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ABSTRACTS

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CHEMISTRY BEYOND THE ACADEMY: DIVERSITY IN SCOTLAND IN THE EARLY 19TH CENTURY

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Outside the formal courses offered by the universities, which existed largely to fulfill the needs of medical students, chemistry teaching proliferated in a multiplicity of forms in late 18th and early 19th century Scotland. Some courses were offered with clear aims in mind, but many of those studying chemistry were caught up in a wave of enthusiasm, simply wanting to discover more about what the subject embraced. There were plenty of proficient teachers available who were willing to help fulfill the demand: the names James Anderson (1739-1808), Thomas Thomson (1773-1862), Andrew Ure (1778-1827), Andrew Fyfe (1792-1861), Edward Turner (1798-1837), William Gregory (1803-1858), David Boswell Reid (1806-1863) and George Wilson (1818-1859) spring to mind. Benefiting from the success of the courses, publishers were encouraged to provide chemical texts, while instrument makers marketed cheap chemistry equipment, allowing practical work to be undertaken at home. The paper will consider the development of extra-mural teaching, the origins of the mechanics movement, and chemistry as a social attainment.

Of those who signed on for the lectures of the legendary Joseph Black (1728-1799), few were studying to fulfill professional requirements. His successor Thomas Charles Hope (1766-1844) had the reputation of discouraging experimentation, driving students into the arms of teachers who were providing courses extramurally. Perhaps surprisingly, these courses could count towards the university requirements of those intending to become doctors. Providing for those at a lower end of the social scale, mechanics institutes had their roots in Glasgow, though the first independent institution, the Edinburgh School of Arts, was established at in 1821. Here, a systematic course of chemistry was immediately offered, filling the lecture room. For those seeking chemical knowledge for amusement‘s sake, Black and Hope could provide a service acclaimed by many; James Boswell was certainly in the minority when he wrote “We were mainly lawyers … I did not feel much curiosity for the science.”

ANNALES DE CHIMIE VS OBSERVATIONS SUR LA PHYSIQUE/JOURNAL DE PHYSIQUE (1789-1803): THE ROLE OF SCIENTIFIC COMMUNICATION IN THE LATE 18TH CENTURY DURING A MAJOR CHANGE IN THE APPROACH TO EMPIRICAL RESEARCH

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The founding of several scientific journals during the second half of the 18th century spawned interesting controversies on chemical issues. In the *Observations sur la physique*, in particular, it is possible to scrutinize in detail the evolution of important discussions concerning specific questions: "Inflammation or Combustion?", "Pure Air or Oxygen Gas?", "Fire or Caloric?" In the *Annales de Chimie*, instead, the discussions were inspired by other questions such as "Simple or Compound substances?" The evolution of all these debates helps us understand how the panorama within the scientific community gradually changed: thanks to the reconstruction of the ongoing dispute between two journals, it is possible to describe how a growing number of chemists, physicists and naturalists, following the progress in experimental chemistry, decided to adopt the principles of Lavoisierian analysis. Furthermore, the migration of new data on the constitution of bodies, both organic and inorganic, had significant effects on the more general domain of life sciences. At the beginning of the nineteenth-century, Jean Baptiste de Lamarck, one of the most active naturalists in the Parisian scientific community, ruled out his own original ideas concerning the applicability of "chemistry" to the study of living beings and accepted the new chemical image of "organized bodies" as natural systems of predictable operations.

THE BEGINNINGS OF CHEMICAL INFORMATION

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Whence arises a new chemical discipline? How does a new field of study first organize itself and then continue to grow? In the case of "chemical literature", as the field of chemical information was originally called, we can establish its birth as occurring in the first quarter of the 20th century. The players involved during the period of its inception included a German Nobel laureate in chemistry, a Belgian documentalist and an Illinois librarian. The converging forces that engendered it were those of necessity, opportunity, and a futuristic view of the structure and importance of information itself. This paper will focus on the nature and origin of these forces, and will look at the emergence of this new field of chemical thought.

DID LUCRETIUS' ATOMISM PLAY ANY ROLE ON THE EARLY MODERN CHEMISTRY?

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Recent historiography has pointed out the influence on early modern chemistry of different classical theories of matter. Among these the reading and interpretation of Lucretius are of particular interest. While the *De rerum natura* has been regarded by religious authorities as a dangerous heterodox work, between 1500 and 1800 chemists throughout Europe became progressively interested in adopting Lucretius' qualitative atomism. I shall argue that such atomism played an important role not only in building an alternative philosophy of matter to that of Aristotle, but also in developing more concrete and operative options, such as the definition of chemical reaction.

PROFESSOR GEORGES SMETS: THE DEVELOPMENT OF MACRMOLECULAR CHEMISTRY IN BELGIUM AND HIS CONTRIBUTIONS TO IT IN THE INTERNATIONAL POLYMER CHEMISTRY COMMUNITY

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Polymer Chemistry in general and particularly in Belgium is inextricably connected with the person of Georges Smets (1915-1991). Indeed Professor Smets has made essential contributions to nearly all fields of macromolecular chemistry. Thus, he was one of the first chemists who showed successfully the possibilities of block- and graft copolymerization by radical chain transfer reaction between a growing chain and a pre-existing polymer. By attaching laterally peroxide-groups to polymers or by putting them at their end, several original methods of graft – and block-copolymerization by radical mechanisms were established years before anionic polymerization would become the customary way to produce them.

Professor Smets' solid background in organic chemistry led him to extensive studies of organic reactions on high high polymers and intramolecular functional interactions. In the course of the studies of these reactions he was one of the first to draw attention on the influence of the intramolecular structure and stereospecificity of the polymers. This thorough knowledge of organic chemistry was also at the basis of Professor Smets' interest in the synthesis of new polymers by such at that time recent methods of organic chemistry as cyclodimerization, dipolar cycloadditions, carbene and azide reactions.

Another topic for which he was well known was the synthesis and properties of photochromic polymers or copolymers, yielding insight in the internal structure and physical properties of polymers such as e.g. chain segment mobility. He was also involved in several photochemical and thermal reactions e.g. isomerization, dissociation and recombination in solid polymer matrices, stressing the importance of the physical properties of the polymer medium on the course of these reactions.

Professor Smets also treated problems such as anionic polymerization, synthesis of polyampholites, etc. The originality and significance of his work was internationally recognized. Apart from an impressive list of awards and honorary degrees he has been President of IUPAC and many of his former students were distinguished by their own work, several of whom hold or held professorial positions in Belgian as well as foreign universities.

HOW SHALL WE TEACH CHEMISTRY – FIRST APPROACHES TO DIDACTICS OF CHEMISTRY IN THE 19TH CENTURY

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On the way of evolving identity for chemical science several problems had to be solved. The questions – "Which is the best way to teach chemistry and to organize the instruction of chemistry?" – had to be solved. One must answer the questions: "What knowledge was to be taught to whom and which concepts of methodology should be used?"

Chemistry was taught in courses of medicine, pharmacy and metallurgy etc. already before the 19th century. Some first ideas of natural science didactics are described in the books of Johann Amos Comenius (1592-1671). We can find a detailed discussion of methodology in teaching natural sciences in the thesis "Res naturales"[1] by Julius Adolph Stöckhardt (1809-1886), who was influenced by pietistic thoughts. He demonstrated the connection between chemistry and other natural sciences which must be reflected in teaching. His book "Schule der Chemie" is an excellent example of a textbook, which considers fundamental teaching methods concerning experiments, which help acquire chemical knowledge. While the diction and the choice of experiments don't agree with modern day requirements, many guidelines and techniques within the book do resemble modern chemistry textbooks. It is remarkable that the book emphasized the networking between chemistry and natural sciences and the aspect of *utilitas*.

Since chemistry lessons in the German countries of the mid 19th century were established in the so-called *Realschulen* and not in the high schools (Gymnasium), there was much discussion about the method of teaching chemistry in school as well as in universities. The work of the chemist and teacher Rudolf Arendt (1828-1902) should be stressed at this point as another example of the instruction of chemistry in school.

For several reasons questions about the organization and about the manner of school teaching were discussed in the universities too. This will be demonstrated with writings of Wilhelm Ostwald (1853-1932). He underlined the importance of didactics by establishing the first professorship in the didactics of chemistry. Julius Wagner (1857-1924), one of his co-workers, held this professorship[2], and in his papers we can again find analogies to the actual discussions in didactics.

[1] Julius Stöckhardt, *Res naturales qua de causa perscrutandae, qua methodo docendae et tractandae, quomodo naturae convenienter disponendae*, (Dresden: Teubner, 1837)
[2] Gisela Boeck, "Julius Wagner - Deutschlands erster Professor für Didaktik der Chemie," *Chemkon* 13 (2006), pp. 184-188.

PRE-REVOLUTIONARY CHEMISTRY AND LAVOISIER'S WORK RECEPTION IN GREEK SPEAKING REGIONS

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In this paper we studied the reception of new scientific ideas, especially in chemical issues, in the Greek speaking regions of the Ottoman Empire during the 17th and 18th centuries. It is of great historiographic interest to see how the new scientific ideas interact with local tradition shaping a new scientific discourse. In these regions there were no universities or academies but Greek schools of higher education in witch Greek scholars have taught, the great majority of them had been educated in Europe. The Greek scholars formed didactic traditions shaping fields of knowledge in the context of experimental philosophy. The investigation of these traditions is based on their textbooks.

Before the Chemical Revolution two didactic traditions appeared (Bokaris and Koutalis 2007). The first, named "the system of chymists", close to the Boylean-Cartesian tradition, accepted, contrary to Aristotelianism, the five "chymical" principles and also the analytical ideal, but the "chymical" principles were not under a conceptual and experimental investigation, as they were in Europe. The second, close to the Boylean- Newtonian tradition, was the integrated presentation of the Newtonian "dream", which maintained a discursive attitude with reference to the "chemical affinities". In this tradition also coexisted, in a discursive synthesis, the "chemical element" of Lavoisier. In contrast after the establishment of Chemical Revolution in Europe in the beginning of the 19th century a third didactic tradition appeared which translated the textbooks of Fourcroy "Chemical Philosophy" and Adet's "Leçons Elémentaires de Chimie, a l'usage des Lycées". Chemistry, now, is mentioned as a new, unknown up to then, science, posed at the top of the development of sciences. The remarkable point is also that Lavoisier's *Traite* had never been translated in Greek.

Although the Chemical Revolution is a complex and multidimensional episode which characterizes complexity and temporality (McEvoy 2000), our research conclusions are formulated as follows: chemistry is connected with the ancient Greek philosophy of elements and the most surprising point between these traditions is that they have never been neither in rupture with the Aristotelian tradition nor between them. The second and third traditions were also under the influence of the Newtonian program. This, from a first view amongst other factors, must be attributed to the influence of the Aristotelian metaphysics which facilitated the connection with orthodox tradition and the social and political aims of the newly appeared upgrading social classes and also to the emergence of the enlightened current of empiricism (Kondylis 2000).

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BORDERLINES OR INTERFACES IN THE LIFE AND WORK OF ROBERT BOYLE (1627-1691): THE AUTHORSHIP OF *PROTESTANT AND PAPIST* REVISITED

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At least four borderlines or interfaces can be distinguished in the life and work of Robert Boyle, namely those of:

(a) The abrupt changes that occurred during his lifetime between a Monarchial government to that of a Commonwealth followed by that of the Restoration to a Monarchial form of government in England and Ireland[1].
(b) The relatively slow transition from alchemy into chemistry that took place in the seventeenth century[2].
(c) The division of his time between studies and publications in science and those on religious, moralistic and ethical topics[3].
(d) His position with regard to the division, within the Christian traditions, as between Protestant and Roman Catholic theology and practices.

Since the first three divisions or interfaces are well documented they will be dealt with quite briefly. The main focus will be given to Boyle's position within the Christian tradition, as between Protestant and Roman Catholic theology and observances. The correct assignment of the authorship of the anonymous tract, known by its short title, *Protestant and Papist*[4], which has been the subject of dispute[5], is critical to the formation of a fair and balanced view of a key and major aspect of Boyle's work and also of his religious outlook on life. *Protestant and Papist* has been assigned in many catalogues as being due to Boyle [6]. Bibliographic evidence, including the existence of a copy with early annotations that this tract was not written by Robert Boyle but by David Abercromby will be outlined. This conclusion is supported by material to demonstrate that Boyle did not have a sufficiently narrow minded sectarian outlook to be able to have written a tract such *Protestant and Papist*.

[1] R. E. W. Maddison, *The life of the Honourable Robert Boyle*, Taylor & Francis, London (1969)
[2] L. M. Principe, *The Aspiring Adept: Robert Boyle and his Alchemical Quest*, Princeton (1998).
[3] J. F. Fulton, *A Bibliography of the Honourable Robert Boyle*, 2nd Edition, Clarendon Press, Oxford (1961).
[4] *Reasons why a Protestant should not turn Papist: Or Protestant Prejudices against the Roman Catholic Religion…., by a Person of Quality*, H. Clark for J. Taylor, London (1687). This is commonly known by its short title *Protestant and Papist*.
[5] E. B. Davis, "The Anonymous Works of Robert Boyle and the Reasons why a Protestant should not turn Papist", *J. Hist. Ideas*, 55, 611-629, (1994); R. D. Tumbleson, *Catholicism in the English Protestant Imagination. Nationalism, Religion and Literature*, Cambridge University Press (1998).
[6] See for example the British Library Catalogue and the catalogue of the digital facsimile books, "Early English Books Online".

AN ENVIRONMENTALLY FRIENDLY PORTUGUESE MANUFACTURING COMPANY

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The 1960s witnessed the growth of concerns, to which previously not much attention had been paid, about environmental issues in general, and specifically, about the chemical substances that were invading the environment in industrialized nations. In 1962, Rachel Carson published her controversial best-selling book *Silent Spring*, which brought into the public the environmental problems arising from the use of DDT. The American government as well as the public became aware of the urgent need to protect ecosystems.

In this talk I intend to focus on and analyse the technologies and policies aimed at the reduction of environmental impact, implemented by one of the most important high-tech companies of the Portuguese chemical sector. The company, CIRES (Industrial Company of Synthetic Resins), devoted to the manufacture of plastics, was established in the early 1960s in Estarreja (Aveiro, Central Portugal). This company was a joint-venture set up by the Portuguese Bank, and Portuguese and Japanese corporations. It began by producing polyvinyl chloride (PVC) through polymerization by suspension (PVC-S). At present, besides manufacturing PVC-S, it has also produced PVC of the emulsion type (PVC-E) since 1982.

In the 1960s environmental concerns were negligible in Portugal. But, the issue at hand is why CIRES notably set itself apart from current practices, conscious to associate the productive process and economic profit with the importance of environmental preservation, always keeping in mind a vision of progress and development for the future.
This talk is part of my ongoing research on the effects of technology and chemicals on the environment and how the technological choices made at that time were responsible for pollution problems in that area.

FROM PHYSICAL CHEMISTRY TO MOLECULAR BIOLOGY: THE CATALAN CONTRIBUTIONS TO NUCLEOHISTONE STUDIES: 1965-1977

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During the 1960s, the Spanish Biochemistry and Molecular Biology received a decisive impulse for their development. A first generation of biochemists, trained abroad, had returned to Spain and set up their own research groups mainly with the support from the Spanish Science Council (CSIC). A new generation, their young graduates, completed their training following the same strategy: postdoctoral stages in research centres in foreign countries.

A particular case, due to their training as chemists, was the group which became to be known as the Catalan Structuralist School, led by Jaume Palau and Joan Antoni Subirana. Their postdoctoral stages abroad represented a change in their scientific interests, from physical chemistry to structural molecular biology, particularly the study of the nucleohistone. Both Palau and Subirana published their first papers during their postdoctoral training within the research groups in which they were working, Subirana with Paul Doty at Harvard, and Palau with John Butler in London. Their international legitimization allowed them to start a research group on nucleohistone structure studies, with the funding of the extramural program of the NIH. Taking into account the importance of the introduction of new techniques and, especially, the role played by the instruments of molecular biology as discipline organizers and knowledge transmitters, it is important to stress the importance of the continuous relationship between Scientifics and technicians.

