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The Public Cult of Natural History and Chemistry in the age of Romanticism

In einem Zeitalter wo man alles Nützliche mit so viel Enthusiasmus auffasst… (I. v. Born und F. W. H. v. Trebra)[1]

The chemical nature of the novel, criticism, wit, sociability, the newest rhetoric and history thus far is self-evident (F. Schlegel)[2]

Chemistry is of the most widespread application and of the most boundless influence on life (Goethe)[3]

In May 1800 the philosopher and theologian Friedrich Daniel Ernst Schleiermacher wrote his sister Charlotte that at the time he was attending in Berlin "lectures about all kinds of sciences, … among others about chemistry."[4] The "chemistry" to which he was referring were the regular public lectures given by the Berlin chemist and apothecary Martin Heinrich Klaproth starting in 1783. The theologian-philosopher's interest in chemistry was by no means superficial, as his lecture notes document.[5] What was it about chemistry of that time that fascinated Schleiermacher? Goethe's *Elective Affinity* ("Wahlverwandtschaft") immediately comes to mind, in which a tragic conflict between marital bonds and love is portrayed in the light of chemical affinities or "elective affinities," as do Johann Wilhelm Ritter's spectacular electrochemical experiments and speculations on natural philosophy. Yet a look at Schleiermacher's notes on Klaproth's lectures from the year 1800 immediately informs us that this would be mistaken. Very little mention of chemical theories can be found in Klaproth's lectures, let alone of speculative natural philosophy. In his lectures Klaproth betook himself instead to the multi-faceted world of material substances.

Schleiermacher's interest in chemistry, and particularly in Klaproth's empirical chemistry of material substances, was not an isolated case. On the contrary, is no exaggeration to state that around 1800 there was a true cult of chemistry in the German lands, comparable only to the public fascination with natural history, especially mineralogy and the history and description of the earth (later geology). In winter 1811/12 Arthur Schopenhauer attended Klaproth's lectures at the newly founded *Friedrich-Wilhelms-Universität* of Berlin.[6] Novalis, too, occupied himself intensively with chemistry, and among the works he studied were also the writings of Klaproth. In the works of Goethe, Schelling and F. Schlegel, too, chemistry played an important role, as in those of the English romantics S. T. Coleridge and W. Wordsworth.[7] In the years around 1800 philosophers and poets were not the only ones to render homage to chemistry. In fact, public chemistry lectures were a major attraction for audiences across professional, class and gender boundaries.[8] A letter to the editor of the journal *Chemische Annalen* ran the following report about Klaproth's chemistry lectures in Berlin: [9]

> You cannot believe how highly the study of chemistry is appreciated here right now, and your—writings—have contributed to this. People of all classes attend the chemical lectures; indeed, what is more, since this winter the regular listeners even include distinguished persons of the fairer sex. I do not know whether, outside our Berlin, any other town can boast the advantage of possessing such ladies who, out of the noble zeal of bettering themselves through chemical knowledge, are resolute enough to forgo coffee and gaming tables, assemblies, picnics and the like, and in their place to staunchly bear cold and heat, fumes and coal dust, and all other inconveniences of a chemical workshop?

There were similar reports from other cities, such as the royal seat of Weimar: "Now in Weimar one speaks of nothing else but *gas, oxigna, combustible substances, readily and rigidly fluid things*. All people of Weimar seem to want to become chemists and Weimar a great melting furnace."[10]

1. Overview of Klaproth's lectures

Klaproth was one of the most famous chemists of his day, praised for his factual knowledge about material substances, chemical analysis and the precision of his experiments. His main publication, *Beiträge zur chemischen Kenntniss der Mineralkörper* (1795–1810), is a six-volume compilation of 207 essays, which deal with nearly this number of different substances along with their chemical analysis. In a commemorative address before the members of the Royal Prussian Academy of Sciences in Berlin Klaproth was described as a chemist among whose treatises "there is not a single one through which we did not gain more precise knowledge of some natural or artificial product," who by means of his "perceptive invention of precise and more thorough methods of chemical analysis (*Scheidungswege*) " also "became acquainted with an abundance of new chemical elements (*Grundstoffe*)," and for whom the objective was always to establish "facts" in "experimental investigations."[11] Klaproth was the incarnation of an experimental chemist, who subjected hundreds of substances to precise chemical analysis and description. His lectures were oriented toward the huge realm of material substances and to experimental analyses, and this largely independent of the specificities of his audience. He dealt with such topics in the same way in his public lectures attended by laymen and women, which had no access to universities at the time, as he did in his lectures for technical professionals at the Berlin college of surgery, the *Collegium medico-chirurgicum*, the Mining Academy, the Artillery College, and for students at the *Friedrich-Wilhelms-Universität* founded in 1810. As far as hypotheses and theories were concerned, Klaproth was known as a skeptic. It proceeds from his lectures that while he placed great hope in the theory of chemical affinities, he held this theory to be incomplete. Thus Arndt and Virmond were right to state that, "with his renunciation of hypotheses and the restriction to experience, Klaproth stood in contrast to the conceptions of nature of the speculative philosophy of his day, but also to empirical natural scientists like the physicist J. W. Ritter, who interpreted his research findings in the sense of early romantic theories."[12]

This image of an analyst and an empirical chemist concerned with a multiplicity of material substances is also confirmed by Schleiermacher's notes about Klaproth's lectures in the year 1800.[13] Thus his notes on the first lecture, which take up 16 sheets of his handwriting, are concerned first with tin and tin compounds, then with a copper ore, and finally with sorrel acid; in the second, shorter record the subject is also tin and tin compounds. Schleiermacher's notes begin in the style of the treatises on substances of the chemistry textbooks of the day, with the natural deposits of a substance, its repositories and its technical extraction. This is followed by descriptions of experiments, in which, for instance, the behavior of tin and tin compounds in chemical reactions is investigated, and by remarks about the utility of the substances. In these descriptive parts along the lines of contemporary natural history, "Considerations" and "Questions" are interspersed, some of which came from Klaproth, but others from Schleiermacher himself.

To give an example of this, Schleiermacher describes one of Klaproth's demonstration experiments on "the vitrification of tinstone" as follows:[14]

> In this (same) fire was placed a small clay crucible with 180 grains of pulverized tinstone without any additives. But it did not reach fluency. This was managed afterward in the porcelain oven. The mass had become liquid, and had, as always happens during this work, a matte, brownish crust on the top edge, a trace of which even continued to spread over the [walls] of the crucible. Under it there was a pure, yellow glass. The lower part had the appearance as if it may well have been fluid, but had crystallized as dross thereafter. To others it appeared to contain a true dross, which was not investigated further.

