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A New Science, and a New Profession: Sugar Chemistry in Louisiana, 1885-1895

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BETWEEN 1885 and 1895 the Louisiana sugar industry experienced a scientific and technological revolution in methods, process apparatus, and scale of operations. The animal-powered mills and open kettles characteristic of the antebellum period were supplanted by large, technically designed, and scientifically controlled central factories. In 1880 there were approximately 1,000 sugar houses in Louisiana with an average annual production of 110 long tons of sugar per house. By 1900 fewer than 300 factories constituted the state's sugar industry, but yearly production averaged over 980 long tons for each sugar house. One commentator of the period, Mark Twain, described a modern Louisiana sugar factory as a "wilderness of tubs and tanks and vats and filters, pumps, pipes and machinery."[1]

This new industrial world that emerged in rural Louisiana was brought about in large part by a variety of local institutions working in alliance with the United States Department of Agriculture. They included the Louisiana Sugar Planters' Association, the Louisiana Sugar Experiment Station, the Audubon Sugar School, and Louisiana State University. These organizations facilitated the introduction of a progressive chemical and engineering technology, derived in part from the European beet sugar industry, into the traditional plantation culture of the Deep South.

The emergence of a scientific and technical institutional infrastructure was crucial to the development of the late nineteenth-century Louisiana sugar industry. Yet this complex transformation of manufacturing processes would never have taken place without the labor and innovations of a large number of experts

working within the organizational structure. One group of experts, the sugar chemists, employed analytical skills and the knowledge of organic reactions to improve production efficiency in the sugar house.

To date, historians of American chemistry have generally focused their attention on the activities of either a few eminent scientists, like Theodore W. Richards, Gilbert N. Lewis, and Ira Remsen, or outstanding chemistry departments, like those at Johns Hopkins University, Harvard University, and the University of Chicago. Second- and third-level chemists and regional institutions have been almost totally neglected. Studies of the elite—the group of scientists at the very apex of the professional pyramid representing the American scientific community—are important indeed. Yet if we are truly to understand the progress of chemistry and chemical technology in America, we must also examine the lower tiers composing the bulk of investigative and commercial applications activity. For example, scholars must not neglect to examine the work of those creative chemists who made significant contributions to the development of the nineteenth-century agricultural and food industries. Their application of organic chemistry to the solution of practical problems was in part responsible for the drive to industrial maturity that occurred in the United States between 1875 and 1914.[2]

Between 1885 and 1895 the sugar chemist in Louisiana could be found plying his trade in either the experiment station, the university, or the sugar-house laboratory. His workplace and his professional world were far from tranquil. On the contrary, they were characterized by change and tension. In part, the challenges that confronted the chemist were the consequence of rapid technological changes. In order to maintain his employer's economically competitive position, the sugar chemist was constantly pressured to keep abreast of new developments in carbohydrate chemistry and process technology. Yet in addition to the everyday strains associated with his scientific and technical responsibilities, the sugar chemist's institutional setting and professional environment made his job even more trying. The chemist was a newcomer to the sugar-industry work force, and

his ability to improve product quality and the efficiency of the manufacturing processes was often viewed with skepticism by the tradition-bound planter. Many Louisiana planters seriously questioned whether the application of scientific principles would ever lead to profits. In addition, the artisan sugar boilers, who previously had been charged with the responsibility of controlling the sugar-making process, correctly perceived the chemists as a threat to their livelihood and occupational status. On many occasions young university-trained chemists, unaccustomed to the coarse manners of the sugar-house floor, were shunned by the experienced and well-seasoned sugar boilers. And finally, many chemists experienced an inner struggle as well. Those sugar chemists who had extensive European educational training were forced to reconcile their vision of the German research ideal and their perceived role within the international scientific community with the reality that utility had priority over pure research and that regionalism, not internationalism, characterized their current working environment in Louisiana.

