

Inside Technology

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1 Beilstein Unbound: The Pedagogical Unraveling of a Man and His *Handbuch*

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Friedrich Konrad Beilstein is the most famous scientist you have never heard of. Unless, that is, you are a chemist, in which case he is the most famous chemist you know absolutely nothing about. Beilstein is a name constantly on the lips of essentially every practicing organic chemist in the world—and has been for over a century—but the amount of information widely known about his life pales in comparison to other less prominent figures such as Bunsen, Davy, and Pauling. Upon his death in 1906, Beilstein elicited the highest praise:

The name *Beilstein* awakes in the currently living generation of chemists feelings of the sincerest gratitude. There is scarcely any work that so often lies open on the chemist's table or in his laboratory as the *Handbuch* that carries Beilstein's name and that is the result of his life's work. It has become an indispensable guide to all those who are active in the area of organic chemistry—"a guidebook for the land of organic chemistry"—and one can scarcely even think now about a "Beilsteinless" era.¹

And there is the source of our ignorance: Beilstein is not known as a person, but rather as a book, a reference work for the properties of all known organic compounds. Beilstein is unknown because historians have not asked "Who is Beilstein?" They have scarcely even asked "What is Beilstein?"

Let us start with *what* Beilstein is. The "Beilstein" (more precisely the *Handbuch der Organischen Chemie*) was first published in 1881–1883 in two volumes comprising 2,200 pages and 15,000 organic compounds. In 1885 the second edition began to appear (completed in 1889 in three volumes), and the 1899–1906 third edition comprised four volumes. These first editions were compiled and edited by Beilstein alone (except the third, with which he had supplementary assistance). By 1981, on the hundredth anniversary of the *Handbuch*, the staff of the Beilstein Institute in Frankfurt am Main stood at 160. As it was simply but emphatically put in a commemorative volume that year: "*The Beilstein Handbook is the most extensive collection of physical data in printed form in the world!*"² The Beilstein *Handbuch* represents the first pure reference handbook of

chemistry, and it became the site of that science's first large-scale communal literary project.³

Yet I come not to praise Beilstein, but to exhume him. I propose that by breaking apart the monolith of the *Handbuch* and looking at the pedagogical roots of its formation, we can come to a better understanding of the multiple ways in which pedagogy was implicated in the development of even the most mundane tools of organic chemistry. The *Handbuch* is an object of pedagogy, having spawned numerous guides inducting students into its proper use, but I will focus on it as a *subject* of pedagogy.⁴

Who was Beilstein?⁵ Even naming him becomes complicated, since for Germans he was Friedrich Konrad Beilstein and for Russians he was Fedor Fedorovich Beil'shtein. (I adopt the former for the sake of convenience.) Later in his life, he would describe himself thus:

Beilstein (Friedrich, Conrad) born in St. Petersburg on 17 (5) February 1838. Completed the German high school in St. Petersburg & then moved to the University of Heidelberg. Studied besides that in Munich (with Jolly and Liebig), in Göttingen (with Wöhler) & in Paris (with Wurtz). Became in 1859 an Assistant in Prof. Löwig's University Laboratory in Breslau. Went in 1860 (early in the year) in the same capacity to the Laborat. of Prof. Wöhler in Göttingen. Received doctorate in Göttingen in 1858 (Dissertation: on murexide). Habilitated in Göttingen in chemistry in 1860 and became an extraordinary professor there in 1865. Moved in autumn to Petersburg as professor of chemistry at the Technological Institute. Became in 1867 a teacher of chemistry at the Military-Engineering Academy there and in 1868 a chemist of the Department of Trade and Manufactures in the Imperial Russian Ministry of Finances.

First scientific work: On the Diffusion of Liquids, conducted in 1855/6 in the physical cabinet of Prof. Jolly in Munich.

Books: Introduction to Qualitative chemical analysis, 5 editions, Chemical Great-Industry at the World Exposition in Vienna 1873,

Handbook of organ. Chemistry. In 2 editions as of 1885.⁶

Even a cursory glance at Beilstein's account shows how he perceived his life to be saturated with pedagogy. What mattered was who trained him, where he trained others, and what texts he published to that end.⁷ I propose we take Beilstein at his word.

I argue that the *Handbuch* emerged out of a long and diverse set of interactions between Beilstein and pedagogies in various contexts. Specifically, I will situate Beilstein as a teacher at Göttingen, as editor of the *Zeitschrift für Chemie*, as professor at the Technological Institute in St. Petersburg, and as editor of the *Handbuch*, and show how in each case the notion of what it meant to train students into practicing chemists was always tied to a particular receptive environment. As his environment in St. Petersburg turned hostile in 1880, Beilstein began to direct his pedagogy more abstractly. Instead of focusing on actual students, Russian or German, he con-

centrated on building a Germanophonic international community of standardized thinkers.

Student Teacher: Beilstein in Germany

Beilstein's paternal line hailed from Darmstadt, and his mother's line, the Rutsches, originated in Baden, both of solidly *Mittelstand* stock. His great uncle, Konrad Rutsch, was a Protestant from the small village of Dühren, which he left at age 16, settling two years later in St. Petersburg in 1810. There he opened a grocery store at the corner of Malaia Morskaia and Nevskii Prospekt, roughly two blocks from the Winter Palace.⁸ In 1838, the year Beilstein was born, Konrad died, turning his business over to his niece Katharina Margarete Rutsch and her husband Karl Friedrich Beilstein. Our Beilstein was the first of their seven children (five boys, two girls), most of whom retained their status as German citizens. He was educated at the Protestant St. Petrischule in St. Petersburg, where he received extremely high marks and upon graduation at age 15 embarked for further study to Germany. An uncle paid for the trip.

In Germany, Beilstein traveled to most of the various educational centers for the modern chemist.⁹ He studied with Robert Wilhelm Bunsen in Heidelberg for two years, then Justus von Liebig in Munich, and became close friends on another stay in Heidelberg with young *Privatdozent* August Kekulé. Beilstein took courses and learned laboratory skills from each of these figures before obtaining his doctoral degree at Göttingen under Friedrich Wöhler in February 1858, a few days shy of his twentieth birthday.¹⁰ Thus armed with academic credentials, he traveled to Paris and worked in Adolphe Wurtz's laboratory, adopting the latter's program of investigating aldehydes. Paris resolved Beilstein on an academic career in chemistry, and he assumed a laboratory assistant position in Breslau in autumn 1859, under the fearsome charge of Carl Jacob Löwig. Breslau, and particularly Löwig's centralized and dismissive attitude towards his students, were not to Beilstein's taste.¹¹ In 1860 Wöhler offered Beilstein a position in Göttingen as a laboratory assistant with better pay (and more congenial working conditions).

Göttingen marked a pedagogically important moment for Beilstein, since this was when he was first expected to train future chemists. His main duties were to conduct practical laboratory instruction, an educational innovation stressed decades earlier by Liebig in his previous incarnation as the doyen of Giessen. After Liebig moved to Munich in the aftermath of the 1848-49 unrest in the German states, his model of chemical education spread essentially everywhere.¹² This type of laboratory-specific teaching put heavy demands on the pedagogue's time. As Beilstein reported to Russian

chemist Aleksandr M. Butlerov: "If you consider, however, that I only have Saturday on which to work; on the other days instruction in the laboratory absorbs my entire activity, then you would make allowances for me and find it excusable if my patience is completely gone."¹³ Nevertheless, despite his complaints, his six years in Göttingen can be considered the most scientifically productive and socially happiest of his life. Of particular note was his work on isomerism. In a series of seminal studies, Beilstein demonstrated that various organic compounds previously considered isomers were in fact the *same* compound, facts he used to expand the credibility of August Kekulé's structure theory. As Beilstein wrote to the latter: "My critics reproach me for having accomplished little of real significance along this line, but it was necessary to show beforehand that there is only *one* benzoic acid, that benzyl chloride and chlorotoluene are different, and so forth, before these could bring to your theory that range and that significance which it had from the beginning."¹⁴ This established Beilstein's reputation as a gifted organic chemist.

Beilstein was not, of course, alone in the teaching labs, and his colleagues, von Uslar and Rudolph Fittig, frequently irritated him. Von Uslar was deplorable as a pharmaceutical chemist with no theoretical interests. Fittig's sins were graver: "[Fittig] is a pedant through and through and treads so closely in the footsteps of his great teacher Limpricht that I consider him to be the most insufferable man I have ever met. . . . The present lecture assistant has fallen ill and Fittig has temporarily taken over his job so I have this monster in my place the whole day."¹⁵ So much for first impressions: Fittig would soon become Beilstein's inseparable colleague (at one point they shared an apartment) and a crucial factor—together with Hans Hübner, another Göttingen *Privatdozent*—in shaping an emerging pedagogical style that stressed collegial cooperation and complementary division of labor among teaching duties in a well-equipped laboratory.¹⁶ Beilstein's magnetic personality made him the clear center of the group. As Fittig commented in his diary:

I respect his knowledge of organic chemistry, and I cannot fail to recognize that he, especially in the matter of such important laboratory studies, has stimulated me many times. . . . He also stands before the laboratory students in a proper but good relation, he tells them jokes and anecdotes . . . and allows the difference between teacher and student to vanish completely. The students like this, as well as his joviality; his sharp humor makes him their darling. I am in this respect entirely different, and I will happily admit that I am abrupt, that I am too much a teacher, too schoolmasterly. . . .¹⁷

This teaching style—using humor and individual attention to motivate students—like so many other aspects of pedagogy, was site-specific. When Beilstein left Göttingen, this casual demeanor became harder to maintain.

As Fittig and Beilstein became more closely acquainted, they discovered other complementary aspects of their characters besides pedagogy. It has often been asserted with respect to the *Handbuch* that Beilstein was anti-theoretical, and thus was predisposed towards empirical compilation. Otto Krätz, for example, in his excellent study of Beilstein's correspondence with Heidelberg (later Munich) chemist Emil Erlenmeyer, contrasts Beilstein as the "man of Praxis" to Erlenmeyer's "man of Theory."¹⁸ Perhaps this is true, but next to Erlenmeyer almost any chemist would seem to be a "man of Praxis." A less skewed contrast is between Fittig and Beilstein, where Fittig is classed as the talented experimentalist, and Beilstein is his theorist complement with his exceptional command of the chemical literature.¹⁹ Beilstein in fact repeatedly stressed the importance of "indispensable" theories that were "supported by noteworthy discoveries," such as Kekulé and Butlerov's structure theory, and was quick to criticize Marcellin Berthelot's textbook as overemphasizing facts to the detriment of theory. Given that Beilstein's reputation was built on the success of structure theory, this conclusion should not strike us as odd, despite Beilstein's occasional later disclaimers of all theoretical speculation.²⁰ Beilstein was able to stake out this middle ground in his research *and* his teaching because Fittig provided enough experimental guidance to balance the students' training.

