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Artibus Academicis Inserenda: Chemistry's Place in Eighteenth and Early Nineteenth Century Universities

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When, in 1731, Hieronymus David Gaubius succeeded his teacher Herman Boerhaave as professor of chemistry at Leyden, he took the opportunity to deliver an inaugural speech aimed at proving that chemistry had a right to be received among the academic disciplines, *chemiam artibus academicis jure esse inserendam.*[1] Given the fact that Gaubius occupied one of the most famous chairs for chemistry in Europe, such a claim for the subject might seem superfluous. Yet, Gaubius was not trying to enmesh his audience in a rhetorical *petitio principii.* From the way he pictured chemistry, it is clear that the academic status of the field was by no means universally agreed upon: instead of well-ordered bookshelves and literary elegance chemistry possessed only furnaces and vessels, and its adept did not sit leisurely at the writing-desk but blackened his hands, 'fumo, cineribus, fuligine obsitum'.[2] When Gaubius concluded his oration with the call 'the laboratory is waiting, the furnaces are burning, come and sweat there with me!',[3] he could confidently expect that few of his auditors would respond to his invitation.

With chemistry, a new type of scholarly pursuit had entered the traditional seats of learning. Its proper place was not the pulpit, but rather the laboratory, if admittedly the discipline was not yet devoted to experimental research, but rather to teaching by demonstration. Hence the professor of chemistry, who had to brush off soot and ash from his gown when he met with his colleagues, was an odd figure among scholars who oriented themselves towards the vanities of lower nobility and the local court.[4] Though Gaubius was one of the few to have an assistant for the rude and technical tasks,

the very nature of laboratory work made it difficult for chemistry to be accepted as a legitimate academic pursuit.

Through much of its history, the position of chemistry within higher education and its demand for recognition have been questioned. Even in the second half of the nineteenth century, it was discussed whether a purely practical and empirical subject such as chemistry should not be banned from the universities or at least from the philosophical faculties. Position and status, the hierarchy of public offices and their reputation within and outside academia, rank and the value of specific disciplines and faculties, all of these were most important issues for the little world of learning, all the more since the world outside took an interest in such hierarchies. This quarrel was not about intellectual values alone. Office and power, competence and influence, salaries and career opportunities, in fact the most tangible values of institutionalized knowledge were involved. From this point of view, chemistry's claims for recognition and an academic position reveal the driving forces behind the mechanisms of continuity, change, and evolution of a scientific discipline.

Scientific disciplines are by no means socially and intellectually homogeneous, and this is especially true during their formative periods.[5] They comprise different groups and individuals, each of which has its own norms and traditions, and pursues its own programmes of research and its own strategies of institutionalization.[6] The various ways in which a discipline and its members respond to their social and institutional context result in a variety of styles and approaches. The Darwinian metaphor 'ecology of knowledge' has quite adequately been applied to the resulting process of competition and adaptation.[7] In this view, the formation of scientific disciplines results from a collective, competitive attempt to create social structures for intellectual activity and to stabilize them institutionally according to the demands and conditions of a changing environment. Success or failure depend to a great extent on the degree of correspondence between the disciplinary programme and the historical opportunities for its realization. The emergence and transformation of a scientific discipline imply intellectual, social, and economic processes at various levels with a constant interaction between them. The overall process of emergence and institutionalization of a discipline is, therefore, unlikely to be a linear succession of logical steps directed more or less towards the same ultimate aim.

Instead, a multilayered and multidirectional growth would be expected, each section of which may very well be aimed at a different destination.

During the eighteenth and early nineteenth centuries, the academic discipline of chemistry traversed various models of institutionalization, each of which can be identified by its underlying assumptions about chemistry's place and destination within the university and society. The purpose of this paper is to distinguish and reflect on those various models. The historical material on which the following analysis is based comes from more than 100 institutions of higher education, such as universities, Jesuit Colleges, Medical Schools for surgeon-physicians, Mining Academies, and technical schools.[8] Central European countries, and especially the German-speaking territories have provided most of the data. This is not only because of availability of sources and literature, but also because in these countries the universities have traditionally been the major centres for the transmission of academic knowledge. However, the demarcation criterion was neither national nor institutional, as opposed to the usual approach favoured by historians of science, but disciplinary, viz. whether or not the teaching of chemistry played any substantial role in that particular institution of higher education. Without understating the importance of national and institutional differences, from the point of view of disciplinary history, the similarities and correspondences are so remarkable and the simultaneousness of disciplinary developments so striking that they justify this approach. After all, through most of the period under discussion, the literature of academic chemistry was in Latin and part of a common European tradition, at least on the Continent.

For well known reasons the German universities have received considerable attention by historians of science and chemistry.[9] Often, however, this has been done from a somewhat distorted point of view by identifying 'the' German university with those features that characterized the major Prussian universities or Göttingen at the turn of the nineteenth century, but did not apply to other German universities such as Greifswald, Rinteln, Ingolstadt or Freiburg. From the scientific aspect, however, the institutional differences between the latter and, for instance, Halle were much greater than those between, say, Vienna and Utrecht, or Leyden and Jena. In addition, historians of science are usually biased in

favour of research-orientation as the decisive if not the only criterion for a true science. From this point of view, however, much of the pre-nineteenth-century history of universities would be of little interest.[10] Yet research is only one, and a rather recent, aspect in the history of an academic discipline. By no means should it be used as a demarcation criterion in disciplinary or institutional history. Teaching was in fact the core of a professor's role and by no means considered as second-rank or merely derivative.[11] By its very nature, a scholarly discipline is formed and maintained by those interactions which transmit a body of knowledge in a well-defined and teachable form.[12] Thus the history of a scientific discipline and the history of a particular science are clearly distinct.[13] Hence, for the purpose of this paper only university-like teaching institutions are considered, and their rivals such as the academies, scientific societies and more practical teaching establishments, are ignored, though, especially during the eighteenth century, the role of the latter in promoting scientific knowledge became a constant challenge to the traditional seats of learning.

