

reactions involving oxygen - perhaps a faint resonance of the historical association of that principle with Lavoisier.

Such silence is perhaps doubly surprising since not only had Lavoisier enunciated the principle of the conservation of matter in 1789, but in Germany Immanuel Kant had laid down a similar principle in his influential *Metaphysical Foundations of Natural Science* of 1786. For Kant, the first principle of mechanics was that "in all changes in the corporeal world the quantity of matter remains on the whole the same, unincreased and undiminished." Yet Kant also assigned to matter primitive attractive and repulsive forces, and the "dynamical" philosophies of nature which were popular in early 19th-century Germany tended to eliminate matter entirely in favor of its construction out of ontologically more primitive forces; hence there was no matter, let alone mass, to be conserved.

The very notion of the conservation of matter was problematic because of the widespread lack of precision concerning the conception of matter as a distinct entity, especially as it related to the nature of the so-called imponderables, i.e. heat, light, electricity, and magnetism, regarded as weightless fluids. (Recall here that even Lavoisier listed caloric and light among the elements.) One prominent writer, Jacob Friedrich Fries, interpreted ponderable matter and the so-called imponderables as merely different states of aggregation of the same underlying substance (4). This was a notion which held out the implicit possibility of the effective disappearance of ponderable matter and hence cut the ground from under the utility of a principle of the conservation of matter. Heidelberg professor of physics Georg Wilhelm Muncke insisted that the alleged weightlessness of the imponderables had not been proven empirically, and thus he held open the possibility that they were only tenuous states of matter, again blurring the concept of ponderable matter and rendering its conservation less than obvious (5). As he observed, the imponderables would only have to be as light with respect to hydrogen as hydrogen is with respect to platinum in order to escape detection by our most sensitive balances. One of Mayer's professors of medicine at Tübingen, the then-prominent Johann Heinrich Ferdinand Autenrieth, concluded his discussion of phenomena of electricity, galvanism, magnetism, chemical reactions, heat, and light with the judgment that "imponderable substances" differ only in degree from "ordinary heavy bodies: They do not constitute a class of entities wholly different from the other material substances, and between the magnetic fluid and rigid flint there is an almost continuous transition" (6). In other words, it would be hard to insist on the conservation of matter as a principle if one's conception of ponderable matter was such that there was nothing in principle to conserve. It took the clarification of the concept of energy and the abandonment of the time-honored but vague notion of the imponderables before the concept of matter was distinct enough to make its conservation a meaningful principle of science.

At issue is not chemists' routine acceptance (after La-

voisier?) of the fact that the weight of the chemical reagents before and after a reaction must be unchanged, but rather the explicit enunciation of a particular principle and the kinds of assumptions which finally made that enunciation reasonable in ways it hadn't been before. The parallel and explicit formulation of both conservation principles as fundamental principles of the sciences of chemistry and physics was in the first instance the work of Robert Mayer. Lavoisier notwithstanding, it appears to me that, for the larger scientific community, the general recognition of the principle of the conservation of matter went hand in hand with, and was only made possible by the general acceptance of the principle of the conservation of energy during the second half of the 19th century.

#### References and Notes

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3. G. Lamé, *Cours de physique de l'Ecole polytechnique*, 3 pts. in 2 Vols., Paris, 1836-37, Vol. 1, 1836, p. 428.
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## PRIDE AND PREJUDICE IN CHEMISTRY

### Chauvinism and the Pursuit of Science

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Imbued as they are with the ideal of scientific objectivity, scientists and their historians can forget or neglect an important truism: scientists are just as susceptible as their fellow human beings to chauvinism, bigotry, greed, ambition, and all the other faults to which humanity is prey. Two news articles published in *Science* in 1989 are relevant to the first sin in my

list. One article describes the concern of members of the chemistry section of the Nobel Prize Committee over the nearly invariable tendency of American chemists to nominate other Americans - in fact, "in the great majority of cases," members of their own departments. The 1988 winners, three Germans, together received nominations from ten countries, but not one from an American chemist (1).

The other article concerns the outcry among French Canadians over a decision to change the name of the Parisian journal *Annales de l'Institut Pasteur: Virology* to *Research in Virology*. The director of the Institut Pasteur defended the decision by pointing out that while about half of their submissions in 1988 were from Francophone countries, nearly all were written in English. One Canadian is quoted as saying that "It is an Anglo-Saxon point of view to say that science is universal and that the language of scientific communication should be English because of that." Another critic argues that the real tragedy is the loss of Pasteur's name from the title, for "Pasteur belongs to the world" (2). The introduction of Pasteur's name into the debate is ironic, for Pasteur himself, an ardent patriot, was involved in a nationalist contretemps. Awarded an honorary doctorate from the University of Bonn, he returned it in anger during the Franco-Prussian War (1870-71), saying that he no longer believed "that science has no country" (3).

He who seeks examples of chauvinist fervor among 19th-century scientists finds a true embarrassment of riches (4). It is my intention here to examine this subject, with the goal of forming a judgment as to the extent to which such an assuredly widespread phenomenon may have been harmful to the successful international pursuit of science. My focus here is not so much on specific international institutions, conventions, congresses, scientific societies, and formal or informal social networks, but rather on the question of how the social-psychological phenomenon of shared prejudices in national groups interacts with the cognitive phenomenon of the growth and transformation of scientific ideas. My case study centers on German views of French chemistry in the 19th century, and especially during the Franco-Prussian War. I will examine the opinions of August Kekulé, who has been accused of Prussian chauvinism (5); more space will be devoted to the views of Kekulé's teacher, Justus Liebig, and his chief tormentor and rival, Hermann Kolbe. I will argue that the prevalence and intensity of chauvinist fervor does not necessarily interfere with the rational and successful pursuit of science.

#### Kekulé, Hofmann, and Kolbe

August Kekulé, August Wilhelm Hofmann, and Hermann Kolbe, the three premier German chemists in the generation after Liebig, form interesting contrasts, in their personal lives as in their science. Kekulé was cosmopolitan and patrician in style, and was much inclined toward internationalism. After his initial education at Liebig's hands, he enjoyed a four and a



August Kekulé

half year "Wanderjahre," divided among the countries of France, Switzerland, and England, followed by a brief period in Heidelberg - all of this being but a prelude to nine years as a professor in French-speaking Belgium. By the time he was called to Bonn he had spent 13 of the previous 16 years abroad; he could speak English and French almost without accent, and fluent Italian as well. He was also principal organizer of the first international chemical congress. Hofmann, for his part, was likewise a product of Liebig's Giessen laboratory; he then spent 20 happy and productive years in England before returning to Germany by accepting a sumptuous position at the University of Berlin. A suave sophisticate like Kekulé, Hofmann's oral and written English was so masterly that he did not hesitate to correct the language of his English students. Henry Armstrong's thumbnail sketches were apt (6):

Kekulé was a born aristocrat in manner. An intellectual of a high order, many-sided in his interests, he was too critical and cynical to be a leader of men in the way that Hofmann was, though even superior to him as an orator; he attracted through his clear-cut talent, his gift of precise speech and his great command of knowledge ... Kolbe was equally simple [as Frankland], never a man of the world, a good lecturer and a far better writer but not an orator: the best chemist of

them all. Hofmann and Kekulé were cosmopolitans; ... Kolbe - just the dear old German, academic pedagogue of the highest class: there is no other way of describing him.

