Chemical & Engineering News
Serving the chemical, life sciences and laboratory worlds

Science & Technology

September 6, 2010
Volume 88, Number 36
pp. 60 - 62

When Science Went International

Looking back 150 years at the conference that led to the assembly of the periodic table

Sarah Everts

University of Karlsruhe archives

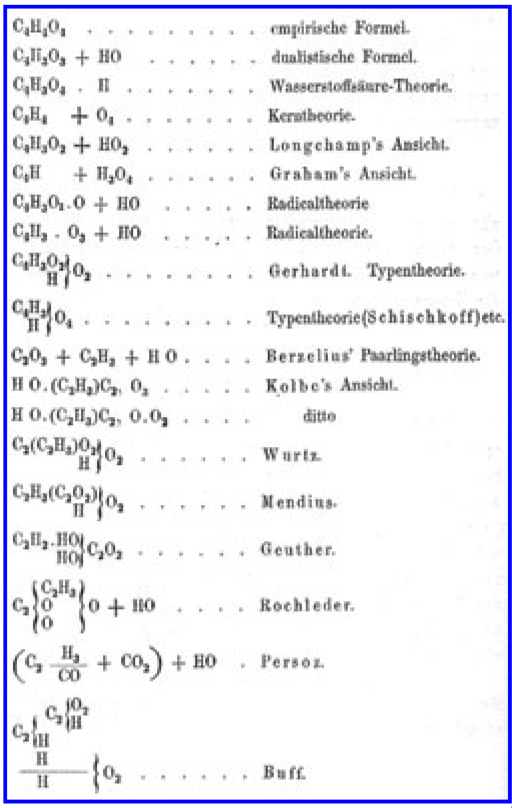
BACK IN THE DAY Conference organizer Karl Weltzien's laboratory in Karlsruhe in the mid-1800s.

Conferences are so ubiquitous these days that it's hard to imagine academic life without them, but 150 years ago this was not the case. On Sept. 3, 1860, the first-ever international scientific conference took place in Karlsruhe, Germany. Besides being an academic landmark, the meeting was essential for clarifying several major conundrums that were stymieing chemistry at the time, enabling the Russian chemist Dmitri Mendeleev and the German chemist Lothar Meyer, who were both in attendance, to later construct the first correct periodic tables.

To celebrate the anniversary, a commemorative conference was scheduled for Sept. 3–4 in Karlsruhe. As C&EN was set to go to press, the meeting was to include presentations from high-profile researchers, including several Nobel Prize winners, on how chemistry might help solve the world's most important challenges in areas such as energy and climate change. Because of their significance for the discipline of chemistry today, these issues were selected to parallel the major challenges facing those who attended the original Karlsruhe Congress, says organizer Joachim Podlech, a chemist at the University of Karlsruhe. However, the anniversary conference will first go back in time with an address by Alan Rocke, a historian of chemistry at Case Western Reserve University who will explain how the 1860 meeting had such a catalytic effect on the evolution of chemistry.

When the 1860 conference began, chemistry was in a total state of disarray. Although most chemists believed in atoms and molecules, nobody could agree on molecular formulas. Even simple molecules such as water were hotly debated: Most leading chemists at the time claimed that water's molecular formula was OH, and a minority argued that it was H_2O. More complex molecules were an even bigger battleground: At least 19 different representations of acetic acid were being used in textbooks of that era.

"The wheels were coming off the science of chemistry, and it was heading for a crash," Rocke tells C&EN. "The foundation of the discipline was insecure, students were confused, dissension among the elite was increasing, and misunderstandings abounded."



$C_4H_4O_4$	empirische Formel.
$C_4H_3O_3 + HO$	dualistische Formel.
$C_4H_3O_4 \,.\, H$	Wasserstoffsäure-Theorie.
$C_4H_4 + O_4$	Kerntheorie.
$C_4H_3O_3 + HO_2$	Longchamp's Ansicht.
$C_4H + H_3O_4$	Graham's Ansicht.
$C_4H_3O_2 . O + HO$	Radicaltheorie
$C_4H_3 \,.\, O_3 + HO$	Radicaltheorie.
$\left.\begin{matrix} C_4H_3O_2 \\ H \end{matrix}\right\} O_2$	Gerhardt. Typentheorie.
$\left.\begin{matrix} C_4H_3 \\ H \end{matrix}\right\} O_4$	Typentheorie(Schischkoff)etc.
$C_2O_3 + C_2H_3 + HO$	Berzelius' Paarlingstheorie.
$HO.(C_2H_3)C_2, O_3$	Kolbe's Ansicht.
$HO.(C_2H_3)C_2, O.O_2$	ditto
$\left.\begin{matrix} C_2(C_2H_3)O_2 \\ H \end{matrix}\right\} O_2$	Wurtz.
$\left.\begin{matrix} C_2H_3(C_2O_2) \\ H \end{matrix}\right\} O_2$	Mendius.
$C_2H_2 . \left.\begin{matrix} HO \\ HO \end{matrix}\right\} C_2O_2$	Geuther.
$C_2 \left\{\begin{matrix} C_2H_3 \\ O \\ O \end{matrix}\right\} O + HO$	Rochleder.
$\left(C_2 \frac{H_3}{CO} + CO_2\right) + HO$	Persoz.
$\frac{C_2 \left\{\begin{matrix} C_2 \left\{\begin{matrix} O_2 \\ H \end{matrix}\right. \\ H \end{matrix}\right.}{\frac{H}{H}} \Big\{ O_2$	Buff.