From the Age of Jackson to the 1880s, a few enlightened planters, along with a small group of medical men and consulting chemists, were the source of chemical expertise in the Louisiana sugar industry. By 1880, however, the Louisiana Sugar Planters' Association (LSPA), a group of the wealthiest and most politically powerful sugar planters in the state, recognized that the lack of scientific expertise could prevent it from successfully competing against the dynamic European beet sugar industry. To overcome this deficiency, this group pursued several strategies to secure university-trained scientists and engineers for their industry. As a result of the relationship it cultivated with the United States Department of Agriculture (USDA) and that existed between the two organizations between 1883 and 1889, the federal agency not only supplied the state with a large corps of formally trained research chemists but also facilitated the transfer of European developments in the chemical control of manufacturing processes and the introduction of new plant apparatus. The USDA's interest in the Louisiana sugar industry re-

sulted in the use of systematic chemical analysis to monitor large-scale processes, as well as the introduction of new extraction, clarification, filtration, and evaporation apparatus.

Nevertheless, Louisiana planters regarded the USDA experiments as only moderately successful, since the agency's trials failed to establish conclusively the economic advantages of the new processes. The presence of the USDA in Louisiana and the unanswered questions from these trials convinced the LSPA leaders to sponsor a sugar experiment station. Through private subscription the LSPA established the Louisiana Sugar Experiment Station, which was first located in Kenner, Louisiana, in 1885.[3] William Carter Stubbs, from the Alabama Experiment Station, was hired as the LSPA station's first director.

Stubbs, who was director of the station between 1885 and 1905, proved to be popular and effective. Born near Williamsburg, Virginia, in 1843, he began his studies at the College of William and Mary in 1860. His studies were interrupted by a brief stint in the Confederate army, and after his capture and parole, he completed his preliminary studies at Randolph-Macon College and again served in the Confederate cavalry until the surrender at Appomattox. In 1865 Stubbs enrolled at the University of Virginia, where he completed the master's course in chemistry and geology in 1867. He then studied analytical chemistry under John William Mallet for one year. Mallet, who had been trained by Friedrich Wöhler at Göttingen, impressed upon Stubbs that chemistry was a quantitative rather than a qualitative discipline. Between 1869 and 1872 Stubbs served as professor of chemistry at Alabama Agricultural and Mechanical College at Auburn. He gained additional responsibilities in 1877, when he assumed the position of Alabama state chemist.[4]

Throughout most of his career, Stubbs's research focused upon field studies. Most significantly, his conception of agricultural chemistry was rooted in traditional American ideas and practices common between 1860 and 1880. His scientific activities in Louisiana were strongly influenced by Samuel W. Johnson's popular treatises, *How Crops Grow* and *How Crops Feed*.[5] Stubbs employed Johnson's views not only in formulating the research

program at the Louisiana Sugar Experiment Station but also in teaching scientific agriculture to his students at Louisiana State University. Stubbs's understanding of plant growth, like that of Johnson, was based upon the analysis of inorganic ash residues and organic compounds, an approach that was the result of chemical and agricultural investigations first proposed by Justus Liebig in the early 1840s and employed extensively by European and American chemists during the late 1840s and early 1850s. Stubbs correlated plant growth stages with the relative quantities of inorganic acidic and basic salts found when various proportions of the plant were ashed. Furthermore, he estimated the volatile components of plants (nitrogen, carbon, hydrogen, oxygen, phosphorus, and sulfur) and extracted such loosely defined organic constituents as fibers, fats, and albuminoids.

During the late 1880s, the experiment station was moved from Kenner to Audubon Park in New Orleans. At about this time Stubbs began to reorient the experiment station's research program away from field trials and more toward sugar processing improvements. This change in emphasis was in part due to a shift in the planters' interest from the culture of sugarcane to the large-scale manufacture of raw sugar. In particular, the planters were debating the merits of the new diffusion process as a possible alternative to the crushing of cane during extraction. Having discovered that many of his assistants possessed a European education in chemistry, Stubbs sought to take advantage of their knowledge in carbohydrate chemistry to solve complex manufacturing problems. He designed manufacturing studies so that data from large-scale sugar production tests would also yield information about the formation of complex carbohydrates and invert sugars in the cane. The conversion of glucose to sucrose, and the complex interaction of gums, pectose sugars, and albuminoids, were chemical reactions that on one level were the basis of manufacturing problems, while on another level explained the biochemical development of cane from seed germination to maturity. Thus, fermentation, an ever-present threat to efficient processing, was closely tied to the

