CHEMISTRY UNDER THE MORRILL ACT: AGENCY THROUGH SERVICE (1)

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In 1930, Arthur Klein, Chief of the US Office of Education's Collegiate and Professional division, surveyed and ranked American land grant colleges and universities. The agency employed a simple metric to measure the quality of the various schools. Chemistry was that analytic tool, especially the quality of a university's faculty and library holdings in that area. The reasons were clear. "Chemistry is a fundamental science upon which agriculture and engineering are based," the report noted. "Chemistry should be one of the strongest departments in land-grant institutions" (2).

That was quite a profound change from the Morrill Act's intent. The law made no provision for anything chemical, much less chemistry departments. Yet chemistry departments would emerge as a critical discriminant in evaluating these schools. That transformation was neither inevitable nor abrupt. To a large degree, it originated with the chemists themselves. They achieved this central position through service, especially service to agriculture.

The Morrill Land Grant College Act was one of four seminal acts passed in 1862 to help fulfill the promise of American democracy. The other three acts—the Homestead Act, the Act to create the USDA and the Act to establish a transcontinental railroad system—provided in the parlance of the time the infrastructure to pursue success. This infrastructure broadened opportunity to participate in the fruits of American society. The Morrill Act was no different. It aimed to open education beyond the well to do—to the sons and daughters of farmers and mechanics—and facilitate entrée into whatever fields they chose to pursue (3).

The new colleges were given an extensive yet concrete mission: "to promote the liberal and practical education of the industrial classes in the several pursuits and professions of life." But Congress had added a kicker. They were to do so "in such a manner as the state legislatures may respectively prescribe" (4).

That last statement was critical. Leaving it up to the states to decide how to reach that objective meant that these institutions would be exquisitely sensitive to political machinations and varied interpretations of how to achieve the law's goals. A few in the northeast immediately wanted the nascent colleges to be specifically industrial: "to advance and disseminate scientific knowledge for the aim of agricultural and industrial development." These "National Schools of Science" would provide "instruction and researches in the mathematical, physical, and natural sciences, with reference to the promotion and diffusion of science" (5).

That model, with its desire to establish a scientific elite to join the traditional elites of clerics, lawyers and doctors, never went anywhere. Slightly more successful was to have these schools mimic longstanding private colleges. These older schools had served the children of the elite as the path into medicine, law, the clergy or business. They provided classical studies—Greek and Latin languages, literature, morals, oratory and ethics—to train and discipline the mind. This approach was about creating mental discipline, not providing specialized knowledge. Replicating that course of instruction in the new schools would enable the new constituency to acquire the same talents as the children of the privileged and so enter those restricted professions (6).

A far more common way, and the form that almost all the land-grant colleges initially took—was to graft some new subjects on what had been the traditional curriculum. Most early land-grant schools supplemented classical studies with a course or courses—not a course of study—in the mechanic arts, in science, and in French and in German, the modern languages. Here the goal was to provide a broad based education appropriate for virtually any endeavor—for the several pursuits and professions of life. As Jonathan Turner, an influential partisan of what would become the University of Illinois, said about these new colleges "the student will not only read the lofty verse of Vergil's [*sic*] 'Georgics,' but will reduce his rules to practice while following the 'trailing-footed' oxen spoken of by Homer. The Differential and Integral Calculus will commingle with the ring of the anvil and the whir of the machine shop. The mechanic's toil will be diversified by the Histories of Tacitus or the eloquence of Cicero and Demosthenes" (7).

In practice, a mere one or two professors handled a wide variety of subjects. For example, Eugene Hilgard, a pioneering soil chemist, taught the following courses during the same year: descriptive botany, economic botany, agricultural operations and implements, chemistry of plants and their products, chemistry and physics of soils, including maintenance of fertility, and chemistry and physics of housekeeping. At the Florida land grant, the sole chemist did not teach anything chemical per se. He taught agriculture, horticulture and Greek (8).

That educational vision did not long dominate. By the 1870s, complaints began to be heard about the new Morrill land-grant colleges. Farmers were the most vociferous complainers. In retrospect, that was not surprising. America was predominantly rural and agricultural. About 80% of the population in 1860 lived in places with populations under 2,000. The vast majority of state legislators were farmers. Farming was seasonal. Legislatures met in the winter when farm duties were few (9).

As the biggest single constituency and the most numerous and most influential contingent in state legislatures, farmers had tremendous political clout and the ken to use it. They often saw land grant curricula as a repudiation of farm life. Training farm children "in the several pursuits and professions of life" contributed to what they recognized as an epidemic of children fleeing farms and moving to cities. It also brought into question the quality of farm living. Education should enhance farming and farm life by enabling the head to guide the hands. The new land-grant education ought to encourage children to remain on farms by making agriculture an intellectual activity. They should lessen the physical burden of farming and increase farm efficiency and profitability (10).

