COMMUNICATING THE VALUE OF CHEMISTRY: EVAN PUGH, PENN STATE, AND PUBLIC CONFIDENCE AT THE TIME OF THE LAND GRANT

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In 2012, American Chemical Society president Bassam Shakhashiri set for the Society the dual goals of advancing chemistry and *communicating* chemistry: that is, communicating the values, roles, and benefits of chemistry to the public. Shakhashiri described widespread science literacy as a necessary characteristic of an informed citizenry (1):

> Science literacy enlightens and enables people to make informed choices; to be skeptical; to reject shams, quackery, and unproven conjecture; and to avoid being bamboozled into making foolish decisions where matters of science and technology are concerned.

Shakhashiri's presidential term also celebrated the Sesquicentennial of the 1862 Morrill Land Grant Act with "a *retrospective* and a *prospective* look" at its role in the development of chemical education. Shakhashiri proposed that "examining the accomplishments of chemistry and contributions of chemists to our country" would facilitate discussions about the present and future of science education. It seems timely, then, to consider how American chemists communicated the value of chemistry and chemical education in the years leading up to and immediately following the Morrill Act.

As both a chemist and a president of an early land grant institution, Evan Pugh of the Agricultural College of Pennsylvania (now the Pennsylvania State University) was an exceptional advocate for chemical education at the time of the Morrill Act. Pugh's efforts to communicate the value of chemistry to an often apathetic and antagonistic public were not unique, but his story exemplifies the monumental shifts and struggles in both higher education and science during the nineteenth century. Evan Pugh's campaign to win public confidence for the Agricultural College of Pennsylvania demonstrates the importance of individual action, communication, and personal relationships in inciting and implementing broad, lasting changes in science education.

Chemical and Agricultural Education in Mid Nineteenth Century America

Evan Pugh, born in 1828, came of age during a time of significant developments in chemistry, agriculture and higher education. Early in the 1800s, chemical education of any sort had been sparse in the United States (2, 3), but in the 1830s and 1840s, growing interest in science drew attention to chemistry and chemical education. Public lectures on science, particularly those featuring exciting chemical demonstrations, "inspire[d] young men to scientific careers" (4), and several educational institutions responded by incorporating chemistry into their curricula. At the same time, advances in chemical research were revealing new possibilities for applied chemistry. In his 1840 publication, *Organic Chemistry in its Application to Agriculture and Physiology* (5), German chemist Justus von Liebig posited a direct, rational relationship between science and agriculture, and in America this work was eagerly received by chemists and agriculturalists alike. Particularly in the northeastern states, where decades of farming had exhausted much of the region's tillable soil, the idea that chemistry could "solve the problems of agriculture" was tantalizing (6). In the late 1840s and early 1850s, interest in agricultural

education ascended towards an apex. Advocates formed state societies of agriculture, leading to the 1852 founding of the United States Agricultural Society, and some began lobbying their state legislatures to make appropriations for agricultural colleges.

Although supporters of agricultural and scientific education were increasingly vocal, however, the movement was hardly widespread. Calls for agricultural education came primarily from middle-class, college-educated reformers, many of whom were "gentleman farmers" who dabbled in agriculture as a hobby and could "afford to experiment with scientific agriculture" (7). In contrast, "rank and file" farmers who made a living off of the sale of crops generally viewed agricultural science and agricultural education with indifference. At best, agricultural education was unavailable, unheard of, and uninteresting, but at worst, farmers viewed scientific agriculture and its advocates with suspicion and distrust (8). Some of this antagonism stemmed from class differences: "practical farmers" reacted with disgust when "book farmers" presumed to tell them how to run their farms.

Misunderstandings and inflated expectations also contributed to farmers' negative perceptions of agricultural science. Expecting to see experimental farms turn a profit, many farmers were disillusioned when Liebig's theories did not lead to immediate improvements in soil fertility and crop production (9). Scientists who, in their excitement over Liebig's research, had overstated the claims of agricultural science "suffered the embarrassment of finding themselves in error" when promises of better farming through chemistry failed to pan out on a favorable timescale (10).

Public confidence in agricultural science (and chemistry specifically) was further damaged by the soil analysis trend of the mid-1840s. In an 1843 publication, Liebig instructed farmers to "apply to the professional chemist" for information about their soil, suggesting that a chemical analysis of a soil sample would indicate what kind of fertilizer was needed. In response, American pseudoscientists began offering soil analyses as a service for farmers, often at a steep fee. (Neither were chemists innocent: Norton at Yale was a leading proponent of soil analysis, and his students analyzed samples for farmers at a cost of five to ten dollars each.) However, the analyses were not scientifically sound (they failed to account for inconsistencies in soil composition, for example) and generally proved useless (11). In many cases, all that a farmer gained in return for a costly analysis was a recommendation to purchase the analyst's own fertilizer. By the early 1850s, few farmers still considered the practice worthwhile, and scientists agreed: agricultural chemist Samuel W. Johnson announced his verdict of soil analysis as "always interesting, often valuable, rarely economical" (12). Johnson and several other chemists openly admitted the mistakes of their chemical predecessors, but resentment over money wasted on soil analysis remained fresh in farmers' minds for decades.

With this antagonism and distrust thus counterbalancing the interest and advocacy relating to agricultural chemistry and chemical education, mid nineteenth century American chemists faced extraordinary challenges in advocating chemistry and chemical education. They had to establish the credibility of the discipline such that "a chemically demonstrated fact should stand unassailable" (13) and that "more rather than less science" was needed to truly improve agriculture and aid farmers (14). They had to convince disinterested Americans to invest state and federal funding in scientific education and to fund costly, rigorous, long-term agricultural experimentation with little short term benefit. In order to win public confidence for themselves and their institutions, American chemists would need to communicate the value of chemistry.