Indeed, Kolbe's was a very different character. With the single exception of Jacob Berzelius, whom he considered an honorary countryman, all of Kolbe's models were German - above all, the heroes of the classical period of the rise of German chemistry: Liebig, Friedrich Wöhler and Robert Bunsen. Educated at the hands of the theoretically conservative experimental masters Wöhler and Bunsen, Kolbe served at the Universities of Marburg and Leipzig after a postdoctoral stint in England. He spent his entire career trying to develop and to preserve the radical theory and its electrochemical basis, in the face of the ultimately successful attacks by a French-English reform movement founded by Charles Gerhardt and Auguste Laurent and promoted by Alexander Williamson and Kekulé. Linguistically as well, Kolbe forms a contrast; although he learned a reasonable amount of English in the 18 months he spent in London, he soon forgot most of it, at least as far as oral communication is concerned (7). There is no evidence he ever mastered or even seriously studied any other foreign language. Apparently he could read French, although certainly he avoided doing so as much as possible. As for foreign travel, aside from his one postdoctoral period and a



Hermann Kolbe

brief laboratory tour to England, a fishing vacation in Norway with his friend Eduard Vieweg, and his semiannual "cures" taken often in Swiss resorts, he never left the German Confederation or Empire. He particularly avoided the Catholic countries of Austria and France.

Kolbe's first recorded derogation of the French dates from the period in 1848 just after the February revolution in Paris and the "March days" in Germany. Certain French chemists, he wrote in an encyclopedia article, had been "irresponsible" in proposing "imagined laws" based on "vague hypotheses" that purported to overturn the radical theory. Similar slurs are found in Kolbe's long paper on radicals published in the fall of 1850 (8). But his language became much sharper when it appeared that the reformers might really carry the day. His concern and anger can be discerned in the first fascicle of his textbook, published in 1854. French chemists, he wrote, were only playing games with formulas, with "unbelievable self-deception." They opposed the (predominantly German) radical theory out of chauvinist spite, since "it had not developed on French soil." There was much more here in a similar vein (9).

#### Liebig and Dumas

But Berzelius was not Kolbe's only model for ferocious critiques; he also followed the pattern established by his other



August Wilhelm Hofmann

great hero, Liebig. Liebig's views of foreign chemistry are best exemplified by examining his relationship with his greatest rival, J. B. Dumas. During the 1830s Liebig and Dumas were contemporaries pursuing the same field of research in different countries, and had much in common - so it was perhaps inevitable that they would become rivals. Both men were demon workers with extraordinarily creative minds, cultivating a field that had too many mysteries and too few facts. Both men had occasion to accuse the other, sometimes justly, of experimental work that was fast but sloppy and both had occasion to accuse the other, probably also sometimes with some truth, of poaching results. As violent as their disputes at times became, by 1840 they found themselves not very far apart - though neither man was then willing to admit this to the other.

In his worst moments Liebig thought of Dumas as a true charlatan or "Schwindler," who was not above using questionable tactics or sleight of hand to achieve renown, and whose greatest concern was pursuit of effect, flourish, and the rhetorical turn of phrase, all for the sake of personal ambition. For his part, Dumas often viewed Liebig as a heavy-handed and hotheaded chemical empire-builder. After a brief alliance at the end of 1837 and the beginning of 1838, Liebig became dissatisfied with the pact he had made with Dumas, and in 1840 made a "total break" from the Frenchman, the quarrel resulting from substitution theories, and based upon some real issues along with some pure misunderstandings. Dumas was a "tightrope dancer," a "Jesuit," a "highwayman," and a "thief," like "nearly all Frenchmen" (10). To Berzelius he complained (11):

These Frenchmen truly have no feeling of true honor, no sense of justice and fairness, they have for many years been occupying themselves with theoretical speculations that are useless for science, and solely to satisfy their own vanity and arrogance; they have discovered that the word Radical must be banned and must be substituted by the word Type. This is the greatest of their discoveries. Unfortunately when I step forward there is in Germany only envy and weakness, so I stand completely alone, no one who has enough power to stand up to them supports me. In short, it is a bad time and I am very unhappy, and have turned from these miserable matters to applications of chemistry to physiology, which now interests me tremendously.

Unfortunately here too Liebig collided with Dumas, when Liebig became convinced in 1842 that Dumas had stolen his original ideas on plant and animal nutrition, and the heat of discord only became more intense (12).

Even in the midst of some of these disputes, however, Liebig was able to recognize Dumas' merits and to concede when he had been in the wrong, and when the violence of his replies sometimes had done nothing but damage (13). On 23 April 1850 Liebig wrote his friend C. F. Kuhlmann in Lille, whom



Justus von Liebig

he was about to visit to help dedicate his new factory; he was very much looking forward to the expectation of seeing Dumas there, as he was anxious to renew their old friendship (14):

... since I have always very highly esteemed Herr Dumas as one of the most outstanding and ingenious men among the chemists and scientists of our day. Perhaps more than any other chemist in Europe I find myself in the position of judging and prizing the value of his work, since we very frequently have encountered each other in our investigations, and have cultivated the same field.

Liebig's hopes for the encounter were realized, as he wrote to Wöhler (15):

We all arrived at the same time, embraced each other, and everything was fine. Dumas was extremely cordial, and looked so young that I hardly recognized him. His wife and daughter were with him, to serve as witnesses to the plans for revenge that he had brewed. On Whitsunday the celebration was splendid and merry, the next evening a banquet, to which the civil and military leaders of Lille were invited. At the end of the banquet Dumas stood up, gave a long speech, flattered me with various puffery, and finally took a decoration for the legion d'honneur from his pocket, and handed it to me along with the brevet in the name of the President of the French Republic. I was unprepared and thought I would faint; but I managed a speech and received an accolade. Thus he revenged himself on me. Despite all he has a magnificent nature.

The following year Liebig dedicated a new edition of his *Chemische Briefe* to Dumas, and the two exchanged a number of warm letters until Liebig's death in 1873.

Kolbe certainly absorbed an extremely negative view of Dumas from Liebig, who was one of his idols and models, and whose diatribes were quite open and often published in the scientific literature. Berzelius, and his former student Wöhler, also had opinions of Dumas and other French chemists which were not much more positive than Liebig's. But Dumas had retreated around 1840 from a leading theoretical role, replaced in the theoretical dialectic by such chemists as Laurent and Gerhardt, and in the 1850s by Adolphe Wurtz as well. Kolbe's relationships with Gerhardt and Wurtz paralleled Liebig's relations with Dumas, except for the lack of a final reconciliation. It was with Gerhardt and Wurtz that Kolbe felt the strongest sense of rivalry, enmity, hatred - and once in a while even affinity, if not regard.