The "best looking fellow" at the Audubon sugar experiment station, New Orleans, 1894.
Courtesy of *The Charles Edward Coates Papers*, Special Collections, LSU Libraries, Louisiana State University and Agricultural and Mechanical College.

presence of albuminoids, and an understanding of these substances and their associated reactions partially revealed the nature of plant growth.

Stubbs's reliance upon the research efforts of the experiment-station chemists who had been trained in the fundamentals of organic structural chemistry led to the practice of a new type of agricultural chemistry at the Audubon experiment station during the 1890s. Investigators focused upon problems related to plant biochemistry, and they often employed new ideas and techniques originating in the European laboratories.

A number of chemists found employment at the station between 1888 and 1905, including some, like T. H. Jones, Maurice Bird, and W. Wipprecht, who had been trained at southern universities. Wipprecht, however, had also been educated at Göttingen, and he proved to be the first of a large number of Bernard Tollens' former students who applied their theoretical knowledge of sugar chemistry to the solution of practical problems at the Louisiana Sugar Experiment Station.[6]

Tollens, who had received his training under Rudolf Fittig at the University of Göttingen, Emil Erlenmeyer at the University of Heidelberg, and Charles Adolphe Wurtz at the University of Paris, had succeeded Wilhelm Wicke in 1873 as professor and director of the laboratory at the Agricultural Institute of Göttingen. Historians of chemistry have neglected Tollens' career in science, perhaps because he was the practical chemist working out in the laboratory the structural theories proposed by better known and more illustrious contemporaries. Nevertheless, Tollens had a central position within the nineteenth-century German community of chemists, frequently interacting with industrial concerns and academic scientists over scientific problems of mutual interest. Until 1911 Tollens and his students focused their efforts on determining the exact chemical nature of the unknown carbohydrates contained in the crude fibers and nitrogen-free extracts of crops. Emil Fischer's work on the structure of carbohydrates enabled Tollens to understand basic carbohydrate reactions like hydrolysis, hydrazone formation, and fermentation.[7] With this knowledge Tollens successfully separated and analyzed many carbohydrate compounds normally found in plant materials, including hexosans, pentosans, and methyl pentosans. He also conducted studies on enzyme reactions and the process of fermentation. Similar studies became the focus of the Louisiana Sugar Experiment Station after 1890, when Tollens' former students Charles A. Browne, Fritz Zerban, Peter A. Yoder, and William E. Cross applied their knowledge of carbohydrate chemistry and structural chemistry to the solution of practical sugar manufacturing problems.

Although a majority of the chemists with Ph.D. degrees work-

ing at the station between 1889 and 1910 were former students of Tollens, graduates of Harvard, Johns Hopkins, and Zürich Polytechnical Institute also made valuable research contributions. Of the two station chemists educated at Harvard—Horace Everett Lincoln Horton and Josiah Thomas Crawley—Crawley studied agricultural and physiological chemistry under Walter Maxwell, who in 1893 replaced his student at the Audubon Sugar School.[8] Also in 1893 Stubbs's staff was enriched by the addition of Jasper L. Beeson, a chemist trained by Remsen. Although manufacturing problems and questions on plant growth remained central, Beeson and Maxwell used their talents, with Stubbs's approval, to redirect the nature of station investigations.

Beeson was born in Alabama in 1867. After graduating from the University of Alabama in 1889, he was appointed instructor of physics at the university, and a year later he found employment as a chemist for the Alabama Geological Survey. In 1891 he entered Johns Hopkins, where he earned a Ph.D. degree in 1893.[9] After joining the staff at the Louisiana Sugar Experiment Station, he conducted research and taught chemistry to students of the station's sugar school.