Evan Pugh and the Farmers' High School of Pennsylvania

In Pennsylvania as in other states, the 1840s and early 1850s were a period of growing interest in agricultural education. In 1850, two members of the Philadelphia Society for Promoting Agriculture published an "Address to the Farmers of Pennsylvania," calling for a state institution "to diffuse a general knowledge of improved systems of husbandry" (15). In response, interested reformers met in Harrisburg and organized the Pennsylvania State Agricultural Society. The Society's activities, especially its agricultural exhibitions, increased awareness of and interest in agricultural science throughout the state. At the first exhibition, held October 1851 in Harrisburg, Andrew Stevenson of the University of Virginia gave an address on agricultural science, declaring that "soils must be analyzed; and for this agricultural chemists are needed" (16). By March 1853, at another convention in Harrisburg, the members of the new State Society had resolved "with an unparalleled unanimity" to establish a "school for the education of Farmers" (17).

Evan Pugh was by this time the proprietor of a small academy in Chester County. Reflecting his interest in agricultural science, the Jordan Bank Academy curriculum included mineralogy, geology, botany, and chemistry.

Pugh's students used rudimentary apparatus to analyze soil and mineral samples, and Pugh himself conducted field experiments with fertilizers on his farm (18). He was thus captivated by the idea of agricultural education, and he quickly realized that schools for farmers would require professors with advanced knowledge of the sciences, particularly chemistry. Encouraged by his mentor Dr. William Darlington, who had once studied medicine under Benjamin Rush at the University of Pennsylvania, Pugh decided to make chemical education "the labor of [his] life" (19). He sold Jordan Bank Academy, and in September 1853, at the age of 25, Pugh sailed to Germany in pursuit of a world class scientific education.

He spent the next six years studying at Europe's most noteworthy universities and laboratories. He began at Leipzig, where he studied theoretical and applied chemistry with Otto Erdmann. He then transferred to Göttingen, where he studied with Friedrich Wöhler and earned a Ph.D. in chemistry and physics. In Heidelberg, Pugh spent several weeks studying gas analysis in the crowded laboratory of Robert Bunsen; in Paris, he attended lectures of prominent French scientists to observe their teaching abilities. In July 1857, at the invitation of English scientists John Bennet Lawes and Joseph Henry Gilbert, Pugh traveled to their well-known experiment station at Rothamsted and began a series of experiments on the origin of nitrogen in vegetables. In the next two years, Pugh's precise and painstaking experimentation won international interest and acclaim. With Lawes and Gilbert, he published a paper in the prestigious *Philosophical Transactions* (20) and presented his results before the Royal Society of London.

Despite the potential for a more lucrative career as a research scientist, Pugh's commitment to chemical education remained constant throughout his studies abroad. He regularly scanned American papers (especially imported issues of the *Pennsylvania Farm Journal*), and he was pleased to read in 1855 that the Pennsylvania State Agricultural Society's efforts to establish an agricultural college were succeeding; Governor James Pollock had signed a charter for the Farmers' High School of Pennsylvania. Pugh did not "doubt the success of a well-directed agricultural effort," but he felt strongly that the director of such a school needed to be a scientist, with a "proper combination of executive talent with intellectual power" (21); otherwise, the institution would be "like a well finished watch minus the mainspring" (22). The trustees of the Farmers' High School felt similarly. To fill the role of principal, they sought a man "with such scientific attainment and capacity to teach" who would also be a "good practical farmer" (23). In 1859, at the recommendation of Yale chemist Samuel W. Johnson (whom Pugh had befriended while studying in Leipzig), the trustees offered Pugh the presidency of the Farmers' High School. A few months later, after a whirlwind tour of Europe's agricultural institutions and chemical apparatus suppliers, Evan Pugh sailed home to Pennsylvania.

In October 1859, Pugh arrived at the Farmers' High School to find it operating under "unfavorable circumstances" (24). Only one of the three planned wings of the college building had been erected. Students were doubled up in their dormitory rooms, and the entire college took their meals in a drafty shanty. Pugh optimistically set a goal of raising $100,000 to complete the construction, but his hopes were quickly shattered; the Panic of 1857 had left little chance of donations or subscriptions from wealthy Pennsylvanians. The trustees were lobbying the Pennsylvania General Assembly for an additional appropriation, but eliciting state funding for higher education was increasingly difficult (25).

These financial concerns were intertwined with broader issues of public confidence and trust. Pugh knew that sustainable funding depended on public support; in 1859, he observed that where agricultural education had failed in America, it was due "in part because of the general feeling of mistrust with which the effort was viewed" by the public (21). His February 1860 inaugural address described this challenge (26):

> The unfinished state of our buildings, and the difficulties we labor under in consequence of their not being finished, point to the necessity of our demonstrating to a skeptical public and a hesitating legislature the practicability of our undertaking, and the necessity of our having material aid to complete the work here begun.

In order for the Farmers' High School to succeed, Pugh would have to articulate the need for agricultural education, demonstrate how the School effectively and efficiently fulfilled that need, overcome popular misconceptions and prejudices, and thereby prove the School worthy of state and local patronage. Each of these tasks required educating nonscientists about science: i.e., distinguishing science from pseudoscience, explaining scientific methods of experimentation, and publicizing the benefits of science not only to the Farm School's students but to the entire state of Pennsylvania.

