CONTRASTING MENTORS FOR ENGLISH-SPEAKING CHEMISTRY STUDENTS IN GERMANY IN THE NINETEENTH CENTURY: LIEBIG, WÖHLER, AND BUNSEN (1)

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Introduction

Aspiring chemists in America and Britain in the mid 1800s, having completed undergraduate training at colleges or universities in their native countries, needed to search elsewhere to continue their training. Their instruction in chemistry at Harvard, Yale, Oxford, Cambridge, and other institutions consisted of lectures, perhaps embellished with some demonstrations; but students had little or no access to laboratory facilities themselves, their exposure to the science being passive rather than active. Furthermore, the lectures were presented by professors who, for the most part, were self-taught and had never ventured from their own roots, often holding positions in their own home academic institution.

Table 1. Educational background of the mentors

JUSTUS VON LIEBIG (1803-1873) D. Phil., Erlangen, 1823 (Kastner); Paris (Gay-Lussac), 1822-1824
FRIEDRICH WÖHLER (1800-1882) D. Med., Heidelberg, 1823 (L. Gmelin); Stockholm (Berzelius), 1823-1824
ROBERT BUNSEN (1811-1899) D. Phil., Göttingen, 1830 (Stromeyer); Habilitation, Göttingen, 1833

The situation, developing rapidly in Germany at mid-century, was far different. (2, 3). German chemists had themselves sought advanced training in Stockholm under Berzelius or in Paris in Gay-Lussac's laboratory, for example. Eilhard Mitscherlich, student at Göttingen with Stromeyer, and Friedrich Wöhler, holding a medical degree from Heidelberg under L. Gmelin, nevertheless sought additional instruction under Berzelius's tutelage and brought back to their native country the benefit of their experiences, which shaped their future scientific careers. Justus von Liebig, awarded the D.Phil. at Erlangen under Kastner, and Robert Bunsen, a Stromeyer student in Göttingen, ventured to Paris and worked in the laboratory of Gay-Lussac, 1832-1833. These individuals, along with several others, then took positions at German universities. By the 1830s, twenty of the twenty-two existing German universities had established institutes of chemistry, with these and other freshly trained and enthusiastic young men as directors. The first doctorate (D.Phil.) in chemistry had already been awarded in 1821 at Kiel to Heinrich Rose, whose dissertation was based on work done in Stockholm.

The Mentors

Americans and British were quickly attracted to the German universities, as their "golden age" was unfolding. Liebig began his famous pharmacy and chemistry institute at Gieβen in 1824 (4, 5, 6), but it became part of the

university only in 1834, when advanced degrees could be awarded. The first doctoral degrees earned by his foreign students (Lyon Playfair, John Stenhouse) were awarded in 1840. Wöhler succeeded Stromeyer in Göttingen in 1836 (7); by 1850 his first English-speaking student (John Hull) had finished his degree. Bunsen began his career at Kassel in 1836 and then moved to Marburg (1846-1851) before holding the chair at Heidelberg (1852-1889) for the rest of his life. (8, 9). He supervised only one British doctoral student at Marburg (Edward Frankland), who finished in 1849 but then mentored several at Heidelberg. These three professors in particular attracted students from abroad in the early years of the development of German research laboratories. All became major choices for foreigners, who came in rather large numbers over the next seven decades, many remaining long enough to earn the D.Phil. Because they were more or less contemporary (Bunsen a decade younger, nevertheless began training students from abroad as early as Wöhler did), they have been selected as contrasting mentors, who, in fact together represent all four subdisciplines of chemistry: analytical, inorganic, organic, and physical. (More detail on mentors can be found in Ref. 3.)

Table 2. Professional positions of mentors

LIEBIG	**Gieβen** (1824-1853)	**Munich** (1852-1873)	
WÖHLER	**Berlin** (1825-1831)	**Kassel** (1831-1836)	**Göttingen** (1836-1880)
BUNSEN	**Kassel** (1839-1846)	**Marburg** (1846-1851)	**Heidelberg** (1851-1889)

In the early years by far the largest number of English-speaking, aspiring chemists chose one or more of the three mentors—Liebig, Wöhler, or Bunsen—at Gieβen, Göttingen, Marburg, or Heidelberg; often they spent time at two or all three locations. Students from America and Britain continued their pilgrimages to all of the 22 German universities over the next few decades, when Johannes Wislicenus (Würzburg, Leipzig) and Wilhelm Ostwald (Leipzig), among others, became favorites (3). By the time of World War I, nearly 800 had earned German doctoral degrees, with the distribution being roughly divided between Americans and British (2, 3). Many others migrated to the German centers of chemistry during that period but without completing requirements for a degree (10).

