CHEMISTS FOR THE COMMON GOOD (1)

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Introduction

Martin Heinrich Klaporth (1743-1817) was the most famous German chemist in the last third of the eighteenth century. He was well known in Europe as an excellent analytical chemist, discoverer and inventor. In 1789 he discovered uranium (in the form of oxide) and what was called "earth of zirconium," that is, zirconium dioxide. In the years to follow he discovered or rediscovered six additional substances: strontia (1793), earth of titanium (titanium dioxide, 1795-97), tellurium (1798), chromium (1798), beryllia (1801), and ceria (1804) (2). Throughout his chemical career Klaproth analyzed, qualitatively and quantitatively, more than 200 substances, most of mineral origin. In each single case "analysis" meant a true research program consisting of numerous experiments (3).

Klaproth carried out most of his experiments in his pharmaceutical laboratory. He was not just a chemist but also an apothecary, who ran his shop until 1800 when, aged 57, he became the director of the laboratory of the Royal Prussian Academy of Sciences. Klaproth came from humble origins. The son of a tailor, he completed a pharmaceutical apprenticeship training (from 1759 until 1764), followed by seven years of service as a journeyman. The famous chemist had neither visited a university nor received any other formal academic education. In 1780, through his marriage to a niece of the Berlin apothecary-chemist Andreas Sigismund Marggraf (1709-1782), he came into sufficient funds to buy his own apothecary's shop in the city of Berlin. In the two decades that followed, his shop prospered both economically and scientifically. Klaproth produced and sold all kinds of remedies as well as luxury goods and chemicals. The eighteenth-century pharmaceutical laboratories belonged to the precursors of the nineteenth-century chemical industry. But Klaproth's reputation as a chemist also grew apace. His private lectures on chemistry became the latest fashion among Berlin's intellectual elite. In 1782, he received a teaching position at the Medical-Surgical College of Berlin (*Collegium medico-chirurgicum*), followed (in 1784) by a salaried teaching position at the Mining Academy of Berlin and another teaching position (in 1787) at the Artillery School of General G. F. v. Tempelhoff (renamed Royal Artillery Academy in 1791), which earned him the title of professor (4). In 1788, he was elected to the Royal Prussian Academy of Sciences, and in 1810, he was appointed the first professor of chemistry at the newly founded University of Berlin.

Parallel to his increasing fame as a chemist, Klaproth also became involved in public service, first as a member of Prussia's highest medical board (in 1782), and then as a consultant to Prussian Minister Friedrich Anton von Heinitz (1725-1802). Beginning in 1786, Minster von Heinitz, who also headed the Department of Mining and Smelting Works in the Prussian government (*Generaldirectorium*), frequently sought Klaproth's chemical and technical counsel concerning industrial inspections and useful practical projects such as Achard's project to extract sugar from beets. Thus the year 1786 seems to have been "the crucial year" in the chemical career of the German Lavoisier. For it was at precisely this time that his research interests turned to mineral analysis and chemical mineralogy. He then designated himself a chemical mineralogist. By contrast, before this time he had studied a broad variety of different subjects, including pharmaceutical preparations (5).

Klaproth understood chemistry as a scientific endeavor that contributed to our understanding of nature, and at the same time as an enterprise that contributed to technological improvement and innovation. Like many scientists of his time, he participated in a social movement that defined technical innovation as a crucial factor for promoting "the common good" (*Gemeinwohl, gemeiner Nutzen*) and social progress. In the last third of the eighteenth century, Prussian chemists and other scientists frequently talked about "useful knowledge," "useful science," "technical progress," and "the common good" (6). They viewed chemistry and chemical mineralogy to be particularly useful knowledge for the Department of Mining and Smelting Works, which directed the Prussian mines and foundries as well as factories linked to mining, such as the Royal Prussian Porcelain Manufactory. Was their talk about useful chemical knowledge mere rhetoric? Or did it have consequences for doing chemistry? My answer to the latter question is a clear Yes, and I want to show this in the next part by discussing briefly Klaproth's discovery of uranium.