In his research Beeson investigated the link between problems in sugar manufacture and the processes of plant growth and nutrition. The most controversial topic among Louisiana planters and sugar manufacturers during the early 1890s was whether diffusion or milling was more economical. Since it had been noticed that juices obtained from two successive milling operations were completely different in color, it was postulated that the material contained in the cane internodes was different from that expressed from the nodes during the second milling. Beeson found that the substances extracted from the nodes were highly colored, giving a heavy precipitate when mixed with a solution of subacetate of lead and coagulating when heated to the boiling point. However, extracts from the internodes were clear and light in color, produced little coagulation upon heating, and contained more albuminoids and reducing sugars than the nodes. In response to these findings, Beeson hypothesized that the physiological function of cane nodes was similar to that of seeds in

flowering plants—storing food for the sustenance of the young plant during that initial period before it had taken root sufficiently to draw nutrients from the earth. In Beeson's experiments on pedigreeing cane, he chemically analyzed sugarcane grown from seed tops, middles, and butts and found no significant differences. However, he discovered the presence of less sugar and more solids—albuminoids, amide nitrogen, and ash—in the tops. Therefore, he suggested using tops for seeds—cutting down to the first joint that had cast its leaves and sending the remaining sugar-rich portion to the mills for processing.[10]

Maxwell also studied fundamental problems in plant biochemistry that had their origin in manufacturing. Born in Great Britain in 1854, Maxwell studied at the City and Guilds Institute at South Kensington. Later he worked with Ernst Schulze at Zürich Polytechnical Institute, where he investigated the chemistry of plant cell membranes and the constituents of leguminous seeds.[11] In 1888 Maxwell enrolled at Harvard, where he conducted a course in physiological chemistry. Between 1889 and 1893 he served the USDA as the assistant chemist supervising the agency's beet sugar experiments at Schuyler, Nebraska. After accepting a position at the Audubon Park sugar station in 1893, Maxwell remained in Louisiana until his appointment in 1895 to the directorship of the Hawaii Sugar Experiment Station.

Maxwell's investigations in Louisiana were conducted in response to problems encountered during diffusion-process trials at the station. He hypothesized that the presence of noncrystallizable organic bodies often interfered with the crystallization of diffusion juices. Diffusion, he thought, also extracted substances that were normally left in the bagasse during milling and left behind other substances usually extracted by pressure treatment.[12] In the past, nitrogen analyses conducted at the station had been based on the assumption that all nitrogen was in the form of albuminoids. However, Maxwell performed a Kjeldahl nitrogen assay on mill and diffusion juices to determine total nitrogen, and then he estimated amide nitrogen by the Stutzer method. Maxwell determined that whereas the nitrogen in mill juices was distributed between albuminoids and nonalbumi-

noids (chiefly in the form of amides) in the ratio of one to two, that in diffusion juices it was distributed in the ratio of one to three. Since albuminoid bodies were necessary for the formation of the coagulation blanket during the clarification process, it was now evident why hot water diffusion was often accompanied by crystallization and clarification problems.

Like his colleague Beeson, Maxwell related his findings to physiological interpretations of cane growth. He claimed that, in mature seed, nitrogen was primarily in an albuminoid form; after the seed germinated, nitrogen was converted to the water-soluble amide form. Thus, amide compounds, along with glucose, were easily transported to the various regions of the plant, where they furnished the raw materials for growth while being reduced to albuminoid form once again.