Liebig, Wöhler, and Bunsen, as newly appointed professors in Gieβen, Göttingen, and Heidelberg, shared in common the designing of new, expanded laboratories in their institutions, either on the original site or in a new location. These included space for routine analytical work and service areas, but also for independent research, as well as private laboratories and offices for the professors. Their living quarters were also part of the establishment. Word of the modern (for that time) facilities, especially at Gieβen and Heidelberg, as well as the growing reputations of the professors surely attracted German chemistry students but also those from abroad. By the end of their careers, the three mentors had sponsored 63 foreign doctoral students (Table 3), Americans being highly favored with Wöhler and British predominant under Liebig. Bunsen's foreign students, some codirected by Kopp, were about evenly divided (2, 3).

Table 3. English-speaking doctoral students

LIEBIG	Gieβen (24)	Munich (0)
WÖHLER	Göttingen (25)	
BUNSEN	Marburg (1)	Heidelberg (13)

The purpose of this essay is to compare and contrast the experiences of the English-speaking foreigners, in particular the early ones, in their interactions with these three prominent mentors. The information has been collected from personal letters but also from anecdotal accounts recorded, often more than once, in secondary sources.

The Students

By 1840, barely two decades after the awarding of the first D.Phil. in chemistry at a German university, Lyon Playfair earned the first doctoral degree conferred on a British student at Gieβen under Liebig. His research, "Ueber das feste Fett der Muscatbutter," was described in *Ann. Chem. Pharm.* (**1841,** *37*, 152-164). Only two years later, the first North American, Jose Vicente Ortigosa, born in Mexico, earned the D.Phil. under Liebig, with a publication in *Ann. Chem. Pharm.* (**1842**, *41*, 114-119), titled "Ueber die Zusammensetzung des Nicotins und einiger seiner Verbindugen." Charles M. Wetherell, from Philadelphia, completed the D.Phil. in 1848, the first US citizen to do so (2).

Figure 1. *Lyon Playfair*

The first of Wöhler's American students completed their degrees in 1852: William Smith Clark and Newton Spaulding Manross, both having written dissertations as part of their requirements (2). His first American student, James Booth, had worked under him in Kassel, but without earning a degree (11).

Figure 2. *William Smith Clark*

Bunsen had only one English-speaking doctoral student at Marburg, Edward Frankland (12), who finished in 1849 with the project "Ueber die Isolirung des Aethyls," work that helped to usher in the field of organometallic chemistry. In Heidelberg Bunsen's first doctoral student, Henry (later Sir) Roscoe, collaborated with his mentor in the photochemical combination of hydrogen and chlorine, officially earning his degree in 1854 (13, 14). Several English-speaking students at Heidelberg were advised by both Bunsen and Hermann Kopp, who joined Bunsen there in 1863.

Figure 3. *Henry Roscoe (left) with Bunsen (seated) and Kirchhoff*

Lectures

It was expected that students would attend daily lectures. Eben Horsford's schedule during his first year in Gieβen may have been extreme: three lectures each morning, the first beginning at 6:30, the third being Liebig's lecture from 11:05-12:30 (15). When Horsford's independent research projects demanded his energy during his second year, he tended to skip Liebig's lectures, a fact that did not go unnoticed. Horsford was admonished about this through Liebig's assistant and mended his ways (16). In writing to authorities in Darmstadt in his early tenure at Gieβen, Liebig stated that students preferred his lectures over those of Zimmerman, whom he was succeeding—even though students paid a fee for Liebig's lectures and could attend those of Zimmerman without paying (17). Students were not necessarily as enthusiastic. Evan Pugh opined that there were probably better teachers of chemistry in Germany (18); E. F. Smith described Wöhler as a far greater teacher than Liebig (19). J. Volhard, Liebig's assistant when the latter moved to Munich, described Liebig's lectures as "neither fluent nor perfect" (20)—in spite of the fact that Liebig's large lectures in Munich were famous and regularly attended by members of the Bavarian royalty.