Beilstein's insistence on the mutual dependence of theory and experiment made him a pedagogue in high demand. In April 1865, St. Petersburg University attempted to hire Beilstein. Wöhler and others lobbied Hannover not to let such a prize teacher go. As the grand old man of Göttingen chemistry wrote to the Ministry in 1865, Beilstein "is the most talented and knowledgeable [of the Assistants], he possesses above all of them the most multifaceted scientific education, and his name known as among the most advantageous through his achievements in the most difficult part of chemistry, organic chemistry, on which he has been giving lectures each semester for 3 years already."²¹ In the end, Göttingen counter-offered to make Beilstein an extraordinary professor at the ripe young age of 27, and threw in a sizable salary to boot—which Beilstein accepted after failing to coax similar blandishments from A. A. Voskresenskii in Petersburg.²² Beilstein couched his final acceptance to Hannover in pedagogical terms: "My entire goal and striving is directed so as to conduct my science, which I place above everything, completely and independently. No place has offered more and better opportunity than here in Göttingen . . . nowhere have I found such a pure scientific sense as here and nowhere are the students as industrious as here. I put specifically a great deal of weight on the last point. We chemists achieve very little ourselves, and only that which we achieve through our students is actually valuable."²³ Anyway, no one really expected that Beilstein would seriously abandon his alma mater.²⁴ That assumption, it turned out, could not be further off the mark.

Beilstein, Editor: The *Zeitschrift für Chemie*

Before continuing with Beilstein's pedagogical peregrinations, however, we need to pause and explore a literary project that grew up alongside Beilstein's teaching style in the culture of Göttingen sociability: his joint editorship of the *Zeitschrift für Chemie* with Hübner and Fittig. The *Zeitschrift* is important to the history of the *Handbuch* both because Beilstein's editorship involved the correlation and processing of diverse chemical material (thus providing necessary experience for his later magnum opus), and because the *Zeitschrift* functioned for roughly a decade as the *only* regular publication outlet for Russian chemists—albeit in German—and thus Beilstein's role on the editorial board facilitated the constitution of a Russo-German chemical community, the eventual breakdown of which would leave traces in the *Handbuch*.

Like Beilstein himself, the *Zeitschrift für Chemie* had a confusing set of appellations. In 1858, a Heidelberg quartet centered on August Kekulé founded the *Kritische Zeitschrift für Chemie, Physik und Mathematik*, which consisted largely of book reviews in the associated three disciplines. In 1859, one of the four, Gustav Lewinstein, assumed control of the journal with former pharmacist, now chemist, Emil Erlenmeyer, who had just become a *Privatdozent* at Heidelberg, and the journal was renamed the cumbersome *Kritische Zeitschrift für Chemie und die verwandten Wissenschaften und Disciplinen als Pharmacie, Technologie, Agriculturchemie, Physik und Mineralogie*. In 1860, as Erlenmeyer assumed more and more control, the editors changed the name yet again to the *Zeitschrift für Chemie und Pharmacie*, which it would remain until 1865. From 1861 to 1864, Erlenmeyer was the sole editor.²⁵

The *Zeitschrift* quickly became more than just a synopsis of the state of the field, as Erlenmeyer increasingly imposed himself on the content of the journal. When excerpting pieces for publication, he would frequently append lengthy and highly critical "Bemerkungen," and he turned the journal into a one-sided vehicle for the promotion of various chemical reforms. Erlenmeyer's frequently ad hominem and aggressive style alienated readers more than it attracted them.²⁶ One of the saving graces of his journal was the frequency with which Russian chemists, particularly those who had studied in Erlenmeyer's laboratory at Heidelberg, published original research in the *Zeitschrift*, including Aleksandr Butlerov's fundamental developments in structure theory. Erlenmeyer's alienation from the community, however, made it difficult to sustain high submission rates or circulation, and he began to offer it to other possible editors in 1864. He explicitly suggested that Butlerov adopt the journal as a German-language Russian chemical organ, an idea possibly suggested to him by Beilstein.²⁷ Butlerov turned it down.

Beilstein did not. In 1865 Erlenmeyer turned the journal over to Hübner at Göttingen, who began to edit it in collaboration with Beilstein and Fittig. The journal—once so tied to Erlenmeyer's name that antipathy toward the one translated into antipathy toward the other—became so identified with the triumvirate that a major obituary for Erlenmeyer neglected to mention that he had ever had any connection to the *Zeitschrift*.²⁸ Beilstein et al. turned the now-renamed *Zeitschrift für Chemie* into a fairly successful journal. They maintained the old format, and Russian contributions remained high—even after the creation of a Russian-language chemical journal under the auspices of the Russian Chemical Society in 1869. Beilstein was particularly insistent on developing the Russian connection, as he wrote to Butlerov on January 29, 1865:

I will in closing stress again that the "Zeitschrift" has in my person a warm advocate of Russia's interests. I wish that Russian chemists won't just slave away laboriously on a Russian [*sic*: German—MG] edition of their works (for you, who writes German so expertly, this is obviously not necessary!). But many can thus postpone the publication of works, and thus I ask that they send me only the *Russian* articles. I will worry about getting a correct translation. . . . Chemists speak only *one* language and thus one should also know in Germany what is appearing in Russia.²⁹

In several publications of this period, Beilstein stressed the important contributions made by Russians in their own language and the lamentable ignorance of these findings on the part of Western chemists. Beilstein's favorable review of Butlerov's Russian textbook in organic chemistry similarly attempted to include Russians into a broader community of chemists.³⁰

The happily advancing juggernaut of the *Zeitschrift* ground to a complete halt in 1871, when it faced staggering competition for its small market niche from the *Berichte der Deutschen Chemischen Gesellschaft*, founded in 1868. The Berlin *Berichte* achieved much higher circulation after 1871 by virtue of its becoming the official organ of the unified German Chemical Society. Beilstein wrote to Erlenmeyer from St. Petersburg on April 26, 1871: "There remains no doubt: the *Zeitschrift für Chemie* can no longer be conducted *the way* that it is now. Through the successful appearance of the Berliner *Berichte* one of the chief tasks of the *Zeitschrift*—to publish quickly—is essentially lost."³¹ Beilstein then took the somewhat perverse move of attempting to foist the journal *back* to Erlenmeyer. The latter, now affiliated with the *Annalen* in Munich, rebuffed these overtures, and the journal folded by the end of the year.

The central problem that the *Zeitschrift* had been created to ameliorate remained unresolved, however. There was still a proliferation of disjointed chemical knowledge among multiple subspecialties, compounded by increasingly nationalistic attitudes towards domestic organs. This linguistic nationalism was most evident among the Russians, a fact Beilstein lamented on several occasions.³² He complained to Erlenmeyer

in April 1871: "What is to become of us, when each city produces its own journal, where one must seek out one's bit of chemistry under dust, garbage, and mouse droppings."³³ The knowledge needed to be systematized or it would be lost.

Beilstein, Russian: The St. Petersburg Technological Institute

In 1864 Beilstein had joked in a letter to Kekulé: "You won't believe how much you have risen in value here [since you left Germany for Belgium]. Look at [Hermann] Kolbe, the poor devil, how he must struggle through with a lot of trouble, and on the other hand, what a big shot [August] Hofmann is now. . . . What kind of big shot will you be, if one draws you back to Germany. I constantly wish to become a professor of chemistry in Peking or in the Sahara desert. Then I should make it difficult for Hofmann to compete with me!"³⁴ He was soon to make a transition perhaps even more dramatic than the Sahara: in 1866, a year after he turned down St. Petersburg University, Beilstein took a position at the less prestigious Technological Institute in the same city.³⁵ The move caught his Göttingen patrons by surprise. As Wöhler wrote to Liebig in November 1866: "The Prussian ministry in Hannover has asked why we let Beilstein go. He has taken a call from St. Petersburg with 2,500 thalers and is already gone."³⁶ The immediate cause was personal. Beilstein's father had died somewhat suddenly at the age of 56 in April 1865, and by 1866 the family needed him back in St. Petersburg. Beilstein was officially appointed a professor at the Technological Institute on 24 September 1866, and by June 1867 he became a subject of the Tsar.³⁷

The Technological Institute was far from ideal. Created under Tsar Nicholas I as a way to train large numbers of civilian engineers, the Institute featured high teaching loads and students who were less interested in the pure sciences.³⁸ Whereas St. Petersburg University was located right next to the Academy of Sciences, the Technological Institute, south of the city center, was marginalized from daily academic interaction. Furthermore, Alexander II's revised university statute of 1863 had expanded faculty posts and generated a renaissance of natural scientific work at the University. This was part of the reason why D. I. Mendeleev, later famous for his 1869 formulation of the periodic system of chemical elements, gradually moved his base of operations from the Technological Institute to the University. Although Mendeleev became a full professor at the University in 1867 and thereafter devoted essentially no attention to the Institute, he did not officially give up his post (or salary) at the Institute until 1871. Beilstein was hired to teach analytic and organic chemistry in a demanding institution that had been long neglected. Hardly a second Göttingen.