The initial institutional context for the development of an academic chemistry was the seventeenth-century medical faculty. As a crucial aspect of the reform of learning intended by the Paracelsians, chemistry entered the universities throughout Europe.[14] Its rise was as spectacular as it was universal. But soon the original, all-embracing cosmological goal of Paracelsianism gave way to more practical and pharmaceutical ends. When, in 1609, Moritz of Hessen, the learned prince-practitioner, created the first chair of medical chemistry (*chemiatria*) at any university, he imagined that chemistry would be the noble keystone of an ideal system of arts and sciences.[15] Shortly afterwards, however, the chemists found themselves in a rather marginal position in the medical curriculum. Faculty statutes of the time mention the subject as an auxiliary to medicine. 'Medicina atque chimia tamquam domina et serva conjunguntur',[16] said Zacharias Brendel, professor of chemistry at Jena, in 1630. It was a servant, moreover, whose service was not yet in great demand. Before the middle of the seventeenth century some eight universities offered chemistry courses on a more or less regular basis, but only Jena (from 1639) and the *Jardin du Roi* at Paris (from 1648) created a special teaching position of *demonstrator*. During the second half of the century, more universities

included chemistry among the statutory duties of one of the professors of medicine: Utrecht and Leipzig in 1668, Leyden in 1669, Erfurt in 1673, Montpellier in 1675, Altdorf in 1677, Oxford and Stockholm in 1683, Strasbourg, Leuven, and Marburg in 1685, and Helmstedt in 1688. At other places the subject appeared in lecture catalogues from time to time, but did not belong to one professor's permanent duties.

The reception of chemistry into the medical faculty was a very decisive step in shaping the subject's content and academic position. It not only liberated chemistry from the suspicion of alchemical obscurity, but also removed it from the rigid framework of both neo-Aristotelian and physico-mechanical natural philosophy, which had proved equally sterile in terms of chemical theory and application. Concrete and well-defined tasks in the field of pharmacy not only supplied, at least in principle, a means of testing chemistry's practical performance; they also challenged the previous direction of its cognitive development. Consequently, this first wave of institutionalization almost entirely emancipated chemistry from the traditional interest of the Aristotelian and later on Cartesian philosophers in causation.[17] Chemistry was now taught by medical men to future physicians, and its main subject was how to prescribe and prepare chemical medicines.

The incorporation of chemistry into the medical faculty was, however, only partly advantageous for the future development of the discipline. As long as chemistry was merely an auxiliary to medicine and usually taught by a low-rank junior professor along with anatomy, botany, or pharmacy, its humble position within the hierarchy of the faculty was inevitably confirmed. As a mere ancillary subject, chemistry was deemed to be useful only insofar as it catered to the needs of its master, medicine. Moreover, an autonomous development was almost impossible, since in the traditional university system faculty chairs devoted to particular sub-disciplines did not exist. Usually the different professorships of a medical faculty were divided only roughly between the theoretical and practical branches of the science. In addition, there was often a distinction between the chairs in terms of rank, privileges, and salary, which reflected their social reputation within and outside academia. Each faculty had its peculiar pecking order and professors succeeded to higher chairs almost exclusively according to seniority.[18] Emancipative attempts of a discipline to obtain a higher

rank would have most automatically provoked opposition from all other parties involved in this rearrangement.[19] Consequently, the professor of chemistry, who usually occupied the least respected and least rewarding chair in the faculty, would have taken the earliest opportunity to proceed to the next in order in the hope of becoming, eventually, *professor primarius*. In this latter position he was able to combine his teaching duties with a more profitable private practice or a position as court physician. This system of succession by seniority (*Aufrücken*), a heritage of the medieval university, continued well into the eighteenth century, although its deficiencies had been recognized much earlier. A junior professor who devoted too much effort to an auxiliary subject such as chemistry would have endangered his subsequent academic career. As a consequence, the teaching of chemistry was frequently neglected by those who were more ambitious. Chemistry became therefore a favourite field for extra-mural teachers, *doctores legentes* or *Fakultäts-Assessoren* who, in this manner, tried to make their way into an academic position.[20] As an evaluation of eighteenth-century academic careers in science proves, the teaching of chemistry was almost regularly a transitional stage, considered as a tedious and, due to the experiments, costly burden, that was reluctantly passed on to assistants or *amanuenses* who in turn used it merely as a stepping-stone to higher positions.