Klaproth's Discovery of "Uranium" and the Invention of "Uranium Yellow

Klaproth discovery of "uranium" relied on long series of experiments in which he analyzed the ore pitchblende, first in the dry way and then in the wet way, using a broad variety of different reagents and analytical techniques (7). When the result of an experiment was ambiguous, he repeated it and performed additional experiments using alternative reagents. After dozens of experiments he was convinced that he had isolated from pitchblende a novel "metal calx" (later: metal oxide). He then tried to reduce the metal calx to a metal. In this final part of his investigation he encountered obstacles. Thus, in his publications, Klaproth openly admitted that his final experiments did not yield absolutely clear results, but ultimately he concluded that he had discovered a novel metal, which he named "uranium" after the planet Uranus discovered by Herschel in 1781 (8). Today we know that Klaproth's uranium was actually uranium dioxide, and that it was Eugène Melchior Peligot (1811-1890) who actually prepared metallic uranium in 1841.

In the very same two publications from 1789 in which Klaproth announced his discovery of uranium to the Republic of Letters, he also announced a new invention—or the incipient work on an invention: the use of "uranium calx" (later: uranium oxide) for coloring glass and porcelain. It was not just a lucky guess by Klaproth that uranium calx might be used as a new color to decorate glass and porcelain. Nor was it just his outstanding experimental skill that enabled him to separate uranium calx from pitchblende. For both his discovery and his invention, the social milieu in which he worked played a crucial role. Pitchblende was an extremely rare mineral, found only in certain mines in Saxony, Bohemia and Sweden. Klaproth experimented with two specimens of pitchblende, which came from a mine (named *Georgwagsfort*) located in the town of Johanngeorgenstadt in Saxony, and from two mines (named *Sächischer Edelleutstollen* and *Hohe Tanne*) located near Joachimsthal in Bohemia. He had access to these materials through his connections to Minister von Heinitz. Since 1786 he had become a member of the inner circle of this influential minister, who directed the Department of Mining and Smelting Works. Just a year before his discovery, in summer 1788, he had traveled to the Saxon towns of Dresden and Freiberg, visiting mines and the famous Mining Academy of Freiberg, where the mineralogist Abraham Gottlob Werner (1749-1817) was teaching. Werner had analyzed pitchblende before Klaproth, and it is very likely that Klaproth received the specimen of pitchblende from him. Clearly, Minister von Heinitz, who had been a leading Saxon mining official from 1763 until 1774, had paved the way for this important visit.

Likewise, Klaproth's role as a consultant to Minister von Heinitz also conditioned his investigation of the practical use of uranium calx. Since 1787 Klaproth had been a member of a committee that inspected the laboratory of the Royal Prussian Porcelain Manufactory, where the pigments for decorating porcelain were prepared (9). Almost all of these pigments were metal calces or metal oxides in our terminology. As uranium calx had a nice yellow color, it was not too far-fetched to assume that one might use it as a new color for porcelain as well as glass, which has properties similar to porcelain. In his publications of 1789, Klaproth described six experiments that "examined the coloring properties" of uranium calx. Three years later, a laboratory worker of the Porcelain Manufactory named Friedrich Bergling, who was a pupil of Klaproth and his experimental collaborator at the manufactory (in the context of the inspection committee), reported on the results of further experiments (10). He had succeeded in preparing a new pigment yielding "a nice yellow color" on porcelain (11). Well into the nineteenth century, the Royal Prussian Porcelain Manufactory used the radioactive "Urangelb" to decorate its products.