#### Chemistry: A French or German Science?

Kolbe's prejudices against foreigners, especially the French, were not necessarily tied to conservative political sentiments. Kolbe's general political orientation during his 30s was quite typical of his class and time period, namely center to center-right liberalism. During his years at Marburg he had nothing but contempt for the reactionary regime governing the state of Electoral Hesse. He vaguely distrusted Prussia but despised Austria; feared republicans, extreme democrats, and socialists; and he hoped for German unification, presumably under Prussian leadership but with constitutional guarantees. He looked with deep suspicion on Bismarck's and King Wilhelm's struggles of the 1860s with the Prussian "Landtag." When in the spring of 1866 war with Austria threatened, Kolbe (with most fellow Germans) feared a catastrophe, for it was by no means clear that the Prussian army was sufficient to the task, and the Austrian yoke promised to be infinitely more onerous than that of Prussia. "Lieber Bismarckisch (so schlimm das auch ist)," commented Kolbe to Edward Frankland about the alternative outcomes of the approaching war, "als österreichisch-Jesuitisch!" Moreover, Saxony (where Kolbe had moved as a result of his call to the University of Leipzig) was ominously sandwiched between Prussia and Austria, and everyone expected the battle zone to be close to Leipzig (16).

In the event, the decisive battle occurred at Sadowa (Königgrätz), 200 miles southeast of Leipzig, and was handily won by the Prussian army. Kolbe's sentiments, again like those of most of his countrymen, were profoundly altered by this military success and by the prospect of a unified German nation. "Say what you like against Bismarck," Kolbe wrote Frankland, "one cannot deny that he is a decisive, quietly reflective man, *the premier statesman of Europe*" (17):

The situation is perhaps the following. Had Austria won the upper hand and destroyed Prussia, Germany would be lost and we would have Austrian conditions: lies, Jesuitism, concordat, systematic corruption, general moral disintegration, destruction of material prosper-

ity, abolition of free scientific research, etc. With the battle of Königgrätz a new star rose over Germany; from this day Germany is a unified nation. Further, our political, material, moral and scientific development will receive a new impetus.

In short, Kolbe was convinced that "Prussia's victory signifies freedom and free development in every direction."

Kolbe's long-simmering hatreds burst into the public domain at the time of the Franco-Prussian War. The decline of his influence in theoretical chemistry, along with his general isolation in the collegial community, must have increased Kolbe's ill temper, and after January 1870 he had his own journal to express his unexpurgated opinions. The war, along with the uproar over Wurtz' opening of his recently published history of chemistry, proclaiming that "chemistry is a French science," provided the occasion for his outbursts (18). In a polemical article "On the State of Chemistry in France" published simultaneously with the French declaration of war (and obviously modeled on Liebig's identically-titled essays on Prussian and Austrian chemistry), Kolbe lambasted the French for their dissolute ways and their feeble scientific establishment. There is *no* French university, he declared, that can compare with *any* German university for chemical education (19).

As the war proceeded Kolbe was even further radicalized. He was delighted by the Prussian victories at Sedan and Metz, but impatiently abided the long siege of Paris; he did not



Jean-Baptiste Dumas

understand why Moltke held off on the bombardment for so long (20). To Franz Varrentrapp he wrote (21):

The French are truly a nation of half children, half madmen. I have had deep hatred and contempt for the French, but I had never considered them so uncivilized, barbarous and base as we now see them to be. I believe France is now in a rapid decline, and will never recover ... The whole nation puts no value at all on honor, only on gloire [sic].

The sharpest contrast in this respect could be drawn between the French and the Germans, Kolbe thought, as he wrote to Frankland (22):

The Germans, who seek their gloire [sic] in the arts of peace, and go to war only as a last resort, would never sacrifice their sons to the whim of anyone, even if a narrow-minded, fanatical, bellicose German emperor should one day accede to the throne. In our country the only kind of war that will be popular and possible is one that defends the fatherland.

Frankland ought therefore have no fear of future German aggression. Furthermore, Kolbe bristled at Frankland's sentiments in favor of a republic, for the example of the United States illustrates that a republic is no more than "a playground for swindlers and adventurers, on which the insolent mediocrity bring their influence to bear, a language in whose dictionary the word 'gentleman' does not appear ... My dear friend, for heaven's sake no republic." The Germans, like the English, Kolbe concluded, would rather have a German king than an emperor, and not one from Prussia; "aber die Nothwendigkeit hat eiserne Arme," and he and his compatriots were delighted with their new situation (22).

When the French Academy of Sciences neglected to remove from the wrapper of their *Comptes rendus* mention of the Alsatian cities of Strasbourg and Mulhouse, and Metz in Lorraine, after their transfer to Germany, Kolbe was enraged (23). He wrote Liebig (24):

My contempt for the whole contemporary French chemical world is beginning more and more to turn into pity. Even the Parisian Academy appears to have no idea how ridiculous it appears to the scholarly world by this miserable bickering, for which Herr Pasteur constituted the ferment. Forgive my exhortation. The behavior of this lost and lying nation sometimes makes me a little passionate.

But Liebig's was a sympathetic ear. The French, Liebig complained, were displaying "insane arrogance," demonstrating that they were a "dissolute race;" the "megalomania of this unfortunate nation is certainly capable of anything" (25). "How terrible it must be for this vain and arrogant nation to have achieved *not a single* advantage in battle" (26). Bismarck's adroit behind-the-scenes manipulations maneuvering

both countries toward crisis had been essentially invisible to the German public, and the war propaganda was skillful. Even Kekulé was induced to denounce the "nation of scoundrels" they were fighting (27).

Emotions began to cool, at least on the German side, after peace was concluded, but Kolbe kept up the heat, continuing his Francophobic polemics for more than two years. Having been elected, with Liebig, Wöhler, and Bunsen, a charter honorary member of the German Chemical Society, Kolbe resigned in 1871 out of anger that the Society had not defended his critique of Wurtz's dictum when that critique had met public foreign opposition. Meanwhile Kekulé, together with Jacob Volhard and Emil Erlenmeyer, successfully persuaded the Society to become less provincial; among other reforms suggested by this group, after 1872 the Society only named foreigners as Honorary Members. But to Kolbe the Society had already been far too internationally oriented (28).

Hofmann, who very much wished to soothe the raw feelings between the two countries, picked up the cue at this point, proposing Auguste Cahours as the first Frenchman to receive such an honorary membership after the war ended. This was the last straw for Kolbe, who protested loudly, both publicly and privately (but without effect, partly because he had now resigned). In his journal he asserted that there were "dozens" of more deserving Germans. "What a disgrace," he wrote Varrentrapp, "again with Cahours; what is the purpose of this international coquetting with France? Hofmann unfortunately lost the fatherland in England" (29).

