The Russian Invasion…in Chemistry: *Interview with David Lewis*

By Svetla Baykoucheva

"Organic chemistry is full of German names and German name reactions,… In part, this may stem from the fact that most English-speaking chemists trace their 'professional genealogy' to the German schools of Liebig, Bunsen, Erlenmeyer, Kolbe, von Baeyer, Kekulé, or Hofmann… However, we tend to overlook the importance of the contributions of the Russian contemporaries of these chemists, despite their names—Saytzeff, Markovnikov, Favorskii, and Zelinsky, to name just a few—appearing widely in most undergraduate organic chemistry textbooks. Moreover, relatively few English-speaking organic chemists realize that some chemists who are almost universally considered German (Beilstein, Kishner, and Wagner…) were, in fact, Russian."

David E. Lewis[1]

Svetla Baykoucheva: *Your poster,[2] "Beilstein, Menshutkin and Mendeleev: End of an era," presented at the ACS National meeting in Boston last year, attracted such a crowd! How would you explain this interest, especially on the part of so many young people who came to talk to you? And why was it the end of an era?*

David Lewis: Like you, I was very surprised at the number of visitors to a poster in the History of Chemistry. A number of the early visitors to the poster were expatriate Russians, who were probably wondering how an Australian-American chemist can present the work of three major figures in Russian chemistry from the nineteenth century. This then snowballed, as others began to wonder what was going on and why there was such a large crowd around a poster in HIST. For the non-Russians who came to the poster, I suspect they were surprised that Beilstein was mentioned as a Russian chemist.

Photo: Members of the chemical section of the First Congress of the Russian Naturalists and Physicians (January 1868, St. Petersburg), who have decided to create the Russian Chemical Society. *Standing (L)*: Vreden F.R., Lachinov P.A., Schmidt G.A., Shuliachenko A.P., Borodin A. P., Menshutkin N. A., Sokovnin N., Beilstein F.F., Lisenko K.I., Mendeleev D.I, Savchenkov F.N. *Sitting (L)*: Richter V. Y., Kovalevskii S.I., Nechaev N.P., Markovnikov V.V., Voskresenskii A.A., Il'enkov P.A., Alekseev P.P., Engel'gardt A.H. Photo is from the personal archive of Mendeleev with notes written by him. *Courtesy from the Mendeleev Museum at St. Petersburg State University.*

The last part of your question—why was it the end of an era?—merits a more detailed response, and requires that I go into the structure of Russian higher education and academia in Russia at the turn of the twentieth century. The rapid rise in the number and quality of Russian organic chemists is frequently traced to the middle of the nineteenth century, when Nikolai Nikolaevich Zinin founded the chemistry school at Kazan' in eastern Russia, although this view (standard under the Soviets) is by no means universal. Zinin, however, was one of the first examples of what became a standard progression through the higher education system in the last half of the nineteenth century in Russia. The degree system in Russia followed the order, *diplom* (roughly the equivalent of today's B.S. degree), *kandidat* (now this degree is the full equivalent of a western Ph.D. degree, but in the nineteenth century it was somewhere between a modern M.S. degree and a modern Ph.D. degree), and *Dr. Khimii*, which was the highest qualification, requiring both a dissertation and a grueling series of advanced examinations in all arreas of chemistry. The *Dr. Khim.* degree still exists in Russia, and is best described as the equivalent of the higher earned (as opposed to honorary) doctorates awarded by universities such as Oxford and Cambridge. In order to obtain a teaching position in Russia, one needed the degree of *kandidat*, and in order to hold a chair of chemistry, one needed the degree of *Dr. Khim*.