Articulating the Need: Turning Apathy into Attention

The first barrier Pugh faced in his advocacy for the Farmers' High School and its scientific curriculum was widespread apathy from the public and particularly from "rank and file" farmers. The "gentleman farmers" of the Pennsylvania State Agricultural Society had been strongest advocates for the establishment of the School (27), but after the enthusiastic peak of the mid 1850s, many of Pennsylvania's state, county, and regional agricultural societies suffered from declining membership and disinterest among remaining members. As a result, Pugh found active support for the Farmers' High School in short supply. J. L. Darlington, president of the Chester County Agricultural Society, told Pugh in 1859 there was "so little sympathy" for the Farmers' High School that his fundraising efforts "fell 'still born'" (28). Complicating Pugh's efforts were the strains of a nation hurtling into civil war. "It certainly cannot be denied that it is not the best time possible to get a candid hearing upon a subject foreign to politics," he remarked in 1860 (29).

Pugh sought to convert this apathy into attention by articulating the need for science and scientifically trained farmers. To "arouse public sentiment and to stimulate public interest" in agricultural science, Pugh gave addresses at state fairs and other events (30). His best known was "What Science Has Done and May Do for Agriculture," an 1860 lecture before the Cumberland County Agricultural Society so persuasive that Charles F. Chandler, a former classmate of Pugh's, said he would "quote from it as long as I teach Ag. chem" (31). In this address and others, Pugh explained the problem of soil exhaustion, pointing out that decades of "practical" farming had led to decreased productivity. He argued that only science could restore fertility to American farms (32):

> The land is worn out, new land must be worked while it is 'resting.' It is well for us that we have new land. The time will come when the land must find rest by letting the people starve. Before that time comes, let us hope that science will be appreciated and her teachings heeded.

Pugh discussed both crop rotation and fertilizers as scientific solutions to agricultural problems, and he asserted that agricultural chemistry would help farmers understand and improve their farming practices. This argument resonated with Pennsylvania farmers, who struggled with decreasing soil productivity amidst increasing competition from the West (10).

In a similar strain, Pugh declared that America (and Pennsylvania) needed better farming, and therefore better educated farmers, to successfully compete with Europe. This theme was common among science educators; "the unblinkable fact of European scientific superiority inspired not humility and resignation but appeals to national honor" (33). In his addresses, Pugh highlighted Europe's advanced farming techniques, enumerated Europe's many agricultural schools and research laboratories, and recounted how farmers abroad employed chemists to analyze fertilizers to regulate the market and protect farmers from fraud.

This final point was also an appeal to farmers' pocketbooks. Chemistry was valuable to farmers, Pugh explained, because chemists could identify overpriced or fraudulently advertised fertilizers. In Europe, Pugh had studied fertilizers in detail "in order more fully to be prepared to give opinions upon the commercial values of manures" (34), and once at the Farmers' High School he experimented with different fertilizer products on the School farm. Pugh's friend Samuel W. Johnson also used this approach; beginning in 1853, Johnson had made a name for himself among agriculturists by analyzing fertilizers, calculating a monetary value for each based on its chemical components, and publishing his results in agricultural papers like the *Country Gentleman* (35). Both Johnson and Pugh were careful to explain that they were assigning costs to fertilizers based on the costs of their chemical components, not guaranteeing their efficacy on any given farm, but each promulgated systematic chemical analysis of artificial manures as a way of regulating the market.

As a final argument for the country's need for agricultural schools, Pugh portrayed the study of chemistry and agricultural science as virtuous and ennobling. The value of chemistry and chemical education to farmers was not solely monetary; Pugh presented it as a "morally superior" solution to social concerns, writing that the evils and temptations of city life, so dangerous to overeducated youth, would be "lessened" if only "a system of education, adapted to the wants of our agricultural community, were made available to the sons of every farmer" (21). This theme, consistent with agricultural education's roots in the reform movement, was generally targeted at gentleman farmers, many of whom believed that practical farmers were by nature ignorant and needed education and social uplift to escape their "lowly" status (36, 37).

The Farmers' High School's manual labor requirement was an especially powerful selling point in this regard. Pugh characterized manual labor as inherently

moral, heatedly contrasting the "enterprising and industrious mechanic and farmer of the north" with the indolent slaveholder of the South (38). He argued that manual labor instilled in young men the dignity of hard work (21):

> Agricultural labor would be dignified, by being intimately associated with profound subjects of thought; it would be made agreeable by affording a pleasant exercise for the cultivated mind, in connexion with all its duties; it would be recognized as honorable, because of its usefulness, and because of the high moral and intellectual standing of those who were following it for a livelihood; they would combine the intellectual qualities of our colleges, with the morality of country life.

While these moral arguments were an appeal to reformers, they also reflected Pugh's own views of science. Like Samuel W. Johnson, Pugh was deeply religious, and both men seemed to consider chemical education a form of "moral heroism" (39).

Demonstrating Value

Having established the need for an agricultural college, Pugh then devised ways to raise awareness about the Farmers' High School's activities, thereby publicizing the value and relevance of its work. One channel for disseminating information was the School's catalog, published yearly in December. While the college catalogs were ostensibly aimed at students, Pugh's catalogs were strategically "devised to inform the general public as much as prospective students" (40). Just two months after his arrival, Pugh prepared and published the 1859 catalog, which included an impassioned essay on Pennsylvania's need for an agricultural school, a summary of the School's progress to date, an outline of its curriculum, and plans for the 1860 term. Pugh sent copies to every member of the Pennsylvania state legislature, each of the "prominent colleges" in the country, and all of the newspapers in Bellefonte and Philadelphia (41).