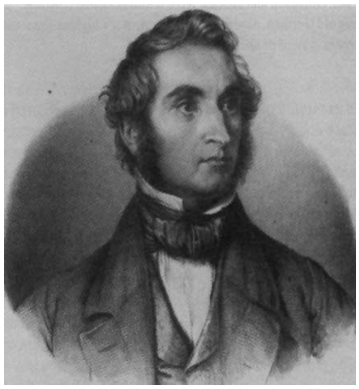

Figure 4. *Justus von Liebig*

Wöhler seems to have been widely appreciated as an inspiring, highly competent lecturer. His broad knowledge on a wide variety of chemistry—organic, inorganic, minerals—probably stemmed in large part from his translation of Berzelius' giant work into German. Pugh's only complaint was that he "teaches too much" (21). Wöhler gradually turned the content of his lectures away from organic subjects, a reflection of the nature of his own investigations. While students in Liebig's lectures tended toward formality, rising when he entered and giving full attention to his impressive presentations (22), those attending Wöhler's lectures at times broke into spontaneous applause, prompted by recognition of the original work by the professor himself in the isolation of silicon, aluminum, and other elements for which he deserved credit (23). Wöhler chose not to mention the history of "his" elements, but did provide that background for other elements.

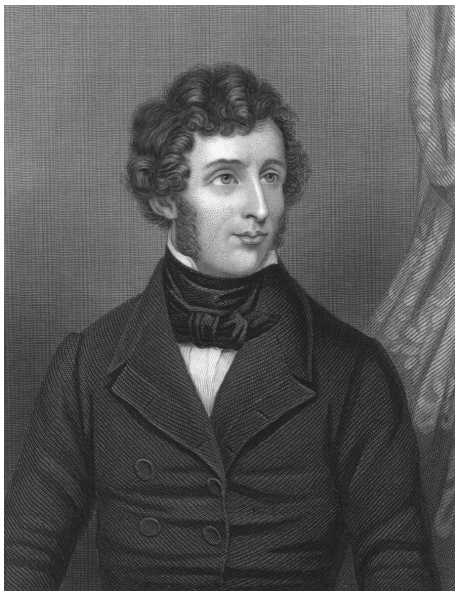

Figure 5. *The young Friedrich Wöhler*

In his brief teaching career at Marburg, Bunsen lectured on a wide variety of topics, including organic chemistry—for which he had diminishing enthusiasm. His course on "experimental chemistry" amounted to 100 hours in a semester. Other courses were centered on "general chemistry," which included metals and metalloids. He also lectured on electrochemistry, which he considered to be one of the most interesting topics. When Bunsen moved to Heidelberg, his impeccable lectures centered around "experimental chemistry," routinely embellished with demonstrations. In a typical winter semester, spanning 20 weeks, he presented 100 lectures in two sections: the introduction and description of the elements. Unlike Liebig, Bunsen did not attempt brilliancy in delivery but lectured with clarity. All his demonstrations were done with his own hands, no assistant being involved (24). He lectured a total of 64 semesters during his career, with attendance ranging from 32 to a high of 104 near the end of his tenure. In one term Friedrich II of Baden attended his lectures (25).

Figure 6. *Robert Bunsen*

The Laboratories

Until 1835, when his space was expanded, Liebig had to limit the capacity of his laboratory to 11 students, who were crowded into a cold, poorly ventilated environment (5). Once he was successful in enlarging the facility and establishing a university rather than strictly private laboratory, he expanded his enrollment. Largely through his personal promotion of the program in pharmacy/chemistry at Gieβen, he began to attract "foreign" students—first those from other German states and then from other countries. Liebig was justifiably proud of the

instruction program he had created. In 1851, when he was offered the Heidelberg professorship (actually taken by Bunsen), he said such a move would be "the ruination of the school at Gieβen, which was my pride and its downfall would be the calamity of my life" (26). Students were required to pay a fee each semester, the amount being based upon the number of days they worked, up to a maximum of six days per week. This covered the cost of equipment and reagents, but students were required to pay for solvents and other consumable items and provide their own balances. Liebig would be able to keep an eye on students from his private office, but he maintained intimate contact with students working in the adjacent laboratory, commenting on each one's project, making suggestions, and even predicting results (27).