The aim of this communication is to show how is has been possible to reconstruct and study their early years, and their change from organic chemistry to molecular biology, taking into account the disciplinary identity of chemistry and the changing relationships with other fields, such as Molecular Biology, studying mainly their correspondence and analyzing their scientific papers, and using interviews with the main characters, in the framework of the historiography of Biochemistry and Molecular Biology in Spain and in the international context, stressing the dynamics established between the centre and the periphery as well, through their international connections.

CHANGING IDENTITY AND PUBLIC IMAGE. A SOCIOSEMIOTIC ANALYSIS OF FAMOUS CHEMICAL LABORATORY PICTURES

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The laboratory is the place in which chemistry has build up and continuously rebuilds its identity as a specific experimental discipline. On the whole, the experimental practices greatly changed in time, however some visible aspects of the chemical laboratory have proved to be permanent and easily recognizable; among these aspects, the most relevant ones are those connected with the simple operations as to grind or to distil. The use of laboratory images as a socially recognizable representation of a specific research activity preceded the birth of chemistry as an autonomous discipline, and went with the development of the discipline until the last decades of the XIX Century. In our paper we analyse the sociosemiotic meaning of famous laboratory pictures by Jan van der Straet (1523-1605), Louis-Jacques Goussier (1722-1799) and Wilhelm Trautschold (1815-1876). The images where published in very different editorial contexts, and the same languages of the accompanying texts are revealing the shifting of the international language of science: Latin,[1] French,[2] and German.[3]

The sociosemiotic analysis of scientific iconography[4] is a powerful means of historical research, which may be added to the linguistic,[5] epistemological[6] and operational[7] instruments in the historians' tool-bag. Anyone of the considered images reflects the complex relationships between the contextual culture, the artist's style, the publishing (production) context and layout. Some results of the analysis confirm our anticipation of continuity aspects, in particular the permanence of certain chemical activities and of social hierarchies among the characters. Other results are somewhat unexpected, as the strong sense of technological innovation in 1638, the avowed presence of a *Chimiste* and a *Physicien* in 1763, the absence of the master among the crowd of pupils in 1842. Overall, the images describe the changing social position of the chemical laboratory: from the economic dependence upon a princely court to the private endeavour of an enlightened bourgeois, and finally to an academic state-owned institution, open to students from all over the world.

[1] *Nova reperta. In Speculum diuersarum imaginum speculatiuarum a varijs viris doctis adinuentarum, atq insignibus pictoribus ac sculptoribus delineatarum* (Antwerp: Galle, 1638). We consider also Straet's oil painting placed in the Studiolo of Francesco I de' Medici (1573).
[2] *Recueil de planches sur les sciences, les arts libéraux et les arts méchaniques, avec leur explication. Seconde livraison. Seconde partie* (Paris: Briasson, David, Le Breton, Durand, 1763)
[3] J. Hofmann, *Das chemische Laboratorium der Ludwigs-Universität zu Giessen* (Heidelberg: Winter, 1842).
[4] G. Kress, T. van Leeuwen, *Reading Images: The Grammar of Visual Design* (London: Routledge, 1996).
[5] L. Cerruti, "Werner's Beitrag: A Linguistic and Epistemological Analysis", in: G.B. Kauffman, *Coordination Chemistry. A Century of Progress* (Washington: ACS, 1994), pp. 43-56.
[6] L. Cerruti, "Chemicals as Instruments. A Language Game", *Hyle*, 4 (1998), pp. 39-61.
[7] L. Cerruti, "The inherent complexity of chemistry", in: R. Benigni *et al.*, *Complexity in the living: a problem-oriented approach* (Roma: ISS, 2005), pp. 1-18.

MEMORY AND HISTORY: THE MEXICAN COMMUNITY OF CHEMISTS TELLS ITS STORY

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A seminar named "Memory and History: The Mexican Community of Chemists Tells its Story" has been organised and initiated by the Mexican Chemical Society, the National University of Mexico and the French Institut de la Recherche pour le Dèveloppement. The main challenge of the seminar is to give the floor to the protagonists and witnesses of relevant facts in the building of chemistry history in Mexico during the XX century. The history of science in Mexico has been widely studied in relation to centuries XVI to XIX (Trabulse, 1983), but only a few reference books have been written for the twentieth century (Garritz, 1991). That is why the authors of this work think that this history deserves to be documented and known by the general public. We try to find the way of Mexican chemistry practice inside the construction of international science and also to characterise its singularities.

A full set of periods and topics was proposed to the members of the Mexican Chemical Society:

1. The National School of Chemical Sciences (1916 – 1935)
2. The petroleum expropriation (1936 – 1940)
3. Syntex and the Institute of Chemistry at UNAM (1941 – 1975)
4. Chemists as academics. The formation of groups of basic research (1941 – 1980)
5. Chemical Engineering and chemical industry in México (1941 – 1970)
6. The strengthening and diversification of chemistry in Mexico in the seventies

The starting session was about 'Petróleos Mexicanos' the public-sector establishment founded in 1940, just after the petroleum expropriation, and the most important industry in Mexico. The subject of the second session was 'Influence of Banco Nacional de Mexico in the chemical industry: The case of Univex, the company producer of caprolactame'.

Besides collecting the written presentations from each participant in order to build up oral archives and publish them, the sessions are also being filmed to share these priceless testimonies with distant and future audiences.

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GETTING TO THE HEART OF THE MATTER: THE CHANGING CONCEPT OF THE WESTERN CHEMICAL ELEMENT IN LATE QING DYNASTY CHINA

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Just as the element was defined as an 'essential substance' in ancient Greece - and thus was regarded as the key to the 'secret' of matters in the universe - so the discovery of the chemical element in the West, and the alternation of its definition, illustrates the progress of chemical science in Western culture.

For China, however, it was not until the period from 1842 to 1895 that the Chinese began to take a serious look at the study of modern Western chemistry. Many textbooks on chemistry were translated during this period, especially after the publication of the first chemical textbook *Huaxue Rumen* (Introduction to Chemistry) in 1868.

Moreover, the changing definitions of the element can also be seen reflected in the various Chinese translations. When the concept of Aristotle's 'elements' was introduced into China at the end of sixteenth century, it was first translated as *yuanxing* (primary phase) – due to the influence of the 'five phase' theory. In the latter half of the nineteenth century, however, there were two similar translations for element - namely *yuanzhi* (primary substance) and *yuanzhi* (original substance). *Zhi* or substance, the second character in the Chinese name, not only shows its modern definition, but also indicates the Chinese acceptance of the Western concept. The elements – that is, oxygen, hydrogen and nitrogen - belong to the 'airs' and thus were not seen, had no weight, and were defined as *qi* (essence or energy); in contrast to matter in the Chinese natural philosophy.

Since the discovery and handling of chemical elements represented the success of chemical science, the Chinese reaction to the study of chemical elements was complex. In 'the essay of elements', the Chinese compared the differences and development of alchemy in China and in the West, and tried to explain why Chinese alchemy could not transform into modern chemistry as in the West. Moreover, they considered that the beginnings of modern Western chemistry were only recent, since 29 elements of 64 were discovered before 1800. In addition, the Chinese believed that many of elements that were discovered in the West – for example, oxygen and hydrogen - had existed in Chinese chemistry, although under different terminologies.

The role of elements in the combination of matter was interpreted by the Chinese during the time that they considered that chemistry was simply the combination and decomposition of elements. Just as one handled elements, so one understood chemistry. But they always interpreted the chemical meaning of elements under the influence of such Chinese thinking as natural philosophy, the concept of *qi*, the doctrine of *taiji*, and the *yin-yang* theory. Thus the scientific effort of innumerable experiments, and improved equipments on the discovery of elements, was to be neglected by Chinese scholars.

ROBERT BOYLE'S EXPERIMENTS ON COLD: A STUDY OF THE ROLE OF CHEMICAL EXPERIMENTS

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In the first half of the 17^{th} century alchemical and chemical practises constituted areas of widespread experimentation in England. Robert Boyle (1627-1691), the English natural philosopher and experimentalist, played an active part in them. In 1649 he initiated his experimental practice with trials of chemical, alchemical and pharmaceutical interest in his newly established laboratory in Stalbridge, Dorset. During this period of early experimentation, Boyle became familiar with various atomic philosophies of his time and developed his first ideas on atomism and the composition of matter. In parallel he designed experimental schemes and started experimenting on the qualities of matter, such as cold, heat, fluidity and firmness.

Two important treatises, where his early experimental work on chemistry was presented, were the treatise *The Sceptical Chymist* (1661) and the essay 'Essay On Nitre'[1]. In the first, chemical experiments were used to refute predominant theories on the constitution of matter. In the second, experiments on the analysis and reintegration of nitre were used to support his views on the atomic structure of matter. At the same time Boyle published two treatises on qualities of matter which he considered the most comprehensive treatises on their subject, *The History of Fluidity and Firmness*[2] (1662) and *New Experiments and Observations Touching Cold or an Experimental History of Cold, Begun* (1665). The treatise on cold consists of a vast number of experiments aimed at the examination of the degrees the quality could reach and its diffusion in air, earth, water and other mediums, the examination of the effects of cold on liquids and solid bodies, with particular experiments designed to examine the expansion of water by freezing and its effects, the examination of phenomena relating to ice, and the examination of the coldness and ability to cause coldness of air, water, earth and bodies that had been chemically processed.

This paper examines the relation between chemical and physical experiments in the treatise of cold. We will focus on the use of chemical processes, substances and experimental practises in various experiments. We will examine the information they provide of chemical interest, as is for instance the use of cold in chemical analysis instead of heat, and on important aspects of the quality, like its degrees. This study will also entail an examination of the role played by chemical experiments in Boyle's effort to form an explanative hypothesis of the nature of cold. The treatise on cold constituted primarily a presentation of 'matters of fact' about the phenomena of cold. Nevertheless, it is made evident by Boyle that his experimental results were also used in the formation of a hypothesis on the nature of cold based on his corpuscular theory of matter. It will be considered whether this evolving theory of matter and its properties, created a context, as shown by case studies like the experiments on cold, where experiments concerning the chemical and physical qualities were inextricably used for a common purpose.

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[1] Short Title for 'A Physico-Chymical Essay, containing an Experiment with some Considerations touching the differing Parts and Redintegration of Salt-Petre' published in the treatise *Certain Physiological Essays,* (1661).
[2] One of the five essays published in *Certain Physiological Essays* (1661).

TECHNOLOGICAL TRANSFER ISSUES: PERCY PARRISH ADVISING AT "CUF, COMPANHIA UNIÃO FABRIL" (40's, TWENTIETH CENTURY)

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The first CUF sulphuric acid factories in Barreiro started working in the beginning of the twentieth century, more precisely 1909, producing sulphuric acid (chamber process) from pyrites with a particular concentration, specific to subsequent production of phosphate fertilizers. Latter, the sulphuric acid produced by chamber process will be also applied in several other important productions of the CUF company, namely sodium sulphate (to glass industry) or copper sulphate (as fungicide).

The industrial "cluster", resulting from relations between those (and other) CUF productions was designed by a French engineer A. L. Stinville, and erected in a record time. By the start of the Great World War, a major part of the "key" product units, that were to become the chemical complex of CUF in Barreiro, worked full on. The close supervising of Stinville as technical adviser of the CUF "cluster" lasted for at least a decade, being perceptible his "leaving the scene" in the mid thirties of the twentieth century.

His withdrawal coincided with the first technical Portuguese management in the CUF factories in Barreiro assumed by Eduardo Madaíl (1927), a chemical engineer formed at Lausanne University. The systematic use of foreign specialty revues must have lead Madaíl to Percy Parrish, already a technical reference by that time, mainly in the heavy inorganic industrial area. The growing demand for more acid felt during the II World War puts CUF facing several technological problems, in particular those resulting from the increase on the production of the industrial units in Barreiro, that required not only several technological reformulation aspects but also new equipment and apparatus.

Meanwhile, the emerging of a new consumer market for a purer and more concentrated acid and the intent of CUF to became a nitrogenous fertilizer producer, starting with the production of the ammonium sulphate (that latest aspect also determines the adoption of a new technological process for sulphuric acid production – the "contact" process – on the CUF-Barreiro), created the opportunity of a new technical foreign consultancy, in heavy chemicals domain, lead by Mr. Percy Parrish, which ended rounded 1947 with his decease.

In this work, we intended to identify and characterize the terms in which this technical relation processed and, in some way, compare it with those of Stinville's.

CHEMISTRY PREPARERS IN PORTUGAL IN THE NINETEENTH CENTURY: SOME ASPECTS OF THEIR EVOLUTION

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Chemistry, and in particular its teaching, are historically linked not only to teachers and scientists, but also to labs and its preparers. Only slightly present in several historical scenarios of the nineteenth century Portuguese institutions, preparers were however, in Portugal and abroad, determinant factors to a normal development of chemistry teaching and laboratories.

As a "professor assistant", executing the minor tasks, connected to investigation and students practical work, the preparer, however, should have a convenient knowledge about a great number of chemical products, processes for their preparation, and also developed good manipulation skills. Pharmaceutics – namely those who had attended a chemistry subject – fitted quite well in that profile and in fact, they used to take those places in the laboratory domain.

As the century went by, especially at the end of its second half, the socio-professional lack between professor and preparer seems to be attenuated, and we can observe a special approaching between them.

With this work we intend to characterize and describe aspects of the professional evolution of the preparers, based on some case studies, and their relation to chemistry development and its teaching in Portugal.

JOAN BAPTISTE VAN HELMONT AND THE QUESTION OF EXPERIMENTAL MODERNISM

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In this paper, I take up the question to what extent and in which sense we can conceive of Johannes Baptista Van Helmont's (1579-1644) style of experimenting as "modern". Connected to this question, I shall reflect upon what Van Helmont's precise contribution to experimental practice was. I will argue - after analysing some of Van Helmont's experiments such as his tree-experiment, ice-experiment, and thermoscope experiment - that Van Helmont had a strong preference to locate experimental designs in places wherein variables can be more easily controlled (and in the limit, in relatively closed physical systems such as paradigmatically the vessel, globe or sphere (/vas, globus, sphera/)). After having reviewed some alternative candidates, I shall argue that Van Helmont's usage of relatively isolated physical systems and a moderate degree of quantification, whereby mathematical procedures mainly refer to guaranteeing that quantities are conserved by roughly determining them, are the characteristics that best captures his contributions to "modern" experimentation.

CHARLES FRIEDEL (1833-1899) AND THE LABORATORY OF PRACTICAL CHEMISTRY OF THE RUE MICHELET IN PARIS

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The Institute of chemistry of the *rue Michelet* is often quoted as an example of one of the first teaching laboratories in practical chemistry in Paris. Officially founded on 29 April 1896, it was located at the Parisian Faculty of sciences. The director was Charles Friedel, professor of organic chemistry in this faculty from 1884. He obtained this creation after senator Poirrier's successful intervention at the parliamentary session en March 1893.

At the Museum of Natural History, Fremy's laboratory of teaching practical chemistry was suddenly closed in January 1892, because of several reasons (Fremy was too old, and the Museum reorganized its departments…). No such a laboratory with the same function was located in Paris at this time. That school was given a training axed on the perfect acquisition of the abilities of practical chemistry, particularly the skills in chemical analysis, furnishing young chemists to industry and also to research (H. Moissan and G. Bertrand were two famous students of Fremy). His school was opened to people without necessity of previous diploma, neither Parisian residency.

Ch. Friedel argued of the lack of such an institution to ask the creation of such a school to replace the Fremy's one. The new laboratory would give a formation during three years, every year sanctioned with a certificate, and a diploma was awarded at the end of the third year. No diploma or Parisian residency was necessary to follow this teaching, as previously in Fremy's school.

But Friedel died in 1899, without seeing the first promotion of his « Institute » as it was often called. Henri Moissan succeeded to Friedel at the head of this laboratory. In 1900, he obtained the chair of chemistry at the Faculty of sciences. This last high position allowed him the possibility to give also a better theoretical level to the future chemists. First, he succeeded in the transformation of the laboratory on a true Institute of chemistry in 1901. Secondly, he obtained that the Institute delivered a diploma with the title of engineer in chemistry in accordance with the French sense, in 1906.