Kolbe's tone became even harsher in his final years, after the death of his wife, when he became truly irrationally preoccupied with his various crusades. Ironically, the French were far less oriented toward structure theory than the Germans; Kolbe noticed this fact with alarm, for to him it indicated a surprising source of French strength that was dangerous for the future health of the German chemical community. "I know full well," he wrote Volhard (30):

... that if Prussia continues to ruin chemistry ... the time will soon return when, as in the second decade of this century, German chemists will go to Paris to educate themselves in chemistry. As at that time, when everyone in Germany was crazy about the Naturphilosophie of Hegel and Schelling, this swindle made no headway in France, and for that very reason France was far superior to us in science, so today, with the single exception of Wurtz, French chemists keep away from the Naturphilosophische swindle of the modern structural and bonding chemistry, and therefore they will gain a head start on us once more.

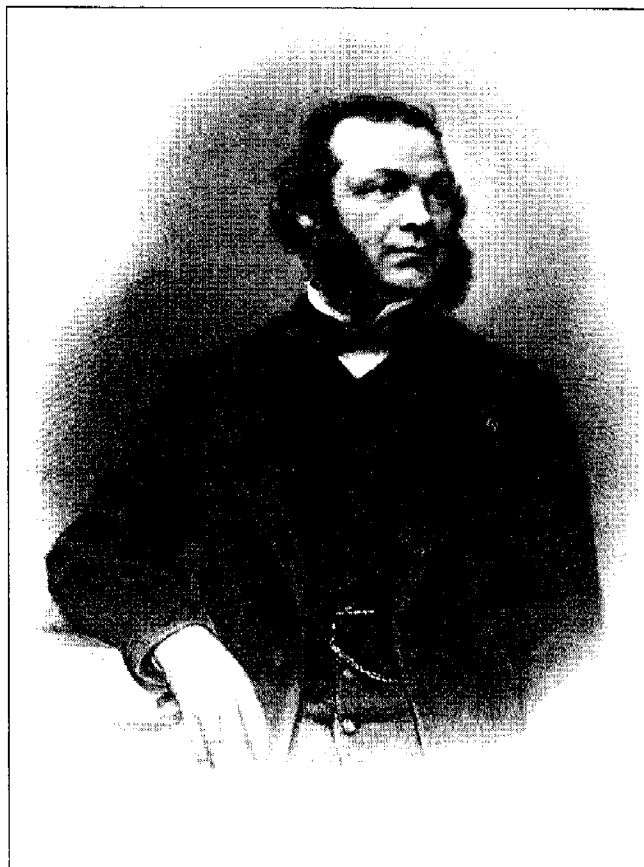
The irony was, as Kolbe well knew and loved to point out, that this same unscientific structural chemistry was a direct product of French chemistry - namely an outgrowth of the type theories of Dumas, Laurent, Gerhardt, and Wurtz. Kolbe thought this was where Kekulé had gone wrong; he had followed not only the bankrupt theories of the French, but also their larcenous

behavior. The more highly Kekulé's textbook was valued, the more Kolbe railed against the "tendentious forgeries" committed by its author (31).

Despite Kolbe's quiriness, he saw a number of points quite clearly. Kekulé was indeed an internationalist at heart, and he had been decisively influenced by the French chemists Dumas, Laurent, Gerhardt, and Wurtz. He and other (predominantly German and German-influenced) chemists - such as Erlenmeyer, Crum Brown, Frankland, Ladenburg, Butlerov, Baeyer, Fischer, Victor Meyer, Graebe, and Wislicenus - had developed structural chemistry from that essentially French background. Kolbe was also correct in viewing Kekulé and Wurtz as flawed historians, for the latter did have hidden agendas in mind, and neglected the very real contributions of those they disagreed with - especially Kolbe, Frankland, and Couper. Finally, Kolbe was right to see Wurtz as one of the few prominent representatives of structural chemistry in France.

Indeed, Wurtz' isolation in France was sort of a mirror image of Kolbe's in Germany, placing the contretemps over his chauvinist historical comment in even sharper relief. Read with attention to the thematic orientation of the entire work, and placed in context with Wurtz' other interpretive, historical and polemical writings of the 1860s, the apparently gratuitous chauvinism of his opening motto is subject to a different, or at least additional interpretation. Wurtz had accepted essential parts of the Gerhardtian reform in 1853; by 1858 he was a full and enthusiastic convert. But continued opposition among his colleagues led him, rather isolated in France, to initiate a concerted campaign for the new chemistry, including structural ideas. He started a new journal (*Répertoire de chimie pure*) and a new society (Société Chimique de Paris), became a leader, with Kekulé, of the Karlsruhe Congress organizers, wrote a heavily subtitled éloge for Gerhardt and Laurent, presented invited historical lectures to the Société Chimique, the Collège de France and the Chemical Society of London, wrote a textbook, and finally published a full, formal history prefacing a multi-volume dictionary. All were designed to propagate the new chemistry in a country still dominated by older ideas. None was notably successful (32).

I want to suggest, in short, that Wurtz' "chemistry is a French science" has a thematic load heavier than mere chauvinism. It was not so much Lavoisier and the first chemical revolution that Wurtz wanted to promote, as Lavoisier's countrymen Laurent and Gerhardt (not to mention of course Wurtz himself, aided by foreign Francophiles such as Williamson and Kekulé) who were the authors of the still incompletely consummated "second" revolution. The work was directed inward rather than outward, its intended audience was Wurtz's fellow Frenchmen. What better way to persuade them to join the new movement than to appeal to their patriotism by arguing for the continued dominance of French chemistry in the international arena? If I am right, we have here an example of nationalism put to rhetorical purposes, but for a cognitive goal - and not for



Adolphe Wurtz

mere chauvinist puffery. But it was difficult for foreigners to get past that first fearsome line.

Kekulé practiced the same technique. His 1859 history of chemical theory, prefacing his textbook, had a number of significant omissions. As was the case with Wurtz, these were partly due to selfish priority interests, and chauvinism may have also played a role; but there was also a rational didactic or rhetorical intent promoted by the distortions. He had a new theory to push, and needed to tell the history behind it in such a way as to make the theory appear rational, even inevitable. The work of Kolbe and Frankland in particular failed to fit into the neat story Kekulé wanted to tell. This historical-didactic technique was of course very old and well-attested (33). It had been practiced with particular skill by Lavoisier himself. Somewhat devious and covert (or perhaps self-deluding) such a procedure may be - but chauvinism was only at best a secondary motive.

The historical work of Hermann Kopp, a close friend to Kolbe, Hofmann, and Liebig, forms a sharp contrast to Kekulé's and Wurtz' partisan histories. Despite having been commissioned to write a history of chemistry "in Germany," moreover just at the time of the Franco-Prussian War and in the immediate aftermath of Wurtz' apparent chauvinism, Kopp's *Ent-*



*wicklung der Chemie in der neueren Zeit* was aggressively and explicitly international in orientation. The case of Kopp is sufficient to show that chauvinist currents were by no means all-pervading, even during the most jingoistic of times (34).