Beilstein expected to be in a tough position when he arrived, since his close interactions in Germany with Russian academics made him aware of their onerous duties. As he recalled in 1893 about A. A. Voskresenskii, Mendeleev's predecessor at St. Petersburg University:

With the paper on theobromine Voskresenskii's scientific activity stopped. . . . Teaching activities totally occupied him. Remember, that in those years the position of the scientist in Russia was unenviable. The meager salary for the position of professor far from protected one from material needs. It was necessary to seek out supplemental lessons for a living, for the preservation of a family, and simply for the needs of scientific activity. But even lessons paid poorly, so that a large part of working time went into teaching and there was no energy left for scientific works. This explains the verdict, which in the past was often heard among foreign scientists, that every year talented Russian scientists left Russia, worked passionately and successfully, but they stopped research as soon as they returned to their homeland.³⁹

Those dire days had passed, but Beilstein faced the additional problem of repairing the consequences of what he would characterize as Mendeleev's neglect. Beilstein stayed here for 30 years and lectured several hours a week (usually three hours inorganic/analytic and four hours organic). Enrollments of engineering students continued to grow throughout the 1870s, with little hope for Beilstein to get either scientifically minded assistants or requisite compensation.⁴⁰ Despite his overt despair, Beilstein was remembered as a gifted lecturer by contemporaries: "Lively, in constant motion, quick with words and actions, even perhaps sharp, Beilstein was markedly exceptional by his order in lectures. He spoke well, very lively, sometimes stepping off the subject, but these were not digressions into other areas of knowledge, like Mendeleev did; if Beilstein digressed, then they always concerned chemistry, and it seemed that he made these digressions in order to invigorate perhaps the exposition of the subject."⁴¹ In 1891, after 25 years of service, he became emeritus, but he continued reading analytical chemistry lectures. He also read weekly chemistry lectures at Nicholas Military Engineering Academy.

We get an excellent sense of the frustrations surrounding Beilstein's initial position at the Institute in an especially revealing letter to Butlerov (then at Kazan) of November 1866:

Perhaps the tidings have not yet reached you in the far East that I have now decided to move to Petersburg. I am Mendeleev's successor at the *Technological Institute* and am busying myself dealing with my imposed duties. That is no small affair, when I tell you that my predecessor—who, as you know, is not really a practical chemist—never bothered with the work of *Praktikanten* and went at most for a few minutes into the laboratory every 1/4 of the year. He was in such a rush to get Chancel and Gerhardt translated, without bothering to consider progress in analytic chemistry in the least. This book was shoved into the hands of each *Praktikant* and then he was discharged with a blessing. You can easily imagine in what kind of dilapidated circumstances I have encountered

almost everything here. How hard it is for me to introduce discipline and order will be clear to you immediately when I add that in one crowded room there are presently—175—yes, yes—175 men working! [as opposed to 80–85 at Göttingen —MG]. . . . What kind of nonsense there is here under these conditions! I had to give up being an academic (*Gelehrter*) and am a schoolmaster (*Schulmeister*) in the harshest meaning of the word. How painfully I feel this biting contrast I don't need to tell you. Although I live here in the circle of my family, I still feel the greatest homesickness for my old laboratory and my old students. I don't have any time at all for my own work. All my free time goes to the preparation of my lectures, that there is so much left here for me to accomplish.⁴²

There are several points of interest here. First, there is Beilstein's hostility to Mendeleev, the rising star of the Petersburg chemical scene. Second, Beilstein was alienated from his students, whose lack of preparation and interest forced him to abandon the collegial teaching style he had developed at Göttingen. With his two assistants, he organized his laboratory "*militarisch*," using the explicit model of Löwig's Breslau laboratory (which he had hated while there).⁴³ Given that he was still editing the *Zeitschrift* at a remove from Göttingen, and since he did not have equally qualified colleagues, he was forced into a cookie-cutter, chemistry-by-numbers approach to deal with his limited resources.

The third point of interest concerns the lack of a proper textbook for teaching analytical chemistry, which brings us to Beilstein's *Anleitung zur qualitativen Analyse* (*Instructions for Qualitative Analysis*), published in the late 1860s in response to the inadequate Mendeleev-generated Russian translation of Charles Gerhardt's book. Beilstein, who had distinguished analytical skills, is still widely known for his "Beilstein test," whereby a flame is used to detect the presence of halogens in an organic substance.⁴⁴ Beilstein's book was an attempt to integrate recent innovations in analytic chemistry in a format that would be useful to unskilled students in the laboratory. Its absence of a formal framework and emphasis on building transferable and widely applicable skills made it uniquely adaptable across major theoretical and experimental divides. The text was published simultaneously in Russian and German, going through six editions and translated into Dutch, English, and French.⁴⁵

Analytic chemistry was widely recognized as the most basic skill set for chemists. You could not do higher levels of organic, inorganic, mineralogical, physiological, or any other kind of chemistry unless you could properly analyze substances in a laboratory.⁴⁶ Erlenmeyer, for example, was quite specific about the need for proper training in analytical chemistry: "Before [the beginner] can go on, he must first have gotten to know exactly the bodies that he is supposed to find from now on by their properties and chemical relations. His first order of business must therefore be to state without a doubt, that he has experimentally studied the properties and transformations of metals, their salts, oxides, chloride, sulfides, etc."⁴⁷ This further implied that not only was analytic chemistry the *first* branch of chemistry to be taught to students, and the most *widely* taught

among the various other natural sciences, but it was also the most *laboratory-intensive* of the sciences. This visibility and importance of the field also made book reviews of analytical chemistry manuals some of the most contentious of the decade.⁴⁸ Beilstein felt his own book had to emphasize laboratory work and provide a sense of unity to the discipline, much as the *Zeitschrift* had tried to do for the chemical literature. He accomplished his pedagogical unification of chemistry by emphasizing the standardization of *skills*. His *Handbuch* would go even further by standardizing chemical concepts.⁴⁹

Beilstein structured his book rather unusually. A very slim volume, the *Anleitung* is organized as a set of instructions, not as a conceptual organization of available techniques and information. The first twenty pages or so, "Examples of Practice in Analysis," were designed to calibrate the student's laboratory. That is, Beilstein walked the student through the basic procedures of titration, heating, etc.: what happens when you carbonize a substance, you moisten it, you put it to a flame, you dissolve it, etc. This part of the book ascertains that all students are using the same equipment in the same way—*militarisch* indeed. The other thirty pages of the book, the "Systematic Course of Analysis," show in an even more explicit step-by-step form what the student is to do when presented with an unknown substance, assuming the set of skills developed earlier. First you take part of the substance and add water. If it dissolves, then move to step 5, if it does not, try sulfuric acid, then move to step 7, and so on. In this fashion, the student should be able to identify the substance qualitatively at the end of the series.

Meanwhile, Beilstein was also one of the most visible members of the Petersburg chemical community. Although Beilstein was awarded the Lomonosov prize of the Academy of Sciences in 1876 on the recommendation of A. M. Butlerov and N. N. Zinin, served as consultant for the Ministry of Finances on patent questions since 1867, and was president of the chemical section of the Russian Technical Society, he still felt scientifically isolated in Petersburg. He wrote to Butlerov late in 1866: "I am here in the big city more than ever in the isolation room of the sciences and each stimulation from the outside would be newly cherished."⁵⁰ He continued in April 1867: "I am until now completely isolated in Petersburg. Zinin, the only really thinking and active natural scientist, is through his high-aristocracy relationships almost unapproachable. The other chemists are either not chemists or look only with indignation or incomprehension on the progress of science."⁵¹ A few months after he moved to Petersburg he began to agitate for Butlerov to be brought there from Kazan as an intellectual companion, and despite some stonewalling by Mendeleev, Butlerov was eventually offered a post at St. Petersburg University and the chair of chemistry at the Academy of Sciences. Relations between Beilstein and Butlerov were exceptionally good throughout the 1860s, when

Beilstein helped to publish the German translation of Butlerov's structure-theoretical textbook and assisted in the propagandizing of his chemical ideas.⁵²

The situation soured when it came to D. I. Mendeleev, long Beilstein's *bête noire*. Mendeleev recalled in his 1861 diary his first meeting with Beilstein, then visiting his family in Russia. At a party in chemist L. N. Shishkov's house, Mendeleev remembered the hubbub about this "dry German," who left him with a very unpleasant impression.⁵³ While Beilstein was still in Göttingen, he could paper over their mutual dislike. He wrote a rather flattering review of Mendeleev's *Organic Chemistry* (1861) in the *Zeitschrift für Chemie*, where he lauded its creative—if somewhat outdated—use of Gerhardt's type theory.⁵⁴ Right before his move to St. Petersburg, Beilstein wrote to Mendeleev to thank him for "all of your kindness [in] naming me your successor at the Institute, which you already promised me last year." He also warned: "I will at first often make you sick of me. Moving to a new circle of activity, I will be obliged to often ask for your advice and help."⁵⁵ After Beilstein had begun to clean up Mendeleev's mess there, however, the goodwill dissipated. Beilstein would have liked to ignore him, but that was becoming less and less feasible.

It became utterly impossible on November 11, 1880, when Mendeleev was denied the chair in technology by the Physical-Mathematical Division of the Imperial Academy of Sciences by a single vote. Butlerov had tried once before to get Mendeleev a post at the Academy (then an adjunct chair in physics), but was rebuffed by the Permanent Secretary, Konstantin Veselovskii. This more public rejection in 1880 sparked a massive outcry from Russian chemists and from newspaper reporters. N. A. Menshutkin, secretary of the Russian Physico-Chemical Society, asked chemists to sign a protest of the Academy's behavior, which he would then publish in a local newspaper. On the grounds that a newspaper was an improper forum, Beilstein was the *only* chemist who refused to sign, proposing instead an honorary address at their next professional meeting.⁵⁶ Beilstein's "desertion" of the cause was attributed to his being a "German," and thus an affiliate of the supposed "German party" in the Academy of Sciences that was widely (and erroneously) believed to have orchestrated Mendeleev's rejection.⁵⁷ In the midst of the newspaper campaign in support of Mendeleev, only one substantial article, published in the capital's German paper, attacked the support for Mendeleev on the grounds (mostly correct) that the Russian was not a technological chemist. Many Petersburgers attributed authorship of the anonymous article to Beilstein.⁵⁸

Injury was added to insult when *Beilstein himself* was awarded the chair in technology in 1882. Drawing on their critique of Mendeleev, anti-Butlerov academicians (Helmersen, Schrenk, Savich, Wild, and Gadolin) proffered Beilstein for the post as a teacher at the *Technological* Institute with a decided emphasis on his contributions to

the chemistry of the oil industry, and as an officer of the Russian *Technological* Society. Anticipating objections from the so-called "Russian party," they added in their December 22, 1881 nomination: "We also remind you, that F. F. Beilstein is a Russian subject, a native of St. Petersburg, where he received his education, and that he commands the Russian language fully."⁵⁹ Butlerov was hard-pressed to offer an adequate riposte. On January 19, 1882, the Physical-Mathematical Division voted on Beilstein's candidacy. Of the 16 present, Beilstein received 12 votes, one more than the necessary two-thirds majority.⁶⁰ Butlerov decided to blackball Beilstein at the General Assembly meeting of March 5, 1882, since a two-thirds vote there was necessary to confirm the January vote. Of the 27 academicians present, Beilstein received 17, one vote shy of the two-thirds majority. He would not receive his chair in technology until after Butlerov's death in 1886. Beilstein was thus marked as German, not Russian, and he began to behave accordingly.⁶¹

After 1880, Mendeleev's fame in the wake of his rejection made the Russian capital uniquely inhospitable for the displaced Göttingener. Before 1882, Beilstein had published 92 articles; afterwards only 21.⁶² One explanation for this is the increasing demands the *Handbuch* placed on his time after its first edition began to appear in 1881. But this itself was a consequence of his increasing isolation, which plunged him more deliberately into his compilatory work and disinclined him from publishing for his local peers. Consider Beilstein's increasing disengagement with local Russian chemists at the Russian Chemical Society. He was one of the Society's founding members in 1868, but among all Petersburg chemists of distinction, he was unique in not being recognized by the Society in any substantial administrative or honorary capacity. In 1903, under the new charter of the Academy, Beilstein lost the presidential election to Aleksandr Zaitsev, a Kazan chemist who was never able to attend a single meeting.⁶³ Mendeleev, on the other hand, became the Society's third honorary member and was elected honorary president for life in the 1890s. Beilstein got the message.