In this communication, I want to expose the conditions of teaching practical chemistry in Paris at the end of the nineteenth century, which explained the creation of the *Institut de chimie*, its teaching and its success. The *Institut de chimie de la rue Michelet* became the *École supérieure de chimie de Paris*, a *Grande École*, for the formation of engineers in chemistry.

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HERMANN MARK. THE VIENNESE BORN AMBASSADOR OF MACRO-MOLECULAR RESEARCH

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The paper examines the academic career and the merits of Hermann Mark (1895–1992). After having spend the first half of his life in Central Europe, the physical chemist emigrated to the United States after Hitler had invaded Austria in 1938. In America he would contribute tremendously to the scientific advancement, academic institutionalisation and education of macromolecular chemistry. In fact, Hermann Mark's efforts had helped the polymer concept to become accepted in the international academic community.
The cornerstones of Mark's scientific success were laid in Central Europe: *First* he had become a specialist in X-ray investigation. In the 1920s, when X-ray analysis was in its infancy, he used the brand new method to analyse the structure of solid substances, such as biological structures and polymers. *Second* Mark gained the ability to organise scientific research in working groups. And *third* Mark advocated interdisciplinarity: he formed a team of physicists, mathematicians, organic and physical chemists and statisticians to study the interrelation of structure and rigidity, elasticity, melting point and so on. In 1932 Mark became professor of physical chemistry in Vienna. There he established macromolecular chemistry at university. Within the next few years Vienna University became one of the few *academic* centers of high polymer research in the world. At that time polymer chemistry was still an industrial domain. In Vienna he had picked up some ambitious Jewish students (E. Guth, F. Eirich, R. Simha). The working group processed a successful project on polymerisation.
In 1938, after the "Anschluss", Mark was dismissed from university. He had been the son of a Jewish father. After Marks dismissal most of his collaborators also lost their engagements in third party (IG Farben) financed research projects: R. Simha, E. Broda, R. Raff, H. Peltzer, H. Dostal and K. Schiff. Most of them had to emigrate because of Jewish background. Mark's assistants F. Eirich and P. Gross also had to leave Austria in 1938. After Hitler's invasion in Austria Mark himself accepted a manager position, he had been offered with a Canadian Company in 1937. In 1940 he went to Brooklyn. Then the imports of shellac were likely to diminish because of the threat of war with Japan. Mark was familiar with the fabrication of synthetic replacements. At that time polymer research was still a branch of industrial chemistry. The need of synthetic replacements of shellac provided Mark with a second opportunity to transform high polymer research, to an academic discipline: His effort in the United States was similar, to what he had done at the University of Vienna, though on a much larger scale: in 1946 Mark founded the Polymer Research Institute, which became the first US institution offering a Phd programme in polymer chemistry. Mark organised the Brooklyn working groups on the model of the Viennese Institute, and he also introduced interdisciplinarity as basic principle of research. In the first years after the opening of the Polymer Institute, Mark staffed it with some of his former Viennese collaborators, who had to leave Austria in 1938. For Simha, Raff and Eirich the Polymer Research Institute became an excellent stepping stone into an academic career. In the meantime some other Viennese collaborators of Mark had already gained a foothold in Great Britain: E. Broda, K. Klanfer, H. Peltzer, K. Schiff, H. Motz. One of his disciples, who had left Austria in the 1930s, had applied Mark's method – X-ray analyses – to analyse hemoglobin: Max Perutz would become Noble prize winner in chemistry.

SPEAKING ABOUT THE OTHER ONES: SWEDISH CHEMISTS ON ALCHEMY, 1730-80

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What did prominent 18th century chemists think about alchemy, and on what grounds did they reject or condone it? This paper explores the views of four major Swedish chemists on the subject of alchemy. The chemists that are discussed are Georg Brandt (1694-1768), Axel Fredrik Cronstedt (1722-65), Johan Gottschalk Wallerius (1709-85) and Torbern Bergman (1735-84). The two first-mentioned were employed in the mining industry, while Wallerius was the first professor of chemistry at Uppsala, and Bergman his successor. The picture that emerges turns out to be far more complex than assumed by previous research. Brandt and Wallerius, the two older chemists, saw alchemy and chemistry as separate activities. Nevertheless they acknowledged continuity between older authors in the chymical tradition, and their own work. Cronstedt and Bergman, on the other hand, employed a more agressive rhetoric against alchemy. The paper argues that this new rhetoric was connected to changes in chemical practice and theory, as well as to the inroads of enlightenment ideals into the Swedish scientific community towards the middle of the 18th century. The picture is however complicated by testimonies of communication between alchemists and chemists throughout the period, and by apparent differences between publicly stated views, and those confessed in private correspondence.

EIGHTEENTH CENTURY CHEMISTRY, BETWEEN NATURAL PHILOSOPHY WITHOUT NATURE AND PHYSICS WITHOUT REASON

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This paper aims to show that, in 18th century Chemistry, there is nothing anymore but only one instance of reality: the existence itself of the bodies. Chemistry gives up the idea of Principles, of a Reason or of a Nature transcending all the chemical phenomena, which prevailed hitherto in this science. In this direction, without real base hiding under perceptible appearances – without Nature thus –, Chemistry leaves by definition natural Philosophy. Its works fit in now with 'tragic processes' consisting in refusing any metaphysical argument to practise a clearly experimental physics, or rather a 'physics of the artifice'; an artifice which would not be anymore a continued Nature since the Nature is henceforth defined as artifice continued. Theory and practice of Chemistry then find their "application to Physics, natural History, Medicine & animal Economy" (2nd part of the title of 1766 Macquer's *Dictionnaire de Chimie*).

Two 18th century definitions of Chemistry reveal this change of statute of bodies on which this science works: 1702 Wilhelm Homberg's definition at the Académie Royale des Sciences and 1753 Gabriel-François Venel's definition in the third volume of Diderot & d'Alembert's *Encyclopédie ou Dictionnaire Raisonnée des Sciences et des Arts*. For the first one, only Chemistry –with its experimental practice– is able to establish a certain truth inside a questionable Physics. Moreover 17th century chemical Principles (Sulphur, Mercury, Salt, Water and Earth) are said to be, not anymore inaccessible substances to reach in a pure form whose qualities explain the properties of the mixed bodies that they constitute (in a Chemistry which knew the perceptible bodies only as instances of these five Principles), but simply five categories of indecomposable (perhaps they by the progress of chemistry will be it, thinks one), and perfectly tangible substances. The second definition wants to define the peculiarity of Chemistry and to justify its autonomy inside general Physics. According to this definition, the last two centuries Chemistry is "riche en faits, en connaissances vraiment chimiques", but unfortunately "[elle] s'est égarée en s'élevant", while prevailing itself to be the art which makes possible to go up to divine Architect, or even "[l'art] rival & réformateur de la Nature"; generally in Physics, one often confused "notions abstraites avec vérités d'existence", and wanted at all costs "rendre raison des choses", or "remonter [par de délicates spéculations] jusqu'aux premières origines". By contrast and out of necessity, Chemistry moves in "vagueness" and "approximation". Chemistry is a thought of the Present –*i.e.* a thought of what exists– , and not anymore of the Past – with its attempts to rediscover the elusive truth of Principles.

So in the absence of metaphysical postulate, of a Reason of the things, Chemistry seems indeed to be distinguished from natural Philosophy and 'ordinary Physics' (according to the non-pejorative expression of Venel). Many elements of the History of 18th century Chemistry express this absence: the refusal of the idea of the homogeneity of the matter, the passage from Chemistry of Salt to Chemistry of salts, Chemistry of airs, the search of an artificial ordination of the substances (Principles of Homberg, Geoffroy 'Table des Rapports' which presents the rule of the Chemist and not a law of Nature[1], Rouelle's table of neutral salts according to their crystalline figure), the refusal of the chemists to subsume chemical affinities –which are not causes but shared possibility of union according to the involved substances– under Newton's Law of universal gravity, the denunciation of the claims to prepare the Philosopher's stone simultaneously with a continuation of the work on Chrysopoeia like pure artificial production, the attraction of the materialist Philosophers for Chemistry, etc.

Nevertheless the change is neither sudden nor necessarily radical. It is not sudden, because the recognition of the lonely instance of reality –the existence of the bodies– is the continuation of the movement of 17th century Chemistry (which rehabilitated the 'corporal' with the use of the Salt Principle (Joseph Du Chesne), then the body with the practice of the second and palpable Principles (handbooks of Chemistry), and finally the search of the establishment of verisimilitude Principles which are not 'metaphysical', *i.e.* indemonstrable (Samuel Cottereau Du Clos, François Saint André)). It is not either necessarily radical, because the practice of Chemistry –which is not reduced to a simple empiricism– try to determine a coherent order in the diversity of the substances which can still use sometimes a indemonstrable Reason (furthermore certain Chemists of first half of the century still remain attached to Chemistry of the Principles). One can finally question oneself if the abandonment at the 18th century of a transcending Principle of unit in Chemistry were not final.

[1] Moreover, Fontenelle, in his report of Geoffroy's memoir will deplore the absence of a Reason on which would be based the various affinities of bodies to combine observed in laboratory: "[…] Mais quel principe d'action peut-on concevoir dans ce plus de convenance?" (p. 36).

THE INTERPLAY OF CHEMICAL TEACHING WITH WORK AND WITH RESEARCH: A CASE STUDY FROM GERMANY AROUND 1800, JOHANN FRIEDRICH AUGUST GÖTTLING AT JENA

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The typical chemist in Germany around 1800 was trained as a pharmacist and worked as a professor at a university or other institution of higher education. These conditions deeply influenced the concept and the practice of chemistry as science. Johann Friedrich August Göttling is an intriguing example for combining, or even merging, his education as an apothecary with his daily duties of teaching and his self-image of a scientific chemist. Through different hybrid media, he linked chemical teaching with work and with research.

Through his *Almanach oder Taschenbuch für Scheidekünstler und Apotheker*, he educated pharmacists and at the same time profited from their laboratory observations. Through the invention of a stove specifically designed for the narrow student's room, he allowed students to do their own experiments and extended the circle of "chemists". Through his *Probir-Cabinette* (portable laboratories), he allowed practitioners (mostly physicians) to learn and learners (mostly pupils at school) to practice. Through his pharmaceutical boarding school, he combined the advantages of academic teaching and craft apprenticeship. By performing his research experiments in his lectures, he could recruit his listeners as witnesses. And by writing textbooks, he developed a new classification for chemistry.

But this strong reliance on teaching had ambiguous consequences for chemistry as a science. The modern epistemic marginalization of teaching with regard to research seems already in play, when Göttling presents chemical processes in his lectures as mere demonstrations with no bearing on chemical knowledge, and when he discusses the merits of his classification of chemical substances merely in terms of didactic appropriateness rather then correspondence with nature. Thus, there was still a tension between the self-image of the scientist and the social reality of the teacher.

THE DIDACTIC USES OF EXPERIMENT IN EARLY 19TH CENTURY FRANCE

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The emergence of new chemistry teaching methods has been usually depicted as the individual enterprise of a young chemist, Justus von Liebig, who was able to conceive and set up with scarce resources but great creativity a revolutionary method of laboratory based teaching that was in many aspects opposed to the traditional lecture experimental demonstration. This paper tries to query this view, focusing on two of its main features: the localised, radical and sudden way in which the emergence of new pedagogical methods is depicted; and the opposition and incommensurability that are created between the use of experiments as a didactic tool in the new laboratory-based pedagogy and the traditional experimental demonstrations.

Our arguments will be based on a detailed analysis of the teaching practices that characterized Louis Jacques Thenard's chemistry courses at the *Collège de France* during the first third of the 19th century. Special attention will be paid to the way experiments were used as didactic tools in the transmission of theoretical and practical knowledge. We will try to show that Thenard's courses, as probably many others in Europe during the first decades of the 19th century, resembled more a space of didactic investigation, where different ways of using experiment as a didactic tool were tested, than a place where traditional and well-defined and consolidated didactic models were applied.

"A SUBVERSIVE ELEMENT": PUBLICS, DISCIPLINES AND THE RISE OF MADRID'S LABORATORY OF RADIOACTIVITY

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Radioactivity was since its inception a hybrid discipline, gathering theoretical and instrumental resources of physics and chemistry. At the same time, its applications and celebrity of some of its leading figures (such as Marie Curie) made radioactivity prominent among the public. The aim of this paper is to show how these factors –disciplinary ambiguity and high public profile- shaped the early appropriation of radioactivity in Spain, and how they made possible the establishment of an space for research in a country with weak academic structures.

In particular, I will focus on the emergence of the Laboratory of Radioactivity at the University of Madrid, which became the leading radioactivity research centre in Spain and also one of the most important chemistry laboratories in the country. The origin of this institution is closely related to the career and activities of José Muñoz de Castillo, professor of "Chemical Mechanics" in the University of Madrid. We will see that, despite initially lacking instrumental and material resources, Muñoz succeed in making the discipline visible in national politics. Nevertheless, this achievement was coupled with a lack of international reputation and visibility. I relate this position to Muñoz attachment to superseded theories of the atom constitution, which can be traced back to early appropriations of radioactivity in the Spanish academia.

NOTION OF "MECHANICAL" AGENT IN RENAISSANCE MATTER THEORIES

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This paper aims to give a new light on the notion of "mechanical" (*mechanicus*) agent, which was often used in the tradition of Renaissance philosophy and then in the current of Paracelsian chemistry. It traces the evolution of this notion from Nicolaus Cusanus and Marsilio Ficino until the time of Joan Baptista Van Helmont and its impact on the natural philosophers of new generation like Pierre Gassendi and Robert Boyle. By doing this, it suggests a reconsideration of the accepted interpretation made by past major historians of science. This paper, based on my double awarded book on *Concept of Seeds in Renaissance Matter Theories*, shall namely treat the idea of "archeus" of Paracelsians chemists.

CHEMISTRY, ENGINEERING, AND RATIONALIZATION IN GERMANY, 1919-1933

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Following the First World War in Germany, chemists encountered a completely new situation. Compared to the prewar era, there were many more young chemists fresh from their university training, and not enough openings in the traditional chemical industry to absorb them. There were various responses to this situation by individuals and chemical associations; some were fairly conservative, such as warning secondary-school students away from the study of chemistry. Others, however, offered innovative solutions to the problem; in part these took advantage of the heightened prestige of chemistry resulting from its strategic role in the war, in part they took advantage of a rising interest in "industrial rationalization," a general movement toward greater efficiency in production. The *Verein Deutscher Chemiker* (VDC, Association of German Chemists), for example, undertook a successful campaign to promote the employment of chemists in other branches of industry.

Along with the movement toward rationalization came closer ties between chemistry and engineering in Germany. Despite the skepticism of some of the most influential industrial leaders such as Carl Duisberg of Bayer, chemical engineering began to emerge in the form of a new discipline called *Verfahrenstechnk* (process technology). Although *Verfahrenstechnk* did not become established until after 1945, closer ties between chemistry and engineering could be seen in the *Technischen Hochschulen* (technical universities), where the classical organic chemists whose idea of industry was small-scale batch production now lost their dominance to representatives of newer subdisciplines representing more "modern" and large-scale technological orientations. One of the most significant promoters of the new interdisciplinarity was Max Buchner, who in 1918 helped to organize the *Fachgruppe für Chemisches Apparatewesen* (FACHEMA, Specialty Group for Chemical Apparatus) within the VDC, in order to promote collaboration among chemists, engineers, machinists, and industry in the development of new chemical process equipment. By 1926 the FACHEMA was reorganized as the *DECHEMA-Gesellschaft für Chemisches Apparatewesen* (Society for Chemical Apparatus), an independent group that remained affiliated with the VDC.

Although the onset of the Great Depression after 1929 increased the unemployment rate of chemists, the success of efforts to promote the expansion of chemistry into new areas was reflected in the fact that chemists lost relatively fewer jobs in the branches of industry outside the traditional chemical industry. By 1933 there were thus almost as many German industrial chemists working outside the chemical industry as within it, and although a majority of chemists in German universities retained a relatively conservative, classical outlook, elsewhere chemistry had become more interdisciplinary as well as more closely tied to engineering than in 1914.