This description of the experiment is followed by the "Considerations":

> Considerations. This decomposition was otherwise held to be impossible. Bergmann first specified a more or less successful method. He let the tinstone digest with concentrated sulfuric acid for a prolonged period at a high temperature and then added hydrochloric acid. But he reclaimed only a few percent of the tinstone. Instead of the acidic solvent, alkaline ones must be applied. Since in most cases these require a considerable degree of heat, otherwise they are used almost exclusively in the dry method, by smoldering the substances to be dissolved with alkali carbonate. Klaproth first successfully availed himself of liquid caustic solutions. The mixture (very hard minerals had to be pulverized first) is evaporated until it is dry and smoldered in an open fire. Klaproth explains the process through the fact that the treatment with alkali opens up the mineral to the effect of the acids, whereas Guiton [Mordeau] disallows it as anything more than a mechanical dissipation. Klaproth intends to respond to this. I do not really understand Klaproth's idea: For what does "open up" mean? and I cannot agree with Guiton's."[15]

This example was cited at full length in order to spell out the main object of Klaproth's lectures, namely technically detailed experiments related to the properties and the reactions of particular substances, which required of the listener a great deal of specialized interest and knowledge about chemical reactions and processes. But Schleiermacher, the preacher and philosopher, apparently followed these lectures with great attention, for he discussed Klaproth's chemical explanation of the experiment and awaited with suspense the rebuttal of the alternative, "mechanical" explanation of the French chemist Louis Bernard Guyton de Morveau.

The question posed at the beginning of this paper as to Schleiermacher's interest in chemistry becomes even more incisive against this backdrop. We have to ask not only what fascinated him and other members of Prussia's intellectual elite about chemistry in general, which would include theory and natural philosophy, but in particular why this fascination clearly extended to, and even focused on the empirical and analytical chemistry of material substances as represented by Klaproth. Is there an explanation for the cult of chemistry, and of the experimental, analytical chemistry of material substances, in the early romantic period? I will tackle this question from two different perspectives: first, from the perspective of cultural and philosophical history, which asks about the participation of early romantic writers and philosophers in the cult of chemistry; second, from a science history perspective that focuses on the broader public interest in chemistry along with an examination of chemistry's practical uses in late eighteenth-century Germany. This is, of course, an incomplete and selective treatment of a complex historical process, which can yield only an approximation to an explanation of the cult of chemistry in Germany around 1800.

2. Chemistry, Natural Philosophy and Poetry

The early romantic period is often portrayed as an era of anti-scientific attitudes characterized by a backlash against the rationalism and faith in science of the Enlightenment, as for instance by Hans Eichner, when he asserts: "romanticism is, perhaps predominantly, a desperate rearguard action against the spirit and the implications of modern science."[16] In such assessments the "modern sciences" are often equated with theoretical mechanics and physics, so that the question as to how early romanticism relates to the natural sciences can be dismissed as irrelevant by the mere mention that the romantics rejected the mechanical world view. Yet in contrast to this, a considerable number of studies has shown impressively that the early romantics did indeed occupy themselves quite intensively with the natural sciences of their day. In the decades around 1800 natural philosophy and poetry drew important impulses from chemistry, mineralogy, the sciences of the earth (geology) as well as from physiology, galvanism, and, from 1820 on, from electromagnetism —as can be seen in particular in the work of Goethe, Schelling, F. Schlegel and Novalis. In Schelling's natural philosophy chemistry played a key role, prompting F. Schlegel to remark that "the best in Schelling is a certain chemical obsession."[17] The theory of chemical affinity, or attraction and repulsion, which was almost universally accepted by chemists at the time, and the equally fundamental concept of the binary constitution of chemical compounds and electrochemical dualism, were developed further in Schelling's natural philosophy, where they were established as universal principles of a comprehensive system of nature. Chemistry took on a similarly central role in the natural philosophy essays by Novalis of the years 1797/98. Friedrich Schlegel, a close friend of both Novalis and Schleiermacher, also occupied himself with chemistry starting in 1798, although less intensively than Novalis and Schelling. As a close friend of Schleiermacher, who shared a dwelling in Berlin with him from 1797 on, he must have been affected the latter's curiosity about chemistry. And as we know, chemistry was an important source for Goethe's *Elective Affinities* (1809). Above and beyond this work, Goethe returned over and again throughout his life to the study of chemical experiments, facts and theories, and acted as a patron of chemists on manifold occasions. To demarcate the cultural and philosophical terrain that presumably piqued these men's interest in chemistry, in the following two sections I will explain in greater detail the chemical activities of Novalis and F. Schlegel.

Novalis

Novalis' occupation with chemistry is distinguished, among other things, by the fact that it was not restricted to only the main features of chemical concepts and theories, but also included the empirical chemistry of material substances. In his *Freiberger Naturwissenschaftliche Studien 1798/99* and his collection of materials for his encyclopedia of the same period, *Das Allgemeine Brouillon*, Novalis discussed a wide range of experiments on the chemistry of material substances, extending all the way to technical details and proposals for improving chemical instruments. He concerned himself with chemical and mineralogical classification; criticized methods by which his teacher in the Freiberg Mining Academy, Gottfried Abraham Werner, identified and classified minerals; made plans for a comprehensive collection of materials to compile a new encyclopedia of all sciences, and like Schleiermacher, drafted excerpts on the chemistry of material substances of M. H. Klaproth and of the French chemist and pharmacist Louis Nicolas Vauquelin.[18] These excerpts concerned experiments that explored the properties, chemical composition and reaction behavior of individual substances like chert, demantspath or corundum, that is, specialized factual knowledge about material substances, which, just as for Schleiermacher, poses the question as to their relevance for these men. What could such details about the chemical composition and properties of individual substances possibly have to do with early romantic natural philosophy or poetics?

This question is raised all the more by Gerhard Schulz's interpretation according to which Novalis' natural science activities were part of his large-scale attempt to achieve "the romantic synthesis of all sciences," in accordance with the contemporary spirit of the day.[19] For "everywhere the point was to find a single principle, a single substance, that was the basis of the various, in part newly discovered phenomena of individual sciences and perhaps of life itself."[20] Following a similar basic concern as Schelling, Schulz continues, Novalis, too, attempted "to discover what unifies and connects [all of] nature."[21] This line of interpretation is also pursued in a number of recent publications, as, for instance, in F. R. Henderson's otherwise innovative study about Novalis' "experimental philosophy."[22] Henderson, too, arrives at the conclusion that Novalis, in harmony with the central concern of romantic natural philosophy, wanted to reinforce the belief in a unified force embracing spirit and nature. If

Novalis' synthesis of the sciences did in fact aspire primarily to the reduction to a single principle, a primal force, then his occupation with the substantial particularities of chemistry would have been counterproductive.

