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The Strong German Influence on Chemistry in Britain and America

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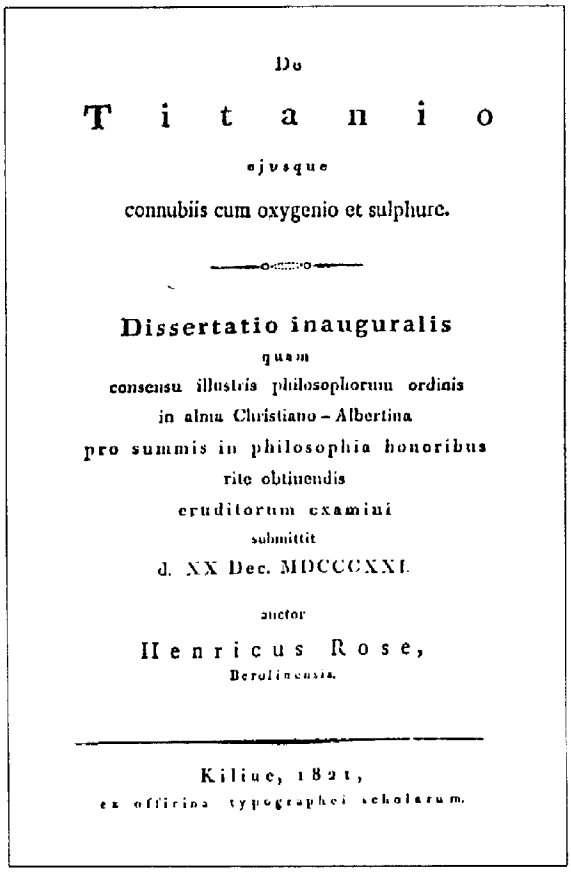
Around the middle of the 19th century, Germany became the recognized center for the training of chemists. Prior to that, students seeking specialized instruction found it necessary to travel to either Paris or Stockholm. Among the students who sought out J. J. Berzelius in Stockholm were Mitscherlich, Henrich Rose (1819-1821) and, shortly thereafter, Wöhler (1823-1825). About the same time (1822-1824), Liebig began his studies with Gay-Lussac in Paris, as did Bunsen ten years later. Gay-Lussac had, in turn, been a pupil of Lavoisier's collaborator, C. L. Berthollet. Indeed, most chemists today can trace their chemical genealogies back to either Berzelius, Berthollet, or to Berthollet's Parisian contemporary, A. F. Fourcroy.

J. W. Döbereiner, self-educated at Jena, did not venture from his homeland. Other Germans who developed careers in chemistry originally studied medicine: for example, O. L. Erdmann, editor of *Journal für praktische Chemie*; O. B. Kühn at Leipzig; N. W. Fischer at Breslau, and F. Stromeyer at Göttingen. L. Gmelin was trained by his father at Göttingen, and the father had been trained, in turn, by *his* father at Tübingen - a case of three generations of self-trained chemists within the same family.

The first German doctoral degree in modern experimental science was awarded to Gustav Rose by the University of Berlin in 1821, where he had studied mineralogy. The following year, his brother, Heinrich Rose, was granted the first doctorate in chemistry at Kiel. His dissertation, based upon work which must have been conducted in Berzelius' laboratory, was entitled *De Titanio ejusque connubiis cum oxygenio et sulphure.*

In the next ten years or so these newly trained chemists assumed professorships at many of the German universities: Mitscherlich and H. Rose at Berlin; Erdmann and Kühn at Leipzig; Stromeyer and Wöhler in Göttingen; Liebig at Giessen and L. Gmelin at Heidelberg. So began the "golden age" of chemistry in the German university and, by the 1830's, only two of the 22 existing universities - Braunsberg and Münster - were lacking professors of chemistry.

In America and Great Britain the situation was quite different. Students were instructed only in lecture halls, without any direct access to laboratory facilities or research opportunities. Those enrolled at Harvard, Yale, Oxford, and Cambridge attended lectures presented by professors who were, for the most part, self-taught and who had not ventured from their home institutions. Consequently, those students who were interested in advanced study in chemistry began, with increasing frequency, to turn their attention toward Germany.