#### Concluding Observations

The somewhat optimistic interpretation to which such considerations lead - that chauvinism in science is perhaps less damaging than has hitherto been thought - can be further supported by looking again at some of the characters we have already met. Liebig, for instance, exhibited prominent elements of Francophilia as well as Francophobia, and not only because his first rigorous scientific education took place in Paris. His biographers emphasized his international outlook, which was often in evidence (35). As the war with France progressed, Liebig expressed compassion and concern for his French colleagues, some of whom were good friends. In September 1870 Liebig wrote his brother-in-law, the army physician Karl Thiersch, then with the Prussians in Versailles, requesting (36):

... that he might seek out Regnault and offer him his help. I wonder how our friends in Paris, Dumas, Peligot, Boussingault, etc. are doing? If only it were possible to do something for them, but they will not be allowed out of Paris. The lovely city, what suffering she faces!

Through Thiersch, Liebig succeeded in getting a letter to Deville in Paris from his wife, a refugee in Geneva. He sent 500 francs to L. C. Barreswil's wife in Boulogne, under the presumption that she needed it; he considered the same charity for Madame Deville (37).

In the first meeting of the Bavarian Academy of Sciences after cessation of hostilities, Liebig delivered a speech assessing the causes of Prussian victory and French defeat. He suggested that German superiority was an indirect but very real consequence of wise governmental policies that, inter alia, gave sufficient support to academic research, which led in the long term to efficacious "scientific" rather than mere rote applications. He concluded with some comments that he intended as conciliatory (38):

This is perhaps the place openly to acknowledge, on the part of our Academy, that racial hatred between the Germanic peoples and the Romanic countries does not exist ... It is characteristic in the nature of the German, with his knowledge of languages, his understanding of foreign nationalities, and his cultural-historical standpoint, to be just to other peoples, often to the point of being unjust to himself; and so we recognize what we owe to the great philosophers, mathematicians, and scientists of France, who have been our mentors and models in so many fields. Forty-eight years ago I came to Paris to study chemistry; ... my entire career was thereby determined.

Indeed, Liebig, like Kekulé, had begun his career as a Francophile, showing nothing but contempt for his previous German teachers. He always revered his French mentors Arago, Dulong, Thenard, and above all Gay-Lussac. He subsequently formed an exceedingly close relation with J. T. Pelouze and others, spoke and wrote French fluently, and until his death kept in close contact with the leading figures of the Parisian establishment. In 1845 he wrote Wöhler: "Indeed, Frenchmen have something exceptionally appealing and amiable that is generally missing from the Germans" (39). As we have seen, he successfully reconciled with Dumas. Even Gerhardt, whom he accused publicly of being an assassin and a highwayman, eventually managed to elicit kind and generous comments from his former teacher, and became fully reconciled before his death in 1856.

Liebig concluded his speech (38):

A warm sympathy for all that is noble and great and an unselfish hospitality are among the finest traits of the French character; these features will be rekindled and reactivated on the neutral ground of science, on which the best minds of the two nations must meet in their endeavors toward the high goal common to both; thus will the ineradicable feeling of brotherhood gradually contribute in the field of science to soothe the bitterness that the deeply wounded French national pride feels toward Germany, as a result of the war which they forced upon us.

Partisan emotion was clearly showing through here, but we must grant that Liebig's heart was in the right place, and at a difficult time for German as well as French hearts.

It may be noted parenthetically that Liebig's relations with English chemists were also very close. Despite disparaging comments on English dilettantism and their lack of attention to pure science, and a public attack on the idol of English experimentalism, Francis Bacon, Liebig's high regard for English chemists and his continuous collegial contact with them has prompted one prominent English Liebig scholar to refer to Liebig quite justly as "very much an honorary Englishman" (40).

In sum, there is no evidence that Liebig was prey to the sort of pathological national prejudice that might have chronically interfered with his appreciation of foreigners' work, and thus with his pursuit of science. None of this is to deny a certain hot-headed and instinctual chauvinism at the heart of Liebig's character, but the judgment of one historian that "Liebig was the undisputed champion of this growing and squalid German nationalism in scientific affairs" is quite unjust (41).

Many would want to award such championship honors to Hermann Kolbe, and in truth it would be hard to find a better candidate. And yet, close examination of Kolbe's career reveals an interesting irony. No one had more contempt for the French or their theories in the late 1840s and early 1850s than Kolbe. However, the striking new reactions and brilliant argu-



ments by Gerhardt, Williamson, Wurtz, and Frankland during the early 1850s that convinced most of Kolbe's German colleagues to accept the French-English theories were by no means lost on Kolbe either. By 1857 he had developed a theory of his own that was strikingly similar to the Williamson-Gerhardt newer type theory, namely that all common organic compounds could be regarded as substitution products of carbonic acid. He retained this theory almost without modification for the rest of his life.

Colleagues, friends and rivals all pointed out, from the late 1850s until Kolbe's death, both publicly and privately, that Kolbe had become a de facto convert to Gerhardt's system. Kolbe denied it with all the energy at his command. There were indeed some substantive distinctions between what Kolbe called his own "real types" and the purely "formal types" of Gerhardt's theory, and between his hierarchical radical formulas based on tetravalent carbon and the structural formulas of the Kekulé school. But the similarities were striking, both to Kolbe's contemporaries and to modern observers. In 1868, two years before the war broke out, Kolbe even converted to modern atomic weight formulas, the last highly visible difference between him and the structuralists - a step that most French chemists did not take for another quarter century.

To put the matter a bit simplistically, Kolbe's pathological chauvinism had failed to prevent him from understanding and being persuaded by the hated French ideas; it had only operated to prevent him from believing he had adopted them. Using his faux types during his most productive years in the 1860s, Kolbe practiced substantively and very successfully the same sort of theoretical chemistry being pursued simultaneously by the structuralists. In short, to the extent that he was an exceptionally good scientist - and there can be little doubt that he was - he was also an internationalist in spite of himself. It would be wrong to suggest that Kolbe's bigotry did not damage the quality of his science, for I believe it is clear that it did, especially after 1870. But what is striking is that a man of such violent and ineradicable prejudices against the very direction that we have come to know as modern chemistry was able essentially to become a modern chemist in spite of himself.

I would not want to push my argument too far, for there are well known instances where national feelings seriously damaged the free interplay of scientific ideas. Just as French chauvinism played a role in delaying for half a century the reception of Newtonian mechanics in a Parisian context dominated by Cartesian ideas, so English chauvinism influenced the retention in Cambridge and Oxford for more than a century of the Newtonian calculus, in preference to the more powerful Leibnizian version. Governmentally enforced pseudoscientific orthodoxies in the Soviet Union and in Nazi Germany, based partly on chauvinist emotion, threatened virtually to destroy certain branches of science deemed foreign and hence maleficent. And yet even here it is significant that the most powerful totalitarian states have great difficulty in

enforcing such dicta from above. Stalin's suppression of genetics required wholesale murder; Hitler could drive many of the finest physicists from Germany, but even so his campaign to purge German science of the "Jewish" theories of relativity and quantum mechanics was largely unsuccessful (42).