Maxwell's investigations opened new areas in sugar chemistry. Yet his work had practical consequences as well. His analytical studies of nitrogen compounds effectively marked the end of diffusion trials in Louisiana. Although the diffusion process had proven itself an effective method of obtaining high extraction yields, the addition of excess water resulted in increased fuel consumption. This dilution problem could have been surmounted, perhaps, by the use of efficient multiple-effect evaporation apparatus. However, chemical process problems, particularly during crystallization, proved to be the process's death knell.[13]

Thus, between 1890 and 1895 the research staff at the Louisiana Sugar Experiment Station concentrated on problems in sugar chemistry that were related not only to manufacturing difficulties but also to important questions in plant physiology and nutrition. This new type of agricultural chemistry practiced at the experiment station at Audubon Park was quite different from the inorganic analyses that Stubbs had conducted at the Kenner location. Unlike Stubbs, Beeson and Maxwell were apparently not satisfied with reporting the results of their work only in the experiment station's bulletins and the *Louisiana Planter and Sugar Manufacturer.* These chemists were eager not only to prove their work to the skeptical planters but also to

gain the recognition of the scientific community. Therefore, it is not surprising that Beeson communicated his findings in the *Journal of the American Chemical Society* nor that Maxwell published his results in the *Sugar Cane.*[14]

Between 1885 and 1895, both the station chemists and the factory chemists wanted to demonstrate their legitimacy within the sugar industry. In particular, the factory chemists wanted to overcome both the skepticism of their employers and the criticisms of the artisans whom they were gradually displacing from the sugar houses. The sugar chemists in Louisiana viewed organization as the best strategy for securing their professional goals.

Factory chemists led an early movement to organize a professional association for sugar chemists in Louisiana. In 1889 Lezin Becnel, a chemist employed at the McCall Bros. Plantation in Ascension Parish, took the initiative to establish a local chemists' society. He acted primarily in response to the perceived widespread opposition to sugar chemists by both skilled and unskilled laborers. Becnel hoped that an association would clearly define the role of the chemist in the sugar industry as well as assist in uniting chemists with their planter employers for their mutual benefit. Becnel asserted that the factory chemist was a misunderstood, frequently maligned professional whom plant workers often called a "crank" working in a "drugstore."[15]

While factory chemists were promoting and clarifying their position, station chemists were recognizing that the scientists whose work was guided by theory suffered from a lack of prestige within the planter circles. Louisiana planters emphasized that their business needed the contributions of *practical* chemists. According to this view, the successful chemist possessed "a large stock of practical knowledge, and of experience in actual sugar house work. . . . To employ a professor of chemistry unpossessed of this experience would be to lose a season."[16] Thus, both industrial and station chemists—two groups of chemists possessing somewhat different educational backgrounds and professional objectives—had sufficient reasons to unite.

On June 15, 1889, the Louisiana Sugar Chemists' Association

held its first meeting at the Audubon sugar experiment station.[17] Some members of the station's staff, including Stubbs, attended, and Bennett Battle Ross from the Baton Rouge station was elected the group's first president. The association's objectives included the dissemination of chemical knowledge, the discussion and evaluation of analytical methods, and the adoption of a standard system of factory chemical-control statistics. Membership in this organization was limited to chemists who were either employed in the analysis of agricultural products or engaged in scientific agriculture. The organization was led by its officers and two permanent committees of three members each. The committee on statistics was selected from practical sugarhouse chemists, whereas the committee on analysis was composed of station chemists.

During the summer of 1889, led by Ross and Bird of the sugar station, the committee on analysis compiled a list of the most satisfactory analytical procedures for the determination of sugar. The fact that they published their data in a widely circulated pamphlet that fall indicated that these station chemists were attempting to establish themselves as experts within the Louisiana community of chemists. The *Report of the Committee on Methods of Sugar Analyses of the Louisiana Sugar Chemists' Association* outlined in a simple manner the methods and apparatus necessary for the determination of sucrose, specific gravity, density, total solids, glucose, ash, and fiber. This detailed description was written for the benefit of analysts who were "just entering . . . or [had] only a limited experience in the laboratory of the sugar house."[18]