Figure 7. *Gieβen Laboratory*

From the outside, Wöhler's laboratory was admired as the handsomest building in town, built of light blue stone and perfectly fireproof. James F. Magee arrived in Göttingen in 1855 with a letter of introduction from James C. Booth, who had been a student with Wöhler in Kassel in 1833. In his memoirs Magee noted the inferiority of the Göttingen laboratory to Booth's private laboratory in Philadelphia, as it was crowded and lacked gas and a blowpipe table (28). Not only students but the cows used the same entrance. But the laboratory was closed on Saturdays. Pugh's description of the Göttingen laboratory operation is extensive. Apparatus was freely available. If something was broken through carelessness, the student was required to pay 2/3 of its value; if broken by accident, there was no charge. Assistants readily provided the apparatus and materials for new experiments on request. At that time the laboratory held 28 students, who worked long hours on original organic and inorganic advanced projects. Pugh contrasted the situation in Göttingen with that in Erdmann's laboratory in Leipzig, where he had worked even longer. Yet, Pugh doubted that any professor but Wöhler could induce students to work in such a dirty place, with its ten thousand disagreeable odors (29).

Figure 8. *Wöhler's original laboratory, Göttingen*

Bunsen's laboratory in Heidelberg was a model of orderliness. The building he inherited, a former monastery, was designed for 20 students, although 30 were enrolled during the first year of his tenure there. The new laboratory, begun in 1854, was designed with separate work places for practical analysis and for advanced students. Bunsen's private laboratory adjoined that for advanced students, so that he could readily move from one to the other. His own laboratory was indeed private, for neither students nor assistants were permitted to enter. With city gas available, the laboratory was equipped with gas lamps and ovens in the cellar, which was constructed under the entire building. An elaborate (for the time) ventilation system provided removal of noxious odors from individual work benches. The lecture hall, with a capacity for 110, was located between the laboratory and Bunsen's private residence (8). Henry Roscoe, the first English-speaking student at Heidelberg, noted that Bunsen built all his own apparatus and tested it himself, with no aid from an assistant. His creativity is well known through his invention of the famous burner and a photometer (13). Yet Bunsen devoted his entire days, besides lectures, in counseling students—beginners as well as advanced—at their benches, often demonstrating the analytical operation himself.

As a meticulous experimenter, Bunsen took issue with the quality of laboratory corks and so found another source: champagne bottles. Curtius recalled his entering the laboratory one day, cigar in hand, doling out champagne to his beloved "Praktikanten." When the bottle had

been emptied, he sliced the cork and distributed sections to his workers (30).

Bunsen and his assistants established a "club," for which each must contribute a minimum of 2 Gulden each semester. This enabled each member access to journals as a means to keep abreast of current publications in chemistry, and the periodicals became the holdings of the institute library. In collaboration with his assistants, Bunsen devised a set of laboratory rules, which were to be followed by all workers, including himself. Anyone guilty of leaving a gas jet open, forgetting to close a balance door, or of any other specified violations, was required to pay a fine. All proceeds, together with club fees, went to finance the library. Eventually Bunsen contributed many of his own books to the library (31).