Franz Carl Achard's Projects

When Klaproth entered the laboratory of the Royal Prussian Academy of Sciences as its new director in April 1801, he was shocked. The floor, the walls and the ceiling of the lab were covered with an ugly brownish substance. Literally everything in the room was filthy. He immediately sent a letter to the directors of the Academy requesting the "quick re-organization of the academic building" as "benefits the honor of the Academy" (12). It was one of the few occasions on which he was truly outraged, but he was partly responsible for the situation. In the year before, he had performed experiments with his friend Franz Carl Achard (1753-1821) on the production of sugar from the syrup of sugar beets. These experiments were carried out on a large technological scale. For this purpose, the Academy's laboratory was rebuilt and equipped with new instruments and officially renamed "sugar beet factory." The experiments in the academic sugar beet factory were crowned with success, yielding several hundred "centner" of sugar (a "centner" is 50 kilograms). Less welcome, however, were the proliferating traces of the large-scale experiments, which had affected not only the laboratory room, but also the apartments of the Academy's chemist and astronomer located in the second floor of the building. While the apartments could be renovated, the state of the laboratory was so desperate that the Academy decided to built a new one.

In spring 1801 Achard, who had been the director of the academic laboratory before Klaproth, was establishing a real sugar beet factory in Silesia. His invention of beet sugar is well known today, but it is by no means his exclusive invention. Achard was perhaps the most energetic academic inventor and researcher in late eighteenth-century Prussia (13). He came from a wealthy family of Huguenots, and, like Klaproth, he had never visited a university. In 1776, at the age of 23, he became Andreas Sigismund Marggraf's laboratory assistant and a member of the Royal Prussian Academy of Sciences. From Marggraf he learned careful chemical experimentation and further received important incentives for his invention of beet sugar. In 1747, Marggraf had discovered that certain kinds of native plants (such as *beta vulgaris*) contained sugar that was identical with the expensive, imported cane sugar. The discovery was made in the context of systematic series of experiments, whose goal to isolate and identify those "proximate components" of plants that caused their sweet taste. These types of experiments were typical for the new field of "plant and animal chemistry," the predecessor of modern organic chemistry (14). Like Klaproth's discovery of uranium, Marggraf's discovery was made in a pharmaceutical laboratory, as Marggraf was also an apothecary (15).

After Marggraf's death, in August 1782, Achard became director of the Academy's laboratory and of its physical class. Yet Achard did not restrict himself to a purely academic life. The Academy of Sciences strongly supported all kinds of combinations of natural research and technological investigation. It encouraged its members to carry out work of invention and participate in practical projects for the state. Most of the members of the physical and mathematical classes of the Academy were not just scientists, but also technical experts and inventors, many of whom were also civil servants in the newly created state departments that directed manufacture, mining, civil architecture, and forestry. Thus, from the beginning of his membership in the Academy, Achard undertook various kinds of useful technological projects. To these belonged the installation of lightning conductors, the examination of building materials, the preparation of new kinds of alloys, the cultivation of exotic tobacco, and the invention of new colors for the Royal Prussian Porcelain Manufactory (15). One of his inventions was *bleu mourant*, a light blue color that had previously been used exclusively at the Royal Porcelain Manufactory of Sèvres. Achard's private life was no less turbulent. He financed many of his technical projects privately, and he went deeply into debt for this purpose. And there were other kinds of temptation. In 1776, the same year he became a member of the Academy of Sciences, he apparently married the wrong woman: she came from a craftsman family, was divorced, and nine years older than himself. In 1784, their marriage ended in divorce. The reasons for this became clear only three years later, when the wife's daughter from her first marriage, then aged seventeen, gave birth to a child by Achard. He and the young lady lived together for many years without getting married, but this second relationship eventually ended in similar circumstances as the first. Achard was attracted to a pretty maid working in the shared household and entered into a new relationship, again without marriage. Needless to say, the directors of the Academy were not terribly pleased by this conduct, but they always helped their members get out of trouble. As a member of an old and influential family of Huguenots, Achard also received support directly from Friedrich II. It was the king himself who had encouraged him to reinvent *bleu mourant* for his Royal Porcelain Manufactory and to cultivate American and Asian tobaccos.

In 1782 Achard bought an estate in the village of Kaulsdorf, east of Berlin, where he began cultivating "sugar beets" with a higher concentration of sugar than the available species of beets. This was the first, agricultural part of his work to invent beet sugar, which took more than ten years. From 1790, he continued the cultivation of sugar beets in a new estate in *Französisch Buchholz*, a Huguenot settlement near Berlin. In 1798, when he published the results of his trials, he wrote to the king that he hoped to have "been useful to the economy of his fatherland." In another letter he wrote that it was his "most ardent wish" that his "work was *gemeinnützig*," that is, promoting the common good (16). One year later, he started the second part of his project: the extraction of sugar from the syrup of sugar beets on a large technological scale, which eventually led to the transformation of the Academy's lab into a "sugar beet factory" and its unwanted consequences.