De

Titanio

ejusque

connubiis cum oxygenio et sulphure.

Dissertatio inauguralis

quam

consensu illustris philosophorum ordinis

in alma Christiano-Albertina

pro summis in philosophia honoribus

rite obtinendis

eruditorum examini

submittit

d. XX Dec. MDCCCXXI.

auctor

Henricus Rose,

Berolinensis.

Kiliae, 1821,

ex officina typographei scholarum.

Title page of the first doctoral thesis in chemistry.

Who were these students from America and Great Britain who ventured abroad to immerse themselves in an academic atmosphere where instruction was carried out in a foreign tongue? From what home institutions did they originate? Where did they choose to study? What sort of professional lives did they ultimately lead? Although information of this sort is well known in a few famous cases, such as Ira Remsen (Baltimore) and Henry Roscoe (Manchester) - to name one from each country - the challenge of trying to answer some of these questions for the less famous as well was the motivation behind the present study. Because much of the information on "German-trained" individuals has originated from secondary sources or from anecdotal accounts, it was decided that identification of these individuals would be confined to those students earning a German doctorate in chemistry in the period between 1840 and 1914. Documentation would be limited to matriculation records, doctoral dissertations, and registries of dissertations at German universities.

The search was carried out in Munich, from September 1982, until August 1983, with the Deutsches Museum (DM) as headquarters. The library in the Research Institute of the DM, specializing in the history of science and technology, was a rich

source of secondary literature, including tabulations of dissertations published in all existing German universities from 1886 (1). Although this source was invaluable for providing information for the later period of study, it did not provide a lead to dissertations written earlier than that time. Complete registries of dissertations for seven universities (of the total of 22 existing in the late 19th century) from their beginning were available and could be used to identify a limited number of dissertation authors (2-8). In most instances, the listing of authors in the registries included their geographical origin, which was either their birthplace or the location from which they traveled to Germany to undertake their studies. The listing of dissertations in chemistry compiled by Bolton (9) and published in 1890 was useful for confirmation of names but could not serve as an initial identification, because no distinction was made between nationalities of the authors. The recent biographical dictionary by Elliott (10) served to identify a few additional American chemistry doctoral students. From examination of these secondary sources a considerable number of individuals were identified, in some cases with the information about their place and dates of study and the title of their dissertations.

However, the most fruitful source of information came from direct examination of original dissertations, housed in three libraries in Munich: those in the DM, in the Universitätbibliothek (UB), and in the Bayerische Staatsbibliothek (BSB). At both the DM and the UB libraries, I was allowed to examine the dissertation collections and thereby sort out those written by non-German students. Although the holdings at the DM are limited, the number of dissertations in the UB library in chemistry alone approaches 13,000, written over the time period from 1820 until about 1920; and, not suprisingly, most of the dissertations which I identified were found in the UB holdings. Still others were eventually located through the catalog in the library of the BSB.

By examining individually the 14,000 dissertations, I was able to identify those written by English-speaking individuals. Pertinent pages of dissertations, once located, were photocopied, including the title page, acknowledgment page, and biographical sketch of the author, the latter two usually, but not always, having been included in the document.

The outcome of this library search was the identification of almost 800 dissertations written by English-speaking individuals, equally divided between Americans and British (Table 1). The dissertations usually provided information about the author's name and birthplace (or home residence), university, the year the doctorate was awarded, the title of dissertation and the research director ("Doktorvater"). Some of this information, if missing from the dissertation, could be pieced together through valuable secondary sources (11-20), which were particularly useful for students at Giessen (14,19-20), Göttingen (16,17), and Leipzig (15). With few exceptions, early doctoral students at Giessen and Heidelberg did not write dissertations but rather published their results, usually in Liebig's *Annalen der Chemie*. Because no registry of doctorates at Heidelberg has yet been published, it was necessary to seek confirmation from the Archives. I am grateful to Dr. Weisert, University Archivist at Heidelberg, for verifying the granting of doctoral degrees without dissertations between 1854 and 1886. The results of this work have been published in the form of a bibliography by the DM (21) and are stored in file form on microcomputer disk. An English edition of the bibliography is also currently being prepared as part of the new series, *Data Sources in the History of Chemistry*, to be published by the Division of the History of Chemistry of the American Chemical Society.