In the case of Novalis it is tempting to dismiss prematurely the question as to the natural philosophy relevance of his study of the detailed empirical chemistry of material substances by pointing to professional demands. For his studies at the Freiberg Mining Academy from December 1797 to spring 1799 did indeed train him for an official career with the salt administration of Saxony. Yet such an interpretation is contradicted by numerous statements by Novalis himself both in the *Freiberger Naturwissenschaftliche Studien* and *Das Allgemeine Brouillon*.[23] For these comments make clear, as will be showed in the following, that Novalis was genuinely fascinated by the variety of substances and phenomena investigated by chemistry and mineralogy. Furthermore, analyzing his work with more precision reveals that while he was searching for a unified system of sciences, this system emanated from the knowledge of the diversity and multifariousness of nature. Thus, in a remark about chemistry in *Das Allgemeine Brouillon,* Novalis emphasized not chemical theory or concepts, but rather its concern with a broad variety of substances and of changes of substances: "CHEMIE. Mannichfache Arten der chymischen Berührungen oder Verhältnisse – z.B. in den monotonischen Pflanzen und Tierstoffen" ("CHEMISTRY. Various kinds of chemical contacts or relations — e.g. in monotonic plants and in animal matter").[24]

Novalis' interest in the multifariousness of nature is also expressed in his intensive examination of G. A. Werner's mineralogy and mineralogical classification and in his own project of collecting materials for an encyclopedia. "Now I want to go through all of the sciences specifically—and collect materials for an encyclopedistics", he wrote in one passage in *Das Allgemeine Brouillon.*[25] The romantic plan that Schulz emphasizes for the "synthesis of all sciences" apparently included the painstaking collection of facts and labor-intensive occupation with many different individual sciences. Another passage of the text provides the reason for this, stating that: "the genus or the general arises later than the individual– and by initially becoming engendered through contact with developed individuals — h[oc] it is made flesh".[26] Novalis' considerations on the relationship between a system of nature, classification and the variety of empirical natural phenomena sometimes culminate in paradox formulations like: "ENC[YCLOPAEDISTIK]. Nicht das Wesentliche – karacterisirt – nicht die Hauptmassen – sondern das Unwesentliche – Eigentümliche. Werner's Oryktogn[osie]. Die voll[kommen] unabh[ängigige] Oryktogn[osie] und die voll[kommen] unab[hängige] mineralische Chemie machen als völlig Heterogène ein System." ("ENC[YCLOPEDISTICS].

Not the essential—characterizes—not the main bulk—rather the inessential—the peculiar. Werner's oryctogn[osy]. Perfectly independent oryctognosy and perfectly independent mineral chemistry, comprise a system on account of their entire heterogeneity."[27]

Novalis' search for a system of nature that was not reduced to a few, let alone one, natural principles, but represented the variety of nature and its objects, entailed many methodological considerations about experimenting and an "elastic kind of thinking"("elastische Art zu denken"). On the latter he noted that his idea was "to go back and forth from the phenomena to the principles, and vice versa—or better to go to and fro at the same time—to chafe unceasingly in both directions".[28] Shortly thereafter he noted: "The observation of the great and the observation of the small must always grow at the same time––the one more various, the other simpler. Compound data of both the universe and of the most individual part thereof (macrocosm and microcosm)."[29] The thematic variety of the notes in which this methodological consideration is embedded appear to exemplify what Novalis meant when he spoke of a "unaufhörliches Reiben an den Phänomenen" ("unceasing chafing against the phenomena": they are immediately preceded by remarks about temperature and barometric measurements and about colored, black and glowing bodies, and followed by remarks about mineralogical classification, the ignition of phosphorus and the generation of phosphorus and sulfur in animal bodies.

No matter how exactly Novalis' methodological remarks are understood, they imply that it is necessary to work through the abundance of empirical material of chemistry, mineralogy and other distinct sciences in order to eventually achieve something like a system of nature. His method of constructing a system was not conceived as a linear, logical inductive process, but rather as a movement in both directions from the variety of phenomena to simpler principles and vice versa, as proceeds also from the following remark in *Das Allgemeine Brouillon*: "We still handle experiences and experiments much too recklessly — We do not understand how to use them — We scarcely study experiences – as the data to the solution and manifold combinations into calculus — We do not consider the experiences carefully enough in relation to conclusions — We do not assume every experience to be a function and member of a series — we do not classify — compare – and simplify the experiences enough — we do not examine an object with all *reagents* — we do not compare it diligently — and variously enough."[30] Here Novalis binds conclusions and simplifications to the accumulation of experience, to series of experience, and to many attempts at the widely varying combinations of experiential data through calculus or other forms of representation; at the same time he exhorts that an object's investigation requires many experimental trials —as was the case in chemistry through the application of all available reagents on a material to be identified. Again, it is not incidental that Novalis referred to chemical experimentation, to the chemists' testing of material objects with a plethora of "reagents" as a model of explorative technique.

Around 1800 chemistry was the only science that had established special spaces for experimentation, laboratories, and in which experiments took place continually on a more or less everyday basis. Chemistry was the paradigmatic laboratory science of the period, which, long before physics and the life sciences, attributed to experimentation a central epistemological significance. [31] Therefore when Novalis demanded that "every town [must have] its scientists and laboratories," chemistry was his archetype.[32] Since the mid-eighteenth century, chemical transformations, the reproduction of natural substances and the manufacture of new substances that did not occur in nature by means of chemical analysis and synthesis stood at the core of this experimental science.[33] Moreover, Novalis was captivated as much by the broad variety of phenomena that chemists investigated as by the fact that their experiments consisted of long trials and examinations of a particular material substance with many different experimental tools, the so-called chemical "reagents." It was this distinct experimental research style of late eighteenth-century chemistry, and of "classical chemistry" as a whole, oriented on the variety of substances and using a whole series of different reagents, that fascinated Novalis. He also highlighted this in remarks like the following: "*Duplication – repetition – division* – (addition – multiplication – exponentiation etc.) on experiments. Composition of experiments. ...Pattern of experimenting. (phosphorus – camphor)."[34] In another note, which concerns the French chemist Antoine-Laurent Lavoisier, he noted: "Could the chemical tools not be much improved? *Multiplication and exhaustion of a phenomenon* through multiplication of the affected and cooperating tools."[35]