Under these circumstances, different models of justification and institutionalization were proposed in the early eighteenth century, aimed at liberating chemistry from its close ancillary association with medicine. By those who perceived a demand for chemistry and were trying to build their career on it, its humble position within the academic hierarchy was felt not only as personally insulting, but also as an impediment to greater intellectual autonomy and disciplinary differentiation. For that purpose, the subject needed a new identity, a new self-consciousness. Two competing lines of argumentation can be easily distinguished. The first one originated in the Leyden iatromechanical school of medicine. Its aim was to make chemistry the basis for a rational, empirically accessible physiology and pathology. The second type of argumentation, more indebted to the physical sciences in a Cartesian or Newtonian tradition, imagined chemistry to be a general science of matter, based upon corpuscles and acting forces.[21] In both cases a programmatic revaluation from an auxiliary subject to a basic science was

intended. This shift of perspective was by no means restricted to the rhetorical stratagems of introductory chapters and inaugural speeches. Its proponents developed programmes of research and counselled new strategies of institutionalization. With reference to the two alternative guidelines for the disciplinary development of chemistry Johann Bartholomaeus Trommsdorff wrote in 1803:

> Having earlier elevated chemistry to the status of a maid of medicine and secured its representation within the teaching faculty, the physicians' control over chemistry was now in decline; and while practising doctors had previously had to plead that their maid be tolerated, the university was now allowed to promote chemistry publicly and to praise it as the grandest science and mother of physics.[22]

Eighteenth-century universities did not regard themselves as institutions of research. They prepared for one of the traditional professions: theology, law, public administration, medicine, and higher education. They were notoriously concerned with their financial difficulties and poor student attendance.[23] Therefore only the first strategy of institutionalization had any real chance of success. The medical faculties alone, though usually the smallest of the four classical faculties, provided a possible base for more serious consideration of chemistry as an academic discipline. Even if still an auxiliary to medicine, chemistry, now that it regarded itself as fundamental to physiology and pathology was in a better position to enhance its status. As Immanuel Kant was to remark in *Der Streit der Fakultäten,* it makes a great difference whether the maid carries the torch ahead of her mistress, or the train of her gown behind her.[24]

It was still a long time, however, before separate chairs exclusively and permanently devoted to chemistry could be established. The most important prerequisite was the abandonment of the succession by seniority, which would have blocked any development towards greater specialization and differentiation. This was clearly recognized by many contemporaries. During the 1730s the universities of Würzburg (1734) and Königsberg (1737), the *Collegium Medico-Chirurgicum* in Berlin (1737), and the universities of Prague (1747) and Erfurt (1756) made early, if unsuccessful, attempts to abandon the seniority principle. In Vienna Gerard van Swieten, a pupil of Boerhaave in charge of the Austrian medical policy and university system, tried to establish specialized

Fachprofessuren for chemistry and botany throughout the Habsburg empire, and his measures were reinforced again during the reforms of Joseph II in 1786. In most cases, however, these attempts failed. This was not so much because of a stubborn tradition, but mainly because of economic difficulties resulting from the decreasing number of students, a typical feature of the latter part of the eighteenth century. Sometimes the universities had no other choice than to combine nominally independent professorships by endowing one professor with the duties and salary of a second, third, or even fourth chair. Boerhaave occupied four medical chairs in addition to his *professio chemiae,* although Leyden, at that time, was much better off than most other universities. In Helmstedt, with fewer than 200 students in the mid-eighteenth century, the combining of chairs proved the only way to provide a livelihood for the professors and to stop their continuous complaints.[25] Consequently, chairs devoted to particular fields of expertise (*Fachprofessuren*) were confined to the very few universities large enough to enable differentiation and specialization. Here chemistry was combined with botany and/or pharmacy, but no longer bound to purely medical topics such as anatomy. Neither did the holders of this new type of chair proceed to higher medical ranks during their subsequent career. Nor were these chairs given to other subjects once a position had become vacant. For the first time, it thus became possible, if still not easy, for practical chemists and especially for apothecaries to be nominated professors of chemistry. Perhaps the earliest example is Johann Conrad Barchusen who in, 1703, was appointed extraordinary professor of chemistry at Utrecht although he had no previous academic qualifications whatsoever and took little interest in the medical applications of the subject.[26] In this way, the medical faculty provided new career opportunities for those who wanted to specialize in chemistry, botany, or pharmacy, rather than necessarily abandoning these subjects in order to become physicians.

At the same time as chemistry gradually began to be differentiated as a specific discipline within the medical curriculum, other factors helped it break free of its dependency on medicine altogether. In the first place, in the course of the eighteenth century, interest in the discipline ceased to be primarily oriented towards the medical use of chemistry and was concentrated instead on its commercial applications and potential impact on the domestic

economy. In 1750 the Swedish chemist Johan Gottschalk Wallerius coined the programmatic notion 'applied chemistry', *chemia applicata*, for this new understanding of chemistry's role.[27] By means of this new conception chemistry gained a wider utilitarian justification which fitted perfectly the general idea of science promoted in the enlightenment.[28] Within a few decades the notion and concept of 'applied chemistry' were adopted throughout Europe. It created an intellectual framework for an institutional development of the discipline in which non-medical applications were to become of crucial importance. Mineralogy, metallurgy, agriculture, the production of glass and ceramics, all began to be recognized as dependent on chemical knowledge. As a result, chemistry became a truly academic pursuit that did not have to justify its position. This development was encouraged by the fact that chemistry's value was far easier to prove in the commerical field than in physiology and pharmacology where its application was highly complex. The new areas of professional competence provided chemistry with a territory of its own, independent of the controversial systems of the various medical schools. According to Trommsdorff it was exactly this fact which enabled chemistry to formulate theoretical conceptions more adequate to its subject matter than had been possible when the discipline was controlled by merely medical questions.[29]

A second, complementary factor influencing the disciplinary development of academic chemistry was cameralism. This was a new discipline which emerged in the German-speaking universities during the last half of the eighteenth century in response to the educational requirements for the administration of the new territorial states.[30] For several decades the 'economic sciences',[31] as they were often called (i.e. mainly agriculture, commerce, and technology[32]), played a decisive role in recommending academic chemistry to state administrators and the general public alike. Five functions were especially important in this regard[33]: (i) the cameralists interpreted chemistry's role in society; (ii) they subsumed chemistry's scientific aims under the broader economic and administrative goals of the state; (iii) in this way they legitimated chemistry's claim to be independent and its demand for adequate support; (iv) they underlined the socio-economic importance of a chemically founded science of industrial production; and (v) they presented society with new perspectives in development and modernization which could be effected by means of university-based training in the

applied sciences. Thus the association of cameralism and chemistry enabled a fundamental revaluation of the latter's academic status and public role.