Following his *kandidat* graduation, Zinin was appointed to Kazan' University to teach chemistry, but since he did not have sufficient formal training in chemistry to teach at the university level, he was sent on a study abroad (a *komandirovka*) in western Europe to attend lectures by the most important organic chemists of the day to get notes for his own teaching on his return to Russia. However, even though his *komandirovka* was never intended as a research experience, Zinin used it to his advantage to carry out research for his *Dr. Khim*. dissertation in the Giessen laboratory of Justus von Liebig. On his return to Russia, Zinin took the examinations and wrote the successful dissertation for his *Dr. Khim.* degree.Whether Zinin's *komandirovka* instilled in him the drive for a research career may be (and has been) debated, but what it did do was to set a precedent that was followed by the next generation of Russian organic chemists. The conversion of this precedent into the norm was also facilitated by the University statutes instituted by Aleksandr II, the great reformer Tsar. Thus, we find that among the luminaries of the next generation of Russian chemists, Butlerov studied with Erlenmeyer in Heidelberg, Kekulé at Bonn, and Wurtz in Paris, Borodin

and Mendeleev studied in France and Italy, and Menshutkin studied with Strecker in Tübingen, Kolbe in Leipzig, and Wurtz in Paris. The generation of organic chemists that followed these, also studied abroad as an important part of the research for their *Dr. Khim*. degrees: Zaitsev studied with Kolbe in Marburg and Wurtz in Paris, Markovnikov studied with Kolbe in Leipzig, and Zelinskii studied with Wislicenus at Leipzig, and with Viktor Meyer at Göttingen. As more and more Russian chemists were trained in western Europe and were coming back to Russia, a significant number of organic chemists became capable of supervising research at a high level of expertise. Thus a generation of Russian organic chemists emerged who would lead Russia's universities into the twentieth century, eliminating the need for sending chemists to study abroad. The three-month period encompassing the end of 1906 and the beginning of 1907 witnessed the passing of the three chemists who were the primary subjects of the poster. By that time there were already ample opportunities for advanced research in organic chemistry within Russia: the Moscow, St. Petersburg, and Kazan' schools were the most prominent ones, but there were many other places where one could carry out research required for a *doktor khimii* degree. This time period really is, in a way, the end of an era—the end of going to western Europe as being the norm and the rise of doctoral research within the Russian empire instead.

Your articles on the history of Russian chemistry show that you have done extensive research in this area.[1,3] How did you get interested in this topic? Could you tell us a little bit about your background?

This story is a little odd and has little to do with organic chemistry. My fascination with things Russian began in high school, when I saw the movie *Dr. Zhivago*. In that movie all the banners and newspapers were written in the Cyrillic alphabet, and there were no English subtitles to say what the words meant. So, I bought some teach-yourself books and learned to read Russian (poorly, and with a dictionary). Later, my attraction to Russia was reinforced when I read *Anna Karenina* and *War and Peace* in English translation (Leo Tolstoy, who also studied at Kazan' remains one of my favorite authors). So when I was working on a possible text book for introductory organic chemistry, I was surprised to find out that Zaitsev (Saytzeff) and Wagner (of the Wagner-Meerwein rearrangement) were Russian (and not German), and felt that one ought to know more about the chemists than just their names. My own background does not suggest that I would become interested in the history of organic chemistry in Russia. I was trained as a natural products chemist in the laboratory of Ralph Massy-Westropp (one of Birch's students) at the University of Adelaide in South Australia and then took a three-year foray into physical/theoretical organic chemistry in the Fry/Sims laboratory at the University of Arkansas. After a year of post-doctoral study at Illinois, I moved to my first tenure-track appointment at Baylor University in Waco, Texas. There I began my work in organic synthesis that I still pursue. I moved from Baylor to South Dakota State University in 1989 and then to the University of Wisconsin-Eau Claire in 1997. My current research interests are in the synthesis and uses of biologically active heterocycles and in the synthesis of novel fluorophores for use in fluorescence microscopy, but I have retained an active interest in the history of organic chemistry in Russia.

David Lewis with some of his former students: (L-R) Glen Gullickson, Grant Sormunen, Jessica Walters, Nick Deprez,, and Kristy McNitt.

There are many periodic tables, but we still know the name of Mendeleev? What counted most in the acceptance of Mendeleev's periodic table. In a recent book on the periodic table Scerri[4] suggested that this happened because his predictions turned out to be true and that his philosophical deliberations whether the elements should be considered "simple" or "basic" substances have given him some advantage?[4] How did Mendeleev get interested in the periodic table?