What is more, Novalis understood the eminently active, experimental science of chemistry as a prototype, not only for all experimental sciences, but also for poetry, philology and philosophy.[36] "*Philologizing*," he wrote in *Das Allgemeine Brouillon*, "is the *truly scholarly* activity. It corresponds with *experimenting*. (I must do a *complete experiment* sometime)."[37] Right before this he remarked: "*In the end* all thinking seems to lead to real experimenting—and the so-called theory of reason—the necessity, method, etc. of experimenting and *living* to imply and prove constant experimentation."[38] The twenty-six-year-old Novalis sometimes expressed his views about active confrontations with objects in a quite drastic fashion: "*In order to perceive an object I must first eat it*, and then copulate with it, *then set it as a seed, fertilize it, conceive it and bear it myself.* Common philosophical analysis has much in common with masturbation."[39]

To sum up, F. R. Henderson has been right to argue that the concept of experiment was a "key term under which Novalis' thought can be analyzed with effective results."[40] What should be emphasized especially in this, however, is that it was a special concept of experiment, namely one oriented on the chemistry of his day, that Novalis attempted to make fruitful for his image of nature as well as for his poetics and linguistics. The chemical style of experimentation meant an exploring, active investigation of material objects just as it did continuously extend to new objects, thus yielding empirical knowledge about the multifariousness of nature.

Friedrich Schlegel

Friedrich Schlegel too held chemistry to be a dominant natural science of his day. In his *Athenäums-Fragmenten* he noted: "It is natural that the French more or less dominate the age. They are a chemical nation. In them the chemical sense is excited more universally than in others. Even in moral chemistry they always conduct their experiments on a grand scale. Likewise, the age is a chemical age."[41] In comparison to Novalis, Schlegel may have been less knowledgeable in chemistry – his confession to his friend Schleiermacher (in summer 1798), that he was "really somewhat afraid" of the natural sciences, and that he would "presumably always be only a guest" in this area, was probably not just an expression of modesty.[42] Nonetheless he drew from chemistry important stimuli for his poetry.[43]

The chemical imagery in Schlegel's poetics (see below) suggest that he saw in chemistry something that may have been characteristic for the romantic movement as a whole and its cult of chemistry, and which was also suggested in the discussion of Novalis above. It was, first of all, chemical experimentation that fascinated Schlegel. Famous aphorisms like "irony is a univ[ersal] experiment"[44] document the model function that Schlegel, just like Novalis, saw for writing in scientific experimentation. Unlike today, around 1800 the term "experiment" was used predominantly in the context of natural inquiry, so that Schlegel's and Novalis' metaphorical transfer to poetry was highly unusual. And chemistry was, as explained above, the paradigmatic laboratory science at this time; at the time daily experimentation in the laboratory and a continual, ever-expanding exploration of an abundance of material substances existed only in chemistry.

As in the case of Novalis, Schlegel's image of an active nature, or as Ernst Behler expressed this, [45] the "experience of the *natura naturans*," thus must have been developed and refined, especially as he delved into the subject of chemical experimentation, with its characteristic continuity, momentum and extraordinary material productivity. Schlegel pointed to the methodological relevance of this style of experimentation for writing by characterizing the essay as "continual" experimentation: "The ess.[ay] not *one* exp.[eriment] but rather continual experimentation."[46]

Chemists' open-ended, relatively autonomous mode of experimental inquiry was directly bound to their studies of material substances and contemporary complexes of questions, methods and techniques tied to these studies. Comparable to botany, zoology and mineralogy, the chemistry of material substances meant, first, the study of an enormous reservoir of natural and commercial particulars, and this alone was sufficient to trigger the stream of experiments. What is more, chemical experiments continually produced new substances that did not occur in nature. For all chemical experiments that served the exploration of the composition and the reactions of a particular natural substance yielded "reaction products" in form of material substances; and these reaction products frequently included new material substances that had never yet been observed. Chemical experimentation thus generated from within itself new material objects not existing in nature, the study of which, in turn, demanded new experiments. By its very nature, through the kind of material objects of inquiry, this was a productive as well as open-ended mode of experimentation. In his *The Laboratory of Poetry. Chemistry and Poetics in the Work of Friedrich Schlegel* (2002) the German studies scholar Michel Chaouli came to a similar conclusion: "The concept of the experiment—of *Versuch* or essay," so Chaouli, "plays a crucial role in Schlegel's reconfiguration of poetics," and he adds the remark about chemistry, that "far from anchoring itself in a single starting point, chemistry in practice begins with a multiplicity that, moreover, threatens continually to proliferate."[47]

Chaouli has further presented a compelling argument concerning additional facets of commonalities between Schlegel's poetics and eighteenth-century chemistry. The chemists of this period interpreted the experimental production of material substances by means of the concepts of reaction, chemical analysis and synthesis, and the related concepts of element and compound; they understood chemical compounds to be the result of a kind of chemical "combinatorics" that allowed for an immense number of possible combinations of simpler chemical substances or "elements" in this relative sense.[48] According to Chaouli, Schlegel translated this productive chemical combinatorics to poetry. He argues that we ought to understand Schlegel's *ars combinatoria* as a "thoroughly chemical combinatorics."

"Schlegel's true invention in aesthetics," so Chaouli "lies in bringing to bear on poetry a combinatorial method gleaned from chemistry."[49]

Chaouli's argument that Schlegel's *ars combinatoria* was inspired significantly by the contemporary chemical concepts and experimental practice of analysis and synthesis is not entirely new. In a similar way, it has already been advanced by Peter Kapitza and Matthew Tanner. "In his *Athenaeum* fragments," Tanner wrote, "Friedrich Schlegel explores and utilises this property of chemical combination to the point where chemistry assumes a pivotal role in his thinking."[50] According to Kapitza, "the experimenting aspect of the romantic-chemical writings" was expressed in Friedrich Schlegel's "constant search for elements that can be brought together as a mixture."[51] Chaouli goes beyond Kapitza and Tanner, however, in that he integrates distinctive aspects of the chemistry of that time more concretely into his argument. This includes, as we have seen, both the identification of a peculiar style of chemical experimentation and of a combinatorics of substances; in he addition also pointed out that the eighteenth-century chemists' theory of forces was of some importance. Eighteenth-century chemistry explained chemical reactions of material substances — especially their striking "elective behavior"— with the different attractive forces, "chemical affinities," between various pairs of substances. Ever since the early eighteenth century, chemists were endeavoring to portray the regularities of chemical affinities by compiling tables, the so-called "affinity tables."[52] In the second half of the eighteenth century the concept of chemical forces was extended to a concept of repulsion, whereby the force of repulsion was attributed to the matter of heat (Lavoisier's *calorique*). It thus appeared possible to explain chemical reactions as the result of two antagonistic, attractice and repulsive, forces. Not only Schelling based his natural philosophy on this chemical theory of attraction and repulsion; for Schlegel, too, the game of "infinitely separating and mixing forces" was a source of fascination.[53] According to Chaouli, for Schlegel the particular fascination that proceeded from this theory of forces emerged not only in linking chemical combinatorics with chemical dynamics; it also resulted from the apparent tensions between a mechanism, along with the possibility of mechanical determinism, and the factual unpredictability of the formation of individual chemical compounds under specific local conditions.