Seeking broader exposure, Pugh also built relationships with newspaper editors in Harrisburg, Philadelphia, and New York in order to secure "favorable notices" of the School in the mainstream press (42). To ensure that all Pennsylvanians would hear of the School's work, he encouraged his students to write columns about their studies and experiences for their hometown newspapers. He also leveraged the agricultural press, which at the time was an influential information channel for agricultural news, politics, and gossip (43). Even prior to his presidential appointment, Pugh had reached out to the editor of the *Pennsylvania Farm Journal* to "feel him gently" on the subject of arranging a formal connection between the *Journal* and the nascent Farmers' High School: "Our practical farmers… patronize the paper, and to have access to its columns would give us access to them" (44). Throughout his presidency, Pugh contributed columns, letters, and news items to agricultural papers like the *Farmer and Gardener*, the *American Agriculturist*, the *Genesee Farmer*, and the *Country Gentleman*. At his encouragement, several students in Pugh's advanced chemistry classes also contributed to these papers, publishing the results of their experiments and analyses. Pugh hoped that the publication of these laboratory investigations might induce a wealthy donor to endow a professorship but felt that, at the very least, "their parents would be 'mightily' pleased with their efforts" (22).

Pugh also publicized the Farm School's activities via voluminous correspondence with his many friends and colleagues. His most valuable contacts were former classmates from his studies abroad, many of whom became key players in chemistry and chemical education in the United States: Samuel W. Johnson, William H. Brewer, and George Brush all took positions at Yale; Charles F. Chandler was at Union College and then followed another classmate, Charles F. Joy, to Columbia; George C. Caldwell and H. A. Warriner both taught at Antioch College and later served in the United States Sanitary Commission; and James P. Kimball was Pugh's contact at the unsuccessful New York State Agricultural College. Pugh was closest with Johnson and Caldwell, but he maintained at least informational correspondence with all of these colleagues throughout his presidency, finding "truth [in] the old proverb that 'in union there is strength'" (45).

As president of the Farmers' High School, Pugh expanded his network, seeking out other influential American chemists. As he had told Johnson in 1855 (46):

> I think we should endeavor to form intimate acquaintances with all the really scientific agriculturalists in our country and keep each other posted upon our plans… as by doing so greater results may be accomplished.

He strengthened these relationships by regularly visiting other educational institutions, including Yale, Columbia, Maryland, and the Free Academy of New York (where he met Oliver Wolcott Gibbs). In 1860, he attended the American Association for the Advancement of Science's meeting in Newport, where he met with Benjamin Silliman Jr., William Barton Rodgers, Joseph Henry, Benjamin Gould, and "others of the American scientific corps"

(47). At each meeting as with every letter, Pugh shared copies of the latest Farmers' High School catalog or report, informing his colleagues of the School's progress. He was especially proud in December 1861 to announce the School's first graduating class, proclaiming that the eleven recipients of the Bachelor of Scientific Agriculture degree had "graduated upon a higher scientific educational standard than is required at any other agricultural college in the world" (48).

Similarly, Pugh frequently invited scientists, educators, and political and social "influentials" to visit the School "to see the class of student we have… [and] to see what we might do if our buildings were completed and all our professorships properly filled upon the basis which our organization anticipates" (49). Visitors to the Farmers' High School were invariably impressed by Pugh and his students and departed with a high opinion of the institution. Such visitors often described what they had seen in newspaper columns or meetings of their professional or social organizations, further promulgating information about the quality and value of the School's work. One early visitor observed that the students looked "cheerful and contented… more healthy than is presented by the usual appearance of boys subjected to the restrictions and studies of the classroom" (50).

Still, both farmers and legislators sought more immediate, practical results out of the state's investment in agricultural education. As one agriculturist wrote in a letter to the *Country Gentleman*, Yankee farmers cared only for "the CORN," and therefore would dismiss any science or scientific institutions that did not directly increase their crop productivity: "Why? *Because they won't bring the corn*" (51). Others more generously allowed that agricultural colleges should get "a little money to spend on books, apparatus, and fitting up," but then drew a line: "let them know they shall have more as fast as they can show results" (52). In response, Pugh had to repeatedly explain to the public that agricultural science was in a "youthful stage" and required "step by step… patient research" (53). He reminded the public that "it must not… be supposed that these results will manifest themselves at once, or that they will pay as experiments are being made: as well might the farmer expect to reap his crop the day he sows his grain" (54). Like his friend Samuel W. Johnson, Pugh called for the establishment of experiment stations as the next step in agricultural improvement. He envisioned a dialogue in which farmers who had learned "how to observe, and what to observe" at an agricultural college would share their observational data with a nearby experiment station, thus contributing to and benefiting from the advancement of agricultural science and scientific education.

Overcoming the Prejudice of the Public

During his presidency, Pugh contended with popular prejudices against chemistry, science, and higher education in general. At the time, classical colleges were believed to produce graduates contemptuous of industrial work, and there was public concern that higher education of any kind would drive farmers' sons away from agriculture as a vocation. An early statement by the School's trustees articulated this fear (55):

> It is a fact universally known, that the literary institutions of the country, as at the present constituted, educate young men to a state of total unfitness not only for the pursuits of a farmer but as a companion for his parents, brothers, and sisters, with whom he is expected to spend his life. He is therefore driven from them—from his father's estate—and into a profession for which he has perhaps little capacity, and where he is subjected to all the temptations of an idle life.