The background story of the periodic table is well told by Michael Gordin in his book, *A Well Ordered Thing: Dmitri Mendeleev and the Shadow of the Periodic Table*.[5] The acceptance of Mendeleev's periodic table, which is one of only two chemical icons almost universally recognized (the DNA double helix is the other), has a lot to do with his bold predictions being borne out during his lifetime, but I think there is more to it than just that.

The Periodic Table was developed as a pedagogical tool, and it still works very well in that capacity. The original development of the table really happened because Mendeleev had committed to write a textbook on the chemical properties of the elements. Mendeleev was running out of time and, facing the potential loss of money due to non-delivery of the manuscript, he looked at possible ways to systematize the chemistry of the elements. Mendeleev simply had two great leaps of faith and intuition: he was willing to make the chemistry of an element supersede its atomic weight, and he was willing to accept the idea that there might be elements that had not yet been discovered. I think that these intuitive ideas ultimately allowed Mendeleev to receive the accolades (whether fairly or unfairly may be debated), and not J.A.R. Newlands, William Odling, or Lothar Meyer.

How did it happen that Russia became a cradle of such amazing chemical research? What were the conditions in the labs compared to those in western Europe?Where did Russian chemists publish their results, and how did they communicate with other chemists at home and abroad?

I wish I knew the full answer to these questions, but I don't. Russia's first forays into modern science were very hesitant. Peter the Great had founded the Imperial Russian Academy of Sciences just before his death, with the first academicians being mainly German and other western Europeans (only one Russian was a member of the first two groups admitted to the Academy). Much of the impetus for the development of a strong chemical research base in Russia was accidental. One example of this is Nikolai Zinin's discovery of the reduction of nitrobenzene to aniline by hydrogen sulfide, which provided a way for this important chemical to be prepared from a source other than coal tar. What made this economically important was that Russia could have aniline produced from something else (e.g., whale oil or Caucause oil) other than coal tar, which it had an obligation to purchase at an exorbitant price as a result of treaty. The Russian schools in chemistry developed both strong synthetic skills (the Kazan' school was the first major center for the synthesis of alcohols using organozinc reagents) and strong theoretical skills (Markovnikov and Butlerov appear to have had an appreciation of molecular structure that was decades ahead of their time).

It is often tempting to expect that the laboratory facilities in Russia were inferior to those in western Europe. While this may have been the case in the 1830's, it did not remain the case later. Borodin, for example, often complained of his unequal competition with Charles Adolphe Wurttz in their studies of the aldol addition reaction, and yet their laboratory facilities were comparable. Thanks to a very enlightened local administrator, the laboratory facilities at Kazan' University were second to none by the 1870's, and this allowed Butlerov, Zaitsev and Markovnikov to take many students into their laboratories.

Typically, Russian chemists would publish their work in German journals (the *Annalen der Chemie und Pharmacie*, the *Berichte der Deutschen chemischen Gesellschaft*, and the *Zeitschrift für Chemie* were their favored journals), as well as in the Russian journal *Zhurnal Fizicheskovo-Khimicheskovo Obshchestva*, founded as the journal of the newly-formed Russian Physical-Chemical Society. The practice of publishing in German journals brought the Russian discoveries to the attention of western Europe. Russian chemists were well informed about what was happening in the field of chemistry, as they maintained a vibrant communication with their western counterparts by means of letters.

What is your opinion about the acceptance of the structural theory and the contributions of Kekulé, Couper, and Butlerov? In a previous issue of the Chemical Information Bulletin*, I interviewed Dr. Alfred Bader[6] who mentioned the Kekulé-Couper controversy. In one of your articles, you have added Butlerov to this equation.*[1]

I do not necessarily agree with Alfred Bader's strongly anti-Kekulé assessment of this important question, but neither do I feel that Butlerov deserves the credit for "inventing" the theory, as had been the stance of the Soviet historians of science. From my perspective, there is clear evidence that Couper and Kekulé developed their theories independently, and both submitted their ideas for publication around the same time. Couper, who later succumbed to what we would now call a nervous breakdown, had the misfortune to be working with Wurtz, who was not a member of the Académie des Sciences; so, it took more time to get his theory presented and this happened only after Kekulé's paper had been published. The resultant fight over priority may have been unseemly, but I do not believe that Kekulé maliciously usurped Couper's rightful place.