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ETIENNE FRANCOIS GEOFFROY, A FRENCH CHEMIST BETWEEN ENGLAND AND GERMANY

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In the first years of the seventeenth century, a fancy for Cartesian physics gained the chemists of the Royal Academy Sciences (Paris) who, like Louis Lémery, tried to bring into play a mechanical program by reducing the operations of chemistry to affaires of spike, pores and choc of bodies. Etienne-François Geoffroy succeeded, however, to establish a chemistry which escape the deadlocks of Cartesian mechanism thanks to his openness towards England (following his stay in England, he knew the works of Newton, of which he translated the first edition of *Optics* for the Royal Academy of Sciences) and towards Germany (as blame his adversaries, who saw in him the evidence of allegiance to the alchemical tradition, he knew the works of Becher and Stahl). The ideas of Geoffroy are assembled in the *Cours de chimie selon les principes de Newton et de Stahl* which has abusively been attributed to Senac and whose true author, if it is not Geoffroy himself, should be one of his disciples. It is this European openness that permitted him to elaborate the table of affinities which constitutes without doubt one of the most important characteristics of the chemistry of this period.

My paper aims to establish most precisely the exact nature of the relationships that Geoffroy maintained with his chemical colleagues of the Royal Society and German chemists of the circle of Stahl.

PHYSICAL CHEMISTRY CROSSED THE BOARDER: INFLUENCES OF PHYSICAL CHEMISTRY IN THE GERMAN CHEMICAL INDUSTRY 1900-1950"

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Before the turn of 20th century the German chemical industry was heavily influenced by the knowledge and modelling approaches of the organic chemist. Although there were some chemical engineers in the industry, the influence regarding a more quantitative approach in industrial design was limited by the predominance of organic chemists. Originally caused by organic chemical constraints to enable various chemical reactions to obtain different colours, the very important "oleum" (sulphuric acid) was produced by the so called "Röst-Process". One decisive feature to control this process was the knowledge in the behaviour of catalysers. At this time, BASF (Heinrich Caro, Rudolf Knietsch) was the leading company in the field to patent catalysers. These patents had strongly influenced the style of physical chemical argumentation and modelling approaches, in opposite to the more common patents in organic chemistry.

With the technical introduction of the Haber-Bosch process before World War One ("Pull-Factor") and the theoretical understanding of the three laws on thermodynamics and the kinetics of heterogeneous systems ("Push-Factor"), both parties (industry, academic) were coming together, certainly also influenced by the multi-discipline genius Wilhelm Ostwald and his "Bridge-Function" (Hapke) capabilities. This congruence was reflected by the increasing number of physical chemical journals[1] (Zeitschrift für physikalische Chemie founded 1887, Zeitschrift für Elektrochemie und angewandte physikalische Chemie 1894, Journal of Physical Chemistry, 1896 etc), and the increasing number of papers as function of time in relation to organic papers[2]. Thus, physical chemistry has crossed the academic boarder. An important mentor and supporter of the PC was Carl Bosch (1874-1940) in opposite to Carl Duisberg (1861-1935), who disliked the mathematical approach of the "modern chemist"; he preferred a more "holistic approach" [3].

The most important protagonist of this branch of sciences (Haber, Nernst, Polanyi, London, Loewenstein, Epstein, Nikodem Caro) had to leave Germany and/or were prosecuted during the NS-regime because of their Jewish origin. It was not surprising that some organic Nazi chemists have declared the physical chemistry as not "ostensive" (Thiel) [4] enough or as a "to intellectual science" (Hansen)[5], like it happened with Heisenberg, Sommerfeld, Bohr, Einstein in the physics ("Deutsche Physik"). At this time there were some "dubious papers" (Jost) published in the journal (Z. f. phys. Chem.) which were caused by political pressure

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1 Schmitz, Hans, „Zur Entwicklung der chemischen Zeitschriftenliteratur", *Laboratoriumspraxis* 19 (1967), pp. 140-142. Hapke, Thomas, *Die Zeitschrift für physikalische Chemie: 100 Jahre Wechselwirkung zwischen Fachwissenschaft, Kommunikationsmedium und Gesellschaft*, Herzberg: Bautz, (1990). Bibliothemata, Vol. 2

2 The journal for physical Chemistry was very successful. The number of volumes increased from 1 to 6 in 16 years, the numbers of pages per volume varied between 600-800 pages.

3 Kahlert, Heinrich, *Chemiker unter Hitler*, Grevenbroich, 2001, p. 46.

4 Thiel A., „Zur Frage nach einer 'anschaulichen' Deutung der Osmose und des osmotischen Druckgesetzes", *Z. phys. Chem.,* vol. A178 (1937); Richter, Steffen, "Die Deutsche Physik", In: Mehrtens/Richter (edit.) *Naturwissenschaft, Technik und NS-Ideologie*. Frankfurt a.M.: Suhrkamp, (1980) pp. 116-141.

5 Kahlert, p. 45; Hansen, Christian. J., *Völkischen Beobachter,* 19/3/1936

(Mentzel), so that the 3 editors (Bodenstein, Bonhoeffer, Jost) had resigned their editorship[1]. One IG-Farben chemist, Heinrich Bütefisch, certainly the best Nazi of the IG-Farben board members, defended the merits of PC and the success in favour of the German economy (synthesis coal to gasoline). Also the notorious opportunist Peter Adolf Thiessen recommended the merits of PC as "decisive to obtain autarchy[2]". This indicates that the Physical Chemistry was well established as well in industry as in the NS political system.

[1] Jost, Wilhelm, "The first 45 years of physical chemistry in Germany." *Annual Review of Physical Chemistry*, Vol. 17 (1966) pp.1-14; Bodenstein, Max, "50 Jahre Chemische Kinetik". *Zeitschrift für Elektrochemie und angewandte physikalische Chemie*, vol. 47 (1941), pp. 667-672.

[2] Bütefisch, H, „Die Bedeutung der physikalischen Chemie für die chemische Grossindustrie", *Die Chemische Fabrik*, Vol. 8 (1935), pp 227-235; Thiessen, P. A., *Beruf und Stand Angewandten Chemie* (1936), pp.19-20.

THE DEVELOPMENT OF ORGANIC CHEMISTRY IN JAPAN: RIKO MAJIMA AND HIS RESEARCH SCHOOL OF NATURAL PRODUCTS CHEMISTRY IN THE FIRST HALF OF THE 20TH CENTURY

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Born in Kyoto, Riko (Toshiyuki) Majima graduated from the Department of Chemistry of the College of Science at the Tokyo Imperial University in 1899. After a four-year, from 1907 to early 1911 stay in Europe, where he studied under Carl Dietrich Harries (1866-1923) in Kiel and under Richard Willstätter (1872-1942) in Zurich, he became a professor of organic chemistry at the newly established Tohoku Imperial University in March 1911. He became famous especially for his study of urushiol (a catechol (o-dihydrobenzene) derivative), the main components of the sap of the Japanese lacquer tree (*Rhus verniciflua* Stokes*, urushi-no-ki* in Japanese). Known in Japan as a black glossy varnish, the lacquer tree is an important indigenous commercial source of natural lacquer. Since the beginning of the research in organic chemistry in Japan in the late 1870s, Japanese chemists often studied local natural products using methods newly developed in Europe. Majima followed the same line. After discovering urushiol, Majima discovered a new synthetic method of making indole and started to study indole derivatives.

A leader of the first generation of Japanese organic research chemists, Majima contributed greatly to the establishment of organic chemistry laboratories at universities and research institutions in Japan, including the Tohoku Imperial University, the Osaka Imperial University, the Tokyo Institute of Technology, and a laboratory in the Research Institute of Physical and Chemical Sciences (RIKEN). He also took the initiative to publish *Complete Chemical Abstracts of Japan*, collections of abstracts of all chemical papers in Japan from 1877 to 1964 which included 348,517 abstracts in 34,211 pages in total with comprehensive subject and author indices.

This paper will analyze the development of Majima's research school, its research strategy and its influence on natural products chemistry in Japan up to 1964, two years after Majima's death, when the Third IUPAC Symposium on the Chemistry of Natural Products in Kyoto was held. This Symposium symbolized the advanced state of Japanese organic chemistry and became a turning point in its further ripening.

ANALYSIS, FIELDWORK AND ENGINEERING: ACCUMULATED PRACTICES AND MULTIPLE IDENTITY OF APPLIED CHEMISTRY AT TOKYO UNIVERSITY, 1874-1900

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This paper discusses the process and mechanism by which the education of applied chemistry at Tokyo University, one of the major sites of chemical education in Meiji Japan, accumulated three elements of teaching practice – analysis, fieldwork and engineering – and contributed to the formation of a distinct and multiple identity of *kagaku k gy ka* (chemical technologist), the differentiation of which from ordinary chemists is epitomised by the separation of the *K gy Kagakukai* (Society of Chemical Industry) from Tokyo Chemical Society in 1898. The English chemist Robert William Atkinson, who studied chemistry at University College London (UCL) and was appointed in 1874 as professor of analytical and applied chemistry at Tokyo University, introduced to Japan the part of UCL's chemical education designed for training of consulting analytical chemists by one of his teachers, Charles Graham. By interacting with his students such as Takamatsu Toyokichi, Atkinson blended his UCL legacy with the Chino-Japanese *jitsugaku* tradition, the fieldwork of local resources and manufactures, and cultivated connection with indigenous manufacturers such as sake, soy sauce and pigments. Takamatsu later redeveloped Atkinson's teaching programme of applied chemistry for Tokyo University and technical colleges in the late 1880s and 1890s. In doing so, Takamatsu combined the above two elements with his later experience of overseas study at Owens College Manchester, where the Zurich-trained industrial chemist, Watson Smith designed an educational scheme mainly for training of works chemists and more engineering-oriented than its UCL counterpart. In conclusion, this paper argues that the mixture of analysis, fieldwork and engineering occurred by the mechanism of what sociologists call "transculturation" within "contact zones," where people with distinct cultural backgrounds mingled and interacted with each other.

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BETWEEN POLICY, ECONOMY AND SCIENCE, THE INSTITUTIONALIZATION OF CHEMISTRY IN MEXICO IN THE TWENTIETH CENTURY

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The aim of our paper is to analyze the institutionalization of Chemistry, as a scientific discipline in 20th-century century in Mexico through the history of its main Higher Education institution of Chemistry, the Faculty of Chemistry of the UNAM, the oldest and the biggest university of Mexico and probably of] Latin America.

Its ancestor, The School of the Chemical Industries was created in 1916 by the government, urged by the Mexican manufacturers, in order to train Chemical Technicians. But engaged in the revolutionary movement, this school taught part not only in the economic development of the country but also in the construction of the Mexican national identity, the struggle against illiteracy and. Here, we shall show how these first assignments evolve in complex interactions with the setting up of Higher Education, industrialization, internal political life and scientific questions. On the one hand, we will see first of all that in the 1930 years, Chemistry was limited to two professions: the pharmacist chemist and the chemical engineer. Then in the 1940 years, chemistry was called to play a part of the dynamic start-up in the industrial modernization. The project of the building up of a secular and socialist society promoted by the President Lazaro Cardenas and his successors made the chemistry practised in Mexico, an ensemble of techniques dedicated mainly to the management of technological process bought directly from foreign countries. Chemistry was also dedicated to the control of the industrial production's quality by the government.

On the other hand, the political situation of Spain in 1936, and then of Europe in 1940, led to the emigration of many well-known scientists to Mexico. Driven by an academic dynamic, those scientists with their Mexican colleagues developed, in the new Chemistry Institute of Research, a scientific niche, based on organic chemistry, particularly in steroid chemistry linked to the industrial sector. However, since the end of the 1903s, Mexican universities acquired considerable autonomy; this autonomy was symbolized first by the UNAM Professors' resistance against the state's supervision of Higher Education, and later, by the International Organisations' intervention, in particular UNESCO, in setting up a scientific policy. This resulted in the creation of the PhD Chemist who undertook scientific research for its own sake, removed from the productive sector.

This paper has shown how the singular historical context of scientific institutionalization is a key element to understand the emphasis national leaders place today on the need to increase the interactions between the academic and industrial sectors in Mexico.

PHARMACEUTICAL AND CHEMICAL LABORATORIES IN EIGHTEENTH-CENTURY GERMANY

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Among the leading German chemists in the 1780s – J. C. Wiegleb (1732-1800), M. H. Klaproth (1743-1817), L. Crell (1745-1816), J. F. Gmelin (1748-1804), J. F. Westrumb (1751-1819), F. C. Achard (1753-1821), J. F. A. Göttling (1753-1809), F. A. C. Gren (1760-1798), and S. F. Hermbstädt (1760-1833) – Wiegleb, Klaproth, Westrumb, Göttling, Gren and Hermbstädt were apprenticed and practicing apothecaries, and Wiegleb and Westrumb remained apothecaries throughout their professional career. Around half of the one to two hundred Germans carrying out chemical investigations and acknowledged as "chemists" in the 1780s became acquainted with chemistry as pharmaceutical apprentices and practicing apothecaries. The interconnectedness of pharmaceutical art and chemistry in eighteenth-century Germany also becomes manifest through the analysis of the readers of and contributors to professional periodicals such as the Chemische Annalen. Among the 564 German subscribers to Crell's Chemische Annalen between 1784 and 1789, 260 (46%) were apothecaries, and among its German contributors more than 40% were apothecaries as well.

The socio-cultural German context can hardly explain how owners of apothecary's shops and manufacturers of remedies became acquainted with the practice and theory of chemistry and how they became visible as skilled and knowledgeable chemists in the Republic of Letters. What kind of activities earned them the attention of a learned and supportive audience? What were the sites and resources of these activities? How did apothecaries' chemical investigations relate to pharmaceutical manufacture? As a matter of fact, A. S. Marggraf, like other apothecary-chemists, did not begin his career as a chemist after leaving the pharmaceutical business, but rather developed it alongside, and even in conjunction with that business, and J. C. Wiegleb and J. F. Westrumb remained apothecaries throughout their careers as learned chemists. Furthermore we may ask why apothecaries, who were trained in an artisanal system of apprenticeship and earned their living as merchants and manufacturers of remedies, merged so smoothly with other factions of chemists, for instance those who had earned a medical doctorate or were mining officials and assayers. Were there any aspects of the actual practice of apothecaries that were similar to other chemists' practice? Were there, in addition to individual talent, collective beliefs, and state intervention, any collective material resources and elements of the practice and material culture of pharmacy that enabled apothecaries to carry out the same or similar kinds of chemical investigations as chemists working at other artisanal sites or at academic institutions?

I argue that Marggraf, like other German apothecaries who became renowned chemists, was a truly hybrid apothecary-chemist, and further, that an indispensable condition for the existence of the persona of an apothecary-chemist in the eighteenth and early nineteenth centuries was the high degree of correspondence between the material culture and practice of pharmacy and the material culture and practice of "academic chemistry." Apothecaries did not have to bridge a huge gap between a rigid "realm of recipes" and pharmaceutical routine, on the one hand, and a realm of innovative, pure chemical science, on the other. Rather, pharmaceutical art and academic chemistry overlapped in the eighteenth and early nineteenth centuries, in Germany and elsewhere in Europe. Laboratories, pharmaceutical and academic-chemical, were the institutions where manufacture (in the case of pharmaceutical laboratories) or technological inquiry (in the case of academic chemical laboratories) and inquiry into nature were firmly entwined.

As a consequence of the introduction and acceptance of "chemical remedies" during the seventeenth century, in the eighteenth century the pharmaceutical art was in a state of persistent change and innovation. There was hardly any recipe for the manufacture of chemical remedies that was not questioned, varied, improved or replaced by a new one. And there was hardly any chemical remedy that was not on the test-bench as a possible adulteration or a material that had not yet been identified unambiguously. Chemical techniques and instruments, connoisseurship of chemical substances, and chemical analysis became significant tools for mastering problems of manufacture. Inversely, the solution of problems of manufacture provided insight into the "nature" of substances and their chemical transformations. The similarity of the material culture and techniques of manufacture in eighteenth-century pharmaceutical art to the material culture and experimental techniques of academic chemistry enabled apothecaries to shift their activities smoothly from pharmaceutical manufacture to the chemical investigation of nature, or to perform chemical analyses alongside pharmaceutical manufacture. Likewise, it enabled chemists performing experiments at academic chemical laboratories to shift from inquiries into nature to pharmaceutical and other technological inquiries.