The trustees saw the Farmers' High School's manual labor requirement as an important selling point for an agricultural college, and indeed it was a popular concept (56). The name the trustees chose for the institution, Farmers' High School, was likewise a conscious effort to set the School apart from classical colleges.

Much of the School's curriculum, too, was a reaction to prejudice against traditional colleges. From its inception, the Farmers' High School trustees aimed to "enrich and ennoble the life of the farmer," but they set careful limits for this social uplift (57). The trustees established the School to teach "that which is valuable for a farmer to know;" they explicitly did not want to prepare students "for the professional pursuit of scientific subjects" (58). Pugh agreed that subjects taught should be useful for agriculturists, but in his view the principles and methods of science were themselves useful (59):

> Was it desirable that the farmer should have such a knowledge of agricultural science, as would enable him to investigate and develop agricultural principles, or was it simply desirable to teach him to practice those rules, which others deduced for him from principles he could not understand?

However, in his first year at the Farmers' High School, confronted by criticism from agriculturists, Pugh conceded and followed a more vocational curriculum. As he confessed to Johnson, he "adopted a somewhat popular plan not because we did not appreciate and desire a plan

more scientific, and consistent with the dignified reserve of science but because the necessities of the times have required the course at our hands which we have followed" (60). Still, while graduates of the School were expected to return to practical farming, Pugh envisioned them as community leaders who would "by the influence of precept and example... infuse new life and intelligence into the several communities they enter" (61).

In addition to prejudice against colleges, Pugh also confronted prejudice against scholars and scientists. "Practical farmers" in Pennsylvania and elsewhere tended to view agricultural scientists as "book farmers" or "men in silk gloves" who had no practical knowledge of farming (62). Pugh thus had to establish his credibility and demonstrate his competence as an agriculturist. His background as a native of rural Pennsylvania served him well on this question; unlike most chemists, Pugh could boast of spending his youth in "almost constant contact with the farmers" (19). Also convincing was his physical appearance. Far from a stereotypically atrophied, lusterless intellectual, Pugh was handsome and robust, with an athletic, strapping build. At six feet, one inch, he was also unusually tall, often referred to as "giant." His appearance immediately dispelled the notion of the "pimply-faced professor" (63); instead, his physique inspired respect among manual laborers and his Farmers' High School students. Legends were told of his displays of exceptional strength, and Pugh himself acknowledged the benefits of working with his students on the college farm: "I could spare you 15 times as much as Shylock wanted for his bond and have 200 lbs. of flesh left" (64).

Farmers' distrust of science and scientific men extended beyond appearance, however. Pugh blamed the pseudoscientific "quacks" who cheated them: "Quacking has already done our cause no little harm and hundreds of farmers are disgusted at what they (with too much reason) term scientific humbug" (19). Pugh thus sought ways to distinguish scientists who used principled methods of analysis from "charlatans." At the same time, he perceived an opportunity to build public confidence (22):

> We could keep up an intimate connection or correspondence with the farmer, and all the humbug chemical salts and quack manures and superphosphate of gypsum!! e.g., etc. that were sent out to the farmer we would make a business of examining and exposing to censure or recommending thus we could secure the confidence and friendship of the farmer, and let him learn that he could depend on us for such information.

In 1860, a newspaper scuffle erupted when fertilizer manufacturer James J. Mapes, angered by Samuel W. Johnson's unfavorable chemical analysis of his product, accused Johnson of slander (65). In a *Country Gentleman* column (66), Pugh came to Johnson's defense with a vindication of his results. Pugh concluded that out of twelve fertilizer samples he analyzed, "the greatest cheat in the whole lot is that of Mapes' so-called nitrogenized superphosphate," which "is sold for nearly three times as much as it is worth." Such dishonesty, Pugh continued, "points out the necessity of our having some means of protecting the farmer from the shameful imposition that sales of such manures inflict." He thus leveraged the "Mapes affair" as an opportunity to set up a dichotomy between himself and Johnson as selfless, public servants of science and Professor Mapes as an archetypal, dishonest quack. This "great stir" brought significant publicity to agricultural chemistry in general as well as Johnson and Pugh specifically. Another manufacturer, whose product had more favorable results in Pugh's analyses, took to including a quotation from his report in their advertisements (67).

Securing Public Support

Having demonstrated the need for science education and his ability to meet that need, Pugh's final challenge was to convince the public that the Farmers' High School deserved and required financial support. After Justin Morrill introduced his land grant bill into Congress for the second time in December 1861, Evan Pugh monitored the progress of the legislation carefully, conscious of the financial impact it could have on the Farmers' High School of Pennsylvania. Pugh himself did not play a prominent role in lobbying for the land grant—he felt he did not deserve "any especial mention on the matter" (68)—but the combined contributions to the effort made by the Farmers' High School's trustees and friends were significant. Pugh later claimed that "without their aid the bill would not have passed" (69).

Pugh's own efforts instead focused on drawing explicit, public connections between the Farmers' High School and the Morrill Act legislation in order to prove that the School merited a land grant endowment. Very few agricultural colleges were in successful operation at the time, and thus Pugh sought to position the Farmers' High School in the public and Congressional view as a model of agricultural education. As he had in the past, Pugh again procured timely "favorable notices" in several prominent newspapers, even persuading Horace Greeley

to print an article about the Farmers' High School in the *New York Tribune,* which had a national audience (70). Pugh sent a clipping of the article to one of the College trustees, along with a note of triumph: "I have received 10 letters today in response to it. I think that with all these and others that will come, we shall be full next session" (71).

