MORRIS LOEB: OSTWALD'S FIRST AMERICAN STUDENT AND AMERICA'S FIRST PHYSICAL CHEMIST

Martin D. Saltzman, Providence College

In the 1880s, John Servos writes, "..a group of chemists... asserted that their science, through its emphasis on composition and structure, threatened to become narrow and sterile(1)." Chief among these critics was Wilhelm Ostwald (1853-1932), who argued that chemists should have as their major preoccupation the study of chemical affinity. Chemists needed to develop principles which would make it possible to predict the course of chemical reactions and not just the synthesis of an infinite number of organic compounds. Ostwald, an iconoclastic figure, was in many ways a thorn in the side of the chemical establishment of imperial Germany. He, along with his contemporaries the Dutch chemist Jacobus van't Hoff (1852-1911) and the Swedish chemist Svante Arrhenius (1859-1927), can be credited with the founding of the modern discipline of physical chemistry. Ostwald, perhaps more than anyone else, had the most profound effect on the development of American physical chemistry. His many American students who studied with him in Leipzig from 1887 until his early retirement in 1906 spread with great enthusiasm his new *allgemeine Chemie*.

Ostwald's first American student was Morris Loeb (1863-1912), who led an extraordinary life as a chemist, teacher, and philanthropist. Loeb was the first to introduce a physical chemistry course in American education. In his publications he sought to popularize the ionist point of view in America. The attribute of being America's first physical chemist is given in the sense that he introduced the program of Ostwald into American chemistry. It was through Ostwald's influence that physical chemistry became an internationally recognized discipline in its own right. This is not to belittle the contributions made by Josiah Willard Gibbs(1839-1903) in the development of thermodynamics in the 1870s. Gibbs' work, however, was little appreciated because it was presented in the literature in such a way that few if any of his contemporaries could understand what his ideas were. In addition Gibbs, as a physicist and engineer by training, applied his thermodynamics in a purely abstract way to chemical problems. Most importantly he left no school to carry on his work. The American students of Ostwald, such as Arthur A. Noyes and Wilder D. Bancroft among others, were as Servos has written ".... critically important teachers and institution builder(1)." These men followed Loeb to Ostwald's laboratory and thus Loeb may be given the appellation of the first American physical chemist.

Morris Loeb was born on May 23, 1863, in Cincinnati, Ohio. His father Solomon (1829-1903) had emigrated from Germany to Cincinnati in 1840 and within a short time became a very prosperous dry-goods merchant. When Morris was two years old the family moved to New York City, where his father had formed a partnership with Abraham Kuhn. The banking house of Kuhn, Loeb & Co. was enormously successful, thus ensuring that Morris would be financially independent. Loëb's primary and secondary education was completed in New York at the Sachs Collegiate Institute, an institution founded by a German immigrant Dr. Julius Sachs. Sachs emphasized classics, language, and Teutonic discipline in his school. Loeb excelled at science but showed no interest in becoming a banker, much to the disappointment of his father., Morris Loeb entered Harvard University in 1879, at the rather young age of sixteen.

Early in his studies at Harvard, Loeb enrolled in the introductory chemistry course taught by Charles Loring Jackson (1847-1935). Morris became fascinated with the science of chemistry as presented by Jackson and decided to major in it along with English. Jackson was a charismatic figure who inspired generations of Harvard chemistry students. He had worked with Robert Bunsen(1811-1899)in Heidelberg for six months in 1873 and August Wilhelm von Hofmann(1812-1892)in Berlin for two and one half years. Jackson returned to Harvard in 1875 and had the distinction of preparing the first new organic compound ever synthesized at Harvard, *p*-bromobenzyl bromide. At Harvard Loeb was also influenced by Henry B. Hill(1849-1903)and Wolcott Gibbs(1822-1908). Hill had also worked in Hofmann's laboratory during 1874 in Berlin and published a large number of research papers in furan chemistry while at Harvard.

Gibbs' major areas of research were inorganic and analytical chemistry. His pioneering work on the preparation and properties of complex inorganic acids, and on those transition metal complexes of cobalt and platinum is noteworthy. When Loeb was at Harvard, Gibbs was teaching in the Physics Department. Here he lectured on thermodynamics and spectroscopy; of Gibbs it has been written, "He inspired his students with a zeal for research...His students had the greatest admiration and affection for him(2)."Loeb carried on research as an undergraduate with Gibbs.