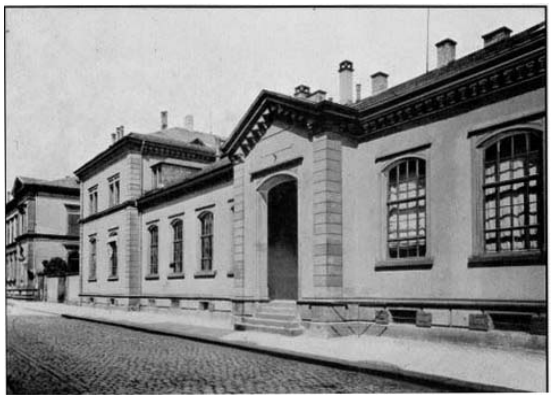

Figure 9. *Heidelberg Laboratory*

Requirements for Degree

The first challenge for English-speaking students was to gain facility in the German language. Liebig informed Horsford, on their first meeting in Liebig's private laboratory, that he would be allowed to continue conversing in English for two or three days, but no longer (22). Beginning students typically set aside a routine regimen for learning and practicing German. In Göttingen the Americans kept close company with one another rather than socializing with German students, thus being tempted to practice the native language less assiduously (32). Nevertheless, Pugh and George Caldwell, who became acquainted in Göttingen, worked on translating Gerhardt and Chancel's text on qualitative analysis (33). Playfair edited an English translation of Liebig's book on agriculture, which was published in 1840, the year of his graduation. Clearly he had sufficient facility in German (34). Liebig apparently conversed in and read English, for in his travels to England and Ireland he attended meetings and socialized with a great many, including Queen Victoria and Albert (35). By his own account, Wöhler had little facility in English, but not for a lack of talent (36). During his tenure in Stockholm he had managed to master Swedish to the extent that he went on to translate Berzelius' works into German. Bunsen carried out his correspondence in German (13).

All students were trained in analytical methods, based upon Liebig's method of quantitative organic analysis for the elements and popularly accepted at other institutions in Germany as well as France. This arduous work, which consumed a full semester or two of a student's time—described by E. K. Muspratt as the 'junior laboratory' (35)—was carefully monitored. Liebig mandated the students be occupied in the laboratory "from morning until evening" and be examined weekly on their progress (37). Bunsen required every student to qualify first in elementary qualitative and quantitative analysis (taught by an assistant), after which he could be advanced to the "master's" instruction. He had a highly structured, elaborate protocol for analyses, which the students could observe by the master's hand and were required to follow. If a student indicated he had carried out a procedure exactly as prescribed—but with faulty results—Bunsen would inform him, sadly but gently, that he must start from the beginning again (38). Wöhler was the most relaxed in his laboratory discipline, but his students likewise put in long days of routine analytical drudgery (11, 28), while also studying German.

The requirement for matriculation might be simply presentation of a passport or perhaps also certification of a baccalaurean diploma. James Hart describes the costs at Göttingen in the 1860s. The fee for admittance to the university was $5, and lecture fees varied from $5 to $30 (39). Magee estimated total cost for a year for housing, meals, lectures, and laboratories to be $205 (40).

Wöhler's students were distinctive in writing doctoral dissertations, sometimes in English but increasingly in German. Liebig's students who earned the D.Phil. published their research results in Liebig's own journal, the *Annalen der Chemie und Pharmacie*. Edward Frankland, Bunsen's only English-speaking doctoral student at Marburg, wrote a dissertation; but those in Heidelberg did not, with the exception of E. W. Hilgard (1854), in this case probably because he was of German heritage (2, 3). Often promotion to D.Phil. was authorized *in absentia*, but students, particularly Wöhler's, were examined orally (41). Henry Roscoe was required to translate a passage from the *Aeneid* into English as his "final" examina-

tion for the D.Phil. at Heidelberg (13). This is in sharp contrast to the account by E. F. Smith of his Göttingen oral examination, carried out over two days, mostly in German but also with a question about the Latin grammar in his *Vita* (42). Hart, a student in jurisprudence and not chemistry at Göttingen, described a most formal setting for the oral examination, held on a Saturday afternoon at the dean's residence, with student and faculty examiners in formal attire: swallow-tail coat, silk hat, white cravat, and white kid gloves. The examination, lasting three hours, included a five-minute intermission, when wine and cake were passed around (43).

According to the Liebig model (4, 5), students were assigned an independent research project, once they had gained competency in analytical skills. Wöhler suggested research subjects of broad scope but ones "that will probably lead to results." (29).

The Mentors' Aura

Liebig, the intensely dedicated scientist, was justifiably proud of his accomplishments and a very ambitious and highly critical individual. He stated publically that he had learned very little from his chemistry mentor, Kastner, at Bonn and Erlangen and considered Gay-Lussac, with whom he collaborated on research in Paris, as his inspiration for the career he pursued—in spite of having eventually been granted the D.Phil. at Erlangen. He did not hesitate to criticize questionable techniques or results of respected personages such as Berzelius (44) or his life-long friend, colleague, and collaborator Wöhler (45). When Horsford first met him and attended lectures, he found the professor intimidating but soon came to respect him (46). Although austere in countenance—students rose in hushed silence upon his entrance into the lecture hall (22)—he showed intense personal interest in his students. As Liebig visited the laboratory, he generously offered suggestions to each student working on individual research projects, ranging widely in organic, plant, and animal chemistry. His knowledge about each topic was keen, and he was one who worked intensely, which probably contributed to a nervous breakdown he sustained in 1833 (47). A typical assessment of Liebig's mentorship comes from one of his students of the 1840s (48):

> …ich kann Sie versichern, dass die Zeit meines Aufenthalts in Gieβen die schönste meines Lebens war. [I can assure you that the time of my sojourn in Giessen was the most wonderful in my life.]