Butlerov's critical contribution, which I think has been missed by practically everyone, was not so much that he developed an independent theory of chemical structure, but that he realized just how powerful a tool such a theory could be (when set out more clearly than either Kekulé or Couper did) to the developing field of organic chemistry. Butlerov was able to apply the structural theory to situations that I am not certain that either Kekulé or Couper had thought of. It is tempting to come to the conclusion that such vision and forward thinking could not but lead to a generation of students with the predisposition to push the envelope of current knowledge. It may be no coincidence that Russian organic chemists did so well, having in mind that Russia was one of the first countries to accept and teach the theory of organic structure. Although it was Butlerov who popularized the use of organic structures, he personally did not believe that the structures had a physical significance—Butlerlov considered them, instead, maps of the linking of chemical affinities. However, the acceptance of the idea of a *chemical* structure had to lead, eventually, to the idea of a *physical* structure as well, and, ultimately, to the work of van't Hoff, Le Bel, and Wislicenus—and to the development of stereochemistry.[7]

Beilstein is a familiar name not only to organic chemists but to information specialists and librarians, as well. We now search the Beilstein database (as CrossFire Beilstein, through DiscoveryGate) to find information about the properties of organic chemical compounds. And it is hard to believe that this huge resource has started with one person. What motivated Beilstein to compile such a huge amount of organic chemistry information in his Handbuch and how was he able to do it?

Beilstein's career path looked to be set when he went to Germany at age 15 to complete his education. He studied under many of the top German chemists of his day. He did his PhD under Wöhler at Göttingen at age 20 and returned there, after a brief post-doctoral stint with Wurtz in Paris. He rapidly developed a reputation as an excellent teacher and was well on his way to become a major academic chemist when his father died in St. Petersburg.

The death of his father and the subsequent need for him to return to Russia changed all that. The post to which he returned in Russia was the one previously held by Mendeleev at the Technological Institute in St. Petersburg. His textbook on analytical chemistry (written in German) went through seven editions and was translated into several languages. Finding that there were no modern textbooks of organic chemistry available for his students, he set out to write a textbook in the late 1880's. His textbook, with its encyclopedic coverage of organic compounds, became the first edition of his *Handbuch*. What is absolutely remarkable is that this book was his own work—he checked every literature reference himself with little or no help.[8]

When doing your research on the contributions of Russian chemists, was there something that you have discovered that still makes you often think about it?

One of the most vibrant schools of chemistry in Russia during the nineteenth and early twentieth centuries was the Kazan' school of chemistry. Kazan' is located on the Volga river some 600 miles east of Moscow and was considered at the edge of Russian civilization (as seen from Moscow and St. Petersburg) at the beginning of the nineteenth century. One can wonder why such a location should blossom into a world-class chemistry school, with world-class chemists as faculty. What was there in Kazan' and this part of Russia that led to the likes of Zinin, Butlerov, Zaitsev, Markovnikov, Vagner, Reformatskii, and Arbuzov? What is even more interesting is that Zinin graduated with a degree in hydrostatics, Butlerov wrote his *kandidat* dissertation in entomology on the Volga region butterflies, Zaitsev and Markovnikov graduated in economic science, Vagner started his study at Kazan' in law and gave up his first two years of study to start again in chemistry, and Reformatskii had been destined for the priesthood when he enrolled at Kazan'. Markovnikov was one of the most brilliant theoreticians of his day, and his intuitive feel for the relationship between structure and reactivity was certainly decades ahead of his time. Zaitsev, on the other hand, was a superb experimentalist, and from his laboratories came organometallic syntheses of alcohols that survived until the development of the Grignard reaction.

So the question in my mind is...Why Kazan'? And I still don't know.

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The original building (now home of the Butlerov Institute) at the University of Kazan, where many well-known chemists have worked. Part of the building now hosts a museum, but there are also working labs in it, too. Plaques on the walls honor these famous Russian chemist