Returning to the field of chemistry, the reception of French antiphlogistic chemistry in the homeland of Stahl provides another interesting case. Karl Hufbauer has shown that during this episode German chemists were strongly conditioned by the cultural nationalism then being promoted so ardently by German romantic writers. Still, Hufbauer demonstrates that Lavoisier's new chemistry conquered Germany nearly completely, despite strenuous (and openly chauvinistic) initial opposition, during the course of only four years, 1789-1793 - moreover, just a few years after French chemists themselves were converted (43). More recently, H. G. Schneider has examined the same events; his emphasis on the outspoken nationalism of the principals only underlines (to my mind) the irony of their relatively fast capitulation to the hated French chemistry. A similar course of events took place when the chemical atomism of Dalton and Berzelius encountered German soil. Despite a romantic antimaterialist culture flirting with Naturphilosophie and other dynamical idealist notions, which one would think ought to have provided an inimical climate of opinion, chemical atoms flourished in Germany as they had elsewhere (44).

Similarly, and despite all of the examples of expressions of virulent German chauvinism given here, in the event the Germans accepted the French-English chemical reforms of the 1850s astonishingly rapidly. In fact, it is a striking irony that these essentially French reforms were pursued much more aggressively and enthusiastically in Germany than in France: by the 1860s structure theory had become a quintessentially German field, while Wurtz felt his to be a voice in the French wilderness.

In sum, the prevalence of nationalist fervor provides much less predictive guidance in explaining the growth, development, and differential national reception of scientific theories than one might have expected. Chauvinism is powerful and pervasive, but so is the strength of ideas and evidence as pursued by conscientious (though very human) scientists.

#### References and Notes

*Author's Note and Acknowledgments:* A companion piece to this essay is "Pride and Prejudice in Chemistry: Kolbe, Hofmann, and German Antisemitism," to be published in Y. Rabkin and I. Robinson, eds., *The Intersection of Jewish and Scientific Cultures*. The latter was actually presented at the Benfey Festschrift session in 1989, and both essays are dedicated to O. T. Benfey. Portions of this essay have also appeared in my book, *The Quiet Revolution: Hermann Kolbe and the Science of Organic Chemistry*, University of California Press,

1993. For their kind assistance and permission to quote from documents in their possession, I wish to thank the staffs of the Archives of the Académie des Sciences, Paris, the Royal Society of Chemistry, London, the Bayerische Staatsbibliothek and the Library of the Deutsches Museum, Munich; also Mr. and Mrs. Raven Frankland, owners of the Frankland letters cited, and Professor Colin Russell, whose microfilm copies I used; and finally, the professional staff of the Vieweg Verlag archive, Wiesbaden. This research was generously supported by the National Endowment for the Humanities, grant RH-20801-88.

1. C. Holden, "Chauvinism in Nobel Nominations," *Science*, **1989**, *243*, 471.
2. D. Dickson, "L'Affair Pasteur' Prompts Canadian Outcry," *Science*, **1989**, *244*, 280-281.
3. For discussions of this event see G. Geison, "Louis Pasteur," in C. Gillispie, ed., *Dictionary of Scientific Biography*, Vol. 10, Scribner's, New York, 1974, pp. 350-416 (on p. 354), and J. Wotiz and S. Rudofsky, "Louis Pasteur, August Kekulé, and the Franco-Prussian War," *J. Chem. Educ.*, **1988**, *6*, 34-36.
4. A convenient discussion and guide to the existing secondary literature on nationalism and internationalism in science is provided in two articles by B. Schroeder-Gudehus: "Science, Technology and Foreign Policy," in I. Spiegel-Rösing and D. Price, eds., *Science, Technology and Society: A Cross-Disciplinary Perspective*, Sage, London, 1977, pp. 473-506; and "Nationalism and Internationalism," in R. C. Olby, G. N. Cantor, J. R. R. Christie, and M. J. S. Hodge, eds., *Companion to the History of Modern Science*, Routledge, London, 1990, pp. 909-19. Not mentioned by Schroeder-Gudehus is E. Crawford, *Nationalism and Internationalism in Science, 1880-1939*, Cambridge, 1992, Chapt. 2; and on the topic of chemistry in particular, see also C. Meinel, "Nationalismus und Internationalismus in der Chemie des 19. Jahrhunderts," in P. Dilg, ed., *Perspektiven der Pharmaziegeschichte*, Akademische Druck- und Verlagsanstalt, Graz, 1983, pp. 225-43. Meinel's and my treatments of this material are essentially complementary; Schroeder-Gudehus is more strongly influenced by the viewpoint of the social construction of scientific knowledge than are either Meinel or myself.
5. J. Wotiz and S. Rudofsky, "The Unknown Kekulé," in J. G. Traynham, ed., *Essays on the History of Organic Chemistry*, Louisiana State University, Baton Rouge, 1987, pp. 21-34 (on 30-31).
6. H. E. Armstrong, "The Doctrine of Atomic Valency," *Nature*, **1930**, *125*, 807-10, on 808-9.
7. Edward Frankland began to give Kolbe English in return for German lessons soon after their arrival in London, and Kolbe could "soon speak with facility" (Frankland to Hermann Ost, 20 December 1884, Sondersammlungen des Deutschen Museums, Munich [hereafter abbreviated "SSDM"], document number 3576). However, by 1864 Kolbe reported to Frankland that he had forgotten so much that he needed to be allowed to speak German in presenting a lecture to the Chemical Society (Kolbe to Frankland, 4 December 1864, microfilm frame number 01.04.59, Frankland archive, Milton Keynes, England). The lecture was never given.
8. H. Kolbe, "Formeln, chemische," in *Handwörterbuch der reinen und angewandten Chemie*, Vol. 3, Vieweg, Braunschweig, 1848, pp. 174-78, on 176; idem, "On the Chemical Constitution and Nature of Organic Radicals," *J. Chem. Soc.*, **1850**, *3*, 369-405, and **1851**, *4*, 41-79, on 76.
9. H. Kolbe, *Ausführliches Lehrbuch der Organischen Chemie*, Vol. 1, Vieweg, Braunschweig, 1854, pp. 35, 40-41.
10. Liebig to Berzelius, 8 May 1831, 2 July 1832, and 17 May 1841, in J. Carrière, ed., *Berzelius und Liebig: Ihre Briefe von 1831-1845*, Lehmann, Munich, 1898, pp. 11, 34, 230.
11. Liebig to Berzelius, 17 April 1841, *ibid.*, p. 223.
12. For a summary of this dispute, see F. L. Holmes, "Justus Liebig," in C. Gillispie, ed., *Dictionary of Scientific Biography*, Vol. 8, Scribner's, New York, 1973, pp. 333-44, and idem, *Claude Bernard and Animal Chemistry*, Harvard University Press, Cambridge, 1974, pp. 34-47.
13. Liebig to Berzelius, 30 May 1833, 14 September 1833 and 31 December 1834, in reference 10, pp. 62, 71, 99. "The most maddening thing is," he wrote in the latter letter, "somewhat upset by the oxamide business, in my paper on the constitution of ether I permitted myself some expressions of a personal nature against Dumas, which I should not have done ... The devil take these accursed affairs." Even earlier (28 December 1831, *ibid.*, p. 25) Liebig expressed great contrition over a published critique of some work of O. B. Kühn: "I will write no more critiques as long as I live," he vowed.
14. Liebig to [C. F. Kuhlmann], 23 April 1850, Archives of the Académie des Sciences, Paris (Dossier Liebig in the Fonds Dumas).
15. *Ibid.* (additional letters from Liebig to Dumas); reference 10, pp. 276-78; Liebig to Wöhler, 1 June 1850, in A. W. Hofmann, ed., *Aus Justus Liebig's und Friedrich Wöhler's Briefwechsel in den Jahren 1829-1873*, 2 Vols., Vieweg, Braunschweig, 1888, in Vol. 1, pp. 352-53.
16. Kolbe to Vieweg, 21 July and 31 December 1862, 19 October 1863, 31 December 1864, and 18 March, 5 and 16 May 1866, Vieweg Verlag archive, Wiesbaden, Kolbe file (hereafter abbreviated "VA"), letters numbered 184, 187, 196, 213, 242, 243, and 245. The passage quoted is from Kolbe to Frankland, 27 May 1866, frame 01.02.1558, Frankland archive.
17. Kolbe to Frankland, 23 July 1866, frame 01.02.1505, Frankland archive; Kolbe expressed similar sentiments in his letters to Vieweg, 9 and 22 July 1866, VA 246 and 247.
18. A. Wurtz, "Histoire des doctrines chimiques depuis Lavoisier," in A. Wurtz, ed., *Dictionnaire de chimie pure et appliquée*, 3 Vols. in 5, Hachette, Paris, 1868-78, volume 1, pp. i-xciv, on p. i (republished monographically in 1869).
19. H. Kolbe, "Über den Zustand der Chemie in Frankreich," *J. prakt. Chem.*, **1870**, *110*, 173-83.
20. Kolbe to Liebig, 12 November 1870 and 2 December 1870, Bayerische Staatsbibliothek, Munich, Liebigiana IIB, Kolbe letters nos. 30 and 31.
21. "Die Franzosen sind doch wirklich eine Nation von halb Kindern, halb Wahnsinnigern. Ich habe in mir tiefen Hass und Verachtung gegen die Franzosen gehabt, aber für so entcivilisirt roh und gemein, wie man sie jetzt kennen gelernt hat, hatte ich sie doch

