in the crystalline structure and the unusual color, that they had found a distinct variety of thomsonite. They gave it the name *Lintonite*, "in honor of Miss Laura A. Linton, a recent graduate of this University to whose patient effort and skill we are indebted for the analysis given in this paper" (8).

Linton graduated with a B.S. from the University of Minnesota in 1879, and then taught for a year at the high school in Lake City, Minnesota. Around this time Stephen Peckham had undertaken the preparation of a report for the 1880 United States Census on the *Production, Technology and Uses of Petroleum and its Products*, and he invited Laura Linton to

help him in this work. Peckham's report, an impressive monograph of 301 pages plus 30 plates, provides a comprehensive history of the discovery of petroleum world wide and makes extensive use of source materials in foreign scientific journals. The chemistry of petroleum and the bitumens is discussed, along with methods of oil production, transportation and storage, the technology of petroleum (distillation, "cracking", and so on), and finally the possible uses of petroleum. Peckham expresses his "obligations to Miss Laura Linton, who has assisted me in the preparation of this report, and to whose varied accomplishments I am indebted for many of the translations and illustrations that add completeness and embellishment to the work" (9). Clearly Laura Linton was well acquainted with the literature on petroleum chemistry when she came to do her research in this area 15 years later.

A view of the Woman's Laboratory Class for the Lowell Institute, circa 1869. This became the Woman's Laboratory of MIT in 1876.

The preparation of the monograph took two years. Following that, in 1882, Laura Linton registered at MIT, where she studied chemistry for two semesters in 1882-83. It seems likely that she would have worked in the Woman's Laboratory, which operated until 1883 under Ellen Swallow Richards' direction. Dahlberg (10) believes that Linton expected to remain at MIT and to graduate (11), but the offer of a faculty position at Lombard University in Galesburgh, Illinois (13) led her to put aside her graduate studies. And thus, at age 30, Linton became Conger Professor of Natural Science at Lombard University (14). She remained there for only one year, however, and then in 1884 she moved back to Minneapolis to become head of the science department in Minneapolis Central High School.

Around 1894, following 10 years of high school teaching, Linton returned to research in chemistry, and it was at this time that she carried out her work on asphalt analysis. She obtained her asphalt samples from Stephen Peckham, who had connections with the Union Oil Company of California, and who was superintendent of that company's Santa Paula refinery for six or eight months during 1894-95. Indeed, Linton states that she did the work described in her 1894 paper in the laboratories of the Union Oil Company. Since the Santa Paula laboratory was the only laboratory operated by the Company at that time (15), she must have gone out to California. A woman chemist working in an oil company laboratory would have been rather rare in 1894, but Linton was an unusual woman, possessing, as Peckham had remarked, "varied accomplishments" (9). Part of the asphalt research was carried out at the University of Michigan, where Linton was enrolled for the year 1895-1896, and during this time she published, jointly with Peckham, her third paper on asphalt analysis (6). Then she left chemical research, and, returning to Minneapolis, enrolled in the College of Medicine at the University of Minnesota. In 1897 she served as Instructor in Physiology, teaching "Physiologic Chemistry" in the College of Medicine (16). She graduated with an M.D. in 1900.

One might wonder why Linton gave up chemistry for medical school just after the publication of her well-received research work. Did she perhaps share some of Ellen Swallow Richards' views (17) that chemistry was a difficult field for women to succeed in? Why had she never completed a graduate degree in chemistry? The latter was clearly within her grasp as far as research abilities were concerned, and its lack was doubtless an additional handicap (beyond that of being a woman) to finding a fulfilling academic position. On the other hand, she may have had more positive reasons for her change of field (18); her family seems to have been strongly drawn towards medicine. Her brother, Thomas Linton, and her sister, Sarah Linton Phelps, were physicians, Sarah having graduated from the Woman's Medical College of Philadelphia (10).

Whatever the reasons for her switch, Linton spent the rest of her life as a physician. She joined the staff of the State Mental Hospital in Rochester, Minnesota, immediately after her graduation in June 1900, and she rose to the position of assistant superintendent in charge of the women's wards (19). She was responsible for introducing one of the earliest known attempts at occupational therapy (a program of needlework and handicrafts for women patients). She also undertook the teaching of a course on dietary principles coupled with practical cooking methods in the nurses' training school of which she was one of the heads (20). This was long before such material was included in standard nurses' training (10). She remained

on the staff of the hospital until her death on 1 April 1915.

In an obituary (21) she is remembered as leading a full life "of service in the teaching and medical professions"; her research work in chemistry is not mentioned. Nevertheless, at one time or another, she was engaged in all the activities we expect of a successful scientist of that day: teaching (at college level), research, and the publication of results in scientific journals. Laura Linton was clearly an active, involved member of the scientific community of her time and attuned to the current ideas. She was a member of the American Association for the Advancement of Science, and the American Association for the Advancement of Women. (She also served as State Chairman for Electricity at the Chicago World's Fair in 1893 (10).) In her chemical career, however, she never obtained a position where she could unite her teaching and research activities. As a chemist she has gone unremembered - until now.