View Enlarged Image

One major stumbling block at the time was that nobody knew the correct atomic weights for elements. Chemists debated whether oxygen's atomic weight was 8 or 16, and carbon's 6 or 12. Fifty years before the Karlsruhe conference, the Italian chemist Amedeo Avogadro had proposed a theory that equal volumes of gases under equal conditions contain equal numbers of molecules. That supposition could have settled the debate, but it had been "uniformly rejected," Rocke says. "If you believed Avogadro's theory, then you could get the correct molecular formula for molecules, as well as the correct atomic weights, which was the groundwork required to construct the periodic table," he says.

Another common misconception was promoted by Jöns Jacob Berzelius, a powerful Swedish chemist of that era, says Michael Laing, a retired chemistry professor at the University of KwaZulu-Natal, in Durban, South Africa, who has written several chemical history articles about the Karlsruhe conference. Berzelius had correctly figured out that electrostatic forces were important for ionic bonding in salt, but then he had incorrectly concluded that all molecular bonding was forged by electrostatic attraction. Using this faulty reasoning, Berzelius argued that diatomic molecules such as H_2 and O_2 were impossible because the atoms would repel each other in the same way that like charges do. By not accepting the existence of diatomic molecules, it was impossible to get the correct formula for water formation, and water itself (H_2 + 1/2 O_2□H_2O). "The trouble with famous scientists then and now is that it can be very difficult for others to successfully attack their theories," Laing says.

By 1860, a potpourri of different systems for describing atoms, molecules, and their formulas was in circulation. Of the theories, the most accurate was proposed by two French chemists, Charles Gerhardt and Auguste Laurent. They were ostracized for their socialistic political views, a fact that didn't help the acceptance of their science. But their theory had a small fan base, which included a trio of chemists who decided to organize the first international conference.

The "secret agenda," of the Karlsruhe organizers, Rocke says, was to bring the international community of chemists together to promote Gerhardt and Laurent's theory—which included accepting Avogadro's theory as well as the existence of diatomic molecules. But there was also an open rationale for the conference, he says: "Everyone in the field of chemistry—old and young, conservatives and reformers—agreed that confusion and dissension were severe."

The actual idea to organize the conference originated with August Kekulé, a young German chemist in his 30s working in Ghent, Belgium, who first proposed that carbon is tetravalent. Kekulé discussed the possibility of the conference with a young French chemist named Adolphe Wurtz, who was based in Paris. The two friends went looking for a third, more established scientist to be the official conference organizer—someone who would successfully attract the high-profile chemists required to make the meeting a success. They approached a German chemist in Karlsruhe named Karl Weltzien. He had the added benefit of living in the German state of Baden, which was near the Black Forest, a very desirable holiday destination during that era. Baden also happened to have a rich ruler, Grand Duke Friedrich, who was a supporter of science and who footed part of the bill, Laing says.

These days, conferences are planned at least a year in advance, but that was not so for the Karlsruhe event. Things got serious in March 1860, when the organizers approached several elite scientists to ask whether their names could be included in an official invitation, which was circulated by early July. The conference was held two months later, in September. "It blows you away that they could plan the conference so efficiently" without e-mail or widespread electricity, Rocke says.

Despite the short notice, some 140 scientists traveled from across Europe—and even from as far away as Mexico—to attend the symposium. Recognizable names such as Robert Bunsen, of the now-famous burner, and Emil Erlenmeyer, who developed the omnipresent flask, were in the audience. In all probability, the contentious debates about molecular formulas ensured high attendance—if only so that participants could make sure their voices were heard.

When the 1860 conference began, chemistry was in a total state of disarray.

But there was also some skepticism about the meeting. For example, Meyer wrote a sarcastic letter to a friend before the conference in which he described the event as an "idiotic church-council in Karlsruhe," where he expected participants would "propose the election of an infallible [molecular] formula-pope," Rocke notes.

Like most current-day conferences, on opening night, "the members fraternized. ... Although this particular meeting was not mentioned in the programme, it was by no means the least relished," wrote one delegate. A Russian chemist named Alexander Borodin, who is better remembered as a composer of several symphonies and the opera "Prince Igor," was in attendance and likely performed music during the gathering, the University of Karlsruhe's Podlech says.

Participants broke into groups to discuss contentious issues, such as stoichiometry or representation of molecular formulas, and then they would return to the plenary hall to share their deliberations, Podlech says. However, sometimes a group's consensus was undermined by the presenter's personal opinions.

In fact, the conference was mostly dominated by voices from the old guard—so much so that the organizers began to fear their efforts were in vain and that the conference was going to be a complete failure. But just before the meeting's close, a relatively unknown Italian chemist named Stanislao Cannizzaro gave a long, impassioned, and eloquent lecture that argued for Avogadro's perspective on molecules. After Cannizzaro's lecture, one of his friends handed out a paper that effectively reiterated his speech and that several important delegates read on their trips home.

"It was as though the scales fell from my eyes; doubt vanished, and it was replaced by a feeling of peaceful certainty," wrote Meyer, who would later go on to construct a correct periodic table around the same time as Mendeleev put his together. Mendeleev wrote that the meeting "produced such a remarkable effect on the history of our science that I consider it a duty ... to describe all the sessions ... and the results."

But Cannizzaro's plea needed some time to sink in, and it took about a decade before scientists hashed out the correct molecular weights that enabled the periodic table to emerge. "On that last day in Karlsruhe, there were no cheers, no sudden enlightenment, no ovation," Rocke notes. "The assembled chemists simply quietly filed out of the hall and went home. In fact, other than very brief notices that appeared in the British *Chemical News* and the French *Moniteur Scientifique,* the Karlsruhe Congress appeared to have vanished without a trace—a total failure," he adds.

But it was actually quite the opposite, Rocke says. Like much in science, it just took a healthy dose of time and perseverance before the result of the conference—the periodic table—came to fruition.

Chemical & Engineering News
ISSN 0009-2347