nicht gehalten. Ich glaube, Frankreich ist stark im Untergange begriffen, und kommt nie wieder auf einen grünen Zweig ... Ehre hat überhaupt bei der ganzen Nation keinen Werth, nur gloire." Kolbe to Franz Varrentrapp, 26 February 1871, VA 267.

22. Kolbe to Frankland, 26 December 1870, frame 01.04.645, Frankland archive. Frankland had regretted to see that "there is far too much Gottes Gnaden in [Wilhelm's] nature," and predicted that "in form & constitution the German Despotism will be worse than the French;" still, he thought that in the results of the war "the rest of the world will be greatly benefitted ... unless indeed (which is not likely) the German people, excited by victory, turn to be a warlike, instead of a peaceful people" (Frankland to Kolbe, 23 December 1870, SSDM 3564).

23. H. Kolbe, "Haltung der Pariser Akademie der Wissenschaften," *J. prak. Chem.*, **1872**, *113*, 225-26; idem, "Chemischer Rückblick auf das Jahr 1872," *ibid.*, **1873**, *114*, 461-70. See also Kolbe's letters to Frankland of 18 March 1872 (Frankland Archive, frame 01.02.948), and to Liebig of 4 April 1872 (see next note).

24. "Meine Verachtung gegen die ganze heutige französische Chemikerwelt fängt mehr und mehr an, sich in Mitleiden zu verwandeln. Auch die Pariser Akademie [sic] scheint gar keine Ahnung davon zu haben, wie lächerlich sie sich von der Gelehrtenwelt durch diese erbärmlichen Zankereien macht, wozu Herr Pasteur das Ferment bildete. Verzeihen Sie meine Expectoration. Das Gebahren dieser verlogenen und verlorenen Nation macht mich zuweilen etwas leidenschaftlich." Kolbe to Liebig, 4 April 1872, Bayerische Staatsbibliothek, Liebigiana IIB, Kolbe letter no. 35. For the allusion to Pasteur, see above, note 3.

25. Liebig to Emma Muspratt, 27 September 1870, H. E. Roscoe Collection, Royal Society of Chemistry, London ("Die Franzosen bei ihrer wahnsinnigen Eitelkeit ..." will surely lose the war); Liebig to Wöhler, 25 September 1870, in Hofmann, reference 15, vol. 2, p. 299 ("Die Franzosen haben sich als ein so verrottetes Geschlecht gezeigt ..."); Liebig to Kolbe, 2 October 1870, SSDM 3614 ("Der Grössen-Wahnsinn dieser unglücklichen Nation ist freilich zu allem fähig").

26. Liebig to Wöhler, August 1870, in Hofmann, reference 15, vol. 2, p. 295.

27. "Hundevoik, diese Franzosen," Kekulé to Hans Hübner, 15 July 1870, August-Kekulé-Sammlung, Institut für Organische Chemie, Technische Hochschule, Darmstadt; cited in Wotiz and Rudofsky, reference 5, n. 6, p. 31. Wotiz and Rudofsky use the phrase "sons of bitches" to translate the German "Hundevoik." Here they have committed the common error of preferring a more literal to a connotatively more accurate translation. In fact, "Hundevoik" is undocumented in the German language. "Hunde-" is simply a negatively intensifying prefix, and has none of the connotations of profanity that the English expression "son of a bitch" has.

28. H. Kolbe, "Chemischer Rückblick," reference 24, pp. 465-66.

29. "Welche Blamage wieder mit Cahours, was soll nur das internationale Cokettiren mit Frankreich? Hofmann ist leider in England das Vaterland abhanden gekommen." Kolbe to Varrentrapp, 22 January 1873, VA 304.

30. "... ich verhehle mir nicht, dass wenn Preussen so fortfährt, die

Chemie zu ruinieren ... so wird bald die Zeit wiederkehren, wo, wie im zweiten Jahrzehnt dieses Jahrhunderts, die deutschen Chemiker, um sich in der Chemie auszubilden, nach Paris gehen. Wie damals, wo in Deutschland alles sich für Hegel-Schellingsche Naturphilosophie begeisterte, dieser Schwindel in Frankreich gar keinen Boden fand und Frankreich eben dadurch in der Wissenschaft uns weit überragte, so halten sich auch jetzt die französischen Chemiker, mit alleiniger Ausnahme von Wurtz, von dem naturphilosophischen Schwindel der modernen Struktur- und Bindungsschemie frei, und sie werden dadurch einen Vorsprung vor uns gewinnen." Kolbe to Volhard, 9 June 1876, SSDM 3681.

31. "... die tendenziösen Fälschungen des Sachverhaltes, welche Kekulé in seinem unverdient hochangesehenen Lehrbuch, das in Wirklichkeit ein liederliches Machwerk voller Unwahrheiten und bewusster Entstellungen ist ..." Kolbe to H. Vieweg, 6 November 1882, VA 482.