Finding a satisfactory career in scientific work was a major problem for women science graduates, then as later. Higher education in scientific fields had opened up to women by the 1880s, and even graduate degrees were possible by the nineties, but strong resistance was concurrently developing to women entering traditional kinds of scientific employment, such as university teaching and government work (22). A capable and ambitious woman science graduate, whose aspirations reached beyond high school teaching or a career as a low-paid research assistant, had a limited range of opportunities available to her: a faculty position in a women's college was one option, but these openings were few; administrative work as dean of women in one of the newly-established co-educational state universities was another possibility; a third was a move into "women's work" in science, in the newly-created, segregated, low-status fields such as hygiene, physical education, or home economics.

Of the early women chemists, a considerable number found careers in home economics, where independent work was possible and normal advancement could be expected. Linton's career in the medical profession offered her similar advantages: here she had scope for innovative work and for the exercise of her leadership capabilities beyond anything a woman could have reasonably expected in chemistry.

References and Notes

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1. At that time Ph.D. dissertation research in chemistry was normally published under the student's name only.

2. E.H. Swallow, "Analysis of Samarskite from a New Locality", *Boston Soc. Nat. Hist.*, **1875**, *17*, 424-428; *Amer. J. Sci.*, **1877**, *14*, 71; "On the Occurrence of Boracic Acid in Mineral Waters", *Boston Soc. Nat. Hist.*, **1875**, *17*, 428-430; E. H. S. Richards, "Note on the Determination of Carbon Monoxide", *Amer. Chem. J.*, **1885-1886**, *7*, 143-144.

3. H. C. de S. Abbott, "On Haematoxylin in the Bark of *Saraca indica*", *Proc. Philad. Acad. Nat. Sci.*, **1886**, 352-354; "A Chemical Study of *Yucca angustifolia*", *Amer. Phil. Soc. Trans.*, **1890**, *16*, 254-285.

4. I. A. Keller, "The Coloring Matter of the Aril of *Celastrus scandans*", *Amer. J. Pharm.*, **1896**, *68*, 183-186. The papers cited in (2), (3) and (4) for these early authors are not intended to be a complete list of their pre-1900 publications; they are merely a sample.

5. L. A. Linton, "On the Technical Analysis of Asphaltum", *J. Amer. Chem. Soc.*, **1894**, *16*, 809-822; "On the Technical Analysis of Asphaltum, No. 2" (with discussion), *Ibid.*, **1896**, *18*, 275-279. This work was later quoted at length in S. F. Peckham's monograph, *Solid Bitumens*, Clark Publishing, New York and Chicago., 1909, pp. 154-167 and 168-171.

6. S. F. Peckham and L. A. Linton, "On Trinidad Pitch", *Amer. J. Sci.*, **1896**, *1*, 193-207.

7. We are especially indebted to Beverly Hermes, Librarian of the Olmsted County Historical Society, Rochester, Minnesota, and to Patricia Harpole of the Reference Library of the Minnesota Historical Society, St. Paul, Minnesota, for biographical information on Laura Linton. They provided copies of obituaries and of two articles by Jean C. Dahlberg: "Laura A. Linton and Lintonite", *Minnesota History*, **1962**, *38(1)*, 21-23, and "A Woman to Remember", *Lapidary Journal*, **1976**, *29(Oct.)*, 1732-1736. We also wish to thank Nancy Bartlett, of the Bently Historical Library, University of Michigan, and Carol Bohlman, University Archives, University of Minnesota, Minneapolis, for information from their records. Mark A. Vargas of the Institute Archives at MIT provided dates, and Carley R. Robison, Archivist at Knox College, Galesburgh, Illinois, gave us copies of records. Finally, Robert J. Endecavageh of the Unocal Corporation, Los Angeles, provided information about the Union Oil Company laboratory facilities in 1894-1896, and about Stephen Farnum Peckham's relationship to the Company.

Some information about Laura Linton is to be found in F. E. Willard and M. A. Livermore, eds., *A Woman of the Century: Biographical Sketches ... of Leading American Women*,, New York, 1893; republished by Gale Research Co., Book Tower, Detroit, 1973, as *American Women, a Revised Edition of "Woman of the Century"*.

8. S. F. Peckham and C. W. Hall, "On Lintonite and Other Forms of Thomsonite: A Preliminary Notice of the Zeolites in the Vicinity of Grand Marais, Cook County, Minnesota", *Amer. J. Sci.*, **1880**, *19*, 122-130.

9. S. F. Peckham, *Production, Technology, and Uses of Petroleum and Its Products, VIII*, United States Census, 1880. (Tenth Census of the United States, Vol. X). Laura Linton could read French and German and was a competent technical draughtswoman (see Dahlberg, reference 10).