ANOTHER EARLY ROOT OF PHYSICAL ORGANIC CHEMISTRY

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This paper deals with building an identity for the new sub-discipline of physical organic chemistry. It addresses its historiography: a consequence of Whig history, as pervasive as it is implicit, is the standard account of the rise of a field. It is ascribed in this case to Hughes and Ingold in the 1930s and to Louis P. Hammett's *Physical Organic Chemistry* (1940). The standard account often masks earlier and nevertheless seminal publications. To turn to the historical long haul — the *longue durée* dear to Fernand Braudel — offers a better perspective. I have drawn attention already to Sidgwick's contribution at the very beginning of the twentieth century with *Organic Chemistry of Nitrogen*. [1]

Here, I turn up an even earlier milestone. Linear free energy relationships come close to a defining feature of physical organic chemistry, ever since Hammett's monograph. But when did they originate? Indeed the historical long haul provides the answer.

To evaluate the relative strengths of organic acids was a priority during the second half of the nineteenth century, even before the contributions by Arrhenius and Sørensen. A key episode was Wilhelm Ostwald's 1884 paper, introducing a novel measurement of acidity. It did so by first mining the history of chemistry and rediscovering Wilhelmy's work from 1850. It gave Ostwald the clue he needed to devise a measurement of the strength of acids, from their ability at catalyzing sucrose inversion. Thus, he correlated thermodynamics (acid strength) with kinetics (reaction rates). Hence the importance of this breakthrough as an antecedent, *avant la lettre*, to physical organic chemistry.

1. Pierre Laszlo, *Ambix* **2003**, *50*: 261–273.

CHEMISTRY COURSES IN FRANCE AT THE MIDDLE OF THE 18TH CENTURY: TRADITION AND INNOVATION

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At the middle of the 18th century chemistry was the object of spectacular public infatuation. In Paris more than 600 auditors crowded into Rouelle's courses at the *Jardin du Roi*. There were about 200 in the laboratory of the *Jardin des apothicaires*, not to mention the many who attended private courses. In the provinces too, the amphitheatre of the *Faculté de Médecine de Montpellier* could accommodate up to 400 students. In order to meet the range of expectations of its diverse public, chemistry taught in France during this period combined apprenticeship and growing theoretical sophistication, while at the same time remaining popular and spectacular.

Although advertisements for chemistry courses emphasized practical applications and the spectacular aspect of experiments, the courses were not free of theory. In fact the analysis of manuscript notes taken by Rouelle's and Venel's students reveal an innovative chemistry, which integrated and synthesised Stahl's, Boerhaave's and Newton's theories. It was a chemistry based on experiment in which theory and practice went hand in hand.

Experiment had several roles: apprenticeship; the teaching of know-how; teaching about apparatus and reagents; and instruction in the techniques and tricks of chemical operations. Experiment was also valuable as evidence. In the 18th century, the operations of decomposition and recomposition were complementary and only through their joint application was it possible to understand the nature of a substance. Finally, experiments were also performed during chemistry courses in order to demonstrate the elements –air, water, earth and phlogiston—that constituted natural substances.

This experimental approach was based on the widespread use of Geoffroy's tables of affinities, which made it possible to both interpret and predict operations.

Each course was specialised, depending on its particular audience. Courses were intended for medical doctors and apothecaries who wanted to understand the basis of chemistry so as to better prescribe and prepare medicines, for philosophers who wanted to pursue their understanding of the nature of matter, for landowners who were interested in the natural resources of their land, for craftsmen who wanted to know about the chemistry of colours and dyes, varnishes, glass, metallurgy, and last for the curious, strollers who wanted to attend the show… and for ladies of quality.

It is this convergence of interests, together with the enthusiasm and vision of a few great teachers, that allows us to understand the infatuation with chemistry in the middle of the Enlightenment.

THE SOCIETE FRANCAISE DE CHIMIE (1857-2007) AS A PLACE FOR THINKING CHEMISTRY IN FRANCE

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The beginnings of the *Société chimique de Paris* have been already well described by several authors (G. Bram and M. Golfier, 1997, J. Fournier, 2003, U. Fell and A. Rocke, 2007). The aim of this paper is to present the way the *Société* was present in the French debates concerning science and chemistry through its whole history from 1857 to 2007. The information comes from the collective work realized by 40 authors on the biographies of the 75 presidents of the *Société*, which will be published for the 150th anniversary of the *Société*, to be celebrated next July 2007.

The main topics of interests are the scientific debates and conferences, which first took place in Paris, then in several local committees; the interaction of the *Société* with industry and with hygienist and public health Committees; the strengthening of the *Société* by the creation of thematic groups, and finally its will of Europeanization through the creation of *European Journals*, which took the place of the national *Bulletin de la Société chimique* in the 1990's; and last, but not least, the great interest of the *Société* for its own history, from the true beginning.

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IS A PHYSICAL CHEMIST A CHEMIST? IDENTITY AND DISCIPLINE BUILDING.

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Svante Arrhenius, well know member of "das wilde Heer der Ionier", received the Nobel prize in chemistry, was professor of physics, and has in Swedish encyclopaedias been called, chemist, physicist, physical chemist, scientist, natural scientist etc. What was his disciplinary identity?

As this example shows and it goes without saying, the concept of discipline is a troublesome concept. Frontiers between disciplines are constantly vague and floating, today as well as in history. We all know this, but we still write books, articles as well as arrange conferences on the question of disciplinary identity and on histories of disciplines. It seems we can not do without them. Of course some kind of organisation, or bureaucracy, is needed if any science at all should be done. There have to be a structure, by which research is organised, money allocated, and teaching carried out. The basic units in such organisation usually are departments with a disciplinary name on the sign outside the door. However, what's on such a sign does not automatically tell what kind of research is going on behind that door.

In my paper I will discuss the question of identity in science in relation to the rise of new disciplinary names, taking physical chemistry and biochemistry in Sweden as examples from which to start (but I hope what I have to say will have bearings on other cases as well). I will suggest the concepts "inner" and "outer" institutionalisation in order to explain the relations between how research in a new field is carried out, and how that research is organised. Inner institutionalisation is then equivalent to the creation of a new research area, whereas outer institutionalisation is how that area is accommodated to existing organisation, how it gets its own door sign. Since there has to be a research field in need for a name, and resources, inner institutionalisation in time precedes outer, and determines what kind of science is done behind the door.

The identity of the new field could thus either be expressed in relation to outer institutionalisation as an administrative unit, in which case disciplinary names are important, or in relation to inner institutionalisation, in which case references to other research groups or certain networks, are important, and disciplinary names are of less significance. Finally I will rise the question if, in the former case, the identity as "professor", or even "Nobel prize winner", and in the latter case the identity of being a "scientist", is not more important than to be identified as a scientist of a certain discipline.

TRONDHEIM OR OSLO? TERRITORIES IN EARLY 20TH CENTURY CHEMISTRY EDUCATION IN NORWAY

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The Royal Frederik University in Oslo (founded in 1811) and the Norwegian Institute of Technology (NTH) were the two main facilities for chemical education in Norway in the first half of the 20th century – the University provided traditional chemistry training for science, pharmacy and medicine students, whereas NTH educated engineers for chemical industry. From the opening of NTH in 1910 the Institute was regarded as an integrated teaching and research institution with modern laboratories,[1] the chemistry department being one of the largest departments, with its own building and four laboratories.[2] NTH and the University in Oslo were not regarded as competitors, as the university did not educate engineers and NTH did not train scientists.

However, this changed in the early 1920s. The University's chemistry laboratory had for a long time suffered from inadequate gas, water and ventilation systems, a subsiding building as well as cramped localities, which made it inadequate even for the elementary courses – educating chemists was reckoned as impossible under such conditions. Plans for a new chemistry laboratory at the new university campus, Blindern, were initiated, culminating in a new building inaugurated in 1934/35.[3] In 1922 Rector of the University, Fredrik Stang, appealed in the daily press about the need to build a new chemistry laboratory. By overtly mentioning the education of (industrial) chemists, the relationship between NTH and the University was exacerbated, creating numerous newspaper discussions. At the NTH it was felt that the University was trespassing their domain. This debate occurred during a time when NTH experienced a stream of professors from Trondheim to Oslo, as the chairs at the University were still regarded as more attractive than a position at NTH. In our talk we will look into the controversy between the two chemistry laboratories in more detail, exemplifying "neighbours and territories" within the same field and country.

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PARTICULAR ASPECTS OF THE COMMUNICATION AND SCIENTIFIC NETWORK OF J H DE MAGELLAN BETWEEN BRITAIN, FLANDERS AND FRANCE

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Establishing communication and networks is a renowned means of spreading science. During the 18th century one of the first to understand its importance was the Portuguese João Jacinto de Magalhães (1722-1790), who developed and implemented a vast network of scientific correspondents all through Europe and America.

Magalhães, also known as Magellan, got the privilege of entering the Republic of Letters where he became acquainted with the most recent novelties of experimental sciences in which discussion he took an active part. His curiosity introduced him in several emerging scientific subjects concerned with physics, chemistry, astronomy, medicine, arts and instruments. With a particular interest on instrumentation he settled in London he considered the best city in Europe to breathe the new winds of modern science and liberty. That curiosity allied with a natural propensity to communicate favoured the establishment of a vast network of correspondents interested in similar philosophical matters.

He took an important role in the spreading of experimental physics and chemistry, namely performing very recent experiments in his different circles of friends. The introduction of pneumatic chemistry in France is the best known.

In this communication we will focus on some of his activities related to chemistry and the network of friends/interlocutors in Flanders and France from the early years of seventies.

DISCIPLINARY IDENTITY AND THE CHEMICAL REVOLUTION

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This presentation will examine the various and varied attempts that historians of science have made to divine the nature of the Chemical Revolution from the disciplinary identity and development of eighteenth-century chemistry. Whereas positivist historians viewed the Chemical Revolution as the moment when chemistry broke with its speculative past and took on the mantle of a scientific discipline, postpositivists, like Arthur Donavan, Evan Melhado, Carleton Perrin, and Robert Schofield, related it to the shifting boundaries between the preexisting scientific disciplines of physics and chemistry, while sociologically minded scholars like John Christie and Jan Golinski, identified eighteenth-century chemistry as a “didactic discipline.” We will see how variations in the accounts of the disciplinary structure of eighteenth-century chemistry reflect significantly different historiographical views of the aims and methods of science.

The interpretive focus on the disciplinary identity and development of the sciences evokes the spirit of Comte’s “positive philosophy,” which upheld both the crucial role of the disciplinary division of labor in the development of science and the need for historians and philosophers of science to offset the associated dangers of specialization by attending to “the relations and concatenations of the sciences.” While these disciplinary interpretations of the Chemical Revolution issued in a range of significantly different accounts of the contributions of Joseph Priestley and Antoine Lavoisier –the leading protagonists of the revolution– to the development of modern chemistry, one way or another, they all succumbed to the retrospective devaluation of Priestley’s science inherent in the presentistic sensibilities of the “positive philosophy.”

Larry Holmes highlighted the retrospective dangers associated with the positivistic enterprise when he argued that the Chemical Revolution was a revolution in “pneumatic chemistry,” understood not in its modern guise as a subdivision of general chemistry, but in its eighteenth-century grandeur as an interdisciplinary activity that encompassed physics, chemistry, and medicine. We will explore the consequences of this reconfiguration of the disciplinary hierarchy of eighteenth-century chemistry for our understanding of the phlogiston theory and its role, as inhibitor or facilitator, in the emergence and development of the science of chemistry. Taking seriously Joseph Priestley’s self-identification as an “aerial philosopher,” this presentation will build on Holmes’s analysis to argue that a genuine historical understanding of the Chemical Revolution must recognize the “relation and concatenation” not only of the sciences, but also of the scientific and nonscientific disciplines that vied for the attention of eighteenth-century natural philosophers.

CHEMICAL CAREERS IN POSTWAR BRITAIN: CENTRIFUGAL DISCIPLINE / CENTRIPETAL PROFESSION?

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At the start of the twentieth century, chemistry was widely perceived arguably as the most fundamental, but definitely as the most 'useful' science; chemists were the largest community of scientists in Britain, finding occupations across industry, government and academia. They were the first British professional group to be organised around a scientific discipline and they served as a model for other emerging scientific and technical professions. Using an anthropomorphic, biographical metaphor for the trajectory of the discipline of chemistry, David Knight has described it as becoming 'middle-aged' during the first half of the twentieth century.[1] The reputation of chemistry was both enhanced and tarnished by participation in two world wars and its intellectual status changed as physics came to be seen as the most fundamental science on the one hand, while biological sciences became the exciting frontier on the other. Indeed, it is often argued that the postwar period saw an apparent dilution of disciplinary identity with an intellectual shift from 'chemistry' to a range of adjectival 'chemistries'. None the less, in Britain, chemistry was the largest undergraduate science subject well into the 1960s. Following a period of disciplinary gloom as undergraduate chemistry enrolments fell and prominent British chemistry departments were closed down, there is talk now, in 2007, of chemistry 'experiencing a renaissance' with increased government funding, the opening of prestigious new teaching laboratories and the undergraduate intake once more on the increase.[2]

Drawing on our "Biographical Database of British Chemists,"[3] this paper looks at the education and careers of the cohort of chemists who entered the profession in the two post-war decades, when there was a marked expansion in both the 'supply' of chemists and 'demand' for them across all sectors of the economy. It will explore how greater opportunities affected career progression, specialization, and mobility. The paper will argue that any trend towards fragmentation in the discipline took time to affect occupational pathways and that this generation of chemists continued to enjoy careers that combined professional success with high mobility. Importantly, core knowledge and skills continued to be seen as highly transferable, enabling chemists to develop careers drawing on values associated with the traditional professional 'ideal type' of the independent practitioner. They have thus maintained a distinct identity which is underpinning the reassertion of the fundamental importance of the science in the twenty-first century.

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CHEMISTRY IN THE 21ST CENTURY: DEATH OR TRANSFORMATION?

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This paper will examine the probable future of chemistry in terms of its past. Chemistry today looks very different from how it did thirty years ago. In effect it is an alliance between biomedicine and material science. The various professional organisations and journals are scrambling to reposition themselves in terms of the "chemical sciences" rather than chemistry per se. But chemistry has always been shaped by its shifting intellectual professional and economic alliances. In the eighteenth century, it was the territory between medicine, assaying and metallurgy, and the study of heat --strikingly evocative of the situation today. Over the last century the pharmaceutical industry has displaced the dyestuffs industry as the major sponsor of organic chemistry. For two centuries, however, chemistry has retained a strong identity despite these changes. The key questions now are whether the current alliance between biomedicine and materials can hold and whether the term "chemistry" really means anything anymore except as a historical throwback to an earlier period (thus paralleling alchemy in the late 17th/early 18th century). Will chemistry be reinvigorated by the creation of a new identity as "chemical sciences" or will it "decompose", reverting back to its parent sciences of medicine (as biomedicine) and metallurgy (as nanotechnology and materials science)?

PHILOSOPHER-SCIENTISTS AT THE INTERFACE OF PHYSICS AND CHEMISTRY: PANETH AND POLANYI ON CHEMISTRY AS AN EXACT SCIENCE

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Historians and philosophers of science, as well as scientists themselves, have distinguished chemistry from physics on grounds including the uniqueness of chemical concepts, ab-initio reductionism, and, most recently, thought experiments. This paper examines some of the chemical work and philosophical reflections at the interface of physics and chemistry by the physical chemists Fritz Paneth (1887-1958) and Michael Polanyi (1891-1976), both émigrés from Germany to England in 1933.

CHEMISTRY AROUND MEDICINE AND PHARMACY IN THE WORK OF *AMATUS LUSITANUS* IN THE XVI CENTURY

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The physician João Rodrigues de Castelo Branco (1511-1568) adopted the name of *Amatus Lusitanus* when he left Portugal, escaping the Inquisition which devastated the south of Europe at the time. He practised medicine in Antwerp, Ferrarra, Ancona and Rome, took refuge in Pesaro and Dubrovnik and finally lived in Thessalonica until the end of his life. Despite having been the physician of Catarina of Medicis and of Pope Julius III he never discriminated any one because of their origins or religion and he never forgot his birthplace making various references to it in his vast work. Among his many books, we can highlight *Index Dioscorides* (Antuerpia 1536), *In Dioscorides Anabarzaei de Medica materia librum quinque ennarrationes eruditissimae* (Venice 1553), *Curationum Medicinalium Centuriae septem* (Venice 1552-1559).