Introduction of a new cadre of technicians, chemists, had accompanied the earliest years of the land grant movement, before the Morrill Act's passage. Their leading lights championed the new German laboratory approach and the assumption that agricultural and life processes could be reduced through laboratory analysis to chemical constituents. Selling their services directly to farmers as soil analysts constituted the chemists' initial venture.

Ideally, the chemists would test the soil and determine what nutrients it lacked for proper crop growth. That proved disastrous, however. Recommendations based on their analysis rarely correlated to optimum growth. In some cases, applying the chemists' concoctions transformed fertile into barren soil (11). With that kind of record, the chemist as soil analyst boom quickly burned out. These now discredited chemists were not without resources. Several claimed that their analytical skills could be put to use analyzing fertilizers. They could indicate if a fertilizer manufacturer sold a product at a price consistent with its nutritional elements. These analyses were quite telling. Analysis after analysis suggested that manufacturers routinely offered products far more costly than their constituents merited. Chemists dramatized these results, which found their way into the many agricultural periodicals, and proclaimed that the nation was awash in an epidemic of fertilizer frauds (12).

The chemists' scathing indictments led rural dominated state legislatures in state after state to create the office of state chemist. Manufacturers were required to submit to these state chemists every fertilizer sold in a state. The chemists then analyzed the materials and placed on each bag a tag detailing their analyses. Armed with this information, farmers then chose fertilizers by rational means, where the tag and price most nearly matched.

Institutionalized in an official capacity, these chemists usually found corresponding employment as professors at the new land-grant colleges. There they accepted a diverse teaching load similar to what Hilgard had taught in Mississippi and California. Their land-grant affiliations initially had little to do with teaching; the chemists' analytical skills secured their posts. In North Carolina, for instance, the state chemist office was created to prevent fertilizer frauds but quickly the legislature added additional tasks: ascertain which fertilizers were "best suited to the various crops of the state, what crops were most advantageous to the soil of the state," and to make analyses for the courts of law, for the geological survey and the superintendent of health, including analyzing "viscera and fluids of the body," tasks required during necropsies (13).

This broad agenda was soon joined by other attempts to demonstrate utility to farmers. State chemists aimed to develop means to increase farm yields and reduce costs. Again in North Carolina, Charles William Dabney, the Göttingen-trained state chemist and later president of the University of Tennessee, went to agricultural society meetings, attended college-sponsored farmers institutes and published bulletins to teach farmers how to mix stable manure with other waste products for a rich nitrogenous fertilizer, to press the otherwise discarded cottonseeds to create an oil to enrich cow feed or to replace olive oil in salad dressing, to burn those seed hulls for potash, and to detect and mine natural phosphate deposits in exposed marl sites (14).

Each activity was to demonstrate the chemists' centrality to farm operations and the land-grant colleges' responsiveness to its politically most powerful constituency. Only one thing hampered this ambitious program, however. Chemists could not provide the services that they claimed the expertise to offer. This proved especially egregious when it came to fertilizers, the very task state chemists' offices were formed to pursue. Analyses run by various state chemists on the same fertilizer samples repeatedly differed in analysis by factors of 10 or more!

The remarkably disparate, inconsistent analyses caused fertilizer manufacturers to howl and their own European-trained chemists vehemently to dispute the state chemists' analyses. Much to the state chemists' credit, they understood the cause of the problem. They were incapable of providing service because they lacked the requisite skill and technique.

In the years after 1880, state chemists took dramatic action. They acquired the expertise required for the jobs they already held. They met, formed a national association in 1884 and then diligently agreed to establish rigorous, consistent analytical standards. The state chemist group standardized what was analyzed—for example, whether calcium, aluminum and iron phosphates were water soluble and should be considered available phosphates. They standardized reagents and nomenclature. They standardized laboratory techniques. They standardized members' training and minimum competencies. In short, they made themselves capable of achieving the analyses necessary for their posts. State chemists' analyses would be consistent, dependable, reproducible.

This new state chemist group was called the Association of Official Agricultural Chemists. (We know it today as the Association of Official Analytical Chemists and it mandates the government-sanctioned methods of analysis for virtually everything we eat, drink or breathe.) Its formation greatly enhanced state chemistry and provided its members stability at land-grant colleges. It also mollified fertilizer manufacturers. Consistent regulatory analyses enabled manufacturers to compound materials that would pass official muster and so regularized the fertilizer industry. The state chemists' standardization efforts also created a vibrant market for chemists. Before 1890, many of the students who had studied with land grant/state chemists found lucrative employment with fertilizer manufacturers, easily the largest industrial employer of chemists nationwide (15).