Thus the committee established itself as an authority in approving the numerous chemical procedures used in the chemical control of the factory. In addition, the committee of station chemists conducted precise polariscopic studies to ascertain the absolute value of the constant employed in Clerget's method for the determination of sucrose in the presence of glucose.[19] This investigation obviously had practical significance to the Louisiana sugar industry, which processed millions of pounds of sugar annually. Even a small variation in Clerget's constant could

affect the profits of large-scale processors. However, the extreme care taken with reagents and experimental conditions, as well as the treatment of data, suggests that Ross and Bird were also hoping to earn the respect of the scientific community. They conducted their experiments utilizing a double-compensating polariscope in a 31°F room at the New Orleans Cold Storage Company. The results were compared with data obtained from gravimetric determinations using Fehling's solution. Indeed, the committee was pursuing work begun by Hans Heinrich Landholt in Germany, and it published its results in the *Journal of Analytical Chemistry.*

Concurrently, the association's statistics committee began to devise a standard form for reporting chemical-process information. It was hoped that these sheets would eventually become the basis for comparing the performance of various Louisiana sugar houses and for indicating manufacturing inefficiencies. Becnel asserted that in the future "our records should also include the cost of every item, from the cutting of the cane to the cost of laying down one pound of sugar on our plantation landings, so as to . . . reduce the actual cost of manufacture."[20] The introduction of chemical control into the Louisiana sugar industry ultimately revolutionized business practices. For example, after St. Mary's Parish planter John N. Pharr employed a chemist at his Glenwild factory, annual reports became more detailed and manufacturing costs were included. The chemists' division of the manufacturing process into units later became the basis for cost accounting.

The Louisiana Sugar Chemists' Association met in the fall and the spring, and discussions usually consisted of works-in-progress reports by various members. Concurrent with the movement to stimulate research within the membership, the chemists' association began to take steps toward identifying itself within a larger scientific community. In 1891 the organization expressed interest in joining a national group of chemists led by Albert C. Peale. By 1893 most of the members had already joined the American Chemical Society (ACS), and in late 1893 the association officially took steps to join that body. In 1894 the

Louisiana Sugar Chemists' Association became a part of the newly formed New Orleans section of the ACS. This local ACS branch was short-lived, however, operating only until 1898.[21]

The efforts of chemists to advance the utility of their profession gained widespread acceptance in Louisiana. The factory chemist became an integral part of sugar manufacturing during the 1890s. To remain competitive, planters were forced to rely upon chemical-control data to minimize process losses and to maximize product quality. However, the status of a research-oriented station chemist never became as secure as that of his factory counterpart. With the repeal of the Bounty Law in 1894, which had levied stiff tariffs on imported sugars, the American market was flooded with cheap imported sugar, and the Louisiana sugar industry began a gradual decline. This economic situation was not conducive to the support of carbohydrate research like that conducted by Beeson and Maxwell. To a large degree, planters saw the answer to their problems not in the study of complex organic substances but in political activities. The redirection of the planters' interest resulted in the decline of first-rate research at the Louisiana Sugar Experiment Station, as pure science assumed a much lower priority than theretofore.

Thus, the world of the sugar chemist in nineteenth-century Louisiana was characterized by change and tension. The agricultural chemistry of Liebig, practiced by Stubbs at the Louisiana Sugar Experiment Station, was unable to solve manufacturing problems that were arising from a new sugar technology. A new kind of American chemist, like Maxwell and Beeson, applied modern organic chemistry to the solution of complex processing problems. Yet these European-trained scientists had to deal with both skepticism and inner conflict. Along with the factory chemists, the station chemists saw organization as a way of overcoming their tensions. Although the utility of chemical control was gradually accepted, a change in economic conditions adversely affected the aspirations of the research-minded station chemists in Louisiana. After 1895 the experiment-station chemists could hope to pursue research only if funded by the federal government. The story of the gradual decline in the

quality of research at the Louisiana Sugar Experiment Station is to be told on another occasion.