Indeed, the eighteenth-century chemical affinity tables allowed no predictions of chemical reactions in a strict philosophical sense. They rather displayed regularities of chemical reactions between pairs of pure inorganic substances under ordinary laboratory conditions; impure substances, the involvement of more than two substances, almost all organic compounds, very high temperature and a whole number of additional factors disturbed these regularities. Around 1800, many chemists began to realize that all efforts to quantify and mathematize chemical affinity had failed.[54] The material objects of chemistry thus seemed to oscillate between a mechanized world and the unpredictable. Chemists' ontology confirmed mechanical predication and calculation only at a first glance; at a second glance it eluded the mechanical world picture. Thus Chaouli reaches the interesting conclusion: "It is to the degree that late-eighteenth-century chemistry *fails* to master its material through mathematical abstraction that it becomes a rich model for the kind of poetics that Schlegel's writing encodes."[55]

3. The Usefulness of Chemistry

While the previous section dealt with the early romantic writers' cult of chemistry and thus concerned an educated class, now we will address the question as to whether there were other dimensions of chemistry at the turn from the eighteenth to the nineteenth century that may have been relevant for its broader popularization. Natural science lectures were a fashion around 1800, and attending them was also a question of sociability and of enjoyment. But the issue to be examined here is more specific: what did the broader well-to-do public get out of the empirical chemistry of material substances described in the first part of this essay? Today it is difficult to imagine that a large audience would be enthusiastic about a lecture on the technicalities of the extraction of, say, iron and the various properties of iron, along with its reactions with acids, sulfur, oxygen, carbon, etc., and its manifold practical applications. Today a Berlin or Weimar is inconceivable about which one could say, as in the late eighteenth century, "All people of Weimar seem to want to become chemists and Weimar a great melting furnace."[56] What made for chemistry's great attraction?

Let us first have a look at a detail from Schleiermacher's notes on Klaproth's lectures. As has been highlighted above, Klaproth's lecture focused on material substances, and it treated a considerably number of different substances, one after the other. Of course, it was not possible to be comprehensive in public lectures and to include information and experiments about all material substances known to the chemists of the day. Klaproth had to make a selection, and this selection is quite interesting. While it would certainly be wrong to describe his lectures as "technological" in the sense of a narrow focus on useful materials, he actually did include quite an impressive number of substances that were applied in the contemporary arts and crafts or distributed on the market. So, for instance, Schleiermacher's lecture about the effect of a tin solution on dyes contains the following practical remark: "Dyers avail themselves of this under the name 'composition,' to boost several colors. It enhances cochenille red into scarlet, and it is also the basis of the secret recipe for red carmine."[57] This is followed by an experiment on the production of "*Spiritus fumans Libavii*," a tin compound that was used as a chemical medicine from the sixteenth century onward and produced almost exclusively for this commercial purpose. Afterward an experiment on the production of "mosaic gold" is described, a gold-colored tin compound used in painting.[58] Klaproth's practical, commercial interests evinced by these experiments and other experiments must be regarded not least in connection with his professional career.

Martin Heinrich Klaproth (1743–1817) was an apothecary for ca. thirty years before he embarked on a purely academic career. First he concluded the standard five-year pharmaceutical apprenticeship and seven years of service as a journeyman, and then accepted a position running an apothecary's shop in Berlin in 1771.[59] Through an advantageous marriage he acquired the necessary finances to buy his own shop in 1780, the *Apotheke zum Bären* on Spandauer Straße. As usual for all apothecary's shops of this period, this one too had its own laboratory, in which the chemical medicines were produced. From 1780 until 1800, Klaproth conducted in this pharmacy laboratory all of the chemical experiments that are documented in a total of 84 publications. Here he analyzed countless substances, discovered the elements uranium and zirconium in 1789, and confirmed the discoveries of a number of other chemical elements. At the same time he began giving lectures on chemistry. From 1782 he taught chemistry at the *Collegium medico-chirurgicum*, a school for surgeons founded in 1724; shortly thereafter he began holding the above mentioned lectures in the circle of the artillerist Captain Gohl; in 1784 he received an appointment to instruct at the Berlin Mining Academy, and three years later a lectureship at the Artillery College, which was renamed the Royal Artillery Academy in 1791. With his election as a member of the Royal Prussian Academy of Sciences in 1788 Klaproth received the recognition as a chemist and *Naturforscher*. In 1800, that is, at the time Schleiermacher was attending his lectures, he was appointed director of the laboratory of the Berlin Academy of Sciences, and in 1810 he received a professorship for chemistry at the newly founded Friedrich-Wilhelms-University of Berlin.

From an apprenticed apothecary to a director of an academic laboratory and to a university professor: at first glance that may seem a quite unusual career path. Indeed, Klaproth had never attended a university, completed only an apprenticeship training, and spent a considerable part of his professional life in his apothecary's shop. But this career was by no means unusual in eighteenth-century Prussia. Klaproth's predecessor as director of the Academy laboratory was Franz Carl Achard, who also advanced without any university education. Achard was known for his technological skills, and became famous after 1800 for his success in extracting sugar from sugar beets on a technical scale. Achard's predecessor, the first director of the laboratory of the Berlin Academy of Sciences, Andreas Sigismund Marggraf, also started out as a apothecary. All three men were empirically oriented chemists focusing on material substances and on their chemical analysis, who had little interest in chemical theories, let alone natural philosophies. And all three were deeply involved in technological projects.

As is well-known, the ideal of useful sciences had already been heralded as a program by Francis Bacon back in the early seventeenth century. The Enlightenment adopted this ideal, adding additional facets. In France, Germany and other mercantilist states of Europe, the actual or hoped-for usefulness of the sciences was an important motive for science patronage. The founding of scientific academies like the Royal Society in England (1660) and the Paris Academy of Sciences (1666) were concrete manifestations of this agenda of applying the sciences to the manual arts and to agriculture. The members of the Paris Academy of Sciences and of the Royal Prussian Academy of Sciences, for instance, took on the task of writing expert opinions for commercial projects, and in the eighteenth century even accepted leading and controlling positions in the state manufactories. The contests sponsored by the Academies were considered to be important incentives for technological studies and to encourage industry, and Academy projects like the *Description des Arts et Métiers* served not least to provide an empirical foundation for such projects.