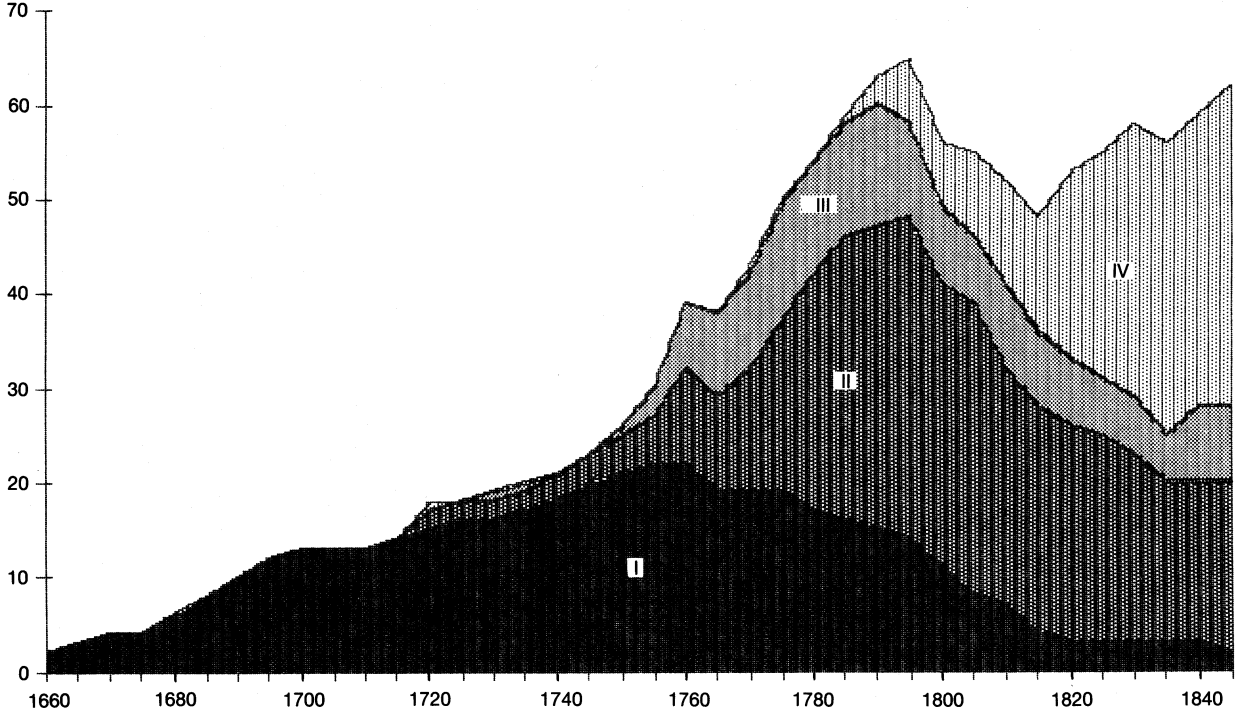
The institutional consequences of this changed perspective and subsequent disciplinary reorientation were especially apparent at universities where the chemical chairs were not from the very beginning exclusively devoted to the training of future physicians. In that regard the Swedish model proved influential, since in Uppsala (1750), Lund (1758) and Åbo (1761) the universities had established their new chairs of chemistry not in the medical faculties, but in the philosophical faculties as part of the economics and administration curriculum. A second model was provided by the various schools of mining, some of which had been given full university status during the last third of the century. These institutions represent a remarkable, though little studied, departure from the traditional patterns of higher education. Primarily devoted to applied science and practical purposes they were, unlike the universities, part of the state's mining monopoly and under immediate administrative control of the mining authorities.[34] The most important of these schools were the mining academies (*Bergakademien*) in Freiberg/Saxony (university status from 1765), Schemnitz/Slovakia (1770), Berlin (1770), and the *École des Mines* in Paris (1783). Here a new kind of chemical professoriate began to emerge, which was neither intellectually, socially, nor institutionally tied to the medical tradition. Consequently the first professors of chemistry who had not initially gone through a medical education appear at these institutions.[35] Several German universities responded to this challenge by creating their own non-medical chairs for chemistry in connection with economics or technology. These chairs were especially common between 1775 and 1820. Sometimes they were incorporated into Cameralist Faculties especially established to receive new disciplines that did not easily fit into the traditional institutional schema. Chemical professorships of this 'economic' type were established in 1760 at the newly founded university of Bützow, at the *Cameral-Hohe Schule* at Lautern (1774–84), at the universities of Giessen (1777–85) and Mainz (1784–98), at the *Staatswirthschafts-Hohe Schule* of Heidelberg (1784–1813), and at the universities in Dillingen (1784–93), Bonn (1789–94), Marburg (1789–1844) and Vienna (1838–42). In some of these institutions the professor of chemistry belonged to the philosophical faculty and

was also responsible for natural history, technology, or economics; in other cases he taught chemistry and pharmacy within the medical faculty, but was also a member of an inter-departmental institute for public economy or of an inter-faculty board of examinations. In other cases the professors of chemistry even belonged to two separate faculties (medical/philosophical or medical/cameralist) at the same time. In this way chemistry had conquered university territory, where it neither had to assert itself against the medical tradition nor to defend itself against charges of being merely a non-academic craft. The scientific and economic results chemistry was now able to promise provided the discipline with a more up-to-date strategy of institutionalization, and opened up new perspectives of professionalization that received public recognition and official support.