Table 1. British and American Doctoral Students in Chemistry at German Universities, 1840-1914.

University	*American*	*British*	*Total*
Berlin	51	18	69
Bonn	3	9	12
Breslau	8	6	14
Erlangen	9	10	19
Freiburg	27	16	43
Giessen	4	33	37
Göttingen	106	41	147
Greifswald	0	1	1
Halle	1	4	5
Heidelberg	46	53	99
Jena	4	24	28
Kiel	3	4	7
Königsberg	1	0	1
Leipzig	52	48	100
Marburg	8	14	22
München	23	31	54
Rostock	6	2	8
Strassburg	17	18	35
Tübingen	10	17	27
Würzburg	7	49	56
TU (1)	2	2	4
TOTAL	388	400	788

(1) Technical Universities in Aachen, Darmstadt, Karlsruhe, and München.

An examination of the resulting data provides an interesting perspective on foreign students studying chemistry in Germany in the 19th century and offers tentative answers to some of the questions posed earlier. It is particularly interesting to note both the similarities and differences between the American and British students.

Lyon Playfair, later Lord Playfair, a graduate of St. Andrews, was the first English-speaking student to earn a

German doctoral degree in chemistry, which was granted in 1840 at Giessen under the direction of Liebig - roughly 20 years after the first German doctoral degree in chemistry had been granted to Heinrich Rose. The first American to complete a chemistry doctorate in Germany was Jose Vincente Ortigiosa, a native of Mexico. A student of Liebig at Giessen, he is depicted in the famous lithograph of Liebig's laboratory made by Trautschold in 1842 (22), the year that he received his degree (5). Charles Mayer Wetherill, a native of Philadelphia, was the first U.S. citizen to complete a degree in Germany, having received his doctorate at Giessen in 1848.

As with most of Liebig's students, neither Playfair, Ortigiosa nor Wetherill wrote dissertations, but rather published the results of their work in Liebig's *Annalen*. Two American students of Wöhler at Göttingen, William Smith Clark and Newton Spaulding Manross, were the first to write dissertations, in 1852, as part of the fulfillment of the requirements for the doctorate. Incidentally, both of these dissertations were written in English, a privilege extended to only a few (about 9%) of the nearly 800 American and British doctoral students during the 70-year period covered.

For every year, except two, in the period from 1842-1914, doctoral degrees were awarded to one or more English-speaking students. The number completing degrees increased regularly until the 1890's, when it began to taper off, a trend which undoubtedly reflects the development by this period of opportunities for advanced training in the U.S. and Britain. Of the 22 German universities in existence in the middle of the 19th century, 19 of them conferred doctoral degrees on English-speaking chemistry students, although to varying extents, ranging from a high of 147 degrees at Göttingen to just one degree each at Greifswald and Königsberg (Table 1).

The choice of institution varied considerably with the time period, and American and British students had their own preferences. Giessen, Göttingen, Heidelberg, and Marburg were favorite choices in the 1840's and 1850's. Only in the 1870's were degrees awarded for the first time at Berlin, Freiburg, Leipzig, Rostock, Strassburg, Tübingen, and Würzburg; and in the 1880's at Bonn, Breslau, Erlangen, Halle, Jena, Kiel, and Munich. Of the nearly 800 English-speaking chemistry students who completed doctoral degrees, over half studied at one of four universities: Göttingen, Leipzig, Heidelberg, and Berlin. In some cases, American and British students showed strong preferences for certain institutions, with the Americans generally preferring Göttingen, Berlin, and Freiburg and the British preferring Giessen, Jena, and Würzburg (Table 2).