The Royal Prussian Society of Sciences of Berlin, which was renamed "Academy" in 1744, also pursued the goal of sponsoring the useful sciences. The founding of professional colleges, which served to train surgeons, mining officials, engineers, officers and other scientific-technical experts, was also connected with the idea of the useful sciences. In Berlin the *Collegium medico-chirurgicum* was founded in 1724, so that surgeons, and especially military surgeons, for whom there was no university curriculum at the time, could benefit from a scientific education. In 1765 a college of the field artillery corps was set up (from 1795 the "Military Academy"), in 1770 a mining college (from 1774 the "Mining Academy") and in 1790 a college for veterinary medicine. In other German cities technological schools and university chairs for cameral sciences and technology were established. At the same time, various scholarly societies tried to encourage the useful sciences and propagate them throughout the population. In many cities in Germany and Europe "economic societies" emerged, which were dedicated especially to the scientific investigation of agriculture, with the goal of intensifying agriculture and improving the utilization of plant resources.[60] Public lectures and journals were regarded as indispensable for spreading scientific knowledge and encouraging scientifically grounded agriculture. Quite often Protestant village preachers, such as Schleiermacher, were active members of the economic societies, taking on the role of intermediaries in the transfer of knowledge to the farmers.

Chemistry was included in nearly all of these newly founded scientific institutions. Two chemists taught the *Collegium medico-chirurgicum*, starting with Johann Heinrich Pott and Caspar Neumann; the first teachers of chemistry at the Mining College in Berlin were Carl Abraham Gerhard and Valentin Rose. Rose was replaced by Achard, whose successor was Martin Heinrich Klaproth; as mentioned, Klaproth also taught at the Military Academy.[61] Above and beyond this, Klaproth also held lectures at the Economic Society of Potsdam. At the same time, the chemists in Berlin made a significant contribution to the international reputation of the Prussian Academy of Sciences, as Maupertuis declared in a report to the king in the year 1748: “Our chemists,” wrote Maupertuis, “outrival all chemists in Europe.”[62] Just a few decades later chemistry had become a cult science, and it maintained its status as a model of experimental science the entire nineteenth century.

I argue that the broader public cult of chemistry around 1800 was due in large part to the usefulness of this science along with the overarching belief in scientific and technological progress, a hallmark of modernity until the end of World War II. It accorded with the Enlightenment concept of progress and its idea of a general social welfare facilitated by technology combined with the sciences, which already had been reflected in the great social utopias of Morus, Campanella and Bacon back in the sixteenth and seventeenth centuries. As in no other science of the period, however, in chemistry there was no gap between the ideal and reality of a useful science. It was less theory than the experimental practice of this science, including concepts and methods that went into it, which constituted the usefulness of this science. The experimental methods of chemical analysis and of the unambiguous identification and classification of chemical substances, a system of chemical concepts that was relevant for experiments (including the concepts of chemical compound, composition, affinity, reaction, analysis, synthesis, purity and so on), knowledge of the composition and properties of a wealth of particular substances and of their chemical reactions among each other were useful knowledge especially for pharmacy, mining and metallurgy, dyeing and calico printing, the manufacture of ceramics and porcelain, and the making of gunpowder.[63] Klaproth and other leading Prussian chemists were thus less occupied with chemical theory, but all the more so with processes of unambiguously identifying substances, and analyzing them chemically and studying their reaction behavior. The empirical, analytical chemistry of material substances, for which they stood and enjoyed an international reputation, was also the useful part of the science of chemistry. The lectures by Klaproth and other chemists in Berlin were therefore also a manifestation of the usefulness of chemistry, exemplifying the potential usefulness of the natural sciences as a whole. In the cult of chemistry of the early romantic period two otherwise relatively independent cultural lines thus converged: the value placed on the useful sciences, and the model function of chemical experimentation and chemical combinatorics for the natural philosophy and poetics of early romantic writers.

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[1] Ignaz von Born und Friedrich Wilhelm Heinrich von Trebra. "Vorrede" in *Bergbaukunde* 1 (1789), zit nach Günter B. Fettweis und Günther Hamann, Über Ignaz Born und die Societät der Bergbaukunde, Wien: Verlag der Österreichischen Akademie der Wissenschaften 1989, p. 72.

[2] *Kritische Friedrich-Schlegel-Ausgabe*. Ed. Ernst Behler, vol. 2, 1. Abtlg.: Kritische Neuausgabe, "Charakteristiken und Kritiken I (1796–1801)," edited and with a preface by Hans Eichner. Munich: Schöningh 1967, p. 284 [426].

[3] Johann Wolfgang von Goethe. *Die Schriften zur Naturwissenschaft*. Ed. Deutsche Akademie der Naturforscher Leopoldina, Erste Abtlg.: Texte vol. 11, "Aufsätze, Fragmente, Studien zur Naturwissenschaft im Allgemeinen," edited by Dorothea Kuhn and Wolf von Engelhardt, Weimar: Böhlau 1970, p. 352.

[4] Andreas Arndt and Wolfgang Virmond. "Historische Einführung" in Friedrich Daniel Ernst Schleiermacher, *Kritische Gesamtausgabe*, ed. Hermann Fischer and Gerhard Eberling, Heinz Kimmerle, Günther Meckenstock, Karl-Victor Selge, Fünfte Abtlg. "Briefwechsel und biographische Dokumente" vol. 4, "Briefwechsel 1800 (Briefe 850–1004)," edited by Andreas Arndt and Wolfgang Virmond, Berlin: de Gruyter 1994, I–LX, p. LV f.

[5] Friedrich Daniel Ernst Schleiermacher. *Kritische Gesamtausgabe*, ed. by Hans-Joachim Birkner and Gerhard Eberling, Hermann Fischer, Heinz Kimmerle, Kurt-Victor Selge, Erste Abtlg. "Schriften und Entwürfe" vol. 3, 101-128 ("Schriften aus der Berliner Zeit 1800–1802," edited by Günter Meckenstock), Berlin: de Gruyter 1988. In the following quoted as KGA I/3.

[6] Schopenhauer left behind lecture notes whose contents are in striking agreement with those of Schleiermacher's notes. See Martin Heinrich Klaproth: *Chemie. Nach der Abschrift von Arthur Schopenhauer, nebst dessen Randbemerkungen, Winter 1811/12*. Revised and edited by Britta Engel, Berlin: Verlag für Wissenschafts- und Regionalgeschichte Dr. Michael Engel 1993.