Morris Loeb

Loeb graduated *magna cum laude* in 1883, being awarded distinctions in chemistry and English. He proceeded to Berlin shortly after graduation to work in the laboratory of the great Hofmann. In 1887 he received his Ph D for his research on phosgene and its reactions with amidines(3). His research in Hofmann's laboratory resulted in his first three scientific papers, published in *Berichte der Deutschen Chemischen Gesellschaft* and *Chemisches Zentralblatt* (4).

Loeb had become disenchanted with organic chemistry by the time he had finished his degree and sought new horizons. This led him to Leipzig and Ostwald after a short detour in Heidelberg. The year 1887 was not only significant for the new Dr. Morris Loeb but also for Ostwald, who had just been called to Leipzig from the Riga (Latvia) Polytechnicum. In that year Ostwald completed his *Lehrbuch der allegemeinen Chemie*, the first textbook of physical chemistry, and founded the *Zeitschrift für Physikalische Chemie*. A Baltic German, Ostwald was a subject of imperial Russia and thus was always an outsider in terms of the German chemical establishment. Even in Leipzig he was always junior to Johannes Wislicenus(1835-1902),the Professor of Organic Chemistry.

Ostwald's new assistant at Leipzig was Hermann Walther Nernst (1864-1941). Nernst had been introduced to Ostwald by one of Ostwald's former Riga students, Svante Arrhenius (1859-1927). Into this hothouse of intellectual curiosity entered the 24-year-old Morris Loeb. Servos(1)contends that the founders of physical chemistry shared a common background in that they were on the periphery of the German chemical world. Their education was much broader in terms of scope. Van't Hoff, Arrhenius, and Ostwald had far better training in physics and mathematics then their Germanic counterparts. By the 1870s rigid divisions between the physical sciences existed, and carbon reigned as king as far as chemistry was concerned.

By the time Loeb had arrived in Leipzig, much of the ionic theory of solutions had been worked out by van't Hoff, Arrhenius, and Ostwald. Van't Hoff contributed the proposal that dilute solutions could be treated in a way analogous to gases. Arrhenius solved the anomaly of electrolytic solutions by proposing the concept of dissociation to form ions. Ostwald contributed his dilution law, which allowed for the calculation of the degree of dissociation over a broad range of concentrations. These discoveries of the ionists, as they became known, were not only of academic interest but were useful in other areas such as the chemical industry, where many processes take place in solution. Applications were also possible in the biological and geological sciences.

Why did Loeb come to Ostwald's laboratory? Charles Baskerville of the City College of New York, in his obituary of Loeb, states, "With the intention of testing the latest views on electrolysis, work which he had begun with Gibbs..., Loeb, with Nernst, carried on a study of the kinetics of substances in solution(5)." It thus appears that Wolcott Gibbs exerted a continued, guiding hand in the career of Loeb. Gibbs, with his interests in physics and chemistry, appreciated the new ideas being introduced by Ostwald and the ionists and may have suggested that Loeb go to Leipzig. In collaboration with Nernst, as well as on his own, Loeb was able to obtain enough results in several months to publish three papers in Ostwald's *Zeitschrift* concerning the kinetics in solution of silver salts and the molecular weight of iodine in solution(6, 7).

With Nernst, Loeb sought to prove the validity of the theory of electrolytic conductivity of Friedrich Kohlrausch (1840-1910). Nernst had worked in the laboratory of Kohlrausch in Würzburg in 1887. Arrhenius had also spent time with Kohlrausch, and the latter's work was crucial in formulating the ionization hypothesis. Among his other accomplishments, Kohlrausch had been the first to measure conductivities of solutions containing electrolytes under various conditions by using alternating current. His work was instrumental in disproving the notion held by many that it was the current that caused ionization. However, Kohlrausch did not believe that ions were present in any significant quantity unless a current was applied. In addition, Kohlrausch developed the concept of molar conductivity and the law of independent migration of ions. He was able to show that the molar conductivity at infinite dilution can be divided into two terms which represent the velocities of the anion and cation, respectively, in the two directions. Interesting relationships were found, in that for pairs of salts with a common ion the velocities were nearly always constant.