Beilstein Bound: The *Handbuch der Organischen Chemie*

In an often-quoted letter, Beilstein drew the central connection between Russia, pedagogical institutions, and the *Handbuch*: "Truly, I could only have written my *Handbuch* in Russia, and thus I have deferred calls back to Germany. At a Russian Polytechnicum professors don't have to be scientifically active, because the students don't give any reason for it, but in Germany they would have looked at me disapprovingly."⁶⁴ This case, however, is purely negative—pedagogy in Petersburg provided the context for the *Handbuch* because of an *absence* of demands. I contend for a more positive claim, that

Beilstein's book emerged out of an initial attempt to write another organic chemistry textbook, but upon facing isolation from his peers and the inability to generalize the model provided by his *Anleitung*, he defaulted to the form of the *Handbuch*.

Beilstein did not approach his material hoping to write a comprehensive reference work. Ever since he was a *Privatdozent* at Göttingen, he had been gathering material on organic compounds and checking them for accuracy. This was specifically for teaching. It was only after he realized the need for an updated organic textbook in Russia that he began to work the material into a *textbook*. As he wrote to Erlenmeyer on February 22, 1878:

I have gone now earnestly about carrying out a plan that I have had in mind for a long time: I am actually writing an organic chemistry. Now I am in a lot of trouble. As I have all the material *completely gathered* before me, so I hope that I can be done with the writing in about 2 years. Now I am already in the 2nd year of work & have only gotten to glycerin.

I have, you see, made it a rule while writing to monitor *all citations* myself & that is what has brought me slowly to such despair. But one can't get around this kind of work if the results are supposed to be reliable. What I have written so far is actually more a *catalog* of organic chemistry rather than a textbook. Since I want to cite *everything*, that is actually *everything*, it seems to me to appear in a purely organic classification (acids with O_2 ; $C_nH_{2n+2}O_2$. . . acids with O_3 . . .). For the purpose of looking things up it is entirely excellent—and I have now had enough opportunity to convince myself satisfactorily of that. But with *reading* it is something else. The story comes out too dry. Thus I miss throughout the relevant pages precisely *your* textbook in which one can look things up, but can also *read*. Time is looming upon me, however: if I want to make everything also nice and easy to digest, I will be done in 5–6 years & that is too much for me. I don't have that much of my life to spend.⁶⁵

The revision process of writing a textbook was forcing him to order the material purely by empirical formula.⁶⁶ He did not attempt any organization that would help students assimilate the material: "I can say clearly what my vision is: I want to put together in *one* volume the *complete* material of org. chemistry ordered completely and clearly with exact information about the literature. Pretty speeches, charming comparisons, lively pictures and the rest of it are as good as completely absent."⁶⁷ No wonder the textbook idea failed.

Nevertheless, Beilstein continually referred to the reference book as essentially rooted in its educational context. He accentuated these textbook origins—origins that *failed* to produce a textbook—before the Russian Chemical Society in 1893:

The material of organic chemistry and particularly of the aromatic series is growing by horrific measures. When I began to gather this material 33 years ago for its special study and for the goal of teaching, it was possible to follow the successes of organic chemistry easily; now this seems to be an impossible task. I began to read Liebig's *Annalen* correctly from its 101st volume. Then I had to reread all 100 volumes. Basing myself on Gerhardt's famous handbook (*rukovodstvo*) to organic

chemistry and with constant corrections in Gmelin's classic handbook, I slowly gathered all the material in a form best suited for my goals. Then I had to look through the entire *Jahresberichte der Chemie* in order to convince myself that nothing had been missed. It stands to reason that it was necessary to take notes from the current periodical literature on all new facts and put them into the collection. Upon the appearance of each new guide to organic chemistry I compared its content with my notes, and in the event of a disagreement—which happened rather often—I had to check with the original articles. Thus I accumulated rather reliable material, but in a form unsuitable for a handbook. I had to rework the factual part, but when this was done, organic chemistry had again moved so far forward that it was necessary to redo everything over again. After 17 years of preparatory work, I went to publish it, and this explains why the entire work appeared in one brief period. . . . When my work was finished, I was sure that it was necessary to write everything over again. And this was done, but first it was necessary to redo everything a third time, so that now it is already clear that it is impossible to keep this arrangement any more. It is inconvenient to divide organic chemistry into a fatty series and an aromatic; an empirical division of camphors should be set up, sugary substances should also be grouped differently, ring-form compounds would be better united in different groups, etc. But I don't have time or energy for this.⁶⁸

(The "Beilstein System," the organizing principle behind the present-day *Handbuch*, was only instituted in 1909, three years after Beilstein's death.)

What on earth did Beilstein mean by repeatedly referring to students in his autobiographical statements about the *Handbuch*? If we think of pedagogy too narrowly as what happens in the classroom, there is no connection between it and the *Handbuch*, a text so patently unusable in such contexts; but if we take a broader view of standardizing practitioners into the chemical community, then a clearer connection emerges. The *Handbuch*, more perhaps than any other text, standardized what it *meant* to be a practitioner of organic chemistry: you worked on the kinds of materials that were in the *Handbuch*. Similarly, the editorial abstracting of the *Zeitschrift* standardized what the field of "chemistry" meant by correlating the disparate strands of chemical publishing into one focused site. Circular, perhaps, but satisfying. A closer look at the first edition of the *Handbuch* bears this out. Beilstein had to create the demand for the kind of information he was providing among those less familiar with structure theory, and therefore distilled into a small introduction a presentation of the basic principles derived from Erlenmeyer's, Gmelin's, Kekulé's, Gerhardt's, and Kolbe's textbooks, and those textbooks alone. For example, on the first page of the introduction he offered the standard history of organic chemistry dating from Wöhler's synthesis of urea in 1828, and then continued to provide a framework to interpret the data included in the compilation, beginning with quantitative organic analysis—determining the composition of organic molecules—before moving on to how their structure might influence their properties.⁶⁹ This development from analysis to higher levels of chemical thinking bears strong marks of his strategy at the Technological Institute: first you teach the basics of

measurement by rote, and then you construct theories of limited abstraction on this foundation. The stages of reasoning were clearly separated in St. Petersburg as they had not been at Göttingen. Beilstein's whirlwind survey of organic chemistry then moved through a series of topics in increasing specificity: "The Determination of Vapor Density," "Rational Formulas—Isomerism," "The Structure of Carbon Compounds," "Radicals," "Substitution," "Homology," and "The Physical Properties of Compounds." He presented a system of organic chemistry, although still a necessarily incomplete one: "As we look over the system of organic chemistry as it presently appears, we note still many holes. The filling of these holes is only a question of time."⁷⁰ This was the incentive to use the *Handbuch*: to ground oneself in basic principles and then become motivated to develop the science in defined directions—to fill in the holes.

For all the similarity to a textbook in motivation, genealogy, and program, the foreword exposed the unique nature of the Beilstein venture:

In the present work I have made the attempt to present together as clearly as possible the completely analyzed organic compounds. I have refrained from an exhaustive characterization of the compounds; one individual doesn't have the strength to do that. Cursory, superficial remarks, imprecisely researched compounds and reactions, etc., have been omitted here or only partially included if there exist no other data for the nature of a body. Thus, as I have included references to the literature as completely as possible, it would be easy for the reader to look up anything that might be missing. Everything that contributes to an exact knowledge of the substances, such as melting point, boiling point, specific weight, solubility, etc., as well as precisely determined transformations and reactions of the bodies, are provided in their entirety.⁷¹

Beilstein wore on his sleeve the amount of personal labor and *individual* effort involved in the compilation of the handbook: "All comments were—as far as they were accessible to me—taken by the author from the *original articles*. In *the entire book there are no citations that I have not looked up before the writing*. All errors are from copying or printing."⁷²

In a letter to Zincke, Beilstein noted the role the attack on his "Germanness" had played in the creation of the *Handbuch*, and the reciprocal effect of the *Handbuch* on the way local chemists identified his nationality:

It will not be unknown to you, that since the political successes of Germans in Russia a hostile mood against Germany and Germans has been spreading ever wider. The systematic smearing of the newspapers was not without results. If I until now remained almost entirely unbothered by Germanophobia (*Deutschenhaß*), I have recently also had to suffer from this evil. The circumstance, that on the occasion of the elections to the chemistry [*sic*] post at the Academy of Sciences here some academicians also wanted to put my name on the list of candidates, has called forth a big storm and drawn a whole array of spiteful comments towards me. . . . Even the fact that my large handbook of organic chemistry was then appearing in *German* (there would be a dearth of buyers for a Russian work), has drawn the censure of the patriots to me.⁷³

The process of revising the *Handbuch* for a second edition shows to what extent Beilstein turned his back on the Russian chemical community that had spurned him. Beilstein directed his solicitations for comments from readers almost entirely to German chemists.⁷⁴ Beilstein put out a second edition by himself by 1889, again in German, but his revision of the third edition pushed him to think about a successor. In 1895 he wrote to Paul Jacobson, who would eventually agree to become a co-editor of the *Handbuch*: "I am becoming old and have no co-worker. Now I worry only with all my powers that the third edition be finished—the heavens can worry about everything else."⁷⁵