Taken together, there were basically four rival forms of institutionalization competing for the limited financial and personal resources the unviersities had to offer for chemical teaching during the second half of the eighteenth century: (i) the more traditional, ancillary chemistry course associated with a predominantly medical chair; (ii) more independent specialized professorships for chemistry and botany, or chemistry and pharmacy in the medical faculties; (iii) chemical positions connected to the teaching of metallurgy, technology, or cameralism outside the medical faculties; and (iv) the first attempts to establish truly independent chemical chairs, usually combined with pharmacy, within the philosophical faculties.

It might be worthwhile to have some quantitative idea of the respective momentum of each strategy of institutionalization. In this field, however, the quantitative methodology has its limitations. The numbers of institutions and individuals involved were small, so that local circumstances, the accidents of history and individual fate interfere with the establishment of secular trends without being eliminated statistically by large numbers. Social historians of science sometimes ignore the fact that 'normal' or 'typical': i.e. more or less standardized biographies began to develop only with the normalization of life expectancy during the nineteenth century. Another limitation of this kind of statistics is that only quantitative changes are recorded whereas the historian of science will usually find information about the quality of teaching and the academic standard of research more worthwhile. In this paper, the method of counting individuals and positions is only used to

Figure 1: Academic teaching positions for chemistry, 1660–1850, cumulative presentation



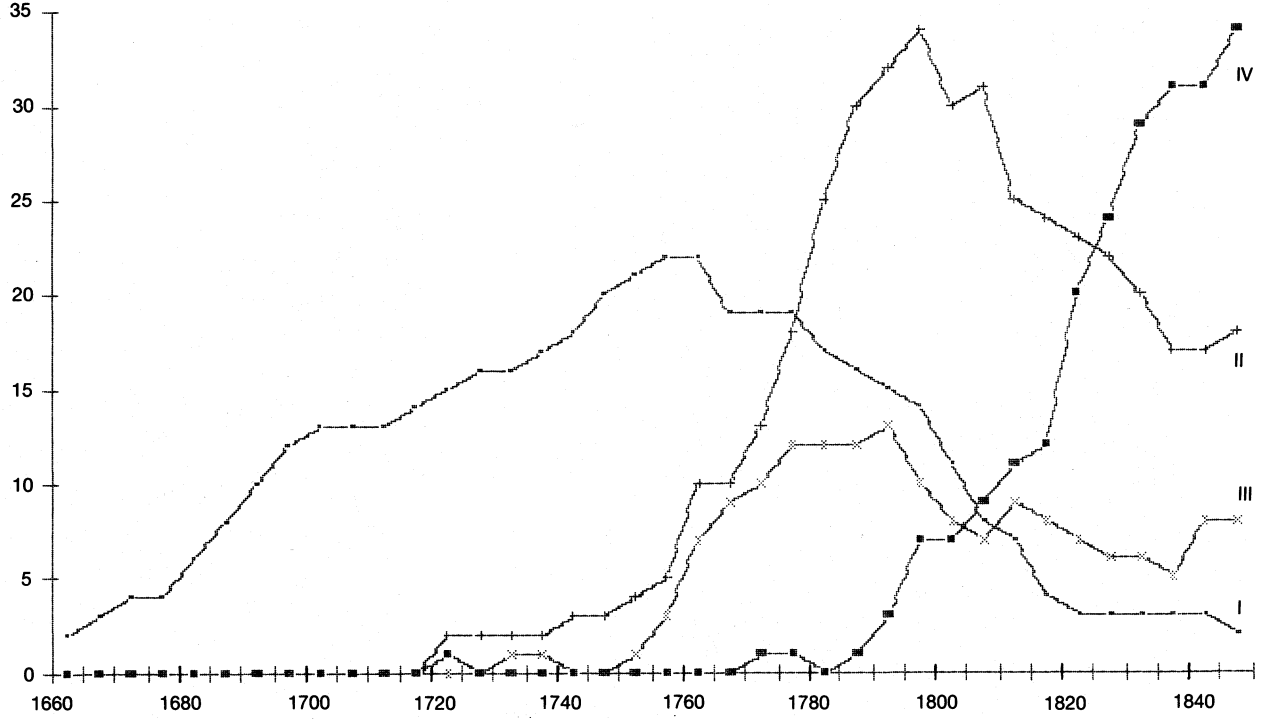
Top line=total numbers (I+II+III+IV); the respective extension of areas I to IV gives the proportion of the corresponding type of professoriate: I=ancillary connection to a predominantly medical chair, II=specialized professorship of chemistry (and botany/pharmacy) in a medical context, III=non-medical chemistry connected to mining or cameralist curricula, IV=chairs of chemistry in purely scientific, non-medical curricula.

indicate tendencies and general changes, and to give some hints as to developments in the cognitive content of the discipline. It is not meant to be an exact description of the processes under consideration, or to replace a more thorough historical analysis.