As I mentioned before, after Achard had begun to establish a sugar beet factory in Silesia, Klaproth became his successor as the director of the Academy's laboratory. A decade later, Klaproth's scientific career culminated in his nomination as the first professor of chemistry at the newly founded University of Berlin. In 1814, at the age of 71, Klaproth suffered a severe stroke, but he continued his lectures at the Berlin University until his illness forced him to retire in 1816. In the time remaining until his death on 1 January 1817, he tried to sell his collection of chemical instruments and preparations to the Prussian state. As a man who had always tried to serve the common good and his "Vaterland," he had privately financed a large part of his research and teaching equipment. In December 1816 he wrote in a letter to the king that his life would soon end and that he hoped that after his death his chemical collection would not be divided into parts and spread outside of the country. It was his "greatest wish," he stated, to submit it as a whole to his "Vaterland." "If I had no children," he continued, "I would sacrifice this beautiful collection to my fatherland" (17). In the next section I will shed light on the social movement in which terms like fatherland and the common good figured prominently.

The Social Movement

After the so-called Wars of Liberation (1813-1815) against Napoleon, the word "Vaterland" cropped up more frequently. For the majority of aristocratic landowners it referred to Prussia, while for the liberals it meant Germany, which was not yet a unified state but divided into dozens of small German-speaking states. In any case, in the decades around 1800 talk about "Vaterland" did not yet serve to legitimize political hegemony and imperialism. It was only after the unification of Germany in 1871 that "Vaterland" acquired a chauvinist connotation. The discourse about the "the common good" was significantly older than that on "Vaterland." It went back to seventeenth-century cameralism and the Enlightenment, but also acquired new facets in the context of nation-state building, the expansion of state bureaucracy, and the establishment of technological schools around 1800. For the liberals participating in the latter discourse, terms like "the common good" and fatherland pointed to more or less the same goals of social and educational reform (18).

Achard and Klaproth were very different individuals, but their social role, and the goals, interests and ideals connected to it, were largely identical. The two men participated in a social and cultural movement that held knowledge and the improvement of technology to be the most promising ways to promote the fatherland and the common good. They struggled to realize an ideal shared by most members of the Royal Prussian Academy of Sciences: the public man serving the common good (*Ideal des gemeinnützigen Mannes*). Acquisition of "useful knowledge" was an important element of the strategy to improve technology for the good of society. The Academy's chemists, in particular, were engaged in numerous useful projects and civil service. Friedrich Hoffmann (1660-1742), Caspar Neumann (1683-1737), Johann Heinrich Pott (1692-1777), Andreas Sigismund Marggraf, Franz Carl Achard, Martin Heinrich Klaproth, Carl-Abraham Gerhard (1738-1821) and Sigismund Friedrich Hermbstaedt (1760-1833) were not just chemists but also inventors, technical experts and consultants to the state. These men asked for neither privileges (or patents) for their inventions nor any financial gratification. On the contrary, they often invested private money in their projects. In correspondence with their technological endeavors, their scientific interests focused on experiments, empirical knowledge about substances, generalized concepts and empirical rules about types of reactions, chemical affinities, and chemical analysis, including quantitative analysis. In the last third of the eighteenth century these chemists were also engaged in the institutionalization of technological research and teaching. In so doing, they contributed to the newly emerging chemical subdisciplines of "metallurgical chemistry" and "technical chemistry" as well as to the so-called "useful sciences" like mining and agriculture (19).