NOTES

1. Samuel L. Clemens [Mark Twain], *Life on the Mississippi* (New York, 1917), 384.
2. Harold Vatter, *The Drive to Industrial Maturity* (Westport, Conn., 1975).
3. William Carter Stubbs, "An Experimental Farm for the Promotion of the Sugar Interest" (MS in William Carter Stubbs Papers, Southern Historical Collection, University of North Carolina at Chapel Hill), and "Charter of the Louisiana Scientific Agricultural Association" (Printed copy in *ibid.*).
4. Stubbs's education was traced in a letter from William Carter Stubbs to Charles Albert Browne, February 27, 1922, in the Charles Albert Browne Papers, Library of Congress. Stubbs's scientific and technical contributions can be best reviewed by examining his many addresses and papers appearing in *Louisiana Planter and Sugar Manufacturer.* His monographs include *Sugar Cane. A Treatise on the History, Botany and Agriculture of Sugar Cane, and the Chemistry and Manufacture of its Juices into Sugar and Other Products* (New Orleans, 1897), *Sugar Cane* (Boston, 1903), and with Herbert Myrick, *The American Sugar Industry: A Practical Manual on the Production of Sugar Beets and Sugar Cane, and on the Manufacture of Sugar Therefrom* (New York, 1899). See also William Carter Stubbs, "Notes on Chemical Analysis" (MS in William Carter Stubbs Papers, College of William and Mary, Williamsburg).
5. Samuel W. Johnson, *How Crops Grow. A Treatise on the Chemical Composition, Structure and Life of the Plant, for All Students of Agriculture* (New York, 1887), and *How Crops Feed. A Treatise on the Atmosphere and the Soil as Related to the Nutrition of Agricultural Plants, with Illustrations* (New York, 1882). For information on Johnson, see Margaret Rossiter, *The Emergence of Agricultural Science: Justus Liebig and the Americans* (New Haven, 1975), 127–48.
6. For information on Jones, see *Louisiana Planter and Sugar Manufacturer,* 1 (1888), 107; C. A. Browne, "Bernard Tollens (1841–1918) and Some American Students of Agricultural Chemistry," *Journal of Chemical Education,* 19 (1942), 253–59. Tollens' work is briefly described in Aaron J. Ihde, *The Development of Modern Chemistry* (New York, 1964), 344–45.
7. To understand Tollens' research, see Bernard Tollens, *Kurzes Handbuch der Kohlenhydrate* (2 vols.; Breslau, 1895); W. E. Cross and B. Tollens, "Versuche über das Verhalten der Pentosen in garenden Mischungen," *Journal für Landwirtschaft,* 59 (1911), 419–28.
8. H. E. L. Horton, "Some Notes on the Determination of Sugars with Fehlings Solution," *Journal of Analytical Chemistry,* 4 (1890), 370–81; J. T. Crawley, "A Simplified Fat-Extracting Apparatus," *American Chemical Journal,* 11 (1889), 507–508.
9. Jasper Luther Beeson, "A Study of the Action of Certain Diazo-Compounds on Methyl and Ethyl Alcohols Under Varying Conditions" (Ph.D. dissertation, Johns Hopkins University, 1893).
10. J. L. Beeson, "A Study of the Constituents of Nodes and Internodes," "The Es-

timation of Crude Fibre in Sugar Cane," "Pedigreeing of Cane—'Tops from Tops,'" and "Effects of Fertilizers Upon Sugar Cane," in *The Chemistry of Sugar Cane and Its Products*, Louisiana Sugar Experiment Station Bulletin, 38 (Baton Rouge, 1895), 1341–71.