In preparing Figs 1 and 2, teaching positions in chemistry at universities and similar institutions of higher education before 1840 were evaluated. This was supplemented by a prosopographical study of the people who occupied these positions. Special attention was paid to career patterns and educational background. In order to eradicate short-term variations the institutional data were recorded as five-year averages. The resulting graph for this overall count (Fig. 1, top line) displays what one would expect: the usual, exponential growth in total numbers with a turning point near 1760, a slight fallback due to the Seven Years War, and a clear depression during the Napoleonic Wars when many of the small and moribund continental universities were abandoned and the entire university system of France and her newly conquered *départements* reorganized. The resulting numerical loss of academic positions was, however, to some extent balanced by the emergence of new institutions such as the *Écoles Centrales* and *Höhere Gewerbeschulen.* Three factors were responsible for the relatively slow recovery after 1815. Firstly, there is evidence that, beginning with the 1790s, chemistry was losing its prominent place as a fashionable 'Lieblingswissenschaft der Großen';[36] a decline of public interest definitely affected the institutional development of the discipline.[37] Secondly, saturation effects appear as soon as the great majority of institutions included in this sample had some kind of teaching position for chemistry, so that the much slower multiplication rate of institutions in the first half of the nineteenth century became a limiting factor for further growth. Finally, these statistics do not include purely pharmaceutical chairs after their institutional separation from chemistry in the early nineteenth century.

An even more interesting picture results if each form of institutionalization is considered on its own (Fig. 2). Graph I charts the number of chemical chairs where the discipline was merely a preparatory subject for medicine and tightly bound to the medical curriculum. Criterion for inclusion was that, in these cases, chemistry was always connected with teaching duties in a purely medical subject, and regularly given up if the respective professor, according to seniority, moved on to higher, purely medical disciplines.

Figure 2: Academic teaching positions for chemistry, 1660–1850, secular trends



The height of each graph corresponds to total number of positions of the respective type: I=ancillary connection to a predominantly medical chair, II=specialized professorship of chemistry (and botany/pharmacy) in a medical context, III=non-medical chemistry connected to mining or cameralist curricula, IV=chairs of chemistry in purely scientific, non-medical curricula.

From the graph it is obvious that this form of institutionalization reached its zenith in the 1750s and declined considerably in importance immediately afterwards.

Instead, the tendency towards the creation of specialized chemical or botanical professorships within the medical faculties gained in momentum (Graph II). The teaching of chemistry still remained primarily addressed to medical students, but it was taken more seriously and enjoyed greater disciplinary autonomy. In research and publications, non-medical aspects became more important and the scientists who held the chairs continued to profess the subject for all of their academic career. Institutionally and socially, the two first lines (I and II) were, of course, interrelated. The process described by curves I and II can be seen, therefore, as primarily a rearrangement within the medical faculty in favour of a more independent chemical discipline, which became clearly differentiated within its traditional institutional context.

The development represented by Graph III, which depicts chemical teaching positions in connection with metallurgy, technology, economics, or cameralism, reflects a very different phenomenon. The association of chemistry with the applied side of these economic subjects proved a feasible way to liberate the discipline from its former domination by medicine and led to a new determination of its place within the academic system and within society as a whole. Consequently, a revaluation of chemistry's cognitive content was possible, in which the practical and commercial aspects received more attention. The type of student, the forms of institutional differentiation, and the professional orientation of the course differ remarkably from the traditional character of academic chemistry. Interestingly, a parallel move towards the practical and the useful can be observed in the chemical publications of university professors after the 1750s. However, the steep rise of this particular curve of institutionalization gave way to an equally sudden decline only a few decades later. There are various reasons underlying this phenomenon. Firstly, the utilitarian *leitmotiv* of enlightenment science, which had been so appealing at first glance, was short lived as the expected material results did not immediately arrive. In addition, Beckmann's programme of technology as an academic subject did not succeed. Finally, cameralism lost its traditional unity, divesting itself of its scientific and natural history aspects and eventually collapsing altogether during the first third of the nineteenth

century.[38] As a consequence, most universities lost their economically-oriented chemistry chairs. Only the limited number of mining schools and polytechnics continued to offer teaching in applied and technical chemistry at an academic level. Nevertheless, the importance of this short intermezzo must not been underestimated. When in the 1790s the new antiphlogistic chemistry with its predominantly non-medical approach made its way through the universities of Europe, the conceptual and institutional framework for a chemical discipline outside of the medical curriculum had already been prepared.

At that time a fourth and last form of institutionalization was just beginning: the establishment of chemical chairs within the philosophical faculty (Graph IV). While the preoccupation with the useful and the needs of the state was exhausting itself, a new concept of a university which would be dedicated to scholarship and pure research was emerging at Göttingen and Halle within the first seminars of history and philology.[39] The institutional place of this new scholarly ideal was to be the philosophical faculty as opposed to the professionally-oriented faculties of medicine, law, and theology. However, most of the early attempts to transfer teaching positions in chemistry from the medical into the philosophical faculty, such as at Ingolstadt (1773), Göttingen (1775), and Halle (1788), failed sooner or later because of limited access to financial resources available in tuition and examination fees.[40] Jena, then the third largest university in the country, was the first German university to create, in 1789, a permanent chair for chemistry, combined with pharmacy and technology in the philosophical faculty. Even then, however, this was not in response to the new challenge posed by the changed role of the faculty, for the foundation at Jena belonged to the old technological and commercial tradition. In fact the earliest foundations of independent chemical positions within the philosophical faculty were almost entirely due to the declining association between chemistry and cameralism. Hence an additional impetus was required to enable the transition of chemistry from the medical to the philosophical faculty and to transform the subject into the new type of research-oriented science that was to prevail in the latter part of the nineteenth century.