Although students freely communicated with their master, the relationship was cordial but rarely intimate. Nevertheless, Liebig was a social individual, entertaining students in his residence, hosted with his wife and daughters. Not long after his arrival in Gieβen, Horsford was invited to supper and encouraged to call on the Liebigs frequently (46). E. K. Muspratt, who, along with his brother James S. (D.Phil., Gieβen, 1844), became prominent businessmen and public servants in Liverpool, spent three years, beginning in 1850, in Liebig's laboratory and followed him to Munich. In his memoirs he describes the active social life of picnics, dinners, and balls, hosted or attended by the Liebigs. He accompanied Liebig to conferences in London and Ireland, even sharing a room with him (49).

Liebig was loyal and supportive of his students and continued communication with them through correspondence and visitations as they found careers in England and America. His strong support for Horsford's successful appointment as Rumford Professor at Harvard is a reflection of the influence he enjoyed internationally (50).

In manner and appearance, Wöhler has been described as the diametrical opposite of Liebig: a modest, soft spoken, nonconfrontational individual, with a casual, unkempt appearance (51). This did not distract in any way from the respect with which he was held by his students. James Magee, one of the group of nine Americans working with Wöhler in the 1850s reflected this respect in a letter to his parents (52):

> We called on the Hofrath [Wöhler] today and talked for nearly an hour with him about the trip we made this summer. He is a very clever man, always in good humour, and spends the entire day with his students in the laboratory, directing the work. There is, I believe, no man more liked by his students.

This sentiment was expressed in the acknowledgments in dissertations, as exemplified in the following quotations from W. S. Clark (53):

> My best thanks are due my highly honored instructor, Prof. Wöhler, for his kindness in furnishing me with specimens for analysis, in allowing me free access to his library and cabinet, and, in short, in rendering me every possible assistance.

and by J. H. Eaton (54):

> ...Es ist mir eine angenehme Pflicht an diesem Orte meinem hochverehrten Lehrer dem Herrn Geheimen-Obermedicinalrath Wöhler meinen herzlichsten Dank für das meiner Arbeit sowohl wie meiner geistigen Ausbildung in Allgemeinen geshenkte Interesse auszusprechen. [It is my particular pleasure on this

> occasion to express my sincerest thanks to my esteemed teacher, Distinguished Director of Medicine Wöhler, for his deep interest in my research as well as my spiritual development.]

Even after his official retirement in 1880, Wöhler continued to visit and counsel students in the laboratory every day.

Wöhler's warm hospitality extended to the wife of one of the students, probably Mrs. Alfred Harkness (55), who kept a diary, a "Vacation Journal" (56) written in her imperfect German. Her account includes reference to many of the "American Colony" in Göttingen in 1855, some living in the same housing facilities: Dean, Hungerford, Chandler, Weymann, Pugh, Tuttle, Hagan, Kimball, Allen, Goodwin, Curtiss, E. P. Eastwick, as well as "mein Mann." The authoress, who was clearly studying not only German but chemistry, described her reading and acquisition of chemistry journals and books. She gives an account of dropping in on Wöhler, unannounced, at his living quarters on a Saturday afternoon to acquire order slips for the library. Although not at home, he returned shortly and cordially filled her request.

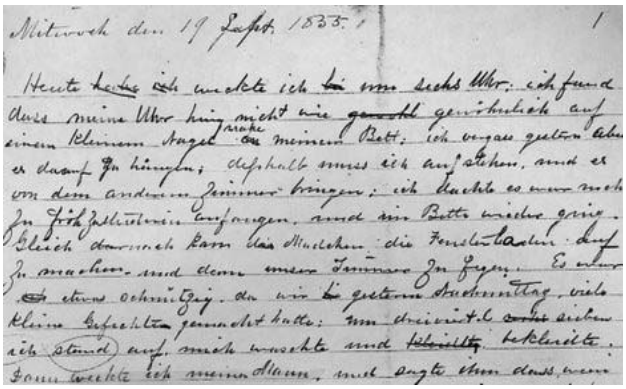

Figure 10. *"Vacation Journal" (Ref. 56)*

While Bunsen kept his private laboratory off limits to students and assistants, he was in every aspect as much a student as the greenest beginner, working alongside with no more bench space than the others. Advanced students were treated as special individuals. Henry Roscoe, working on photochemical studies and needing to work in the dark, was assigned to a loft boarded off for his own laboratory (57). Roscoe praised Bunsen's guidance (58):

> Without Bunsens' advice, assistance, and cooperation I should never have succeeded in obtaining the results we did; and although I carried out the experimental part of the work, the elaboration of the results was mainly due to him.