11. C. A. Browne, "Dr. Walter Maxwell," *Facts About Sugar*, 27 (1932), 24. One can readily ascertain the influence of Schulze upon Maxwell by examining the latter's early publications. See W. Maxwell, "On the Solubility of the Constituents of Seeds in Prepared Solutions of Ptyalin, Pepsin, and Trypsin," *American Chemical Journal*, 11 (1889), 354–57, "On the Presence of Sugar-Yielding Insoluble Carbohydrates in Seeds," *ibid.*, 12 (1890), 51–60, "On the Soluble Carbohydrates Present in the Seeds of Legumes," *ibid.*, 12 (1890), 265–69, "On the Methods of Estimation of Fatty Bodies in Vegetable Organisms," *ibid.*, 13 (1891), 13–16, and "On the Behavior of the Fatty Bodies, and the Role of the Lecithines, During Normal Germination," *ibid.*, 13 (1891), 16–24. Maxwell's interest in nitrogen compounds is reflected in "On the Nitrogenous Bases Present in the Cotton Seed," *ibid.*, 13 (1891), 469–71. His early studies on germination were published in "Movement of the Element Phosphorus in the Mineral, Vegetable, and Animal Kingdoms, and the Biological Function of the Lecithines," *ibid.*, 15 (1893), 185–95. Maxwell's USDA publications include: Walter Maxwell and Harvey W. Wiley, *Experiments with Sugar Beets in 1892*, USDA Division of Chemistry Bulletin, 36 (Washington, D.C., 1893) and *Experiments with Sugar Beets in 1893*, USDA Division of Chemistry Bulletin, 39 (Washington, D.C., 1894).
12. Walter Maxwell, "Organic Solids Not Sugar in Cane Juices," "Sulphurous Acid, Acid Phosphate and Lime as Clarifying Agents," and "Fermentation of Cane Juices," in *The Chemistry of Sugar Cane and Its Products*, Louisiana Sugar Experiment Station Bulletin, 38 (Baton Rouge, 1895), 1371–1408.
13. "Milling v. Diffusion," *Sugar Cane*, 27 (1895), 428.
14. See J. L. Beeson, "Notes on the Estimation of Crude Fiber in Sugar Cane," *Journal of the American Chemical Society*, 16 (1894), 308–13, "A Simple and Convenient Extraction Apparatus for Food-Stuff Analysis," *ibid.*, 18 (1896), 744–45, and "A Study of the Clarification of Sugar Cane Juice," *ibid.*, 19 (1897), 56–61.
15. "Louisiana Chemists Organizing," *Louisiana Planter and Sugar Manufacturer*, 2 (1889), 270. To understand Becnel's work, see Lezin A. Becnel, *Report on the Results of Belle Alliance, Evan Hall and Souvenir Sugar Houses, for the Crop of 1888* (New Orleans, 1889), and "General Plantation and Sugar House Statistics, the Manner of Keeping Same, and the Necessary Chemical Control," *Louisiana Planter and Sugar Manufacturer*, 2 (1889), 286–87.
16. "Notes and Comments," *Louisiana Planter and Sugar Manufacturer*, 3 (1889), 370.
17. "The Sugar Chemists," *ibid.*, 2 (1889), 283.
18. *Report of the Committee on Methods of Sugar Analysis of the Louisiana Sugar Chemists' Association* (Baton Rouge, n.d. [1889]), 201, reprinted in *Journal of Analytical Chemistry*, 4 (1890), 1–19.
19. The proposed revision of the constant used in Clerget's method caused a controversy among analytical chemists. See "Changes of Methods of Analyses by the Association of Official Agricultural Chemists," *Journal of Analytical*

Chemistry, 6 (1892), 259–62, and "Concerning the Constant to Be Used in Clerget's Inversion Process," *ibid.*, 6 (1892), 432–35, 519–24, 633–36. Clerget's procedure, first proposed in 1849, enables the analyst to determine the percentage of sucrose in a solution containing other optically active substances. Cane sugar (sucrose) is hydrolyzed by either acid or the enzyme invertase to a 1:1 mixture of glucose and fructose, which rotates polarized light in the opposite direction. The amount of change in rotation is proportional to the concentration of sucrose. For additional information on Clerget's method, see C. A. Browne and F. W. Zerban, *Physical and Chemical Methods of Sugar Analysis* (New York, 1941), 402–405.

20. Becnel, "General Plantation and Sugar House Statistics," 287.
21. Between 1896 and 1898 the inside cover of the *Journal of the American Chemical Society* listed a local New Orleans chapter. In 1900 the New Orleans section was no longer included, and in 1906 a second New Orleans chemists' association affiliated with the ACS was established.