In the discourse about useful knowledge and the common good, neither "useful knowledge" nor "the common good" were sharply defined terms. But in the eighteenth century the meaning of these two terms was more or less evident to everybody. "Useful knowledge" was directed towards mundane practices and improvements to technology (20). Thus it was clearly demarcated from high theory, natural theology and abstract philosophy of nature. It was further distinguished from everyday beliefs and from those parts of artisanal knowledge that were clearly restricted to local observation and narrowly defined local interests. However, "useful knowledge" by no means excluded artisanal knowledge *per se*. On the contrary, it included all kinds of articulated and more generalized experiential knowledge, originating in academic and artisanal or in industrial contexts.

Likewise, talk of "the common good" and "civil service" promoting the common good conveyed a clear message, although these terms were not clearly defined. The message was political, and it was paralleled by the emergence of the modern nation-state and state departments promoting industry, the military, and civil service. In continental Europe these deep historical changes began while absolutism was still flourishing. Thus talk of "the common good" and civil service meant a reorientation away from the absolutist king and towards civil society. In Prussia, unlike France, this discourse did not feed into a political revolution, but it helped to achieve more modest political and social reforms in the early nineteenth century.

Conclusion

Like their European colleagues, late eighteenth-century Prussian chemists performed technological experiments and work of invention. Franz Carl Achard transformed the laboratory of the Royal Prussian Academy of Sciences into a "beet factory" in order to test the production of beet sugar on a large technological scale. Martin Heinrich Klaproth, who had discovered uranium in 1789, performed experiments with a laboratory worker (*Laborant*) of the Royal Prussian Porcelain Manufactory in order to prepare "uranium yellow" to be used for decorating porcelain. All Prussian chemists argued for the usefulness of chemistry, and they further highlighted distinct parts of chemistry—"metallurgical chemistry," "technical chemistry," "applied chemistry" and analytical methods—that matched with practical fields. In the eyes of these chemists, chemical knowledge was an indispensable part of useful knowledge, technological innovation and progress, which would promote the economy of their fatherland and the common good. Around 1800, "fatherland" and "the common good" were key words in the discourse about the usefulness of knowledge and the promotion of the common good. A century later, these words still played an important role, but their meaning had been transformed. When Fritz Haber performed research on chemical weapons for the sake of his fatherland and the common good, nationalism and imperialism had radically changed the originally liberal meaning of these two terms.

References and Notes

1. HIST Award Address, presented at the 252nd National Meeting of the American Chemical Society, Philadelphia, PA, August 23, 2016, HIST 34.
2. See also J. R. Partington, *A History of Chemistry*, 4 vols., Macmillan, London, 1961-1970, vol. 3, 656f.
3. This paper is based on U. Klein, "Klaproth's Discovery of Uranium," in U. Klein and C. Reinhardt Eds., *Objects of Chemical Inquiry*, Science History Publications, Sagamore Beach, MA, 2014, 21-46; U. Klein, *Humboldts Preußen, Wissenschaft und Technik im Aufbruch*, Wissenschaftliche Buchgesellschaft, Darmstadt, Germany, 2015, and U. Klein, *Nützliches Wissen, die Erfindung der Technikwissenschaften, Wallstein*, Wallstein, Göttingen, 2016. For a biography on Klaproth see also G. E. Dann, *Martin Heinrich Klaproth (1743-1817): Ein deutscher Apotheker und Chemiker, sein Weg und seine Leistung*, Akademie-Verlag, Berlin, 1958.
4. The Berlin "Mining Academy," founded in 1770, was not a true academy or school but rather a series of lectures organized and funded by the Mining and Smelting Department; see U. Klein, "Ein Bergrat, zwei Minister und sechs Lehrende: Versuche der Gründung einer Bergakademie in Berlin um 1770," *NTM Zeitschrift für Geschichte der Wissenschaften, Technik und Medizin,* **2010**, *18*, 437-468. See Ref. 3, (2015) and (2016).
5. Klaproth collected his most important experimental essays in book form, entitled *Beiträge zur chemischen Kenntniss der Mineralkörper* (1795-1810). By 1810 the six volumes of this book comprised a total of 207 experimental essays, which dealt with nearly the same number of different mineralogical species along with their chemical analysis.
6. See Ref. 3 (2016).
7. These experiments are described in detail in Ref. 3 (2014).
8. See M. H. Klaproth, "Chemische Untersuchung des Uranits, einer neuentdeckten metallischen Substanz," *Ann. Chem.,* **1789**, part 2, 387-403; M. H. Klaproth, "Mémoire chimique et minéralogique sur l'Urane," Mémoires de L'Académie Royale des Sciences et Belles Lettres **1786/87**, 160-174; the latter paper appeared in 1789 as

well.