Beilstein wanted the *Handbuch* to be continued as a cooperative venture, run as the special branch of a scientific society, and he petitioned the German Chemical Society in Berlin, snubbing his local peers entirely in favor of an "international" (read: German) community. This was quite a transformation for the chemist who in 1873 at the Vienna international exposition had been quite sanguine about the prospects for Russia to become a full-fledged member of the international scientific community.⁷⁶ Opinion in the German chemical community was divided on whether the German Chemical Society should take on the task, with Erlenmeyer in support of the idea as "not bad," but Volhard opposing since he thought the matter was "better left to private industry."⁷⁷ It was eventually adopted in 1896, and after the third edition's appearance and Beilstein's death in 1906, it moved there entirely.⁷⁸ As Beilstein wrote to M. M. Richter: "Now I can peacefully retreat from the scene, since I am now sure that my work will be continued in the best manner, and good and complete handbooks will be available at a cheap price."⁷⁹

Reviews of the *Handbuch* were ecstatic from the start. Richard Meyer wrote to Erlenmeyer in 1882: "I use Beilstein's book daily; it became immediately indispensable; but there is a mass of errors in it! One has to go to the original articles every time; but what is good is that you can find them quickly through the book."⁸⁰ Even the normally gruff V. V. Markovnikov was enthusiastic about "Beilstein's wonderful reference book," and P. P. Alekseev in Kiev commented in a letter to Butlerov in 1880: "I am now studying Beilstein and Kekulé. Beilstein's book is really a capital production. It is a pity, though, that the generalizations are rather short."⁸¹ Perhaps the most personally satisfying review for Beilstein was the letter sent by Henry E. Armstrong, president of the Chemical Society of London, to congratulate the Russian Chemical Society on its twenty-fifth anniversary on November 6, 1893. In a statement addressed to Mendeleev, he wrote: "Our Society is proud to have enrolled your name in its list [*sic*] of foreign members and to have welcomed you as one of its Faraday lectures [*sic*]; and the roll also includes the name of Beilstein—which, however, is no longer the mere name of an

individual but a household word and one which cannot be mentioned without the feeling of gratitude arising in the chemists [*sic*] mind."⁸² The ever-sarcastic Beilstein must have smiled internally from his seat on the same dais to hear Mendeleev intone such an endorsement. Beilstein's *Handbuch*, the rejection of both his Petersburg pedagogy and his Petersburg peers, was extolled in their midst.

Conclusion: Beilstein Abandoned

Beilstein adapted his pedagogical styles to different contexts without changing certain principles about the necessity of theory for proper experimentation and the uselessness of theory once it moved beyond the limits experiment set for it. Thus, at Göttingen, he stressed the importance of collegial relations in the laboratory in order to initiate young chemists into a community he perceived as standardized by just such a lack of hierarchy—an attitude present in his collegial editing of the *Zeitschrift für Chemie* with Hübner and Fittig. When he moved to the Technological Institute in St. Petersburg, his less-prepared students compelled him to move to a yet more fundamental level of standardization—that of analytical chemical practice, as encoded in his *Anleitung*. Finally, after his hope for an integrated international community of practitioners was crushed by the polarizing of the scientific community into nationalized camps after the 1880 Mendeleev affair, when he was classed as a *German* chemist somewhat against his will, he moved once again to a more fundamental level and sought to standardize for practitioners of organic chemistry the very objects of their study. In each case, Beilstein maneuvered among the multiple instantiations of pedagogy as a category for history of science in his attempt simultaneously to define a chemical community and the means for stabilizing it.

One of Beilstein's last public actions at the Russian Physico-Chemical Society was to argue for the Geneva compromise on organic nomenclature. Already in 1890 Beilstein announced the existence of both the German and French commissions which were working to standardize organic terminology on an *international* footing, a sorely needed reform. As the local representative of these committees to St. Petersburg—mediated through his frequent vacations in Germany—Beilstein asked for any suggestions or comments from Russians.⁸³ Apparently, no one volunteered any suggestions, although debates about a *Russian* nomenclature in the early 1870s had sparked a good deal of interest. When the Geneva compromise system finally emerged, Beilstein was the only one to support it publicly. In the face of opposition from (among others) Beketov and Mendeleev—whose objections were remarkably insubstantial—Beilstein noted that the Geneva system was already being introduced into the *Handbuch* and would most likely

become the standard, so it would behoove the Russians to adopt it.⁸⁴ Nikolai Menshutkin, editor of the Russian chemical journal, translated the nomenclature's French rules into Russian. When Beilstein correctly identified errors in the translation which would cause confusion, Menshutkin grudgingly admitted his mistake while belittling Beilstein's suggestions for repairing the Russian error.⁸⁵ Even in areas like organic classification, where Beilstein was clearly the resident expert, his advice was rejected.

A similar snub can be seen after Beilstein's death. It is a rule of thumb that a chemist's contemporary stature can be fairly well gauged by the kind of obituary he or she received. In the German *Berichte*, Beilstein's obituary was a full and judicious account penned by another Russian "foreigner," Helsinki chemist Edvard Hjelt. In the Russian *Zhurnal*, Beilstein received slightly over a page of impromptu comments by Beketov, his colleague at the Academy of Sciences (an institution not mentioned in the obituary), at a time when even minor chemists received at least ten pages and individuals of Beilstein's international reputation often received over 100 pages of memorial. Beilstein's death was quickly papered over to discuss a looming budget crisis.⁸⁶ Little attention was paid to his pedagogical importance, either in the Russian context or through his *Handbuch*, which received a passing mention.

It is important to remember that the constitution of a *scientific* community was far from the only kind of community these chemists were in. In particular, the formation of national communities of scientists who *thought of themselves* as Russian or German chemists, and not chemists in Russia or Germany, was an important causal factor in why such seemingly neutral texts as the *Handbuch* took on the form they did.⁸⁷ Even opting to publish it in German—and not, for example, simultaneously in Russian, as he had for the *Anleitung*—was a statement by Beilstein about linguistic dominance in the sciences, and such questions about language are central to both pedagogy and nation formation.⁸⁸ After both world wars, for example, the *Handbuch* was held up by German chemists as a testament of the possibility for goodness in German culture; Beilstein's systematization of chemical knowledge atoned for other sins.⁸⁹ These signs of the times continue: since 1981, all 230 volumes of "Beilstein" were published exclusively in English, as is today's on-line version.⁹⁰

Finally, I would like to stress the contingency of seemingly universal, immobile, and "indispensable" reference works, such as Beilstein's *Handbuch*. Had his father's death not prompted him to abandon his beloved Göttingen for Petersburg, Beilstein himself believed he would not have even embarked on the project. And had the rejection of Mendeleev by the Academy of Sciences not taken on its nationalist dimensions, that *Handbuch* would most likely, I argue, have looked more like a textbook with a (very)

long appendix of data on compounds. In a letter to Paul Jacobson shortly before his death, Beilstein commented on the contingency of the *Handbuch*: "If I look now, in all calmness, on the achievements of my last 40 years, it seems to me a lucky stroke of fate from the heavens that I was born and lived in a time, when such an undertaking as my Chemistry could be completed. Here all the necessary conditions happened to come together. Only a few years different and all would be in vain."⁹¹ Beilstein's point was purely about the chemistry: had he been earlier, Kekulé's theory would not have existed as a basis; had he been later, there would have been too many compounds for one man to organize. But the contingency, like the *Handbuch* itself, can be applied much more widely than its author intended.

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Notes

The follow abbreviations are used in the notes: ADIM: Arkhiv-Muzei D. I. Mendeleeva (D. I. Mendeleev Archive-Museum), St. Petersburg, Russia; *Ber.*: *Berichte der Deutschen Chemischen Gesellschaft*; PFARAN: Peterburgskii Filial Arkhiva Rossiiskoi Akademii Nauk (Petersburg Division of the Archive of the Russian Academy of Sciences), St. Petersburg, Russia; RGIA: Rossiiskii Gosudarstvennyi Istoricheskii Arkhiv (Russian State Historical Archive), St. Petersburg, Russia; TsGIASpb: Tsentral'nyi Gosudarstvennyi Istoricheskii Arkhiv Sankt-Peterburga (Central State Historical Archive of St. Petersburg), St. Petersburg, Russia; *ZfC*: *Zeitschrift für Chemie*; *ZhRFKhO*: *Zhurnal Russkago Fiziko-Khimicheskago Obshchestva* (*Journal of the Russian Physico-Chemical Society*).

All dates in German texts or in correspondence to or from Germany are given in the new-style Gregorian calendar. Dates that occur unambiguously in Russia are given according to the old-style Julian calendar, which lagged 12 days behind the Western calendar in the nineteenth century, 13 in the twentieth. Transliterations from Russian follow a modification of the standard Library of Congress format. All unattributed translations are mine.

1. Edv. Hjelt, "Friedrich Konrad Beilstein," *Ber.* 40 (1907): 5041–5078, on 5041.
2. Highlighted in orange in *How to Use Beilstein: Beilstein Handbook of Organic Chemistry* (Beilstein Institute, 1979), 8.

3. F. Richter, "K. F. Beilstein, sein Werk und seine Zeit: Zur Erinnerung an die 100. Wiederkehr seines Geburtstages," *Ber.* 71A (1938): 35–71, on 46. Richter was then editor of the *Handbuch*. Chemical handbooks have, of course, a long history, beginning with French efforts in the eighteenth century and continuing, most importantly, in Leopold Gmelin's *Handbuch der Chemie*. In Gmelin's initial handbook, organic materials took up barely half the space. In the fourth edition (1841–1870), they occupied about two-thirds of the ten volumes. See Leopold Gmelin, *Handbuch der Chemie*, fourth edition (Karl Winter, 1843). Beilstein's organic classification is heavily based on the Laurent method used by Gmelin. On Gmelin, see E. Pietsch with E. Beyer, "Leopold Gmelin—der Mensch, sein Werk und seine Zeit," *Ber.* 72A (1939): 5–51. For a superficial survey of handbook history, see Heinz Götz, "Das wissenschaftliche Handbuch," in *Einhundert Jahre Beilsteins Handbuch der Organischen Chemie* (H. Stürtz, 1981), 83–98.