In February 1862, Pugh suggested renaming the Farmers' High School as the "Pennsylvania State Agricultural College," a title that reflected the School's advanced level of coursework while also mimicking the title commonly used for the proposed "Agricultural College Bill" (72). The trustees officially settled on "Agricultural College of Pennsylvania" at their May 1862 gathering. At the same meeting, desiring that Pennsylvanians should know how Agricultural College flourished "notwithstanding the disturbed state of the times, while all other attempts of a similar character have failed in this country," the trustees resolved to "secure a full statement" of the Agricultural College's institutional history (*73*). That fall, Pugh published *The Agricultural College of Pennsylvania; Embracing a Succinct History of Agricultural Education in Europe and America, Together with the Circumstances of the Origin, Rise and Progress of the Agricultural College of Pennsylvania; as also a Statement of the Present Condition, Aims and Prospects of this Institution, its Course of Instruction, Facilities for Study, Terms of Admission, &c. &c.* The *History* documented the College's difficulties and accomplishments and asserted its entitlement to Pennsylvania's land grant endowment, concluding that there could be "no doubt of its ultimate success… now that… the Agricultural College bill has passed Congress." Pugh described how the College would use the land grant funds to support agricultural experimentation on the College grounds, and he also offered an early view of how the "mechanic arts" might be integrated into the College's curriculum. In the chemical course, as Pugh now described it, the student studied the science first and its "practical application to agriculture and the industrial arts" second. Each student would learn laboratory methods of analysis for agriculturally relevant compounds (fertilizers, for example) but also industrial compounds like ores, slags, alloys, and metals.

Pugh's efforts to prove the College worthy of financial support culminated with seeming success on April 1, 1863, when Pennsylvania Governor Andrew Curtin signed a bill accepting the terms of the federal land grant and designating the Agricultural College of Pennsylvania as the recipient. As soon as the Pennsylvania General Assembly reconvened in 1864, however, several other Pennsylvania colleges challenged the bill, vying to win part of the land grant designation for themselves (25). Pugh thus needed to unequivocally demonstrate that the Agricultural College met the requirements of the Morrill Act more robustly than any other Pennsylvania institution.

In January 1864, he produced another strategic document, a 35-page monograph titled *A Report Upon a Plan for the Organization of Colleges for Agriculture and the Mechanic Arts, with Especial Reference to the Organization of the Agricultural College of Pennsylvania, in View of the Endowment of This Institution by the Land Scrip Fund, Donated by Congress to the State of Pennsylvania* (69). Ostensibly addressed to the College trustees but distributed widely, the Report outlined in detail the Pugh's vision of a "first class Industrial College" and calculated the level of financial support it needed to thrive. Pugh concluded that the land grand endowment would be "barely sufficient" to support one agricultural institution, let alone several, and he pointedly criticized the "literary colleges" that made a "general scramble for a share of the spoils" to which "they had not the slightest legitimate claim." On March 3, 1864, Pugh revisited these arguments point by point in a long address to the General Assembly's Judiciary Committee, and later that month he hosted a dinner for the legislators and their wives on the College campus.

This intense advocacy took a physical toll on Pugh. In April 1864, while drafting yet another address to the state legislature, Pugh was seized with a "violent chill." He gave a final chemistry lecture to his senior students before retreating to Bellefonte for rest and medical care. He was diagnosed with typhoid fever and died within a week. As his assistant later wrote, "It is only marvelous to me that he did not sooner sink under the burden" (74).

Legacy

Perhaps the best indication of the importance and extent of Pugh's ability to communicate the value of chemistry and chemical education is the despair that followed in his absence. Without his guiding vision, the Agricultural College of Pennsylvania fell into a seventeen year era of "drift" and "strange transmutations" (75). Pugh's "ability was everywhere recognized; he enjoyed the confidence and esteem of the Trustees, of the student body, and of the public," and thus his death was "a disaster from which it took years to recover." Although continued wrangling did retain the land grant designation for the Agricultural College of Pennsylvania, financial

issues remained a constant concern and embarrassment. Only a few years after Pugh's death, the Agricultural College of Pennsylvania lost the public confidence he had worked so hard to earn.

Further muddying the path Pugh had set for the institution, his first few successors made abrupt and significant changes to the College's curriculum. The College's scientific courses soon crumbled, undermining the themes of Pugh's advocacy. Pugh's former classmate George C. Caldwell filled the chemical chair for a short time, but he could not forestall the decay of Pugh's scientific vision. By the 1870s, much of the chemical apparatus Pugh imported from Europe was in storage, and some had even been burned as kindling. In 1874, President James Calder changed the institution's name to the Pennsylvania State College, saying that the Agricultural College name "misled many persons as to its real character" (76).

In the 1880s, Evan Pugh's legacy was reclaimed by men who shared his devotion to science education and his talent for communicating its value to the public. In 1881, a team of Pennsylvania State College faculty members reorganized Calder's curriculum into a progressive program that recalled Pugh's broad vision of blending the practical and the scientific. Two of the faculty members involved were Whitman H. Jordan, a former student of Samuel W. Johnson, and C. Alfred Smith, Pugh's former student and assistant (77). Concurrently, the trustees appointed George Atherton, an experienced administrator, to the College presidency. Atherton had close ties to Justin Morrill and would be instrumental in the passage of the 1890 Morrill Act, which provided desperately needed supplementary funding to Penn State and other struggling land grant institutions (78). Atherton considered science education a high priority and early in his committed funding for the construction of a new chemistry and physics laboratory building. In 1888, Atherton hired George Gilbert Pond as the head of the College's Department of Chemistry. Pond had studied chemistry and mineralogy at the University of Göttingen, like Pugh, and under his thirty years of leadership, student enrollment in Penn State chemistry classes increased tenfold.