32. A. Wurtz, "Eloge de Laurent et de Gerhardt," *Moniteur scientifique*, **1862**, *4*, 482-513 (also an offprint separate); "Histoire générale des glycols," in Société Chimique de Paris, *Leçons de chimie professées en 1860*, Hachette, Paris, 1861, pp. 101-39; "On Oxide of Ethylene, Considered as a Link between Organic and Mineral Chemistry," *J. Chem. Soc.*, **1862**, *15*, 387-406; *Leçons de chimie professées en 1863*, Hachette, Paris, 1864; identical to *Leçons de philosophie chimique*, same publ. and date); *Cours de philosophie chimique*, privately printed, Paris, 1864; *Leçons élémentaire de chimie moderne*, Masson, Paris, 1867-68; *Dictionnaire de chimie pure et appliquée*.

33. See L. Graham, W. Lepenies, and P. Weingart, eds., *The Functions and Uses of Disciplinary Histories*, Reidel, Dordrecht, 1983. For the discipline of chemistry, see also J. Weyer, *Chemiegeschichte von Wiegleb (1790) bis Partington (1970)*, Gerstenberg, Hildesheim, 1974; and C. A. Russell, "'Rude and Disgraceful Beginnings': A View of History of Chemistry from the Nineteenth Century," *Brit. J. Hist. Sci.*, **1988**, *21*, 273-94, on pp. 288-94, who has some additional apposite examples.

34. H. Kopp, *Entwicklung der Chemie in der neueren Zeit*, Oldenbourg, Munich, 1873. The work was published in three parts, beginning in 1871. A discussion of this work in a Kolbean context is my "'Between Two Stools': Kopp, Kolbe, and the History of Chemistry," *Bull. Hist. Chem.*, **1990**, *7*, 19-24.

35. See, for example, J. Volhard, *Justus von Liebig*, 2 Vols., Barth, Leipzig, 1909, vol. 2, pp. 418-22.

36. Liebig to Wöhler, 30 September 1870, in Hofmann, *Briefwechsel*, reference 15, Vol. 2, p. 300.

37. Liebig to Wöhler, 7 December 1870, in *ibid.*, p. 304.

38. Liebig, "Eröffnungsworte ... nach dem Friedensschluss," 28 March 1871, in *Reden und Abhandlungen*, Winter, Leipzig and Heidelberg, 1874, pp. 331-33; excerpted by Volhard, reference 36, 420-22.

39. Liebig to Wöhler, 24 May 1845, in Hofmann, *Briefwechsel*, reference 15, Vol. 1, p. 257.

40. W. H. Brock, "Liebig, Wöhler, Hofmann: An English Perspective," in W. Lewicki, ed., *Wöhler und Liebig: Briefe von 1829-1873*,

Cromm, Göttingen, 1982, pp. xvi-xviii (this is a photographic one-volume republication, with new front matter, of Hofmann's edition of the Liebig-Wöhler correspondence).

41. S. Kapoor, "Jean-Baptiste Dumas," in C. Gillispie, ed., *Dictionary of Scientific Biography*, Vol. 4, Scribner's, New York, 1971, 242-48 (on p. 243).

42. On which see L. R. Graham, *Science and Philosophy in the Soviet Union*, Knopf, New York, 1972; and A. D. Beyerchen, *Scientists Under Hitler: Politics and the Physics Community in the Third Reich*, Yale University Press, New Haven, 1977.

43. K. Hufbauer, *The Formation of the German Chemical Community (1720-1795)*, University of California Press, Berkeley, 1982, pp. 96-144.

44. H. G. Schneider, "The 'Fatherland of Chemistry': Early Nationalistic Currents in Late Eighteenth Century German Chemistry," *Ambix*, 1989, 36, 14-21; A. J. Rocke, "The Reception of Chemical Atomism in Germany," *Isis*, 1979, 70, 519-36.

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## THE CHEMISTS' WAR

### The Impact of World War I on the American Chemical Profession

*David J. Rhees, The Bakken Library and Museum*

World War I was one of those momentous and horrifying events in American history that permanently reoriented, even revolutionized, American society. Indeed, it is difficult for us today to imagine the profound shock experienced by Americans in general and chemists in particular upon the outbreak of the war with Germany - that most scientific of all nations - in August 1914. Various known as the European War, the Kaiser's War, the Great War, the Great Crusade, and, of course, the Chemists' War, it was a major turning point in Western civilization, marking the actual, if not the chronological divide between the Victorian world of the 19th century and the modern world of the 20th - a divide, a fault line, that was simultaneously social, political, economic, cultural, and moral.

In the standard accounts of the history of American science, however, World War I is usually overshadowed by its even more destructive successor. Understandably, the development of radar, the synthetic rubber project, and the Manhattan

Project have captured the lion's share of historians' attention. I certainly would not dispute the importance of the Second World War in giving rise to Big Science, characterized by large-scale team research, close relations with industry, and heavy reliance upon government (especially military) funding. Nevertheless, I would like to suggest that insufficient attention has been paid to the importance of the First World War in terms of its impact upon the scientific profession, particularly the chemical profession. After all, chemistry played an extremely important role in the production of high explosives, poison gas, optical glass, synthetic coal-tar dyes and pharmaceuticals, and other chemical products of direct or indirect military value.

Although historians of science and technology are more or less familiar with how chemistry changed the war, relatively little is known about how the war changed chemistry (or, more precisely, the chemical profession), and it is the latter which constitutes the subject of this paper. Even though the United States was involved in the Great War for only 18 months (from April 1917 to November 1918), I wish to argue that it affected the American chemical community in five important ways:

1. *Industrialization*: The war greatly accelerated the growth of the American chemical industry, thus enhancing the financial and ideological importance of industry to the chemical profession.

2. *Militarization*: The war resulted in the development of strong ties between the chemical profession and the military establishment.

3. *Politicization*: The war jolted chemists out of their ivory-tower, laissez-faire mentality and led them to engage in aggressive political lobbying for the first time.

4. *Nationalization*: The war stimulated a surge of patriotism in the chemical community which helped build morale and pride in the achievements of American chemistry, but which at times degenerated into strident nationalism and nativism.

5. *Popularization*: The war engendered a new self-consciousness among chemists and a new awareness of their public image which led to a vigorous campaign to popularize chemistry.

Before I proceed to discuss these five trends, a few qualifications are in order. First, this analysis can only suggest the broad lines of change and is intended to be suggestive rather than comprehensive. This is particularly true of my necessarily brief discussion of the role of chemistry in the war, which, of course, is fundamental to any understanding of the impact of the war on chemistry. Secondly, I do not wish to overemphasize the importance of the war, for nearly all of the five trends I have identified had their origins in the prewar era. My point is simply that the war dramatically and decisively accelerated the pace of these trends. And third, I do not wish to imply that other scientific disciplines played trivial roles in the war. The important work of American physicists on submarine detection devices and of psychologists on Army "intelligence" tests, to cite but two examples, are well known. Nonetheless, of all