[7] On the relationship between chemistry and poetics in Schelling see Manfred Durner. "Die Rezeption der zeitgenössischen Chemie in Schellings früher Naturphilosophie" in Reinhard Heckmann, Hermann Krings and Rudolf W. Meyers (eds). *Natur und Subjektivität. Zur Auseinandersetzung mit der Naturphilosophie des jungen Schelling.* Stuttgart: Fromann-Holzboog, 1985: 15–38. On Coleridge's relationship with chemistry see Trevor H. Levere, *Poetry Realized in Nature. Samuel Taylor Coleridge and Early Nineteenth-Century Science*, Cambridge: Cambridge University Press 1981.

[8] According to Nicolai, a total of 21 natural science lectures were offered in Berlin around 1786; see Friedrich Nicolai. *Beschreibung der Königlichen Residenzstätte Berlin und*

Potsdam. Berlin: Nicolai 1786, 726–728. The lectures were regularly advertised in newspapers. See also Arndt and Virmond, p. LVII.

[9] *Annalen der Chemie* 1784, Teil 1: 342 (the letter was published anonymously). The "chemical workshop" presumably refers to Klaproth's laboratory in the *Zum Bären* pharmacy on Spandauer Straße 17; Nicolai explicitly mentions Spandauerstraße as a location of Klaproth's lectures (Nicolai, p. 727). According to Dann, at this time Klaproth held public lectures in a circle organized by a Captain Gohl, and in which women also participated; see Georg Edmund Dann. *Martin Heinrich Klaproth (1743–1817): ein deutscher Apotheker und Chemiker, sein Weg und seine Leistung*. Berlin: Akademie Verlag 1958, 66. It is not possible to assert with complete certainty that the portrayal concerns Klaproth's lectures, since at the same time Franz Carl Achard and Carl Abraham Gerhard also offered chemistry lectures (see Nicolai 1786, 726–728).

[10] Joseph Rückert. *Bemerkungen über Weimar 1799*. Edited and with an afterword by Eberhard Haufe. Weimar: Gustav Kiepenheuer 1969, pp. 53f. This description from the year 1799 looks back on the previous year, in which the chemist Alexander Nicolaus Scherer for the first time offered "chemical lectures for all classes" in Weimar.

[11] E. G. Fischer, "Denkschrift auf Klaproth" in *Abhandlungen der Königlichen Akademie der Wissenschaften in Berlin* Band 1818/19 (1820): 11–26, p. 14, 15, 18.

[12] Arndt and Virmond, p. LX.

[13] KGA 1/3, 101-128.

[14] KGA I/3, 105.

[15] Ibid. 106.

[16] Hans Eichner. "The Rise of Modern Science and the Genesis of Romanticism" in *PLMA (Publications of the Modern Language Association of America)* 97 (1982): 8–30. p. 8.

[17] *Kritische Friedrich-Schlegel-Ausgabe*, ed. Ernst Behler, vol. 18, 2. Abtlg.: Schriften aus dem Nachlaß, Philosophische Lehrjahre 1796–1806 nebst philosophischen Manuskripten aus den Jahren 1796–1828, Munich: Schöningh 1963, p. 135.

[18] *Novalis Schriften. Die Werke Friedrich von Hardenberg*, ed. Paul Kluckhohn and Richard Samuel, vol. 3: Das Philosophische Werk II (Hsg. R. Samuel), Darmstadt: Wissenschaftliche Buchgesellschaft 1968, pp. 182–183, 189–194.

[19] Gerhard Schulz. "Einleitung" to the Freiberger naturwissenschaftliche Studien 1798/99 in *Novalis Schriften* vol. 3, p. 18.

[20] Ibid., p. 6.

[21] Ibid., p. 19.

[22] Fergus Roy Henderson. *Novalis's Idea of 'Experimentalphilosophie'. A Study of Romantic Science in its Context*. Dordrecht: Kluwer 2001.

[23] On Novalis' reception of chemistry, see also Peter Kapitza. *Die frühromantische Theorie der Mischung. Über den Zusammenhang von romantischer Dichtkunst und zeitgenössischer Chemie*. Munich: Max Hueber 1968.

[24] *Novalis Schriften,* vol. 3, p. 270 (158).

[25] "Jezt will ich alle W[issenschaften] speciell durchgehen – und Materialien zur Encycopaedistik sammeln"). Ibid., p. 279 (229).

[26] "Die Gattung oder das Gemeinsame später, als das Einzelne entsteht – indem es erst durch den Contact der gebildeten Individuen erzeugt wird – h[oc] ins Fleisch kommt". Ibid., p. 257 (90).

[27] Ibid., p. 278 (222). Oryctognosy is an old term for mineralogy. Novalis repeatedly discusses the differences between an oryctognosy that identifies and classifies minerals on the basis of their observable characteristics, and a "chemical mineralogy" in which the knowledge of the compositions of the minerals based on chemical analysis was the decisive criterion for identification and classification.