Intrigued by the story of his predecessor, Pond tracked down and recovered for the College as much of Pugh's apparatus, correspondence, and library as he could find, compiling it into a small museum honoring the past president. The centerpiece of the collection was an enormous canvas diagram that Pugh had used to present his experiments on nitrogen fixation to the Royal Society of London. Securing this diagram was a "long, hard struggle," but Pond "felt it to be the greatest treasure the College could possess" (79). The diagram now hangs in Penn State's Physical and Mathematical Sciences Library, a fitting tribute to a scientist and educator who dedicated his life to advancing and communicating the value of chemistry.

References and Notes

1. B. Z. Shakhashiri, "Advancing Chemistry / Communicating Chemistry," ACS Presidents Column, Younger Chemists Committee, American Chemical Society, 2011, http://ycc.sites.acs.org/apps/blog/show/8152190-bassam-z-shakhashiri-ph-d-2011-acs-president-elect (accessed Dec. 19, 2013)
2. S. M. Guralnick, *Science and the Ante-Bellum American College*, American Philosophical Society, Philadelphia, 1975.
3. C. A. Browne, "Chemical Education in America between the Years 1820 and 1870," *J. Chem. Educ.*, **1932**, *9*, 696-743.
4. R. V. Bruce, *The Launching of Modern American Science 1846-1876*, Alfred A. Knopf, New York, 1987, 42.
5. J. Liebig, *Organic Chemistry in Its Application to Agriculture and Physiology* (L. Playfair, Ed.), Taylor and Walton, London, 1840.
6. M. W. Rossiter, *The Emergence of Agricultural Science: Justus Liebig and the Americans, 1840-1880*, Yale University Press, New Haven, 1975, 11.
7. Ref. 6, p 8.
8. E. L. Johnson, "Misconceptions about the Early Land-grant Colleges," *J. Higher Educ.*, **1981**, *52*, 336-339. See also: E. D. Ross, *Democracy's College: The Land-Grant Movement in the Formative State*, Arno Press, New York, 1969, 97.
9. C. E. Rosenberg, *No Other Gods: On Science and American Social Thought*, Johns Hopkins University Press, Baltimore, 1997, 147.
10. Ref. 6, p xiii.
11. Ref. 4, p 146. See also Ref. 6, p 103.
12. S. W. Johnson, "On the Practical Value of the Analyses of Soils," *Country Gentleman*, **1854**, *4*, 5-6.
13. E. Osborne, Ed., *From the Letter-Files of S. W. Johnson, Professor of Agricultural Chemistry in Yale University, 1856-1896*, Yale University Press, New Haven, 1913, 1.
14. Ref. 6, pp xiv, 127.
15. S. W. Fletcher, *The Philadelphia Society for Promoting Agriculture, 1785-1955*, Philadelphia Society for Promoting Agriculture, Philadelphia, 1959. 16. *First Annual Report of the Transactions of the Pennsylvania State Agricultural Society*, A. Boyd Hamilton, Harrisburg, 1854, 320.
17. Ref. 16, p 8.
18. J. Bloom, "The Education of a Scientist, 1828-1859," M.A. Thesis, Pennsylvania State University, 1960.