Loeb and Nernst calculated the velocity of the silver ion by using Kohlrausch's methods. The study of eight different silver salts resulted in a very narrow range of measured values and thus validated the independent nature of ions in solution. In Leipzig, Loeb had also proved that the molecular weight of iodine varied in solution. Loeb showed this by osmotic pressure measurements. "By the advice of Professor Ostwald, I undertook to attack the problem of molecular weight in its solutions by the vapor-tension method...(7)." Under conditions ranging from extreme dilution to saturation it was possible to determine a constant molecular weight. The molecular weight, which was found to be constant at a particular concentration, always seemed to increase with increasing concentration.

Having now been transformed into a physical chemist by Ostwald and Nernst, Loeb returned to America to spend a year working with Wolcott Gibbs, who had recently retired from Harvard and established a private laboratory near his home in Newport, Rhode Island. The wealth of the Loeb family provided Morris the means to work as a volunteer in Gibbs' laboratory.

Through Gibbs' intervention, Loeb was appointed as a docent in physical chemistry at Clark University in Worcester, Massachusetts in 1889. Clark University had been established in 1887 as a graduate school based upon the Germanic model with programs in chemistry(8), physics, biology, mathematics, and psychology. John Ulrich Nef (1862-1915), an organic chemist who had studied with Baeyer, was the first Professor of Chemistry; Loeb was the only other chemist on the faculty during Nef's brief time at Clark(1889-1891). In 1891, at the age of 28, Morris Loeb was elected Professor of Chemistry at New York University, becoming the first physical chemist to be a full professor in a chemistry department in the United States.

While at Clark, Loeb taught what may have been the first physical chemistry course in the United States in 1889. The introductory lecture to this course found in Loeb's papers was edited by T.W. Richards. This lecture, "The Fundamental Ideas of Physical Chemistry," appears in a memorial volume dedicated to Loeb's scientific work which appeared in 1913, the year after his death(9):

> In commencing this course of lectures, whose subject matter and title are avowedly new to the American student, I feel the need of giving some justification, of presenting some reason why I should seek to add one more rung to the ladder of learning already so alarmingly long.

Loeb than lashed out at the tyranny of organic chemistry and the perceived emphasis that chemistry is a practical science and its main role is to make new compounds which may have commercial value(9):

> Like to the miners of '49 the specialist in organic chemistry has but one thought. Arrived at his diggings, he delves assiduously, and if favored by fortune and skill is rewarded with many a rich nugget.

> But if, resting awhile from his labors he decides to retrace his steps and revisit former scenes, he is astounded to find that lands passed by as cheerless and barren have been occupied by settlers, who with patience and care have cultivated and beautified them, and are now reaping wealth more lasting and productive than his own gold.

Loeb's view just may have been somewhat clouded by his German experience.

Servos has written of the American experience as follows(10):

> ...American physical chemists confronted both the advantages and disadvantages of their nation's comparative backwardness. Instead of elbowing their way into existing laboratories and institutes, American physical chemists had to build them; instead of asserting themselves against powerful intellectual rivals they had to create traditions of research and scholarship in a country that has long proved resistant to both.

What then is physical chemistry according to Loeb?(11):

> Thus our chemical philosophy becomes an attempt to interpret the actions of these imaginary atoms constituting matters under the play of the various forms of energy which pertain to them; and these actions must be supposed to take place in tridimensional space during perceptible time.