In Dutch universities the new institutional setting was provided by state intervention. In 1815 a royal decree on the organization of

higher education in the Northern Provinces divided the philosophical faculty into a faculty of mathematics and natural sciences which included chemistry, and a faculty of speculative philosophy and arts.[41] By this measure chemistry in the Netherlands was disconnected from medicine institutionally once and for all. In the beginning, however, most students were still future doctors, since there were few professional prospects in non-medical chemistry at the time. Nevertheless, the separation at least brought to an end the quarrel between chemistry and medicine about their respective rank in academia.

In Germany, on the other hand, the very idea of a separate science faculty would have been alien to the Humboldtian neohumanist ideal of a university. The demand for a faculty of natural sciences was uttered for the first time during the revolutionary year of 1848, but it was not before 1863 that Tübingen succeeded in establishing the first science faculty. Even then the division was preceded by controversies between the representatives of medical and 'scientific' chemistry.[42] It is interesting, therefore, to note that it was pharmacy which played the crucial part in the final institutionalization of its sister-discipline, chemistry. During the last decades of the eighteenth century, the traditional way of training apothecaries, in the form of a craft-like apprenticeship, was criticized both by medical officials and within the profession. The access to academic education, however, was difficult since most pharmacists did not have the entrance requirements for a university matriculation. Therefore, leading representatives of the pharmaceutical profession, concerned with both the social and the scientific status of pharmacy, insisted on a reform of their own professional training. They wanted to make pharmacy more of an academic, science-based profession. A thorough training in chemistry, above all in chemical analysis, was seen as the best way to reach this goal. Following the model provided by Johann Christian Wiegleb, one of the leading figures in German chemistry in the 1780s, many private scientific boarding schools were established, designed to train not only future apothecaries, but also chemical manufacturers, food producers, and civil servants, in practical chemistry and the related natural sciences.[43] The most famous of these private institutions was Johann Bartholomäus Trommsdorff's *Chemisch-physikalische und pharmaceutische Pensionsanstalt für Jünglinge* which was opened in

Erfurt in 1795. It received official recognition as equivalent to a regular university training from 1823.[44]

These private pharmaceutical institutes played a decisive role in the subsequent development of university chemistry. In many cases their owners also held chairs in chemistry or pharmacy at the local university, and, over the years, these professors were able to incorporate their formerly private schools into the institutional and financial framework of the universities.[45] The philosophical faculty was the most obvious place for these teaching establishments, since it was the faculty where the journeymen-apothecaries could matriculate as full-time students without the usual requirement of having completed their studies at a *Gymnasium* first—a reflection of the philosophical faculty's ancient role as a preparatory school for the upper faculties. The small *Chemisch-pharmaceutisches Institut* established by Justus Liebig, then a 22 year old professor of chemistry at Giessen, together with Friedrich Christian Gregor Wernekinck, a mineralogist, Georg Gottlieb Schmitt, a physicist, and Hermann Umpfenbach, a mathematician, was a direct adoption of Trommsdorff's model—even though Liebig, in his later years, made every effort to make it appear as an immediate imitation of the chemical laboratory of the *Ecole Polytechnique* in Paris. It was run as an entirely private and quite profitable enterprise in the shadow of the official university. At the beginning, the university officials were, for obvious reasons, rather suspicious about this new kind of establishment. As one member of Senate stated, it was the university's duty to train professionals for the civil service; but it was not its trask to create pharmacists, soap-boilers, brewers, liquor distillers, dyers, vinegar workers, druggists and the like, for all of these were private entrepreneurs. Although the owners were allowed to continue their private teaching, the institute was not recognized as part of the university until 1835.[46]

After several countries had introduced a compulsory university training for apothecaries in imitation of Austria (1804), Bavaria (1808) and Prussia (1825), the former private institutes lost their importance or were transformed into regular university laboratories for chemistry and pharmacy. Many of them now belonged to the philosophical faculty which, at that time, would not otherwise have been able to sustain a purely chemical discipline, had not pharmacy provided a practical justification for the subject's support. From the point of view of the subsequent development of

academic chemistry this may very well appear as a, to some extent, conscious strategy. Humboldtian professors of chemistry made use of the traditional function of the university as a training-ground for professionals needed by the state, in order to promote a new concept within academia of chemistry as a research-oriented, narrowly specialized scientific discipline.[47] Liebig, for one, until 1840, followed this strategy with unparalleled success, teaching pharmacy but making it perfectly clear that the training of apothecaries was not one of his primary concerns.[48] His conception of academic chemistry centred on pure chemistry and not on its application.[49] It was exactly this aspect of the Giessen school that constituted its international fame.[50] Liebig launched fierce attacks against the proponents of the old utilitarian lines, especially in Prussia and Austria, the two countries with the strongest cameralist tradition. His vision of chemistry was of a scientific discipline whose primary goal was to educate the mind.[51]

From the 1830s it was this neo-humanist, Humboldtian concept of university education which provided the conceptual framework for the promotion of an institutionally-independent chemical discipline. It is not yet entirely clear why the sciences, and especially why chemistry, the most applied of all, so reluctantly accepted the Humboldtian challenge. Nevertheless, its acceptance was crucial. Unlike pharmacy, training in which was publicly needed and even legally required, the independence of chemistry remained insecure and questioned as long as there was no real governmental or industrial demand for trained chemists. As a result, chemistry's utilitarian and applied aspects were given much less consideration in justificatory discourse, in order not to strengthen the hand of those who once again demanded that chemistry and similarly applied branches of science should be banned entirely from the universities and confined to polytechnics and professional schools.[52] Characteristically, the academic status of chemistry was now defended by comparing it not with the professional studies of theology, law, or medicine, but rather with philology and history.