Bunsen's personality contrasted sharply with Liebig's. He avoided public recognition of his many discoveries, which he freely communicated to other scientists. The idea of capitalizing on their practical application was a practice he found repugnant (59): "Von allen Menschen waren mir die feierlichen die ekelhaftesten." [Of all people, the most disgusting to me were the pompous ones.]

Bunsen was tall in stature; his manner simple yet dignified and his expression intelligent and kindly (60). He had lost the sight in one eye from his famous experiments on cacodyl, his sole exploration in organic chemistry (61). A lifelong bachelor, he treated his students as his family. He was famous for his forgetfulness: being deeply absorbed in a research experiment for several months, he made a second proposal of marriage to his fiancée, having forgotten he had already done so, whereupon she cancelled the engagement (61).

Continued Contact with Mentors

All three mentors—Liebig, Wöhler, and Bunsen—corresponded with former English-speaking students and received them as visitors in their laboratories; in the case of Liebig, he was hosted by them in England. Horsford maintained an active correspondence with his mentor Liebig, mainly on the subject of baking powder (62), but he entreated Liebig, to no avail, to visit the United States (63):

> Come [to America] and let your American pupils show how truly and how deeply grateful they feel toward you.

Wöhler, ever the prolific correspondent, kept in touch with many of his foreign students, particularly the Americans. His letters to his German student and former assistant, Charles A. Goesmann, whose chemical career eventually led to his directorship of the Massachusetts Agricultural Experiment Station (11), include greetings and inquiries about his other students. Charles Joy (D.Phil., Göttingen, 1853) married a German woman and lived the last part of his life in Germany. Wöhler, fond of Joy's wife Laura, with whom he carried on a warm correspondence, named a mineral—"laurite"—after her (64).

Henry Roscoe in particular continued his association with his mentor Bunsen. He returned to Heidelberg after his graduation to execute experiments but also took vacations with Bunsen and sometimes also Kirchhoff to Bavaria, the Tyrol, and Switzerland over a period of several years. Their deep friendship is evident in letters from

Bunsen, in which he addresses Roscoe as "Theurester Freund" (13).

Perhaps the most forceful testimony to the respect for their German mentors by foreign students was their influence in encouraging their own students to study abroad. Several of Horsford's Harvard undergraduates (Chandler, Caldwell) took that route. Most impressive is the case of 28 Amherst students of Elijah Harris (D.Phil., Göttingen, 1859), who went to Göttingen at his urging over the course of the last decades of the 1800s. More than half earned the D.Phil. (3). Other less dramatic examples of this trend were taking place in England as well.

Conclusion

Evan Pugh, who spent parts of four years in the 1850s in laboratories in Göttingen, Leipzig, Heidelberg, Switzerland, France, and England, missed the opportunity of studying under Liebig, who by then limited his professional activity in Munich to large lectures, having specified that he take no research students in his new position. Nevertheless, Pugh may have summed up the situation of early German chemical education as well as anyone (65):

> I must say that Göttingen is the place of places…for physical chemistry Heidelberg has no equal. I would advise a student to go first to Wiesbaden (Fresenius) or Gieβen for good lab instruction and poor lectures; then go to Wöhler and get excellent lectures embracing principles easily understood and good process instruction in the lab; finally close with Bunsen for physical chemistry in the lab, and the most profound and philosophical lectures to be held in...Germany.

It is clear from the biographies, letters, and diaries cited in this essay that the mentoring styles of Liebig, Wöhler, and Bunsen were distinctive but each effective in its unique way. As role models, their legacy was the influence instilled in their students, including those from Britain and America, who returned to their homelands and created academic programs modeled after those they had experienced as students at their German alma maters (3).

Acknowledgment

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