9. One of the goals of this committee was to foster improvements of pigments used for overglaze painting on porcelain. This included the organization of written, reliable recipes for the preparation of long-used pigments as well as the invention of new pigments that extended the spectrum and shades of colors. See U. Klein, “Chemical Experts at the Royal Prussian Porcelain Manufactory,” *Ambix,* **2013**, *60*, 99-121; U. Klein, “Depersonalizing the Arcanum,” *Technology and Culture,* **2014**, *55(3)*, 591-621; U. Klein, “Chemical Expertise: Chemistry at the Royal Prussian Porcelain Manufactory,” *Osiris*, **2014**, *29*, 262-282.
10. Königliche Porzellan-Manufaktur archive, XVII.12, folios 51-59.
11. Ref. 10, folio 58. Uranium yellow (*Urangelb*) is mentioned in a table of porcelain colors from 1838 by the manufactory’s director Georg Friedrich C. Frick; see E. Köllmann and M. Jarchow, *Berliner Porzellan*, *Textband*, Klinkhardt & Biermann, Munich, 1987, p 323 (color number 28 of the table).
12. Archive of the Berlin-Brandenburg Academy of Sciences I-XIII-26, folio 11.
13. On Achard, see also H.-H. Müller, *Franz Carl Achard (1753-1821), Biographie*, A. Bartens, Berlin, 2002.
14. F. L. Holmes, *Eighteenth-Century Chemistry as an Investigative Enterprise,* University of California Press, Berkeley, 1989. U. Klein, “Shifting Ontologies, Changing Classifications: Plant Materials from 1700 to 1830,” *Stud. Hist. Phil. Sci.*, **2005**, *36A*, 261-329. U. Klein and W. Lefèvre, *Materials in Eighteenth-Century Science: A Historical Ontology,* MIT Press, Cambridge, MA, 2007.
15. See Ref. 3 (2015).
16. Quoted in Müller, Ref. 13, p 165.
17. Geheimes Staatsarchiv Preußischer Kulturbesitz, I. HA, Rep. 76 Kultusministerium, Abt. Va, Sekt. 2, Tit. X, Nr. 17, folio 12.
18. For more details, see Ref. 3 (2015).
19. See P. M. Jones, *Agricultural Enlightenment: Knowledge, Technology, and Nature, 1750-1840*, Oxford University Press, Oxford, 2016. Ref. 3 (2016).
20. For more details, see U. Klein, “‘Useful Knowledge’—‘Useful Science’,” in T. Morel, G. Parolini, and C. Pastorino, Eds., *The Making of Useful Knowledge*, Preprint 481 of the Max Planck Institute for the History of Science, Berlin, 2016, pp 39-48. Ref. 3 (2016).

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National Historic Chemical Landmarks

The National Historic Chemical Landmarks program is celebrating its 25th anniversary this year. A half-day symposium in its honor is scheduled for the HIST program at the 254th American Chemical Society meeting in Washington. The symposium is scheduled for Monday morning, August 21. The landmarks program began in 1992 as an effort of HIST and the ACS Office of Public Outreach, and it is currently under the ACS Committee on Public Affairs and Public Relations. The first Landmark dedicated by the program was on Leo Hendrick Baekeland and the Invention of Bakelite, at the National Museum of American History in Washington, DC, in 1993. The most recently dedicated Landmarks were on Chlorofluorocarbons and Ozone Depletion (at the University of California, Irvine) and the Mars Mariner Infrared Spectrometer (at the University of California, Berkeley) both in 2017. More information on the Landmarks program can be found at https://www.acs.org/content/acs/en/education/whatischemistry/landmarks.html