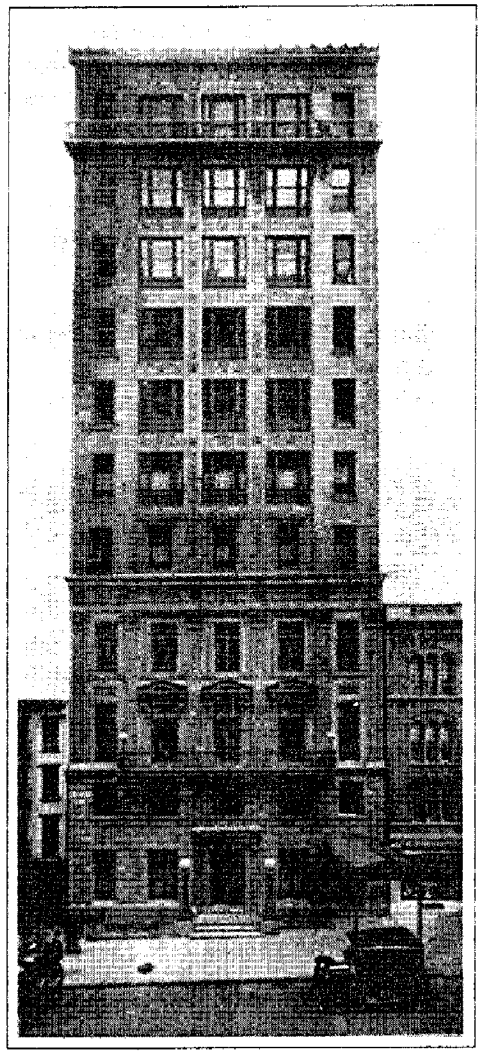
During his brief tenure at Clark University, Loeb made notable contributions on behalf of the cause of physical chemistry. He was one of the 43 chemists who attended the first national meeting of the American Chemical Society held outside of New York, organized by Charles E. Munroe (1849-1938). At this meeting, held in Newport, RI on August 6 and 7, 1890, Loeb presented a paper entitled, "On the Use of the Gooch Crucible as a Silver Voltammeter (12)."

For exact measurements of electric currents, no method is more convenient and more free from objections than the determination of the amount of silver deposited from a neutral solution of a silver salt. The sole source of error, especially where weak currents are concerned, arises from the imperfect adhesion of the silver upon the cathode.

Loeb found that a Gooch crucible with asbestos-covered holes was better suited as a cathode, provided leakage did not occur during electrolysis. Leakage was prevented by replacing the platinum cap with a glass siphon of special form. After the electrolysis has been completed, the siphon action built into the Gooch would drain away the excess silver nitrate solution.

The move to NYU initiated a new chapter in Loeb's life, that of teacher and administrator. His fervor for physical chemistry did not diminish but more and more of his time was being taken up with teaching and other activities of an educational, civic, and charitable nature.

Charles Baskerville writes of Morris Loeb as a teacher, "He was fired with zeal of those captain teachers and his own lighted torch he passed on by students



The Chemists' Building. 52 East Forty-First Street, New York

of his who now reflect in many responsible positions that spirit of the eighties(5)."

The heavy burden of teaching, which Loeb thoroughly enjoyed, had a serious effect on the time available for research. He always tried to keep up with the latest advances in the literature, however. When Solomon Loeb died on December 21, 1903, Morris assumed much of the responsibility previously shouldered by his father in the civic, religious, and charitable work associated with the Loeb family. Being one of the most prominent German Jewish families in New York, the Loebs had their duty to their less fortunate brethren who were arriving from eastern Europe in great numbers at that time.

Morris Loeb served on the boards of the American Jewish Committee, Hebrew Technical School, Jewish Agricultural and Industrial Aid Society, Jewish Theological Seminary, and the Education Alliance. He was a member of the New York School Board and many other organizations too numerous to mention. Loeb was very generous with the family fortune but personally he had, according to Stephen Birmingham "a fetish about money, and a fear of spending it...Morris scrimped and saved pennies and squirreled them away. When the Loeb house was demolished many years later some of Morris' deposits were discovered behind moldings and beneath floor boards; the wallpaper of one room was interlined with thousand dollar bills(13)."