It has been possible to identify the research director for 95% of the doctoral students, mainly from acknowledgment pages in the dissertations. Some of the secondary sources mentioned earlier have also been helpful in this regard. A few German chemistry faculty stand out as dominant mentors of the American students. Several of these were at Göttingen, where such a large number of Americans earned their degrees. Wöhler served as research director for 20 Americans over a 30-year career. Less well-recognized is Hübner, Wöhler's colleague and successor, who, in a brief 15-year period, also directed the dissertations of some 20 Americans. Wallach served as mentor for another 20 American students over a 25-year career and Tollens directed doctoral dissertations of 11 Americans in a 20-year period. An account of the experiences of one American under Tollens' tutelage was published in 1942 (23). Fittig and V. Meyer also directed research for another nine Americans during their rather brief careers at Göttingen.

Liebig's doctoral students at Giessen were overwhelmingly British: 21, as compared to three Americans, in the short span of 13 years. Although Bunsen served as Doktorvater for only five students (of whom four were British) during his long career at Heidelberg, he and Kopp jointly directed dissertations by eight students, six of whom were Americans. The English-speaking doctoral students trained by Fittig in Tübingen and Strassburg and by V. Meyer in Heidelberg were about equally divided between Americans and British. A. W. Hofmann's English-speaking students at Berlin were predominantly American (18 of 23), as were Ostwald's at Leipzig (17 of 23). Emil Fischer directed predominantly British students at Würzburg (12 of 15 in seven years) but mainly Americans at Berlin (12 of 16 in 22 years). Hantzsch, during relatively brief careers at Würzburg and Leipzig, directed dissertations of 29 English-speaking foreigners, 27 being British. However, the record for total number of English-speaking doctoral students goes to J. Wislicenus, who was mentor to ten American and 23 British students at Würzburg and Leipzig. Perhaps his experience as a private assistant to Horsford at Harvard, during the years 1853-1856, made him sympathetic to other young men in a foreign land (24).

The impact on the chemistry profession in America and Britain exerted by these German-trained students can be assessed by following their careers after they returned home. The

Table 2. Distribution of American and British Chemistry Students Among the Top Ten German Universities, 1840-1914.

University	*% American*	*% British*
Göttingen	72	28
Leipzig	51	49
Heidelberg	47	53
Berlin	71	29
Würzburg	12	88
München	43	57
Freiburg	65	35
Giessen	11	89
Strassburg	49	51
Jena	14	86

professional lives of many of them have been gleaned from the secondary sources already cited, as well as from *American Men of Science, Appleton's Cyclopedia, Poggendorff*, and individual biographies and obituaries. Unfortunately, it has not been possible to trace the subsequent lives of all of them. Several of the Americans trained in the 1850's and 1860's were killed during the Civil War. Others became active in educational institutions, often those from which they had received their undergraduate degrees. Specific examples are provided by the University of Pennsylvania, where Samuel P. Sadtler (Göttingen, 1871) and Edgar Fahs Smith (Göttingen, 1876) were faculty members; Columbia, with Charles A. Joy (Göttingen, 1853) and Charles F. Chandler (Göttingen, 1856); Amherst College, with William S. Clark (Göttingen, 1852) and Elijah R. Harris (Göttingen, 1859); and MIT, with Augustus H. Gill (Leipzig, 1890), Arthur A. Noyes (Leipzig, 1890), Lewis M. Norton (Göttingen, 1879), Samuel P. Mulliken (Leipzig, 1890), and Benjamin E. Talbott (Frieburg, 1900). At Johns Hopkins University, founded in 1876, Ira Remsen (Göttingen, 1870) and his assistant, Harmon N. Morse (Göttingen, 1875), developed the chemistry instructional program, and Remsen later served as president of the University.

Liebig's laboratory at Giessen was a favorite among British students.

A conservative estimate of the institutions being served by these early generation, German-trained Americans numbers well over 50, and they vary from early, well-established schools, such as the University of Pennsylvania, to liberal arts colleges, such as Amherst, Williams, and Beloit, to newly founded technical schools, such as the Columbia School of Mines and MIT, to the land-grant institutions founded after the Civil War. Several also served as presidents of the American Chemical Society (25).