The logical way of establishing chemistry's academic independence was to separate the discipline institutionally from pharmacy, since the latter had never denied its immediate ties to the needs of the profession. Most universities took this measure at sometime during the nineteenth century, beginning with Erlangen (1818), Jena (1820), Bonn (1821), Würzburg and Vienna (1836). When this

occurred pharmacy often remained within the medical curriculum, whereas chemistry was transferred into the philosophical faculty. Figure 2 clearly shows how, between the 1810s and 1840s, the number of positions in medical chemistry (Graph II) decreased, if the decrease was not so dramatic as it appears from the graph since the separate pharmaceutical chairs have not been taken into account. Simultaneously, the number of chairs dedicated to chemistry as an independent science was increasing at the expense of the medical ones.

In this way the process of disciplinary differentiation and distinction of chemistry from neighbouring sciences had reached fruition. The former, mainly hierarchical stratification of these sciences had given way to a more functional division into academic disciplines with more narrowly specialized areas of competence and expertise, a typical feature of the modern understanding of the structure of knowledge.[53] Once this 'external' differentiation had been largely completed, processes of 'internal' differentiation and specialization became more dominant.

While the debates about the position and academic value of chemistry were losing their original vigour, a new quarrel between the different types of institution emerged. The rise of technical and commercial schools fighting for academic recognition polarized the entire system of higher education and also influenced the disciplinary development of chemistry at the respective institutional level. As a consequence the Humboldtian universities almost exclusively favoured pure, organic chemistry as the basis for the study of chemical theory, whereas applied, analytical, and inorganic chemistry were considered merely introductory or auxiliary subjects. This tendency was by no means confined to the German countries; it rather applied more or less wherever chemistry was institutionalized according to the guidelines laid down by Liebig's Giessen model.[54] It was defended by the somewhat contradictory claim that it was exactly its character as a pure and disinterested science which made university chemistry so eminently useful for the national economy. It is still a source of controversy among historians whether in the course of the nineteenth century there was a real polarization between academic chemistry and the requirements of industry.[55] What can be certainly said is that applied and technical chemistry, with a few exceptions such as the Leipzig chair of Otto Linné Erdmann, had to depart again from the universities and turn

to the new polytechnics and *Gewerbeschulen*. Eventually, in the 1870s, there was no academic institution in all of Europe for the study of advanced inorganic chemistry except in Zurich and Paris.[56]

From the seventeenth century the academic discipline of chemistry, originally an ancillary subject of medicine, went through several stages of institutionalization which finally removed it from the medical context and turned it into an independent scientific discipline. The quasi-quantitative evaluation of this process supports the conclusion that several alternative strategies of institutionalization were competing with each other, leading to different forms of disciplinary differentiation. Accordingly, the overall process was not a straight development towards an already fixed end, but rather consisted of a succession of clearly distinct phases of differentiation, each of which had its specific underlying assumptions about what constituted the discipline and how it would best be institutionalized. It would not be illegitimate, therefore, to say that, during these two centuries, different types of chemistry were struggling for survival within the intellectual, cultural and social framework provided by the university system. Therefore, the common notion of a discipline's 'emergence' or 'development' is misleading, for it implies a, so to speak, pre-Darwinian idea of the subject as pre-existent from the very beginning and needing only to be freed from accidental disguises. This is equally true for the distinction commonly made between a discipline's prehistory, its emergence or genesis proper, and its subsequent development.[57] Historically it makes little sense to presuppose the present-day definition of a particular scientific discipline, and then to look for continuity rather than vicissitudes in its history. Disciplines are not metaphysical entities that retain their essence throughout their changing modes of existence. To assign them a 'hidden potentiality'[58] of development, antedating their real genesis or existence, would be historiographical scholasticism. It is our habit of looking back at these historical processes which creates the illusion of a coherent path of logical steps leading to the present. For a more adequate 'epigenetic' description we should rather study the ongoing tension between change and continuity. Subsequent adaptation and transformation processes affect both the institutional structure and the cognitive content of a scientific discipline. Its identity and definition, both internally and externally, are constantly being revised and continue to be open to future change.

For the purpose of this paper, we have had to focus on structural aspects and could touch on changes in the content of chemistry only briefly. But there is no doubt that both these aspects are closely related and affect each other, as they relate in turn to the wider transformation of cognitive, social, political, and economic structures within society. The universities, insofar as they play a key role in acculturation, are at the intersection of all these influences. Continuity and change in a society are necessarily reflected in the universities; but at the same time, the universities provide mechanisms to create continuity, as well as to enable intellectual and social change.

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3. *Ibid.*, 48: 'patet rursum officina, ardebunt furni, accedite et mecum ad hoc desudate'.
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