He was the first to observe the valves of the veins (1547) giving a precious contribution to the study of the blood circulation and the *Pharamacopea Lusitana* (Coimbra, 1704) refers to their contributions. He also was a notable botanical observer and recorder. The collection of the seven *Medicinalium Centuriae* reunited an enormous set of episodes reporting medical situations in which he participated, well succeeded or not. Described with detail, all the work relieves his meritorious human as well as technical aspects. He referred all the materials used, the operations needed for the preparation of medicines and the proper medical interventions. The rigour and critical reflection about his decisions and results are one of their main scientific attributes.

If the culture of the 16th century rises up the humanism in its knowledge concept, Medicine and Pharmacy, like today, were very close and between them grew up a chemistry art and knowledge which established one of the biggest contact bridges. At the same time Chemistry joined knowledge and techniques which will help it to impose with its proper rights, few centuries later. The work of *Amatus Lusitanus* is full of aspects evidencing Chemistry associated to Pharmacy and Medicine. We will give examples of materials and substances, instruments, techniques, practices and reflections, recalled from the text of *Medicinalium Centuriae* evidencing those aspects:
1 - The most used ingredients were organic; botanical species coming from the Mediterranean flora but also a vast range of animal origin materials were used. We also found minerals.
2 – There are descriptions or references to numerous operations in order to prepare the medicines and aspects related with precision and rigour in the prescriptions, particularly in what respects measurements of the quantities used in the preparation of medicines. In the first case we can refer extractions or decoctions. In what refers to the second case, *Amatus Lusitanus* can be considered a symbol of an anticipated rigour which could be translated into the more general and foundational Modern Chemistry principle, mass conservation.

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BOUNDARIES OF CHEMISTRY: INTEREST AND IDENTITY IN EARLY 20TH CENTURY

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The first part of the paper discusses the boundary problem in general terms, such as the essentialist approach, the epistemological approach (Popper, Kuhn, Lakatos), sociological approach (Merton) and the contemporary policy approaches. From the historical changes of the boundaries, the paper concludes that any kind of essentialist approach seems hopeless now but not in historical perspectives. In the second part, the paper recapitulates the events of the first chemistry congress in Hungary, held in 1911. The analysis of the goals and work of the congress proves the practical, interest directed, policy oriented character of the contemporary approach. It aimed at a territorial occupation that seems to repeat the 18th century situation in France. Later in the 20th century, big business and the academic disciplinary interests strengthened the essentialist approaches of chemistry in Hungary.

BETWEEN PHYSICS AND CHEMISTRY: ARTIFICIAL COLD AND THE INSTITUT INTERNATIONAL DU FROID

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Nineteenth-century interest in the liquefaction of gases is traced back to Faraday's liquefaction of chlorine in 1823. However, the most important landmarks of gas liquefaction are situated in the period characterised by the application of thermodynamics and chemical theory and the elaboration of increasingly complex equipment and skills. Louis P. Cailletet (1832-1913), and Raul P. Pictet (1846-1926) liquefied oxygen in 1877, Karol S. Olszewski (1846-1915) and Zygmut von Wroblewski (1845-1888) liquefied nitrogen and carbon monoxide in 1883, James Dewar (1842-1923) liquefied hydrogen in 1898, and ultimately Heike Kamerlingh Onnes (1853-1926) liquefied helium in 1908. These were both chemists and physicists, who were employing both physical techniques and chemical methods, and were interested in using the low temperatures for looking into the properties of matter, and for extending their theoretical understanding of these properties. In the late 19th century research in the low temperatures was not readily delineated as a distinct sub-field of physics.

In tandem with scientific research, the low temperatures and the various techniques of liquefaction found their way into an expanding industry. Around the turn of the century, scientists, engineers and industrialists who worked and were interested in the domain of artificial cold, became conscious of the need to get organised, and affirm the emergence of a very heterogeneous community that revolved around the production and use of artificial cold. The organisation of the first International Congress of Refrigeration in 1908, which gave birth a year later to the International Association of Refrigeration, is indicative of such a pursuit. Kamerlingh Onnes was one of the main actors involved in the organisation of the Congress, and one of the founding members of the Association. His unquestionable expertise in the low temperatures that was further consolidated with the liquefaction of helium, but also his international spirit of collaboration rendered him one of the prime movers in the emerging community of low temperature physicists and the institutionalisation of the field of artificial cold in general.

In this paper we would like to examine the participation of chemists in the various sections of the Association, from its day of inception until 1936, when the 7th international congress of refrigeration took place in Hague. This field is of particular interest to historians of chemistry on two counts: the multifarious activities of the Institute offer a privileged terrain for the analysis of the changing disciplinary boundaries between chemistry and other neighbouring sciences – especially physics – as well as the analysis of the reciprocal interactions and synergy between chemical research in the low temperatures and the use of low-temperature products and procedures in chemical industries. Along with our examination of the 7 international congresses of refrigeration, and the monthly Bulletin of the Association, we will carry out a bibliometric study on the leading academic and engineering chemical journals between 1885 and 1936 in order to determine the amount of work related to low temperatures carried out during different periods of time and the changes in the objects and orientations of research.

THE EMERGENCE OF THE MACROMOLECULAR PARADIGM IN THE WORLD OF CHEMISTRY

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The physical world in which we live is replete with macromolecules. All biological systems are composed of proteins and nucleic acids. However, the conceptual world of the chemist did not include such objects until recently. The general acceptance of the macromolecular paradigm dates from the 1930's. The present paper follows the development of the concept of large molecules from antiquity to the Faraday Society Discussion in 1935 that established it as a progressive research programme.

In spite of occasional references to ατομος in Greek literature, the dominant perspective for most of modern human history has been that of Aristotle: the physical world is composed of mixtures of intrinsically continuous substances. This paradigm is still the most useful one for much of industrial chemistry. However, liquids can be separated into "droplets" and solids can be divided into "grains." Philosophical reflections on the actual limits of division formed an important thread in the history of chemistry.

The rise of the "mechanical philosophy" brought corpuscles back into the discussion. Since many solutions of solids in liquids appear homogeneous, even in a powerful microscope, Dalton concluded that the basic particles of matter must be very small. He also speculated that these basic objects could best be understood as discrete aggregates of elementary particles known as "atoms." What was missing was any explanation for why the "atoms" should aggregate in the first place. Berzelius was impressed with the strength of electrical attraction between opposite charges and proposed that "polymers" could be formed by groups of charged "atoms."

The notion of covalent assemblies of atoms made unsteady progress during the 19th century, but Kekule, van 't Hoff and Wurtz produced extensive works on such species. Since they clearly understood the concepts of polyvalent "atoms", it might be supposed that the notion of covalent macromolecules would have been warmly embraced by these chemists. But, there were grave doubts about the chemical stability of such species. Even Perrin was skeptical of the existence of genuine macromolecules.

Gradually the number of synthetic polymers increased. The measured molecular weight for these molecules was large, but physical chemists were not yet ready to accept the existence of covalent macromolecules. These large objects were pictured as colloidal aggregates. One of the cradles of polymer science was colloid science, since macromolecules in solution exhibit all the properties of colloids and most of the leading physical chemists were interested in colloids. One of the major distinguishing features of linear macromolecules in solution is the enormous increase in solution viscosity at very low volume fractions of polymer. Staudinger appealed to this observation as conclusive proof for the existence of macromolecules, but serious errors in his understanding of both solutions and viscosity undermined the persuasive force of his arguments, even for those who might otherwise have believed in macromolecules.

The preparation of crystalline polymers further complicated the picture. The unit cell was observed to be quite small. Only when Polanyi and Mark solved this riddle was it possible to consistently argue that long covalent chains were the molecular species involved in crystalline and dissolved macromolecules. After the Faraday Discussion of 1932 a large group of chemists committed themselves to the study of macromolecules. Both synthetic chemists (Carothers) and physical chemists(Mark, Kuhn, Debye, Flory) collaborated in the rapid growth of understanding of these chemical species. By the time of the 1935 Faraday Discussion, the macromolecular paradigm was firmly established.

ESTABLISHING ACTA CHEMICA SCANDINAVICA IN 1946

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Before the Second World War the chemists in the Nordic countries mainly wrote their scientific papers in German and published them in German journals. In addition each country had their national chemistry journals for papers mainly written in their native language. A network of Scandinavian chemists was well established. The 5th Nordic Chemists Meeting was held in Copenhagen in July 1939 (360 participants), the 4th in Oslo in June 1932 (285 participants).

After the war many Scandinavian chemists wanted to write and publish their work in English, but the number of available journals without restrictions was limited. In Norway professor N.A. Sørensen (1909-87) at NTH in Trondheim took an initiative in the summer of 1945 and in Denmark similar ideas were discussed in the fall. After some negotiations between the chemical societies in each country Acta Chemica Scandinavica (ACTA) was founded at a meeting in Copenhagen November 20-21 1946. The Nobel laureate of 1945 Artturi Virtanen summed it up: *Our hope and firm conviction is that this decision will promote chemical research in the Nordic countries and give the rest of the world a focused impression of the basic research in chemistry in Scandinavia*. The owners of ACTA were the chemical societies in Denmark (Kemisk Forening and Selskabet for analytisk Kemi), Finland, (Soumalaisten Kemistien Seura and Finska Kemistsamfundet), Norway (Norsk Kjemisk Selskap) and Sweden (Kemistsamfundet). The ownership was divided equally among the societies. However, the expenses should be divided among the owners based on the relative number of pages published from each country. The journal should publish papers on basic research in chemistry on an international level in English, French or German. The authors should be Scandinavian chemists (included Iceland) and foreign chemists working in Scandinavian laboratories.

The first number was published in January of 1947 and until 1974 ten issues were published in each volume. The editors from each country in this period are given in the table below. Karl Myrbäck, professor of biochemistry in Stockholm, was the editor-in-chief. The reputation of the journal grew with the years and the number of subscribers increased slowly, but the economy in the first thirty years was always frail, and at times the chemical societies needed external support to cover the publishing expenses.

ACTA was built on a network of Scandinavian professors of chemistry nourished by the Nordic Chemists Meetings. In 2000 the journal merged with the corresponding journals published by the Royal Chemical Society in London. In this talk I will concentrate on the background of the foundation of the journal in 1946 and not on the end.

Demark	1947-62	Jens Anton Christiansen
	1963-73	Carl Johan Ballhausen
Finland	1947-66	Artturi Ilmari Virtanen
	1967	Eero Tommila
	1968-73	Heikki Soumalainen
Norway	1947-56	Odd Hassel
	1957-65	Olav Foss
	1966-68	Alf Wickström
	1969-73	Olav Notevarp
Sweden	1947-73	Karl Myrbäck

ALCHEMICAL *VERSUS* CHEMICAL USE OF DISTILLATION TECHNIQUES AND MATERIALS: MUTUAL INFLUENCE AND DIVERGENT DEVELOPMENTS.

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Recent scholarship on alchemical experimental practices belonging to Renaissance and Early Modern Europe has revealed unexpected quantitative approaches followed by contemporary alchemists in their laboratory work.[1] However, alchemy is still being reported as more connected with religion and occult practices than with true science,[2] in spite of the well documented "relationship of alchemy to the pursuit of natural knowledge", in Prof. Moran's words.[3] According to that view, it is generally acknowledged that only laboratory techniques and equipment invented by the alchemists are worth of considering for the development of chemistry, and this distinction applies particularly to distillation procedures and glassware. However, and surprisingly, these technical innovations are frequently considered by scholars possessing some technical background with no reference to the alchemical context for which they were formerly developed, and hence they are generally and unreservedly attached to incipient chemical knowledge. On the other hand, and opposite to this view, it is not uncommon to find in the literature of the field uncritical attributions of a supposedly alchemical meaning to any prior 17th century work that deals with distillation, particularly if iconographic material is included. In both cases, the purposes for which the distillation procedures were originally used in the corresponding work remain overshadowed, precluding in this way a proper evaluation of either its alchemical or chemical relevance. Therefore, both approaches have distorted the correct appreciation of many documents relevant for the history of chemistry.

Placing distillation techniques in the right context might transform itself in a powerful tool, a sort of Ariadna's thread to distinguish between chemical and alchemical practices before the 18th century, and would improve our knowledge of the alchemical heritage of modern chemistry.

In this work several examples will be provided to show the specificity of the alchemical use of distillation techniques, how these techniques were experiencing a progressive transference process to metallurgical and pharmaceutical fields, while, interestingly, theoretical approaches borrowed from alchemy were to survive only in the latter. In this way, in 16th century distillation of strong acids for metallurgical use was already seen as no more than a technical operation, while the same equipment, furnaces, glassware and materials were operated for the preparation of chemical remedies in a philosophical context still impregnated of alchemical legacy.

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CHEMISTRY COURSES, THE PARISIAN CHEMICAL COMMUNITY AND THE CHEMICAL REVOLUTION, 1770-1790

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The last two decades of the *ancien régime* saw a rapid growth in the number of chemistry courses being offered in Paris. By the late 1780s there were about twenty-five, given in public institutions or taught privately, some free and others charging a fee, and they attracted audiences that ranged from several hundreds to ten or fewer. Some were open to all-comers, while others were restricted to particular groups of students or to a group of friends. It has been widely recognized that such courses were central to the continuing popularisation of chemistry, but they played an equally important role in the development of a large and dynamic community of chemical practitioners in Paris. However, the dominant approach that historians have adopted to studying the Chemical Revolution has led to an almost exclusive focus on the relatively small group of chemists (perhaps 20) in and around the Académie Royale des Sciences who were directly involved in Lavoisier's campaign. Consequently, the wider Parisian community of between 150 and 200 chemists has been ignored.

This paper will present a typology of these courses and survey their professors, audiences and finances, and compare them with the parallel growth of courses in the provinces. It will then explore their role in the development of the Parisian chemical community through:

1. the career opportunities they provided;
2. the networks of connection and patronage that grew up around them;
3. the opportunities they presented for building a reputation, creating a public image, publicising discoveries and engaging in chemical disputes;
4. the material circumstances they provided for conducting research.

The paper will conclude by exploring the role that the courses, and the wider chemical community they supported, played in the Chemical Revolution.

HOMBERG’S CHEMISTRY: A CERTAIN TRUTH IN A DISPUTABLE PHYSICS

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This paper aims to provide a detailed account of Homberg’s definition of chemistry as given in the first part of his “Essays de chimie”, published in 1702 in the Mémoires de l'Académie Royale des Sciences. We show that his definition inverts the relative status traditionally assigned to chemistry and physics, allowing Homberg to found chemistry as a science in its own right. For Homberg, chemistry alone is true, whereas physical explanation, though plausible, remains subject to debate. Nevertheless, in the course of his chemical writings, Homberg does not hesitate to make use of physical principles, even if they are dismissed as such, in order to account for purely chemical phenomena. The paradox is resolved by claiming that the use of physical principles amounts to providing an intelligible model for chemical phenomena which would seem to be inconceivable (e.g. Homberg’s 1705 claim to have transformed mercury into gold). If such a phenomenon can be physically accounted for (i.e. using figures and movements of corpuscles), then we can be certain that it is real, and not an experimental illusion. The inversion of status is then achieved: the question of whether or not physics is true is moot, because the only veritable science of matter is chemistry.

CHEMISTRY AND METALLURGY IN PORTUGAL IN THE 18TH CENTURY - THE CASES OF GOLD AND SILVER

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In the 18th century the metallurgy of gold and silver using ores either rich or poor in such metals received a strong impulse from chemistry: chemical techniques "invaded" a field where the physical ones prevailed.

That was of the up most importance to the Portuguese crown because the use of such techniques meant the immediate improvement of the metallurgy (extraction and purification) of the gold exploited in colonial Brazil and could also eventually be used in obtaining silver that was thought to exist in abundance in the colony, as in the case of Spanish America.