4. The list of works explicating the so-called "Beilstein system" is large. See, for example, B. Prager, D. Stern, and K. Ilberg, *System der organischen Verbindungen: Ein Leitfaden für die Benutzung von Beilsteins Handbuch der Organischen Chemie* (Julius Springer, 1929); Oskar Weissbach, *The Beilstein Guide: A Manual for the Use of Beilsteins Handbuch der Organischen Chemie* (Springer-Verlag, 1976); *How to Use Beilstein*; Friedo Giese, *Beilstein's Index: Trivial Names in Systematic Nomenclature of Organic Chemistry* (Springer-Verlag, 1986); Ernest Hamlin Huntress, *A Brief Introduction to the Use of Beilstein's Handbuch der Organischen Chemie* (Wiley, 1930); Friedrich Richter, *Kurze Anleitung zur Orientierung in Beilsteins Handbuch der Organischen Chemie* (Julius Springer, 1936). Some of these, such as Huntress's text, include problem sets for practice.

5. The only book-length biography of Beilstein in any language remains L. A. Shmulevich and Iu. S. Musabekov, *Fedor Fedorovich Beil'shtein, 1838–1906* (Nauka, 1971), which goes to some effort to dismiss Beilstein's real conflicts in Russia. The best overall works are the collection of essays on the *Handbuch* by Friedrich Richter: "How Beilstein Is Made," tr. Ralph E. Oesper, *Journal of Chemical Education* 15 (1938): 310–316; "Beilsteins Handbuch—75 Jahre organisch-chemischer Dokumentation," *Angewandte Chemie* 70 (1958): 279–284; "Friedrich Beilstein, Gedanken zur hundertsten Wiederkehr seines Geburtstages," *Angewandte Chemie* 51, no. 7 (1938): 101–107; "K. F. Beilstein, sein Werk und seine Zeit." See also *75 Jahre Beilsteins Handbuch der Organischen Chemie: Aufsätze und Reden*, ed. Richter (Springer-Verlag, 1957). For obituaries, see Hjelt, "Friedrich Konrad Beilstein"; Otto N. Witt, "Friedrich Konrad Beilstein," *Journal of the Chemical Society* 99 (1911): 1646–1649. Also valuable are Ernest H. Huntress, "1938: The one hundredth anniversary of the birth of Friedrich Konrad Beilstein (1838–1906)," *Journal of Chemical Education* 15 (1938): 303–309; Iu. S. Musabekov and L. A. Shmulevich, "Akademik F. F. Beil'shtein i ego vklad v khimiiu," *Voprosy Istorii Estestvoznaniia i Tekhniki*, no. 3 (28) (1969): 61–66; M. Gerchinov, "Beil'shteinovskie daty," *Khimiia i sotsialisticheskoe khoziaistvo*, no. 7 (1931): 142. Almost all the information on Beilstein on p. 15 of John Turkevich, *Chemistry in the Soviet Union* (Van Nostrand, 1965), down to the chemist's first name and his publications, is incorrect.

6. Sent into the Krause Album and preserved at the Deutsches Museum in Munich. Reproduced in *Beilstein-Erlenmeyer: Briefe zur Geschichte der chemischen Dokumentation und des chemischen Zeitschriftenwesens*, ed. Otto Krätz (Werner Fritsch, 1972), p. 8. Beilstein wrote a similar letter for his file in St. Petersburg, dated July 1, 1867. TsGIASpb, f. 492, op. 2, d. 2073, ll. 1–10b. This version displays some grammatical lapses in the Russian.

7. Of course, man does not live by pedagogy alone, and I will pass over Beilstein's important work on industrial chemistry and especially the chemistry of Russian oil. See F. Beilstein, *Die chemische Grossindustrie auf der Weltausstellung zu Wien im Jahre 1873* (Quandt and Handel, 1873); F. Beilstein and A. Kurbatow, "Ueber die Natur des kaukasischen Petroleum," *Ber.* 13 (1880): 1818–1821; idem, "II. Ueber kaukasischen Petroleum," *Ber.* 14 (1881): 1620–1622; idem, "Ueber die Kohlenwasserstoffe des amerikanischen Petroleum," *Ber.* 13 (1880): 2028–2029. For an opposing contemporary view on Russian oil, see W. Markownikoff and J. Spady, "Zur Constitution der Kohlenwasserstoffe, C_nH_{2n} , des kaukasischen Petroleum," *Ber.* 20 (1887): 1850–1853. Markovnikov's citation of Beilstein's work was always positive and respectful. See, for example, Markovnikov and V. N. Ogloblin, "Issledovanie kavkazskoi nefiti," in V. V. Markovnikov, *Izbrannye trudy. Klassiki nauki*, ed. A. F. Plate and G. V. Bykov (Izd. AN SSSR, 1955), 331–332. While some Soviet commentators ignore Beilstein's work on oil entirely in their surveys (such as S. R. Sergienko, *Ocherk razvitiia khimii i pererabotki nefiti* [Izd. AN SSSR, 1955]), leaping directly from Mendeleev to Markovnikov, it is clear that Beilstein, not Mendeleev, was responsible for scientific interest in the composition of Baku oil. See V. I. Kuznetsov, *Vozniknovenie khimii alitsiklicheskikh soedinenii* (Izd. AN SSSR, 1961), 68.

8. This biographical outline is drawn from the sources in note 5.

9. Travel was crucial in this period for unifying various scientific cultures. See, for example, the account of Bunsen's travels in Fritz Krafft, "Das Reisen ist des Chemikers Lust—auf den Spuren Robert Bunsens: Zu Robert Wilhelm Bunsens 100. Todestag," *Berichte zur Wissenschaftsgeschichte* 22 (1999): 217–238.

10. For his early work, see F. Beilstein, "Ueber die Diffusion von Flüssigkeiten," *Annalen der Chemie und Pharmacie* 99 (1856): 165–197; idem, "Ueber das Murexid," *Annalen der Chemie und Pharmacie* 107 (1858): 176–191.

11. Huntress, "1938," 304.

12. The classic work on this transformation remains Peter Borscheid, *Naturwissenschaft, Staat und Industrie in Baden (1848–1914)* (Ernst Klett, 1976). On the laboratory at Göttingen, see the letter from Beilstein to Kekulé, June 3, 1860, reproduced in Huntress, "1938," 305.

13. Beilstein to Butlerov, 14/2 December 1862, reprinted in G. W. Bykov and L. M. Bekassowa, "Beiträge zur Geschichte der Chemie der 60-er Jahre des XIX. Jahrhunderts: II. F. Beilsteins Briefe an A. M. Butlerow," *Physis* 8 (1966): 267–285, on 268.

14. Quoted in Richter, "How Beilstein is made," 311. For the original researches, see F. Beilstein, "Ueber die Identität des Chlorbenzols mit dem gechlorten Chlorbenzyl (Bichlortoluol)," *Annalen der Chemie und Pharmacie* 116 (1860): 336–356; E. Reichenbach and F. Beilstein, "Ueber die Natur der sogenannten Salysäure," *Annalen der Chemie und Pharmacie* 132 (1864): 309–321.

15. Quoted in Huntress, "1938," 305.

16. On Beilstein's two associates, see the obituaries by F. Beilstein, "Hans (Julius Anton Edward) Hübner," *Ber.* 17 (1884): 763–776; R. M., "Rudolph Fittig," *Journal of the Chemical Society* 99 (1911): 1651–1653.

17. Fittig's diary entry of Sunday, November 24, 1860, quoted in Fr. Fichter, "Rudolph Fittig," *Ber.* 44 (1911): 1339–1401, on 1352. As Fittig continued in 1860: "Everything that he [Beilstein] says is original and funny, he looks at everything with a sharp understanding and a very healthy judgment. His judgments and criticisms of others are most delightful. First he praises a lot, then follows a 'However,' by which the praise is supposed to be qualified a bit, only as a rule nothing of the praise remains at all." Quoted in Richter, "Friedrich Beilstein, Gedanken zur hundertsten Wiederkehr seines Geburtstages," 102.

18. Editor's introduction in Krätz, *Beilstein-Erlenmeyer*, 11.

19. Fichter, "Rudolph Fittig," 1364; Hjelt, "Friedrich Konrad Beilstein," 5046.

20. "In order to not be entirely hindered by false preconceived notions while working, I have bid farewell to all speculations and am in the best sense a fierce enemy of all theories." Quoted in Richter, "K. F. Beilstein, sein Werk und seine Zeit," 41. On Beilstein's support of structure theory, see Beilstein to Butlerov, 29/17 January 1865, in Bykov and Bekassowa, "II. F. Beilsteins Briefe an A. M. Butlerow," 270–271; F. Beilstein, Review of Marcellin Berthelot's *Chimie organique fondée sur la synthèse*, *Göttingische gelehrte Anzeigen*, no. 1 (1861): 542–560, on 560.

21. Quoted in Richter, "K. F. Beilstein, sein Werk und seine Zeit," 39–40.

22. TsGIASPB, f. 14, op. 1, d. 6203, l. 4, quoted in Shmulevich and Musabekov, *Fedor Fedorovich Beil'shtein*, 33–34.

23. Quoted in Richter, "K. F. Beilstein, sein Werk und seine Zeit," 41–42.

24. See, for example, the assessment by the typically astute V. V. Markovnikov to his mentor Butlerov, August 7 and September 13 [1865], reproduced in G. V. Bykov, ed., *Pis'ma russkikh khimikov k A. M. Butlerovu, Nauchnoe Nasledstvo*, v. 4 (Izd. AN SSSR, 1961), 216–217.

25. The best secondary article on the *Zeitschrift* remains G. V. Bykov and Z. I. Sheptunova, "Nemetskii 'Zhurnal khimii' (1858–1871) i russkie khimiki (K istorii khimicheskoi periodiki)," *Trudy Istorii Estestvoznaniia i Tekhniki* 30 (1960): 97–110. This episode, as well as the major institutions of German organic chemistry in this period, has been well treated in the seminal study by Alan J. Rocke, *The Quiet Revolution: Hermann Kolbe and the Science of Organic Chemistry* (University of California Press, 1993).

26. Rita Meyer, Emil Erlenmeyer (1825–1909) als Chemietheoretiker und sein Beitrag zur Entwicklung der Strukturchemie (dissertation, Medical Faculty of Ludwig-Maximilians Universität, Munich, 1984).