[28] "Von den Erscheinungen zu den Principien, und umgekehrt hin und her zu gehn —oder besser zugleich hierhin und dorthin zu gehn — in doppelten Richtungen unaufhörlich sich zu reiben". Ibid., p. 58, my emphasis.
[29] "Die Betrachtung des Großen und die Betrachtung des Kleinen müssen immer zugleich wachsen — jene mannichfacher, diese einfacher werden. Zusammengesetzte Data sowohl des Weltgebäudes, als auch des Individuellsten Theils desselben (Macroscosm und Microcosm)." Ibid., 59.
[30] "Man geht mit den Erfahrungen und Experimenten noch viel zu sorglos um – Man versteht sie nicht zu benutzen – Man betrachtet zu wenig die Erfahrungen – als Data zur Auflösung und mannichfaltigen Combinationen zum Calcül – Man überlegt die Erfahrungen, in Beziehung auf Schlüsse, nicht sorgfältig genug – Man nimmt nicht jede Erfahrung, als Function und Glied einer Reihe an – man ordnet – vergleicht – und simplificirt die Erfahrungen nicht genug – man prüft einen Gegenstand nicht mit allen *Reagentien* – man vergleicht ihn nicht fleißig – und mannichfach genug. " Ibid., 427 (805).
[31] See Ursula Klein. "Die technowissenschaftlichen Laboratorien der Frühen Neuzeit," *N.T.M.* 2008, 5– 38; Ursula Klein. "The Laboratory Challenge: Some Revisions of the Standard View of Early Modern Experimentation," *Isis* 99 (4): 769–82.
[32] *Novalis Schriften,* vol. 3, p. 179.
[33] See Ursula Klein and Wolfgang Lefèvre. *Materials in Eighteenth-Century Science. A Historical Ontology*. Cambridge (Mass.): MIT Press 2007.
[34] "*Vervielfältigung – Wiederholung – Zertheilung* – (Addition – Multiplikation – Exponenziation etc.) von Experimenten. Zusammensetzung von Experimenten. ...Muster des Experimentirens. (Phosphor – Kampfer)."*Novalis Schriften,* vol. 3, p. 435 (863).
[35] "Ließen sich nicht die chymischen Werckzeuge noch sehr verbessern? *Vermannichfaltigung und Exhaustion eines Phaenomens* durch Vermannichfaltigung der tangirenden und cooperirenden W[erck]z[euge]". Ibid., p. 426 (802).
[36] Of course, this does not include other, primarily philosophical sources of his concept of experiment, as elaborated by Henderson (see Henderson 2001). Munich: M. Hueber 1968. On the role of experimental praxis in chemistry for Novalis' natural philosophy, see also Ralf Liedtke. *Das romantische Paradigma der Chemie. Friedrich von Hardenbergs Naturphilosophie zwischen Empirie und alchemistischer Spekulation*. Paderborn: Mentis 2003.
[37] "„*Philologisiren* ist die *wahrhaft gelehrte* Beschäftigung. Es entspricht dem *Experimentiren*. (Ich muß einmal ein *vollst[ändiges] Experiment* machen)." *Novalis Schriften,* vol. 3, p. 408 (724).
[38] "*Am Ende* scheint alles Nachdenken auf ächtes Experimentiren zu führen – und die sog[enannte] Vernunftlehre – die Nothwendigkeit, Methode, etc. des Experimentirens und *Lebens*, als eines beständigen Experimentirens zu enthalten und beweisen". Ibid., 402 (702).
[39] "*Um einen Gegenstand wahrzunehmen, muß ich ihn erst essen*, und mich dann mit ihm begatten, *dann ihn als Keim setzen, ihn befruchten, selbst empfangen und gebähren*. Die gemeine philosophische Analyse hat viel Ähnlichkeit mit d[er] Onanie." Ibid., p. 88.
[40] Henderson, p. 33.
[41] "Es ist natürlich, dass die Franzosen etwas dominieren im Zeitalter. Sie sind eine chemische Nation, der chemische Sinn ist bei ihnen am allgemeinsten erregt, und sie machen ihre Versuche auch in der moralischen Chemie immer im Großen. Das Zeitalter ist gleichfalls ein chemisches Zeitalter." *Kritische Friedrich-Schlegel-Ausgabe*, vol. 2, 1. Abtlg., p. 284 [426].
[42] Cited according to Ernst Behler, "Einleitung" in *Kritische Friedrich-Schlegel-Ausgabe*, ed. Ernst Behler, vol. 18, 2. Abtlg.: Schriften aus dem Nachlaß, Philosophische Lehrjahre 1796–1806 nebst philosophischen Manuskripten aus den Jahren 1796–1828, Munich: Schöningh 1963: IX–LXX, p. XXXI. Michel Chaouli thus noted, "What distinguishes him [F. Schegel]

from some of his contemporaries is not his knowledge of this emerging science [chemistry], but in fact his lack of systematic understanding"; Michel Chaouli. *The Laboratory of Poetry. Chemistry and Poetics in the Work of Friedrich Schlegel*. Baltimore and London: The Johns Hopkins University Press 2002, p. 2.

[43] Michel Chaouli thus noted, "What distinguishes him [F. Schegel] from some of his contemporaries is not his knowledge of this emerging science [chemistry], but in fact his lack of systematic understanding"; Michel Chaouli. *The Laboratory of Poetry. Chemistry and Poetics in the Work of Friedrich Schlegel*. Baltimore and London: The Johns Hopkins University Press 2002, p. 2. Schlegel's remarks on the experiential chemistry of material substances are indeed strikingly brief and more or less idiosyncratic, like: "*salt* (as nature produces in great amounts) appears to be that which puts the metals and stones in rapport with other spheres" (ibid., p. 162 [462]); or: "Before one has achieved as much in hydrogeneration as in oxidation, no system of chemistry is conceivable" (ibid., p. 181 [656]); in this remark Schlegel alludes to the central role of oxygen and hydrogen in this sub-discipline.

[44] "Ironie ist Univ[erselles] Experiment." Ibid., p. 217 [279].

[45] Behler "Einleitung," p. XXXII.

[46] "Der Ess.[ay] nicht *Ein* Exp.[eriment] sondern ein beständiges Experimentiren." *Kritische Friedrich-Schlegel-Ausgabe*, vol. 18, 2. Abtlg., p. 215 [248].

[47] Chaouli, p. 97.

[48] On this system of concepts in the chemistry of the eighteenth century, which also involves the concept of chemical affinity, see also Ursula Klein, *Verbindung und Affinität*, Basel: Birkhäuser 1994.

[49] Chaouli, p. 120, 121. To support this statement Chaouli lists a number of convincing quotes by Schlegel, such as: "This combinatorial aspect is what I ... designate as scientific wit. It cannot emerge without universality, for only where an abundance of different kinds of substances are unified can new chemical compounds and penetrations of these take place" (cited according to Chaouli, p. 244, footnote 48).

[50] Mattew Tanner. "Chemistry in Schlegel's Athenäum Fragments" in *Form for Modern Language Studies* 31 (1995): 140–53, p. 140.

[51] Kapitza 37; see also pp. 72–80.

[52] See Alistair Duncun, *Laws and Order in Eighteenth-century Chemistry*, Oxford: Clrendon Press 1996; Klein and Lefèvre 2007.

[53] Chaouli, p. 87, 237.

[54] This was a central theme in Claude-Louis Berthollet's *Essai de statique chimie* (1803).

[55] Chaouli, p. 84.

[56] Rückert. p. 53 f.

[57] Schleiermacher, *Kritische Gesamtausgabe*, Erste Abtlg. "Schriften und Entwürfe" vol. 3, p. 110.

[58] Ibid., pp. 111–112.

[59] This pharmacy, *Zum Weißen Schwan*, belonged to the apothecary and chemist Valentin Rose. On Klaproth's biography, see Dann.

[60] See Marcus Popplow "Economizing Agricultural Resources in the German Economic Enlightenment" In Ursula Klein and E. C. Spary, *Materials and Expertise in Early Modern Europe. Between Market and Laboratory*, Chicago: The University of Chicago Press 2010, 261-287.

[61] See on this also Karl Hufbauer. The Formation of the German chemical Community (1720–1795). Berkeley: University of California Press 1982, pp. 232–234.

[62] Adolf Harnack. *Geschichte der Königlich Preussischen Akademie der Wissenschaften zu Berlin*, 4 vols., Berlin: Reichsdruckerei 1900, 1 (1): 440.

[63] On this, see also Klein and Lefèvre 2007.