19. Pugh to A. L. Elwyn, 1855, Evan Pugh Papers, Pennsylvania State University Archives. [Hereafter designated as EPP.]
20. J. B. Lawes, J. H. Gilbert, and E. Pugh, "On the Sources of the Nitrogen of Vegetation; with Special Reference to the Question Whether Plants Assimilate Free or Uncombined Nitrogen," *Philos. Trans. R. Soc. London*, **1861**, *151*, 431-577.
21. E. Pugh, *Catalogue of the Officers and Students of the Farmers' High School of Pennsylvania: For the Year 1859*, King & Baird, Philadelphia, 1859.
22. Pugh to S. W. Johnson, Feb. 22, 1855, EPP.
23. E. Pugh, *The Agricultural College of Pennsylvania; Embracing a Succinct History of Agricultural Education in Europe and America, Together with the Circumstances of the Origin, Rise and Progress of the Agricultural College of Pennsylvania; as also a Statement of the Present Condition, Aims and Prospects of this Institution, its Course of Instruction, Facilities for Study, Terms of Admission, &c. &c.*, William S. Young, Philadelphia, 1862, 22.
24. W. F. Dunaway, *History of the Pennsylvania State College*, Lancaster Press, Lancaster, PA, 1946, 22-25.
25. P. L. Moran and R. L. Williams, "Saving the Land Grant for the Agricultural College of Pennsylvania," conference presentation at The Legacy and the Promise: 150 Years of Land-Grant Universities, University Park, PA, 2012.
26. E. Pugh, *An Inaugural Address Delivered by the President of the Farmers High School of Pennsylvania, Before the Students of That Institution, at the Commencement of Its Second Annual Session*, William S. Young, Philadelphia, 1860.
27. Ref. 24, pp 3-4, 9-11.
28. J. L. Darlington to E. Pugh, Dec. 28, 1859, EPP.
29. E. Pugh, *Address to the Cumberland County Agricultural Society, at their Fall Meeting, October 1860, By Dr. Evan Pugh, Principal of the Farmers' High School of Pennsylvania*, Cumberland County Agricultural Society, Carlisle, 1860, 2.
30. Ref. 24, p 34.
31. C. F. Chandler to E. Pugh, May 3, 1861, EPP.
32. Ref. 29, p 8.
33. Ref. 4, p 26. See, for example, D. C. Gilman, "Scientific Schools in Europe: Considered in Reference to their Prevalence, Utility, Scope and Desirability in America," *Am. J. Educ.*, **1855**, *1*, 317-328.
34. Pugh to F. Watts, Mar. 3, 1859, EPP.
35. S. W. Johnson, "Superphosphate of Lime," *Country Gentleman*, **1853**, *1*, 43-44. See also Ref. 13, pp 105, 112-115.
36. B. R. Cohen, *Notes from the Ground: Science, Soil, and Society in the American Countryside*, Yale University Press, New Haven, 2009.
37. Ref. 9, p 135-152.
38. E. Pugh, "Rambles in Virginia," undated, EPP.
39. Ref. 9, p 139.
40. M. T. Riley, "Penn State's First President: Scientist, Educator, Administrator," *Penn State Alumni News*, **1960**, January, 9.
41. Pugh to H. N. McAllister, Dec. 15, 1859 and Feb. 1, 1860, EPP.
42. Pugh to H. N. McAllister, Mar. 27, 1861, EPP.
43. A. C. True, *A History of Agricultural Education in the United States, 1785-1925*, US Department of Agriculture, Washington, DC, 1929, 28-29.
44. Pugh to S. W. Johnson, Feb. 22, 1855 and Mar. 16, 1855, EPP.
45. Pugh to S. W. Johnson, July 23, 1855, EPP.
46. Pugh to S. W. Johnson, Nov. 14, 1855, EPP.
47. Pugh to H. N. McAllister, Aug. 5, 1860, EPP.
48. Ref. 23, p 43. Pugh believed at the time that the Farmers' High School class of 1861 was the first to graduate from an agricultural college in the United States, but this was not precisely true. Michigan State Agricultural College issued its first degrees in the fall of 1861 to a class of seven students. No commencement exercises had been held, however, since the graduating class left campus promptly to join the Union Army. T. C. Abbot to E. Pugh, Dec. 19, 1862, EPP.
49. Pugh to H. N. McAllister, Apr. 12, 1860, EPP.
50. W. F., "From Centre County," *Pennsylvania Daily Telegraph*, Oct. 20, 1860, p 2.
51. J. R. Dey, "Lodi Poudrette," *Country Gentleman*, **1862**, *24*, 250-251.
52. As quoted in E. D. Ross, *Democracy's College: The Land-Grant Movement in the Formative State*, Arno Press, New York, 1969, 91.
53. Pugh to F. Watts, June 11, 1859, EPP.
54. Ref. 23, p 47.
55. *Second Annual Report of the Transactions of the Pennsylvania State Agricultural Society*, A. Boyd Hamilton, Harrisburg, 1855, 30.
56. Ref. 43, p 116. See also Ref. 52, p 118.
57. Ref. 24, pp 16, 27.
58. Ref. 16, p 7.
59. Ref. 23, p 14.
60. Pugh to S. W. Johnson, Jan. 6, 1860, EPP.
61. Ref. 23, p 45.
62. A. E. Martin, "Pennsylvania's Land Grant Under the Morrill Act of 1862," *Pennsylvania History*, **1942**, *9*, 85-117. See also Ref. 36, p 50.
63. Ref. 52, p 120.
64. Pugh to S. W. Johnson, Nov. 18, 1861, EPP.
65. Ref. 6, pp 149-151.
66. E. Pugh, "Artificial Manures," *Country Gentleman*, **1862**, *24*, 201-202.
67. For example, "Rhodes' Superphosphate—The Standard Manure," *Genesee Farmer*, **1862**, *23*, 165.
68. Handwritten annotation on J. Denison to E. Pugh, May 4, 1863, Farmers' High School and Agricultural College of Pennsylvania Letters, Pennsylvania State University Archives.
69. E. Pugh, *A Report Upon a Plan for the Organization of Colleges for Agriculture and the Mechanic Arts, with*

Especial Reference to the Organization of the Agricultural College of Pennsylvania, in View of the Endowment of This Institution by the Land Scrip Fund, Donated by Congress to the State of Pennsylvania, Singerly & Myers, Harrisburg, 1864, 34.
70. H. Greeley, "Farmers' High School of Pennsylvania," *New York Tribune*, Jan. 16, 1862, 7.
71. Pugh to H. N. McAllister, Jan. 20, 1862, EPP.
72. F. Watts to E. Pugh, Feb. 26, 1862, Farmers' High School and Agricultural College of Pennsylvania Letters, Pennsylvania State University Archives.
73. Ref. 23, p 2.
74. C. A. Smith, Evan Pugh, Ph.D., F.C.S. Memorial Address, delivered at the Pennsylvania State College, June 25, 1890.
75. Ref. 24, p 58-59, 94.
76. Ref. 24, p 81.
77. Ref. 24, p 104-105.
78. R. L. Williams, *The Origins of Federal Support for Higher Education: George W. Atherton and the Land-Grand College Movement*, Pennsylvania State University Press, University Park, 1991.
79. H. Pond to A. Cromer, Mar. 5, 1949, Helen Pond Author and Biography Vertical File, Pennsylvania State University Archives.

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