The chemists' regulatory success so delighted their farm constituents that it was not surprising that when Congress passed the Hatch Agricultural Experiment Station Act in 1887 chemistry benefited greatly. The Hatch Act created and funded institutions for agricultural experimentation and investigation in each state. Virtually all of these entities were placed at land-grant schools both fortifying the relationship of these schools to agriculture and the chemists' position within them. Now firmly entrenched, chemists had gained more than a modicum of agency through their service (16).

The Hatch Act's encouragement of research in support of agriculture ensured that the well-established pattern of agency through service would persist. In chemistry, dairies became the next point of public intersection. In state after state, dairymen complained that creameries were not offering fair value for their milk. Rather than pay for quality, which was measured by butterfat content, they paid for quantity; unscrupulous entrepreneurs added water to their milk to increase its volume and thus adulterated the milk to get a greater price. Land-grant college chemists in most dairy states turned their attention to rectifying this distressing situation. They labored to develop a simple dairy- and creamery-administered butterfat test. Several were developed. The University of Wisconsin's Steven M. Babcock's test proved the most convenient and therefore successful. It was said to do more to make men honest than the bible (17).

Academic administrators recognized the chemists' importance to the preservation and furtherance of their institutions. For years after he announced his useful technique, Babcock accompanied the University of Wisconsin's president whenever the president addressed or lobbied the state assembly. In this case, the chemist served as testament to the land-grant university's agricultural importance and the importance of the college to the public weal (18).

The many regulatory or analytical activities that land-grant college chemists did in service to agriculture—their regulatory orientation—made chemists indispensible to the land-grant enterprise. Recognition of their centrality by university administrators and state legislatures ironically provided them something they had initially lacked, a measure of autonomy. Chemists used the new freedom to embrace original, fundamental research. That research quickly paid off for their academic and political constituents and for American society generally. Land-grant chemists uncovered the essential amino acids, most of the vitamins, and general principles of nutrition. Their scrutiny of humus transformed soil bacteriology—a set series of chemical reactions—into soil microbiology—the chemical reactions of any given soil population. Forays into pharmaceuticals happened a bit later; land-grant and other chemists were hamstrung by the broad range of longstanding German chemical patents, which were only abrogated during and after World War I. Despite that obstacle, they contributed mightily to antibiosis theory and antibiotic synthesis (19).

Imitation was the sincerest form of flattery and the chemists' agricultural success became a roadmap for another emergent group, the industrial chemists. Industrial chemists, later known as chemical engineers, were generally located within land grant chemistry departments through 1920. Many of these industrial chemists in the Midwest and South recognized the power of the agricultural lobby and fit comfortably among their colleges' prevailing farmer-centric ethos. It was not uncommon for them to work with agricultural wastes to create new farm income-raising industries. Orland R. Sweeney at Ohio State and then North Dakota State was symptomatic of these Midwesterners. He destructively distilled corncobs by grinding and drying them and then heating them in a retort. He collected the gases as fractions and sold these harvested organic chemicals to make plastics and adhesives. Sweeney also developed a soybean oil paint and established a process for making disposable baby diapers composed of peat (20).

Most land-grant chemistry departments remained closely affixed to agriculture through the 1920s. In the northeastern part of the United States, the situation was a bit different. Although it remained until 1920 for Americans living in places of over 2,500 to outnumber those in smaller venues, great manufacturing cities had begun to emerge in the 1870s and were increasingly gaining political clout. Legislatures, still rural-controlled, began to recognize and understand the new economic calculus. So too did northeastern land-grants and their industrial chemists. Rather than concentrate of agricultural- and farm-related questions, these chemists examined chemistry-based industrial processes. Many designed entire facilities around a single product. MIT's Arthur D. Little offered a compelling alternative. He created the concept of unit operations in 1916, which deconstructed industrial processes into component parts. These parts, then, could be assembled as was necessary. Each varied industrial manufacture was constructed from these stock standard parts, which speeded production capacity, increased flexibility and reduced waste (21).

This was the state of land-grant chemistry in 1920. There was every reason for the Office of Education a decade later to single out chemistry departments to measure land-grant quality. Chemists had been very savvy. From a relatively minor position, they capitalized upon the fundamental political nature of land-grant universities. Always service institutions, whether to promote democracy, the working classes, agricultural life or industry, the land-grants ultimately delivered to their most influential political backers. A curious kind of symbiosis marked the early chemist-land grant relationship. Land grants owed a large measure of their success to chemists and chemists would owe considerable success to their affiliation with land-grants. Chemists and land-grant colleges and universities secured positions for themselves by being useful, by successfully undertaking those tasks for which there was substantial political support—even if they had to create that support through their endeavors. Only then could they add additional functions and, in the case of chemists, expand their professional repertoire. In almost every case, however, the new tasks needed to help advance the institution's already extant service mission.

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