Chemical techniques applied in the course of the amalgamation and the fusion methods were described in more or less detail in books and memoirs published in Portugal and abroad, written by several authors, namely: Vicente C. Seabra (~1764 - 1804) and Manuel F. da Camara (~1762 - 1835), both born in Brazil, the Portuguese Manuel J. Barjona (1760 - 1831) and Joaquim F. Sequeira (? - 1833), and the Italian Domenico Vandelli (1734-1816). Brief descriptions of such techniques are described in the present paper.

Apart from that, the Portuguese crown was happy in receiving from different parts of Europe technical reports about such procedures, becoming involved in a kind of "industrial espionage", as well as forbidding books where such descriptions were made, as in the case of the Italian Jesuit A. J. Antonil who wrote about the amalgamation of silver.

STAUDINGER – MARK – KUHN - THE DEVELOPMENT OF MACROMOLECULAR CHEMISTRY BETWEEN 1920 AND 1940

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In 1920 Hermann Staudinger, then professor at the Eidgenössische Hochschule Zürich postulated the existance of what he called long chainmolecules or polymers. The scientific community was very reluctant to accept his views. Famous chemists like Paul Karrer (in 1920) and Heinrich Wieland (in 1927), both later Nobelprize winners in chemistry thought that there was a limit for the size of organic molecules around molecular weights of 5000. Apparently larger molecules should be micelles, aggregates of smaller units. Also Hermann Mark initially believed that the small unit cell found by x-ray crystallography was an indication for the micellar theory. In 1926 Richard Willstätter organized a meeting in Düsseldorf where Staudinger (who became director of the chemistry department at Freiburg in this year) and his opponents explained their positions. After the opponents, who came from organic chemistry, had presented their views of the micellar theory, the physical chemist Mark told that his results with x-ray crystallography could not decide the question, but show that long chains could exist. In 1928 Mark and Kurt H. Meyer at the BASF found results that supported Staudinger´s macromolecules. Also the work of Wallace H. Carothers at the end of the 1920s showed that macromolecules really existed. Staudinger believed that these macromolecules were stiff rods. Mark and Meyer concluded they were statistical coils. This view was settled by the theoretical work of Werner Kuhn starting in 1934. Paul J. Flory who became a coworker of Carothers in 1934 continued and improved Kuhn´s theory in the 1940s.

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THEORIES IN THE EVOLUTION OF CHEMICAL EQUILIBRIUM: IMPLICATIONS FOR ITS TEACHING AND LEARNING

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Among science education researchers there is an emergent consensus about the incorporation of a sound treatment of the history and philosophy of science (HPS) into the curriculum[1] (1). A necessary initial condition for an effective introduction of the HPS in the science curriculum implies the elaboration of available works that teachers may find helpful in the reconstruction of some essential concepts. This paper deals with chemical equilibrium reactions.

Despite the fact that 'affinity' was the key concept for the development of the chemical equilibrium idea during the last quarter of the 18th century and 19th century, the concept was not given a precise definition.[2] To its vague and ambiguous meanings we must add its polysemy.[3] This study is divided into two main related parts. Firstly, a brief historical reconstruction will present the role of theories of chemical equilibria that evolved around different research programs concerning the attempts at measuring chemical affinities; and secondly, this previous historical research serves as a base for suggesting an appropriate sequencing of the teaching and learning of chemical equilibrium.

This communication will search for the theoretical grounds of four basic chemical equilibrium concepts: 'incomplete reaction,' 'reversibility.' 'equilibrium constant,' and 'molecular dynamics'. That is, we will discuss how scientists tried to determine the factors affecting affinity and how they tried to measure this property of chemicals, all of which led eventually to both mathematical reasoning and molecular dynamics as key theoretical tools in the explanations given to equilibrium reactions. The starting point of this historical reconstruction will be the state of the art in the construction of the first affinity tables. Berthollet reworked this first theory, considering that the amount of the substances involved in a reaction was a key factor accounting for the chemical forces. Guldberg and Waage attempted to measure those forces, formulating the first affinity mathematical equations. Afterwards, the first ideas providing a molecular interpretation of the macroscopic properties of equilibrium reactions will be presented. Eventually, theoretical chemists integrated previous findings into a new field: thermodynamics.[4]

Finally, this study tries to go beyond the development of teachers' conceptions of the nature of chemistry, for not only does it focus on the history and philosophy of chemical equilibrium, but also it gives suggestions about how teachers may translate such understandings into classroom practice.

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"THE ONE EXPLAINETH THE OTHER": GEORGE RIPLEY AND ALCHEMICAL CONSENSUS

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It is common to find authors of alchemical tracts seeking to demonstrate the credibility of their works by appropriating the wisdom of their authoritative predecessors, while condemning the practices of 'false' alchemists. Sometimes, however, respected authorities appear to disagree, both with one another and with other texts attributed to them. The mineral-based alchemical philosophy of the *Speculum Alchemiae*, a fourteenth century text attributed to Roger Bacon, for instance, directly contradicts that found in Bacon's thirteenth-century writings. Later authors, aware of such conflicts, at times struggled to reconcile contradictions between their authorities, adopting a range of rhetorical strategies to "save the phenomena" of transmutation and a unified alchemical tradition.

One example is the English alchemist George Ripley (c.1415-1490), Canon of Bridlington, renowned for his popularisation of the works of pseudo-Ramon Lull, but also an admirer of other alchemists, including Guido de Montanor. Ripley's attempt to reconcile his favourite authors takes different forms, ranging from a sustained discussion in the *Concordantiae Guidonis et Raimundi* (a Latin prose work) to more discreet strategies in the *Compound of Alchemy* (an alchemical poem written in English, and apparently directed to a royal patron). Ripley was himself to become an established authority, his own works – and those attributed to him – recycled and reinterpreted throughout the sixteenth and seventeenth centuries. This paper will examine Ripley's role, as both author and subject, in the search for consensus among "the Philosophers," and the degree to which such efforts helped assert the validity of alchemy as a discipline.

APPLIED NEIGHBOURSHIP. PHYSICAL METHODS AND THEIR PERCEPTION IN CHEMISTRY

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In the twentieth century, more and more chemists applied research techniques with origins in physics to their research. Seeking a contrast from their own tools of the trade, chemists named them physical methods. This notion carried a bundle of mixed meanings, among them a perceived superiority of the "more fundamental" discipline and the attractiveness of high-technology in an age of electronics. But it also points to the "otherness" of physics with respect to the loss of a chemist's identity when applying the instrumentation of the neighbouring discipline.

In my talk, I will explore some perceptions of physical methods in chemistry, leading from opposition to embracement, and ranging from attempts to strip away physical meaning to endeavours of using methods as carriers of concepts and theories. In the outcome, so my argument, some chemists saw their fortunes in using the image of physics and high-technology for the distribution of research methods, building up a community of method makers that did not just cross the boundaries inside the physical sciences, but of the life sciences and medicine as well.

NEIGHBOURS AND TERRITORIES: WHAT DO CREATIVITY, INTELLIGENCE AND RESPONSIBILITY HAVE IN COMMON? HISTORICAL AND CURRENT CONSIDERATIONS ABOUT THE SOCIO-POLITICAL RESPONSIBILITY OF SCIENCE

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At scientific meetings and academic jubilees, results and achievements are always praised but responsibility is seldom discussed. Nevertheless, we know that to be a sound scientist requires more than being able to deliver research results and to teach the subject. In this respect also history of Science has to be more than the description of facts from yesterday. Especially those of us located in central Europe should know something about the traps of over-emphasising scientific achievements [1-3]. Fritz Haber [4], Adolf Butenandt [3], Richard Kuhn [5] and even Hermann Staudinger [6] are historically interesting scientists, and they were active in politically extremely difficult times.

Although the autonomy of our universities in Europe is no longer endangered in a political sense, they exist today in a turbulent atmosphere, driven by absurd saving plans, sometimes bizarre elitism and influenced by evaluation games and over-bureaucracy. And there is one more problem, surely at the heart of the matter: It is difficult for our universities to avoid being pulled into the nowadays only profit-driven speculations of the overdeveloped Neo-liberalism (Milton Friedman, Nobel Prize for Economy in 1976) with the sometimes brutally acting stock market as its accomplice. The "absolute open-market economy" and "laissez-faire capitalism" regard research and responsibility only as a money oriented short term amusement for our Fun-Society [7]. Certainly competition and world-wide activities do change our local situations. But many negative economic developments [8-10] cannot simply be justified by the slogan of globalization [11, 12] (Joseph Stiglitz, Nobel Prize for Economy in 2001).

What is the intrinsic value and meaning of knowledge? This question is nowadays often replaced by the question of what type of knowledge do we need to fulfil predetermined functions. This increasing misuse of Science – i.e. its transformation to mainly develop and support technology often for purely stock market effects – threatens to destroy its critical, purely truth-oriented function. The increasing connection between KNOWLEDGE and INTEREST – first discussed socio-critically by the German philosopher Jürgen Habermas [13, 14] – seems to have become the norm to such an extent that the value of Science is endangered to vanish in goals and reasons defined outside science: "Truth is what is useful". Does this not demand a response from our universities and research institutions?

Where is all this taking us? We are in a transition state: In Europe we are under pressure to restructure our shaking Industrial Societies into Knowledge Based Societies! Because we cannot keep the basic industrial production in our developed countries, knowledge, originality, and richness of ideas are more in demand then ever for further developments. Thus, we need a science education system that is able to nurture creativity, and an uncomplicated fast and open exchange of scientific and technological aspects with industry. We cannot allow our universities to be instrumentalized: Neither politically – as in the Third Reich – nor now political-economically, e.g. by "laissez-faire capitalism". We are all responsible together for what is to come [15].

What is to come? “The best way to predict the future is to invent it” [16]: Independent universities and research institution are a prerequisite for the education of creative, courageous, non-aligned scientists, willing to accept their responsibility as citizens and as professionals [17].

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[17]But isn`t every professional a responsible citizen anyhow? Yes, but see the beginning of this abstract! Too often we scientists exchange our “citizen jacket” against our “lab-coat” as soon as we enter our laboratories and offices.

TO BE BOTH IONIST AND ANTI-ATOMIST: A CONTRADICTION?

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On the one hand, Wilhelm Ostwald is renowned for his "energetical" and anti-atomistic attitudes. On the other he has been honoured with the Nobel Prize in 1909 for his pioneer work on catalysis, and he was the inventor of modern ionic theory (together with van 't Hoff and Arrhenius). Both catalysis and ions are strongly connected to an atomistic world picture in a modern chemistry. As to the on-going philosophical disputes about the correct interpretation of the term "pure chemical substance" it is intriguing which position the anti-atomist but "Ionist" Ostwald took.

As main historical source for this investigation I shall use the chapter XI, which is the last chapter, of the most fundamental non-atomistic if not anti-atomistic treatise within 20th century chemistry, the "Prinzipien der Chemie" from 1907. Surprisingly, this programmatic "introduction to all chemistry textbooks" is only rarely referred to in the history and philosophy of chemistry. In that chapter "Die Ionen", Ostwald says that some soluble salts seem to be one pure substance ("Stoff") in solid state, and two different substances in solution. These two constituents are the "cation" and the "anion" (both in the singular). These ions are of equal chemical composition but of different energetic value with the respective elements: thus they are "electrolytic" isomers according to Ostwald´s approach (p. 518). The original salt has no impact on the chemical behaviour of the cation or anion. Thus, the phenomenalistic substance definition holds at least at that level of investigation. According to Ostwald, there is no need of "hypothetic" atomistic language. Consequently, he makes no use of atomistic vocabulary throughout the "Prinzipien". Moreover, Ostwald demonstrates that Faraday´s law can be applied without atomic hypothesis, and he shows that the phase rule is applicable when electro neutrality is taken into account.

Hence, it can be shown that up to a certain degree Ostwald´s phenomenalistic, non-atomistic concept is able to grasp fundamental chemical phenomena. Although his collaboration with Arrhenius regarding electrolytic dissociation and ions fell into what may be called his early "atomistic" period (<1892), he held his point of view until the end of his active career as chemist (supposedly beyond that). And, he even applied this view to the theory of chemical ions. It is doubtful, anyway, whether or not Ostwald opposed the atomic theory of matter (as Brock has put it) rather than the atomic theory of chemical substances.

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FROM SCIENCE TO TECHNOSCIENCE: THE FORMATION OF THE DISCIPLINARY IDENTITY OF CHEMISTRY IN THE 19TH CENTURY

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The 19th century is widely considered the most important period of modern discipline formation. The establishment of research universities and the upgrading of the philosophical faculties -- on par with the faculties of theology, medicine, and law -- provided an important social context in which the identities of the main scientific disciplines were shaped still for much of the 20th-century. In this paper I analyze four factors that contributed to the formation of the disciplinary identity of chemistry, focused on synthetic organic chemistry and oriented toward what we today would call technoscience. The first one is chemistry's disciplinary academic origin in the faculties of medicine that continued to be influential during the 19th century, although chemistry departments moved to or were newly established in the philosophical faculties.

I argue that the traditional link to medicine enabled the rapid growth of what soon came to be known as organic chemistry. The second factor is the parallel formation of other disciplines from which chemistry needed to distinguish itself and among which I will particularly look at the formation of modern physics. I argue that the discipline of modern physics emerged quite late both by assuming specific research fields that previously belonged to other disciplines, including mathematics and chemistry, and by assuming the role of being fundamental to all the other sciences, both of which had a profound impact on the research questions at the core of the disciplinary identity of chemistry. As a third factor I consider internal developments of chemistry from the late 18th to the mid-19th century. Against the background of the classical methodological pair of analysis and synthesis, I argue that the early emphasis on analysis turned into a strong emphasis of synthesis. All three factors shaped the disciplinary identity of chemistry in such a way that synthetic organic chemistry became the lead area in the second half of the 19th-century, which was eventually reinforced by a forth factor, the emergence of the dye-stuff and pharmaceutical industries. I conclude with some remarks on how this still influential disciplinary profile has contributed to the public image of chemistry, its scientific status, and remoteness from philosophy.

INTRODUCING A. L. STINVILLE (1868 – 1949)

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At the 5th International Conference on History of Chemistry (Estoril/Lisbon, September 2005) we have presented a poster under the title "Do you know Mr. Stinville?" (unfortunately not graphically reproduced in the text edited in respective proceedings, pages 569 to 578) in which we reported the state of the affairs in our search of biographic data about Auguste Lucien Stinville (1868 – 1949), a French chemist and engineer that was called to Portugal to establish in Barreiro, near Lisbon, a century ago, a remarkable chemical complex for the production of fertilizers, acids and other inorganic chemicals, with an European size.

In the meantime this quest has notably progressed and we could establish the profile and recognize some of the major projects in charge of Stinville, with an analysis of his practical formation, knowledge and capability to carry on other meaningful achievements, such as the sulphuric acid and phosphate fertilizer plants of Honfleur and LaPalice in France, to the Compagnie du Guano-Phosphate, both erected in the last years of the XIX century, as well as projects in the "city gas" ring around Paris and in the diffusion and application in Europe, after I World War, of the electrostatic precipitators with Cottrell-technology.

His engagement by industrial entrepreneurs outside France demonstrates well the industrial opportunities opened to peripheral European countries, like Portugal, to establish their own industrial chemical centres similar to those of Central Europe and typifies the relations with independent consultants and know-how providers for the establishment from grass-roots of competitive industrial chemical complexes with integrated facilities and utilities and using as much as possible locally available raw materials, at that time.

The biographic elements collected about Auguste Lucien Stinville also refer a vivid personality, that has met, in his life, strong characters like Jules Lefebvre, the PDG of Guano-Phosphate, Alfredo da Silva (1871-1942), the Portuguese industrial tycoon that established the CUF Group, the French minister Louis Loucher (1872-1931), known as "an engineer, a statesman and a modernizer of France", and provide suitable answers to the questions we have raised in the mentioned poster and related text. Now, we may say that "we know Mr. Stinville".