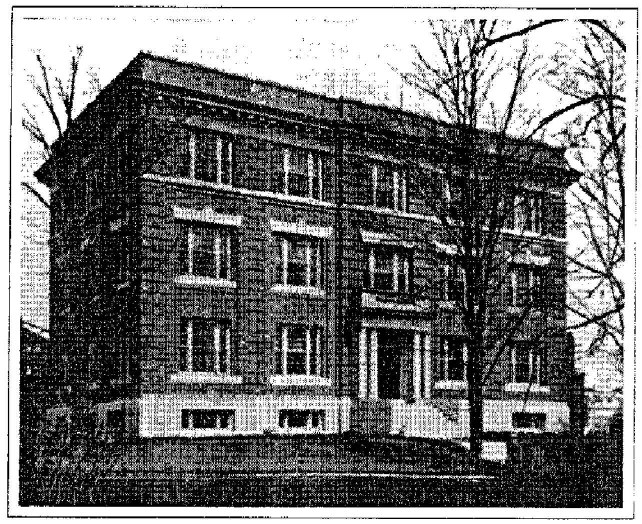
Another recipient of Loeb's generosity was the Chemists' Club of New York, which he served as vice-president and president at various times. During his first term as president in 1909 Loeb proposed that the club should acquire a permanent headquarters "planned to serve under one roof the social, intellectual, and practical needs of the chemical profession not of New York alone, but of our beloved country(14)." A ten- story building was erected on East 41st Street in New York City on a lot donated by Loeb. This building contained social rooms, meeting rooms, a 16,000-volume library, and accommodations for visitors. The top five floors were devoted to laboratories, one of which Loeb used and which was named after him after his death.

The Chemists' Building itself was owned by a stock company, of which Loeb was the chief shareholder, along with other chemists and chemical manufacturers. In his will he left all his shares to the Chemists' Club which made it much easier for the club itself finally to purchase the building. As Loeb remarked upon the opening of the building(15):

> The existence of a complete building, devoted solely to the interests of the chemists, will probably be the best demonstration to the American public of the importance which this profession has now assumed from the technical and business point...This building does not owe its erection to some benevolent demigod extending his protecting wing over people unable to care for themselves; it is a building by the chemists, of the chemists, and for the chemists.

Harvard University occupied a very special affection for Loeb and he served on many of its committees, one of which was concerned with laboratory facilities. This committee, on March 27, 1909, recommended that a new laboratory building was needed specifically dedicated to inorganic and physical chemical research(16):

> Harvard has always been a leader in university education in this country, and it is still aiming strenuously to maintain that position. Is it not wise, therefore, in planning the education of her students, to give due encouragement to the distinguished staff which is now laboring under exceeding difficulties to maintain a well-earned supremacy in this department?



Wolcott Gibbs Memorial Laboratory, Harvard University

Within a month after this report had been sent to the Board of Overseers, Morris Loeb and his younger brother James donated $50,000 to the projected $100,000 cost of the building. At Loeb's suggestion, the building which opened in 1913 was named after his mentor Wolcott Gibbs, who had died in 1908.

In 1891 Loeb was a founding member and first secretary of the New York Section (the second oldest after the Rhode Island section) of the American Chemical Society. One of his major interests was the promotion of international cooperation among chemists and chemical societies. He was one of the organizers of the Eighth International Congress of Applied Chemistry held both in Washington and New York in September, 1912. He also contributed a paper on the speed of reductions of iron (III) by aluminum, manganese, and thorium salts.

As Loeb wrote in an editorial in *Industrial and Engineering Chemistry*(17):

> And now we have entered into a new era, practically with the opening of the twentieth century, that of the utter abolition of national boundaries so far as scientific endeavor is concerned. A new chemical discovery in Paris is known in London, New York and Tokyo in far less time than was consumed in the transmission of Priestley's or Cavendish's communications to the Royal Society in London, and the time is rapidly passing when the possession and guarding of a scientific secret could be deemed a national advantage. To meet the leaders of chemical knowledge and of chemical manufacture, from abroad as well as at home, to listen to a free exchange of thought and practical experience, are privileges for which innumerable chemists have traveled to Berlin, London, Paris, Vienna, and Rome. We all now have these chances at home, coupled with opportunity to benefit by free and generous criticism of whatever we may desire to bring to their view.

While in Washington during the Congress, Loeb apparently ate contaminated oysters and contracted typhoid fever, which led to pneumonia. Morris Loeb, America's first physical chemist, died on October 8, 1912, in his forty-ninth year at his estate in Sea Bright, New Jersey. His passing elicited an outpouring of tributes from all those groups he had so generously supported by his hard work and his financial resources and of testimonials to his scientific accomplishments.

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ABOUT THE AUTHOR

Martin D. Saltzman is Professor of Natural Science at Providence College, Providence, RI 02918. He is the recipient of the 1988 Outstanding Paper Award for his paper, "From Small Misunderstandings Mighty Disputes Grow: E. D. Hughes' American Paper" (*Bull. Hist. Chem.*, **1994**, *15/16*, 37-43.)