In contrast to the multitude and variety of schools in the United States, centers for higher learning in Great Britain were few in number. In 1840, in England, only three institutions were active sites for chemistry instruction: Cambridge, Oxford, and University College, London. Other students learning chemistry did so as part of their medical training at one of the hospitals. In Scotland, there were four universities, all founded in the late 15th and early 16th centuries. Benjamin C. Brodie, one of Liebig's doctoral students (Giessen, 1850), assumed the professorship in chemistry at Oxford, which he held until 1873. At University College, another Liebig student, Alexander Williamson (Giessen, 1845), occupied the professorship from 1855-1887, being the successor to George Fownes, also a Liebig student (Giessen, 1841), who had died at an early age. Edward Frankland, a student of Bunsen at Marburg (1849), first filled the professorship at Owens College (later University of Manchester) and eventually succeeded Hofmann at the Royal College. Frankland's successor at Manchester, Henry Roscoe, was one of Bunsen's students at Heidelberg (1854), and was very influential in developing the doctoral program in chemistry, modeled after the research teaching of Bunsen and Liebig (26). This, in turn, became the model for graduate programs throughout Britain. All of the these chemists, except Fownes, also served terms as President of the Chemical Society of London.

Meanwhile in Scotland, the German training was noticeable as well. Serving as professor at Edinburgh from 1858-1868 was Lyon Playfair, also a student of Liebig (Giessen, 1840). He resigned to enter public life, serving as advisor to Prince Albert, an organizer of the Royal College of Chemistry and, eventually, as a member of Parliament. For 30 years, beginning in 1839, Frederick Penny held the professorship at Glasgow. Penny had visited Liebig in Giessen and was awarded the doctorate in 1842 on the basis of research published in the *Annalen*, but apparently carried out at Glasgow.

These returning chemists in America and Britain, undoubtedly enthusiastic over their stimulating training in the laboratories of Germany, were anxious to pass on their professional heritage. As they helped found new departments of chemistry and new institutions, they also encouraged their own students to continue the cycle by studying in Germany. Elijah Harris, a doctoral student of Wöhler's at Göttingen (1859), returned to Amherst College as professor from 1868-1907. During this tenure, he sent 28 students abroad, all of them to Göttingen - more than half of whom earned doctoral degrees. Many other examples could be cited of this trend, which took place in Britain as well. In some instances, the family influence was strong, as with William Henry Perkin, Jr. (Würzburg, 1882), whose younger brother, Frederick, studied under him at Owens College and then earned a doctoral degree at Würzburg with

Hantzsch in 1897. Three generations of Franklands were German-trained doctoral students. Besides Edward Frankland, already mentioned, both his son Percy and grandson Edward P. earned doctorates at Würzburg, the son under Wislicenus in 1880 and the grandson under Tafel in 1908.

This discussion has been limited largely to the influence of first-generation American and British students of the German tradition. As the chemical industry began to develop, first in Britain and later in America, it was natural that its leadership was assumed by many of these chemists, often second or later generation. Thus, Irving Langmuir, a doctoral student of Nernst at Göttingen, and future Nobel Prize winner, was a strong influence in the development of research at General Electric.

Not only did the returning Americans and British exert significant influence on the development of chemistry in their homelands, but some native Germans, emigrating at a time when the economic and social conditions were unfavorable in their native country, became prominent chemists abroad, including Charles Goessmann at the Massachusetts Agricultural Station; John Maisch at the Philadelphia College of Pharmacy; Frederick Genth at the University of Pennsylvania; William Elderhorst at RPI, and Hermann Endemann, a student of Kolbe at Marburg and the first editor of *JACS* . In England, the name of August W. Hofmann, the first director of the Royal College of Chemistry, (1845-1864), comes immediately to mind, along with that of Carl Schorlemmer, who was hired by Roscoe as the first Professor of Organic Chemistry at Owens College, a position he held from 1874-1892 (26).

If one could eventually learn about all 800 of the American and British students who completed doctoral degrees in Germany before 1914, a demonstration of the strong impact on chemistry communities in their native lands would be even more impressive than that gleaned by looking only at the first generation. Furthermore, it must not be forgotten that these ambassadors of chemistry, through their "Doktorväter", owed their professional success indirectly to that original trio of influential tutors in Stockholm and Paris.

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