27. See Erlenmeyer to Butlerov, March 25, 1864, reproduced in G. W. Bykov and L. M. Bekassowa, "Beiträge zur Geschichte der Chemie der 60-er Jahre des XIX. Jahrhunderts: I. Briefwechsel zwischen E. Erlenmeyer und A. M. Butlerow (von 1862 bis 1876)," *Physis* 8 (1966): 185–198, on 191. Beilstein later somewhat exaggerated his role in publicizing the work of Russian chemists through the *Zeitschrift*: F. F. Beil'shtein [Beilstein], "O rabotakh chlenov Russkago Fiziko-Khimicheskago Obshchestva po aromatcheskomu riadu," in *Russkoe Khimicheskoe Obshchestvo. XXV (1868–1893). Otdelenie khimii Russkago fiziko-khimicheskago obshchestva* (V. Demakov, 1894), 39–56, on 47–48.

Many of these Russians became acquainted with Erlenmeyer personally in Heidelberg. On the broader Russian colony in Heidelberg, see Willy Birkenmaier, *Das russische Heidelberg: Zur Geschichte der deutsch-russischen Beziehungen im 19. Jahrhundert* (Wunderhorn, 1995). Beilstein is never considered by Birkenmaier or other researchers as a true member of the Russian colony. He is mentioned, however, in the appendix to *Das russische Heidelberg*, on 175.

28. W. H. Perkin, "Emil Erlenmeyer," *Journal of the Chemical Society* 99 (1911): 1651–1653.

29. Reprinted in Bykow and Bekassowa, "II. F. Beilsteins Briefe an A. M. Butlerow," on 271, with ellipses. Beilstein's efforts in translation were marked by occasionally significant errors. When Mendeleev gave Beilstein the original article on the periodic system to be published in the *Zeitschrift*, Beilstein had a student, A. A. Ferman, undertake the translation, who erroneously replaced "periodicheskii" with "stufenweise," instead of "periodische," where Mendeleev described the nature of the changes in properties with increasing atomic weight. While not Beilstein's fault, Mendeleev resented the error, which later complicated the priority dispute with Lothar Meyer. K. Bening, *D. I. Mendeleev i L. Meier* (Tsentral'naia tip., 1911), i–iii.

30. F. Beilstein, Review of A. Butlerow's *Einleitung in das Studium der organischen Chemie*, *ZfC*, N.S. 1 (1865): 727–730. See also F. Beilstein, Review of Marcellin Berthelot's *Chimie organique fondée sur la synthèse*, *Göttingische gelehrte Anzeigen*, no. 1 (1861): 542–560, on 553; F. Beilstein, Review of August Kekulé's *Lehrbuch der organischen Chemie oder der Chemie der Kohlenstoffverbindungen*, *Göttingische gelehrte Anzeigen*, no. 1 (1863): 493–507, on 500: "He [Nikolai Beketov] placed his observations in a dissertation which was published in April 1853 in Russian and surely because of the latter circumstance remains unknown by the majority of chemists."

31. Reproduced in Krätz, *Beilstein-Erlenmeyer*, letter 1, 16–17.

32. Beilstein to Erlenmeyer, May 11, 1872: "Now the Russians however have become great patriots: they don't want to publish their articles any more in foreign languages. Only a few, e.g. [Nikolai] Menshutkin, are so kindly as to worry about taking care of a translation themselves. Thus it is predictable that many useful works will be lost" (Krätz, *Beilstein-Erlenmeyer*, 26). And again in Beilstein to Erlenmeyer, October 5, 1873: "My patriotic friends will make a stink if I don't provide the fatherland's journal with original articles" (ibid., 41).

33. Krätz, *Beilstein-Erlenmeyer*, 15.

34. Quoted in Richter, "Friedrich Beilstein, Gedanken zur hundertsten Wiederkehr seines Geburtstages," 102

35. Beilstein's appointment by the Technological Institute was a stunning 16–1 vote, far ahead of the other two (Russian) candidates. "Zhurnal uchebnago komiteta S. Peterburgskago Prakticheskago Tekhnologicheskago Instituta," September 24, 1866, RGIA, f. 733, op. 159, d. 12, l. 1ob.

36. Quoted in Reiner Luckenbach, "Der Beilstein: Geschichte, Gegenwart, und Zukunft," in *Einhundert Jahre Beilsteins Handbuch der Organischen Chemie*, 36.

37. This was necessary to become a professor under the Institute's statute. His official term of service only began with his renunciation of German citizenship. Director of the Technological

Institute to the Department of Trade and Manufactures, October 11, 1869, RGIA, f. 733, op. 159, d. 12, l. 3. The German papers attesting to his nationality as well as his academic transcripts are attached to this document. In his farewell letter to v. Warnsdet on October 18, 1866, Beilstein commented that he would prefer to keep his German citizenship as long as possible. See the excerpt in Richter, "K. F. Beilstein, sein Werk und seine Zeit," 53.

38. On the Technological Institute, see *Piatidesiatiletnii iubilei S.-Peterburgskago Prakticheskago Tekhnologicheskago Instituta: 28-go noiabria 1878 g.* (A. M. Kotomin, 1879).

39. Beilstein, "O rabotakh chlenov Russkago Fiziko-Khimicheskago Obschestva po aromaticheskomu riadu," 40–41.

40. Beilstein to Erlenmeyer, October 2, 1871: "Our Institute counts at the moment about 1300 students, I have in one lecture course over 550 attending, whose honoraria here apparently end up landing in the State's money-bag." Krätz, *Beilstein-Erlenmeyer*, 25.

41. V. V. Kurilov, "Tri korifeia russkoi khimii. (F. F. Beil'shtein, D. I. Mendeleev i N. A. Menshutkin)," in *Sbornik statei Ekaterinoslavskago nauchnago obschestva*, ed. I. F. Aldyrev, t. 7 (Tip. Arteli Ekaterin. Raboch. Pechatnago dela, 1907), 53–61, on 60. For a more favorable assessment of Mendeleev's style, see V. P. Veinberg, *Iz vospominanii o D. I. Mendeleee kak lektor* (Tip. Gubernskago Upravleniia, 1910).

42. Letter of November 6, 1868, reprinted in Bykow and Bekassowa, "II. F. Beilsteins Briefe an A. M. Butlerow," 278–279. Beilstein continued to agitate for renovation of the laboratory at the Institute up to his full retirement in 1896. Shortly before he left the institution, he managed to wrangle funds for a complete overhaul of the facilities. See his report at RGIA, f. 741, op. 1, d. 186, ll. 8–9ob.

43. Hjelt, "Friedrich Konrad Beilstein," 5051. Beilstein developed a distaste for his Russian students: "He sympathized little with Russian students in general, who obviously belonged to an entirely different type than their German comrades" (ibid., 5053). Beilstein was on good terms with a few of his students at the Institute, such as A. Kurbatov and L. Jawein, with whom he co-authored pieces and whom he sponsored for membership in the Russian Chemical Society.

44. F. Beilstein, "Ueber den Nachweis von Chlor, Brom und Jod in organischen Substanzen," *Ber.* 5 (1872): 620–621. The test was simultaneously published in Russian as F. Beil'shtein, "Ob otkrytii khloro, bromo i ioda v organicheskikh soedineniiakh," *ZhRFKHo* 4 (1872), no. 9: 358–359.

45. F. Beilstein, *Anleitung zur qualitativen chemischen Analyse*, second edition (Quandt and Handel, 1870; fifth edition, 1877; sixth edition, 1887). The first English translation was done by William Ramsay, later the famous discoverer of the noble gases. In his preface, he praises the book: "The translation of the present work has been undertaken with a view to furnish laboratory students with a manual, which should contain the principal methods of Qualitative Chemical Analysis. It is well known and extensively used in Germany, and the name of its author cannot fail to be a guarantee of its excellence." F. Beilstein, *A Manual of Qualitative Chemical Analysis*, tr. William Ramsay (G. P. Putnam's Sons, 1873), 5. For more on its popularity, see the later American translations and adaptations: W. S. Christopher, *Chemical Experiments for Medical Students Arranged after*

Beilstein (Robert Clarke, 1888), 3; Charles O. Curtman, *Dr. F. Beilstein's Lessons in Qualitative Chemical Analysis, Arranged on the Basis of the Fifth German Edition*, second edition (Druggist Publishing, 1886), v. Curtman indicates that Beilstein authorized the translation.

46. G. Lewinstein, Review of W. Stein's *Anleitung zur qualitativen Analyse und zu den wichtigsten Gehaltsprüfungen*, *ZfC* 3 (1860): 78–80, on 78.

47. E. Erlenmeyer, "Zur qualitativen Analyse," *ZfC* 3 (1861): 29–32, on 30. Beilstein agreed, as seen in his review of the *Zeitschrift für analytische Chemie, Göttingische gelehrte Anzeigen*, no. 2 (1863): 940–945, on 940.

48. Louis Ernst, Review of C. F. Rammelsberg's *Leitfaden für die qualitative chemische Analyse*, *ZfC* 3 (1861): 159–160.

49. On the importance of skills in transcending theoretical divides, see H. M. Collins, *Changing Order: Replication and Induction in Scientific Practice* (Sage, 1985); Peter L. Galison, *Image and Logic: A Material Culture of Microphysics* (University of Chicago Press, 1997).

50. Letter of November 6, 1866, reprinted in Bykow and Bekassowa, "II. F. Beilsteins Briefe an A. M. Butlerow," 280. We know from Beilstein's students that he rarely sought out companions in the capital and worked long hours alone. See Richter, "Beilsteins Handbuch," 280.

51. Reprinted in Bykow and Bekassowa, "II. F. Beilsteins Briefe an A. M. Butlerow," 282.

52. See Bykov, *Pis'ma russkikh khimikov k A. M. Butlerovu*, 51. Beilstein also wrote Erlenmeyer mockingly about Butlerov's increasing fascination with Spiritualism. Krätz, *Beilstein-Erlenmeyer*, 19. For more on Spiritualism and Butlerov, see Michael D. Gordin, *A Well-Ordered Thing: Dmitrii Mendeleev and the Shadow of the Periodic Table* (Basic Books, 2004), 85–87.