10. J. C. Dahlberg, "A Woman to Remember", *Lapidary Journal*, **1976**, *29(Oct)*, 1732-1736.

11. It is unclear what degree Linton would have received from MIT. Ellen Swallow (Richards), with a bachelor's degree from Vassar, had applied to MIT in 1870 for admission to the graduate

program in chemistry, but had had to settle for being a candidate for a second bachelor's degree (Rossiter, reference 12, pp. 30-31).

12. M. W. Rossiter, *Women Scientists in America. Struggles and Strategies to 1940*, Johns Hopkins, Baltimore, MD, 1982.

13. Lombard University, a Universalist college and theological school, merged with Knox College during the Depression. We thank Carley R. Robison, Knox College, for this information.

14. *Catalogue of the Officers and Students of Lombard University, Galesburgh, Illinois, for the Year Ending June 18, 1884.*

15. Personal communication from Robert J. Endecavageh, Unocal Corporation, Los Angeles.

16. Anon., "College of Medicine", *Ariel* (College of Medicine, University of Minnesota), **1897**, *20 , No. 33(June)*, 34.

17. For a discussion of the precarious position of women scientists in academia at this period, and Ellen Swallow Richards' experiences in particular, see Rossiter, reference 12, Chapter 3, "Women's Work in Science".

18. Linton, however, was hardly putting aside chemistry for any "soft" alternative; even in 1896, two decades or so after the first of the pioneering generation of women students (including some Americans) had made their way into the medical schools of Switzerland and France, setting out to get an M.D. was no small challenge for a woman.

19. Anon., "Dr. Laura Linton Dies at Rochester", obituary in *Minneapolis Journal*, **1915**, *April 2*.

20. It was about this time that Ellen Swallow Richards was founding the field of Home Economics, and stressing the importance of dietary studies (Rossiter, reference 12, p. 69). It is tempting to postulate some influence from the older woman's thinking on Linton's undertakings.

21. Anon., "Useful Life is Ended", obituary in *Rochester Post and Record*, **1915**, *9 April*.

22. See Rossiter, reference 12, chapter 3, and also L. B. Arnold, *Four Lives in Science. Women's Education in the Nineteenth Century*, Schocken Books, New York, 1984, especially Chapter 6.

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OLD CHEMISTRIES

John Penington's "Chemical and Economic Essays"

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1990 marks the bicentennial of a unique early American chemistry book. When John Penington's *Chemical and Economical Essays* (1) was published in 1790, George Washington was in the second year of his presidency. The contemporary chemist, James Cutbush, called Penington's work "the first chemical book published in the United States" (2). That statement is not literally true. While there were American imprints on chemistry prior to 1790, Penington's *Essays* may be labeled the first full-size book devoted only to chemistry (3). In addition to reviewing Penington's *Essays*, this paper will present some unpublished material from a journal he kept while studying in Europe.

John Penington was born in Philadelphia on 29 September 1768, the son of Edward and Sarah Penington (4). A dedicated, disciplined young man, he packed considerable experience into a short 25-year lifetime. In addition to writing America's first chemistry book, he was the founder and president of America's first chemical society and, 70 years before Pasteur, devised a method of heat-preserving milk. Penington grew up in a period when Philadelphia was the center of governmental, intellectual and scientific activity. Since his family appears to have been well-to-do, he probably associated with people we would now regard as historically famous.

Comments in his book suggest that Penington was involved in industrial chemistry as a youth. His interest in chemistry may have been initiated by the family-owned sugar works (5). In one of the later essays, written as he neared graduation from medical school, he remarked that he had "now in some measure left chemistry as a profession." He also indicated prior chemical experience by referring to "the path I have trodden" when describing sulfuric acid production (6).

As a medical student at the College of Philadelphia, Penington studied chemistry under Benjamin Rush in the winter of 1788-89 (7). This was the last year that Rush taught chemistry; he was succeeded by Casper Wistar, who offered the course from 1789 till 1791. Penington's intense interest in chemistry may have led him to also attend Wistar's lectures in 1789-90. In dedicating his *Essays* to Wistar, Penington wrote (8):

To CASPER WISTAR, JUNIOR, M.D. AND PROFESSOR OF CHEMISTRY in the College of PHILADELPHIA, The Friend and Patron of CHEMICAL INQUIRIES IN AMERICA, These Essays are inscribed, by His sincere friend and pupil, JOHN PENINGTON. Philadelphia, May 25, 1790.

In a newspaper article on the history of chemistry in Philadelphia, James Cutbush reported Penington's activities in the first American chemical society (9):

During the spring of the year 1789, in consequence of the efforts of the late Dr. J. Pennington [sic], a chemical society was formed, and the doctor was elected to the presidency; whose duty it was to deliver discourses on chemical subjects. This was performed with great ability; each subject was illustrated by experiments, with much