53. Diary entry of August 16, 1861, in D. I. Mendeleev, "Dnevnik 1861 g.," *Nauchnoe Nasedstvo* 2 (1951): 111–212, on 163. Mendeleev's impression did not improve when he went to a party in honor of Beilstein at Fritzsche's house on August 16 (*ibid.*, 164). He also met Beilstein among a group of chemists on October 10 (*ibid.*, 188). Shmulevich and Musabekov fudge somewhat in trying to explain away the blatant hostility between the two. Shmulevich and Musabekov, *Fedor Fedorovich Beil'shtein*, 52.

54. F. Beilstein, Review of Mendelejeff's *Organische Chemie*, *ZfC* 5 (1862): 271–276, on 271. On this textbook and its role in the creation of the periodic system, see Michael D. Gordin, "The organic roots of Mendeleev's periodic law," *Historical Studies in the Physical and Biological Sciences* 32 (2002): 263–290.

55. F. Beilstein to D. Mendeleev, September 27, 1866, Göttingen, ADIM I-V-39-1-46.

56. These events are chronicled in detail in Gordin, *A Well-Ordered Thing*, chapter 5, including a translation of Beilstein's response to Menshutkin on 122. For an alternative, Butlerov-centric, interpretation of these events, see I. S. Dmitriev, "Skuchnaia istoriia (o neizbranii D. I. Mendeleeva v Imperatorskuiu akademiiu nauk v 1880 g.)," *Voprosy Istorii Estestvoznaniia i Tekhniki*, no. 2 (2002): 231–280.

57. Beilstein ironically had denounced the silliness of the notion of German and Russian parties in a letter to Butlerov on October 15, 1867, a full 13 years before it would resurface. Bykow and Bekassowa, "II. F. Beilsteins Briefe an A. M. Butlerow," 284. As a further irony, it was Butlerov who resurrected the German party case most strongly in a popular article published in the right-wing journal *Rus'*. See A. M. Butlerov, *Sochineniia*, 3 v. (Izd. AN SSSR, 1953), III, 118.

58. "Zur Nichtwahl Mendelejew's," *St. Petersburger Zeitung*, December 24, 1880, 359: 2.

59. "Predlozhenie i balotirovanie professora F. F. Beil'shteina v ordinarnye akademiki po tekhnologii i khimii, prisposoblennoi k iskusstvam i remeslam," *Zapiski Imperatorskoi Akademii nauk* 41 (1882), no. 1: 84–167, on 86.

60. "Predlozhenie i balotirovanie professora F. F. Beil'shteina," 125.

61. To be specific about what I mean about Beilstein's alienation qua German: he was *not* alienated from the civil service or the Russian bureaucracy, and he attained the level of privy councillor—also Mendeleev's rank as Director of the Chief Bureau of Weights and Measures—in 1895, and he was elected honorary member of several institutions like Kiev University. But among *Petersburg chemists* he felt himself *persona non grata*. On his honors, see Hjelt, "Friedrich Konrad Beilstein," 5068.

62. Shmulevich and Musabekov, *Fedor Fedorovich Beil'shtein*, 44. Beilstein's complete bibliography of non-Russian articles shows a marked decline into the 1880s. See Hjelt, "Friedrich Konrad Beilstein," 5078.

63. Protocols of Chemical Division of the Russian Physico-Chemical Society, December 4, 1903, *ZhRfKhO* 35 (1903), no. 9: 1265.

64. Hjelt, "Friedrich Konrad Beilstein," 5054.

65. Krätz, *Beilstein-Erlenmeyer*, 60.

66. Beilstein continued to Erlenmeyer on March 17, 1878: "My worry is, that I can't finish revising my materials in 2 years, as I had thought at first. I beg you to consider, that I have before me *the totally gathered complete materials*. While writing I take the original in hand each time. Now I am only asking each Christian individual to gather the 'material'! Woe is the unfortunate one who has gotten it into his head to be able to complete the entire Jahresberichte alone. What I possess are excerpts crafted *only from the originals*. Those I bring now all prettily in order nicely and clearly arranged by *empirical formula*. . . ." Krätz, *Beilstein-Erlenmeyer*, 64.

67. Beilstein to Erlenmeyer, March 17, 1878, in Krätz, *Beilstein-Erlenmeyer*, 64. This may be a reference to Mendeleev's famously encyclopedic *Principles of Chemistry*.

68. Beilstein, "O rabotakh chlenov Russkago Fiziko-Khimicheskago Obshchestva po aromaticheskomu riadu," 52–53.

69. F. Beilstein, *Handbuch der Organischen Chemie*, 2 v. (Leopold Voss, 1883), I, 2–3. The front matter and format did not change until the post-Beilstein *Handbuch*. Of course, the material in the catalog was heavily expanded, corrected, and updated.

70. Beilstein, *Handbuch der Organischen Chemie*, I, 35.
71. Beilstein, *Handbuch der Organischen Chemie*, I, v.
72. Beilstein, *Handbuch der Organischen Chemie*, I, v. This was, in one sense, an attempt to remedy the faults of previous textbooks, like that of August Kekulé. As Beilstein commented in his review of that work: "The material is selected with skill and everywhere is pointed to by citations to the original articles. By these citations the author takes into account primarily Kopp's *Jahresbericht* and Liebig's *Annalen*, which however is unfair to many works." That is, by not looking at *all* journals, Kekulé risked undermining his own synthesis. F. Beilstein, Review of Kekulé's *Lehrbuch der organischen Chemie*, 493.
73. Quoted in Richter, "Friedrich Beilstein, Gedanken zur hundertsten Wiederkehr seines Geburtstages," 103.
74. Beilstein, *Handbuch der Organischen Chemie*, I, vii–viii. See also his request in the minutes of the March 10, 1884 meeting of the German Chemical Society, printed in *Ber.* 17 (1884): 489. Krätz reproduces one of Beilstein's letters to an anonymous colleague dated August 17, 1883, soliciting help on the *Handbuch*. Krätz, *Beilstein-Erlenmeyer*, 81–82.
75. Quoted in Hjelt, "Friedrich Konrad Beilstein," 5064.
76. Beilstein, *Die chemische Grossindustrie auf der Weltausstellung zu Wien im Jahre 1873*, 55.
77. Erlenmeyer to an unknown recipient June 13, 1895, and Vollhard to Erlenmeyer, March 27, 1896, both in Krätz, *Beilstein-Erlenmeyer*, 83.
78. For the official acceptance, see "Rundschreiben," from the minutes of the February 4, 1896 meeting of the German Chemical Society, *Ber.* 29 (1896): 321–324. On the later history of the *Handbuch* after this transformation, see Richter, "Beilsteins Handbuch," 280–281.
79. Quoted in Hjelt, "Friedrich Konrad Beilstein," 5065.
80. Letter of November 5, 1882, reproduced in Meyer, Emil Erlenmeyer (1825–1909) als Chemietheoretiker, 391.
81. Markovnikov quotation from "Nafteny i ikh proizvodnye v obshchei sisteme organicheskikh soedinenii (1902)," in Markovnikov, *Izbrannye trudy*, 516. The Alekseev letter is reproduced in Bykov, *Pis'ma russkikh khimikov k A. M. Butlerovu*, 25. Alekseev had studied under Beilstein for a year in Göttingen. See P. P. Alekseev to A. M. Butlerov, December 8, 1863, in *ibid.*, 13. See also K. M. Zaitsev to Butlerov, May 16, 1862, in *ibid.*, 145. Beilstein maintained contact with Alekseev through the 1880s after the latter moved to Kiev (*ibid.*, 20, 26).
82. *Russkoe Khimicheskoe Obshchestvo. XXV (1868–1893)*, 4.
83. Protocols of Chemical Division of the Russian Physico-Chemical Society, September 13, 1890, *ZhRfKhO* 22 (1890), no. 7: 480.
84. Protocols of Chemical Division of the Russian Physico-Chemical Society, October 8, 1892, *ZhRfKhO* 24 (1892), no. 8: 542–543.

85. N. Menshutkin, "K voprosu o khimicheskoi nomenklature: Sostavlenie nazvanii organicheskikh kislot," *ZhRfKhO* 25 (1893), no. 1: 10.
86. N. N. Beketov, "Pamiati Fed. Fed. Beil'shteina," in Protocols of Chemical Division of the Russian Physico-Chemical Society, November 2, 1906, *ZhRfKhO* 38 (1906), no. 9: 1279–1280.
87. Consider the way Beilstein's "homeland" (*Heimat*) has been treated. *Heimat* is one of those notoriously tricky German words that serve as political touchstones. Biographers have tended to declare that Beilstein's birthplace—Russia—was his *Heimat*, as in Hjelt, "Friedrich Konrad Beilstein," 5047, while German commentators in the twentieth century have selected Germany for the honor of being "always his spiritual *Heimat*." Luckenbach, "Der Beilstein," 36. Beilstein himself sided with the latter, as he declared in a letter to Erlenmeyer on October 5, 1873: "I have lived alone 12 years in Germany and consider it always as my *scientific* homeland (*Heimath*), for which I always have and will have the greatest respect." Krätz, *Beilstein-Erlenmeyer*, 43. Although Beilstein was fluent in Russian (and French and English, and proficient in both Italian and Swedish), he strongly preferred to speak German at home and among friends.
88. William Coleman, "Prussian Pedagogy: Purkyne at Breslau, 1823–1839," in *The Investigative Enterprise: Experimental Physiology in Nineteenth-Century Medicine*, ed. William Coleman and Frederic L. Holmes (University of California Press, 1988), 15–64, on 35.
89. F. Richter, "75 Jahre Beilsteins Handbuch der Organischen Chemie: Ein Jubiläum der Wissenschaft," *Frankfurter Allgemeine Zeitung*, December 13, 1956, reprinted in Richter, *75 Jahre Beilsteins Handbuch der Organischen Chemie* (1957), 5–10, on 5; *idem*, "Zur Feierstunde am 14. Dezember 1956," in *ibid.*, 19–25, on 19, for World War II; Paul Jacobson, "Beilsteins Handbuch der Organischen Chemie, ein Spiegel ihrer Entwicklung," in *ibid.*, 85–93, on 93.
90. Dermot A. O'Sullivan, "Germany's Beilstein will change to English," *Chemical and Engineering News* 59 (1981), May 18: 21–22, reprinted in *Einhundert Jahre Beilsteins Handbuch der Organischen Chemie*, 123–127.
91. Letter of October 7, 1906, quoted in Hjelt, "Friedrich Konrad Beilstein," 5066.