WORKING IN A TRANSITIONAL TERRITORY? CHEMICAL CONSULTANTS IN THE UNITED KINGDOM, 1870-1914

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An example of the evolving identity of chemistry and the chemical profession can be found in the changing activities of the chemical consultant in the United Kingdom, particularly in the period leading up to the First World War. To earn a living, consultants typically took on a number of roles including general analytical work, government appointments such as public analysts and industrial consultancy. This latter role involved performing process and product control, advising on chemical practice, and undertaking research.[1] However during the period 1870-1914, the territories occupied by the chemical consultant changed as professional borders evolved. Initially the chemical consultant worked independently in his own laboratory providing expertise on various chemical questions for a range of customers. By the end of the period, the specific expertise required by governmental and industrial laboratories was beginning to be provided by in-house employees rather by than independent practitioners.

A quantitative examination of these changes in professional borders will be undertaken using the Open University's "Biographical Database of the British Chemical Community" which contains data on around 10,000 chemists.[2] Statistics will be presented on the percentage of chemists working as independent consultants, along with the type of work they were undertaking, and how this changed over time. The extent of multi-sector working will be examined and case studies will be used to illustrate how the diversity of work undertaken by consultants reflected the flexibility of chemical skills. Furthermore, by studying consultants' educational background and their membership of specific chemical societies, an insight will be given into how the professional boundaries within which they were working were shifting.

Through focusing on one group of chemical practitioners, this paper will explore whether consulting chemists in the period 1870-1914 were working in a transitional territory, both in terms of employment location and disciplinary focus, before in-house research came to be widely adopted. As chemistry's identity evolved, the dynamic and versatile contributions made by consultants to the economy were transformed.

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CHEMISTRY AND PHARMACY IN THE EIGHTEENTH CENTURY; LESSONS FROM AND LIMITS TO A DISCIPLINARY APPROACH

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In 2005, I published *Chemistry, Pharmacy and Revolution in France, 1777–1803*, which dealt with the relationship between pharmacy and chemistry in France at the time of the French Revolution. In particular, my aim was to explore the chemical revolution associated with the name of Antoine-Laurent Lavoisier from the perspective of pharmacy. I propose to start this presentation by briefly outlining my thesis that the separation of chemistry from pharmacy should be considered a constitutive element of this scientific revolution. Indeed, in order to comprehend the nature of modern chemistry, we need to understand how it succeeded in establishing an identity independent from the 'chemical arts'. This introduction will serve as a prelude to a critical assessment of the limits to this approach. Since completing this research, I have reflected on the arguments I make in the book and their situation in the context of the history of chemistry and the history of science more generally. I will underline the theoretical principles behind the approach I adopted, and what I would defend as the most important lessons it can bring to the history of science. Finally, I want to indicate the limits of this kind of approach, particularly in terms of understanding the continuity of 'philosophical chemistry' and the history of the integration of chemistry into the burgeoning nineteenth-century educational system. These reflections will open up onto the subject of chemistry's place in the industrialized world, and will also introduce the question of the extent to which the exceptional, revolutionary history of France can legitimately be translated into other national contexts.

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LEIBNIZ AND STAHL ON THE LIMITS OF CHEMISTRY

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What does it mean to be a physician in the early 18th century, if you are also a chemist? Stahl and Leibniz illustrate two types of answers to this question. The debate between the two took place against the background of contemporary attempts to subsume medicine under chemistry and mechanics.

This paper analyzes the debate between Stahl and Leibniz over the relation of chemistry and medicine, and theory and practice. For Stahl, chemistry and medicine had an identical basis, although their roles were opposites: the mixt, compound bodies and aggregates, and the processes leading to their formation, provided the conceptual foundations of *positive* chemical interpretation of matter, but also provided a *negative* key to the understanding of organic substances. Stahl felt that there existed an obvious difference between long-lasting bodies and others whose quick disintegration puts the chemist into difficulty. The realm of living things was, in his eyes, characterized by complex structures that managed to resist corruption for a considerable time, while quickly disintegrating if separated from their "principle". For Stahl, medicine cannot be based on the longevity characteristic of chemical bodies, but needs to focus on that type of longevity that depends on the integration of a thing into the larger "compound" of an "organic body". Facing such "organic bodies", Stahl believes, the chemist must cede to the representative of a different science, which investigates the larger organic body and its ability to endow its sub-parts with forces counteracting corruption. This type of higher organization, which *is life*, transcends chemistry!

Leibniz could not accept Stahl's ontological distinction between the mixt and the living. For him, the difference was not categorical, but one of the degree of organization. Nor did he share Stahl's characterization of the nature of matter itself. Unlike the latter's atoms whose combinations were brought about by repulsive and attractive "forces", Leibniz' matter was infinitely divisible and inherently dynamic. In the debate between Leibniz and Stahl, the key question became whether one had to investigate into differences between movements and effects (Leibniz), or instead into that type of movement that succeeded in protecting an organized "body" against the effect of a natural chemical or atomic "disagreement" (Stahl).

Leibniz and Stahl did not reach any agreement, but ended up insulting each other. Yet, the stakes were high. Was the practice of science directed towards generalization or increasing specialization? Should the framework be theoretical ("this must be like that") or rather practical ("this will be operative")? The Leibnizian motto, "for the sake of reason, this must be," and his integration of medicine into chemistry and metaphysics displeased Stahl, who dubbed Leibniz a "grammarian" because of his many philosophical subtleties.

My lecture shall end with some words about the significance of this debate for the emergent status of chemistry between a general natural philosophy and a study of life.

CHEMICAL MICROBIOLOGY, AN INTERDISCIPLINARY FIELD ON THE ROAD TO MOLECULAR BIOLOGY, 1920-1948.

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In 1913 the strategy of *dynamic biochemistry* as a new interdisciplinary science was outlined by the Cambridge biochemist F.G. Hopkins. Hopkins' program influenced biochemistry development in Europe for the forty years to come. One of its main consequences became focus on chemical approaches in solving biological problems and increasing attention of chemists to living matter, especially the cell. This trend culminated in the 1960s and 1970s in the formation of molecular biology. The road from dynamic biochemistry to molecular biology was paved by a number of interdisciplinary fields, in the first place by chemical microbiology. In compliance with Hopkins' programme chemical research into the microbial cell was pursued since the 1920s by a group of scientists led by Hopkins's pupil Marjory Stephenson (1885-1948). The institutional base of the team became a newly constituted research unit in chemical microbiology of the Medical Research Council in Cambridge. The laboratory focused on research into metabolic activities in microorganisms, especially the actions of bacterial enzymes, with the chemical phenomena in microorganisms investigated as a model for better understanding cellular events in general – an approach later overtaken by molecular biology. Research into hydrogen-activating enzymes and identification of several new enzymes in the 1930s assured the laboratory her high reputation both in Britain and abroad. In 1930, Stephenson and Leonard Stickland discovered a new enzyme, formic hydrogenlyase, produced by various coliform organisms including *Escherichia coli.* Experiments performed in the years 1932 to 1936 with John Yudkin and Ernest F. Gale proved that this and several other enzymes are formed in *E. coli* and yeast as a direct response of the enzymatic composition of the cell to the constituents of the growth medium. Enzymatic adaptation (later known as enzymatic induction) was taken up by Jacques Monod in the 1940s to become a point of departure for the theories of cellular regulatory mechanisms and protein synthesis developed in the 1950s and 1960s. Practice oriented wartime projects managed by Stephenson investigated strategically important biotechnological production of organic compounds and contributed to the fast advance of biotechnology after WW2.

The institutional and communication base of the new field chemical microbiology, also known as general microbiology, became the Society of General Microbiology (1945) and the Journal of General Microbiology (1947). Its program was formulated in Stephenson's monograph *Bacterial Metabolism* (1930, revised editions1939 and 1949) and in her lecture *Levels of Microbiological Investigation* read at the inaugural meeting of the Society for General Microbiology, where Stephenson presented a strategic vision later fully realised by molecular biology.

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CHEMIST FOR INDUSTRY IN EUROPEAN PERIPHERY: TRAINNING AND PROFESSIONALISM IN SPAIN DURING THE FIRST HALF OF XXTH CENTURY

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At the end of the XIXth century, technicians and entrepreneurs of the main European chemical industries thought necessary incorporate new specialists to direct new factories, whose scale and volume of production had increased significantly. Chemical Engineering was one of the new disciplines that slowly emerged in Europe, especially in Great Britain (Donnelly 1988). Different subjects and spaces growth in other "Centre European" countries. In France appeared the 'Instituts Annexes de Science Appliquées', whose programs of Industrial Chemistry were guided to the resolution of practical problems of local industries (Nye 1986). The influence of organic chemical industry in Germany determined the scale of production and the relationship between chemist and mechanical engineers (Meyer-Thurow 1982). At the same time, assistant professors of Industrial Chemistry in the German Technischen Hochschulen claimed that technicians assigned to inorganic industry had to receive a specialised trainning. Meanwhile German Science Faculties incorporated Technical Chemistry as a way to introduce chemist into the study and classification of chemical processes and its products. Like some authors have recently shown, when educational models are introduced and appropriated in another country, they are influenced by local actors and educational forces (Bertomeu-Sánchez, García-Belmar, 2006). During the first quarter of the XXth century, several actors took actions to create a group of specialist that were able to direct chemical plants in Spain. This industry grew significantly due to the arrival of European companies and to the massive installation of small factories of chemical products during the First World War. The Civil War truncated some of these initiatives. Once the Civil War was finished, a group of chemists very close to franquism authorities tried that new chemist, arisen from the faculty of Sciences of Madrid, turned into the technicians able to direct the national chemical industry that survived to war. At the same time industrial engineers attempted modernize their educational practices in order to avoid the massive arrival of chemist to industry (Toca 2006). What were the models of trainings adopted in Spain during these periods of the XX century? Who were their protagonists? What consequences did they have for the professionalism of specialists? These questions will try to answer in our communication.

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CHEMISTRY BUILDINGS AT BUDAPEST UNIVERSITY OF SCIENCES, 1860-2006

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In the life of Hungarian universities the year 1860 brought about radical alterations. The fall of absolutism, the re-introduction of the mother tongue instead of German in training lead to the appointment of new professors and, from 1867 on, a university reform. For education in chemistry this meant that –upon the recommendation of Redtenbacher, Bunsen and Wertheim– then 25-year-old Károly than was appointed head of the then only department of chemistry. Science in Hungary in general, and chemistry in particular, were lagging by about 50 years after western Europe. According to than: "… when I took over the department of the royal Hungarian university, I took over a small chemical workshop, the lecture hall had 90 seats, and in the corridors a total of only 15 [laboratory] desks were installed… Soon it turned out that the establishment of a new institute meeting the present demands of science could not be delayed any more without jeopardizing the success of education. As it is, from the year 1860 on the number of chemistry students and trainees increased fortunately to such an extent that the number of the first ones surpassed 300 and that of the latter 50."[1] Than urged the establishing a new chemistry building as soon as from 1863 on.

The plans of a new chemistry building were included in the objectives of the university reform started in 1867. The monarch approved of establishing the new building on may 29, 1867.[2] Károly than was sent on a study trip for visiting modern institutes of chemistry, and for collecting data and advice for the establishment of the new building. Building started in 1868, and in autumn 1871 education could be started in it. After Than's death in 1908 his department was divided in two parts, and the building was enlarged by a new wing as soon as in 1909.[3] The paper is dealing with Than's study trip, the ground-plans and the equipment of the institutions used as models, and describe the area arrangement and equipment of the then famously modern and exemplary building erected in the then botanical garden. This building served as examples to the establishment of the chemistry institutes of Rome, Birmingham, Graz, Aachen and Boston.

The paper is going to deal with the increase in the number of the departments of chemistry, and the reflection of the delimitations – according to specialities – in the equipment of the building. For chemistry, the 21st century constructed a new palace at the other side of the Danube, where even the smallest lecture hall can hold 300 persons.

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[1] Károly Than: Akadémiai Értesít□, 1871, p. 215.
[2] Imre Szentpétery: A királyi magyar Pázmány Péter Tudományegyetem története. IV. kötet. A bölcsészettudományi kar története 1635-1935. (History of the Royal Hungarian University of Sciences Pázmány Péter. Vol. IV. History of the Faculty of Philosophy 1635-1935). Budapest, Királyi Magyar Egyetemi Nyomda, p. 480-481.
[3] Ibid., p. 562.

DEUTERIUM AS A PROBE OF THE BOUNDARIES BETWEEN PHYSICS, CHEMISTRY AND BIOCHEMISTRY

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The first editorial in *Industrial & Engineering Chemistry* for 1934 asserted that "the importance of the discovery and preparation of the isotope of hydrogen, named 'deuterium,' may be far greater than that of most elements. It seems certain that in years to come it will be ranked among the great discoveries in science".[1] G. N. Lewis speculated that "it [deuterium] will be so different from common hydrogen that it will be regarded almost as a new element".[2] Deuterium was discovered by Urey and coworkers in 1932;[3] about 200 papers concerning deuterium were published in 1934 alone. Yet historians of chemistry have given little attention to deuterium or other stable isotopes, instead focusing almost exclusively on radioisotopes and radioactivity. Not only are stable isotopes of inherent interest; their history also shows the role of experimental practices and cultures in defining and blurring the boundaries between chemistry, physics and biochemistry. Two concerns dominate any experimental work with isotopes – detection and quantitation. Stable isotopes lack the radiation "signature" of radioisotopes. For chemists, however, the traditional elemental signature had been atomic weight, which after the discovery of isotopy had been replaced by nuclidic mass. Chemists' rapid embrace of deuterium for various uses shortly after its discovery undoubtedly owed much to their ability to track and measure it by employing familiar techniques –degradation, combustion, and density measurements on the product, partially deuterated water. Furthermore, chemists' focus on mass, in the context of the newly quantized molecular ball-and-stick model, revealed the kinetic isotope effect as a powerful tool for mechanistic studies.

By contrast, physicists were more interested in nuclear charge and spin. Their studies of these properties, carried out under high vacuum with the aid of electric and magnetic fields, resulted in the construction of prototypes of the mass spectrometer. However, these technologies were alien to most chemists in the 1930s and 40s and, furthermore, were not then applicable to chemically interesting molecules or even to deuterated water. The gap between chemists' and physicists' approaches to tracking and assaying deuterium was bridged by a small cadre of biochemists who were anxious to utilize the isotope's potential in metabolism studies. The biochemists generally shared the chemists' outlook but had the additional constraint of small sample size. They devised several successful microanalytical techniques, including one in which the partially deuterated water was equilibrated with H_2 and the gas then analyzed mass spectrometrically.[4] Eventually, chemists adopted not only mass spectrometry, but spin-based nuclear magnetic resonance as well. Ironically, the initial role of deuterium in NMR was a negative one – its significance lay not in its being "heavy hydrogen" but rather in its being "invisible hydrogen".

[1] H. E. Howe, "The Editor's Page", *Industrial & Engineering Chemistry*, 1934, 26: 1.
[2] G. N. Lewis, "The Isotope of Hydrogen", *Journal of the American Chemical Society*, 1933, 55: 1297-98, on 1298.
[3] H. Urey, F. G. Brickwedde and G. M. Murphy, "A Hydrogen Isotope of Mass 2", *Physical Review*, 1932, 68: 164-65.
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THERMOCHEMISTRY: THE MEETING POINT OF PHYSICS, CHEMISTRY AND MECHANICS. THERMOCHEMICAL LABORATORY OF MOSCOW UNIVERSITY AND V.F.LUGININ

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Turning of chemistry from descriptive science into science, studying reasons and mechanisms of chemical transformations, happened at the moment, when chemical research in the end of XIX century started relying upon physical principles, when thermodynamics started to be used to explain conditions of passing of chemical processes. At the crossroads of physics, chemistry and mechanics at this period thermochemistry has been successfully developing. Progress in this area of knowledge depended first of all on the development of its experimental method – calorimetry. Radical changes to the technics of calorimetry were introduced in 1881 by P.E.M. Berthelot, which has created a calorimetric bomb. Methods of its usage were substantially improved by a Russian scientist V.F.Luginin.

The name of V.F.Luginin (1834-1911) is valued and respected in Russia. On the verge of XIX-XX centuries he established in Moscow University the school of thermochemists and presented as a gift to the university the equipment of his laboratory. From 1889 to 1906 all scientific and pedagogic activity of Luginin is connected with Moscow University. By 1892 he managed to equip (at his own expense) a specialized thermochemical laboratory, where workshop for students and trainees was organized and course of calorimetry and thermometry was read. In opinion of contemporaries, the laboratory was equipped with such an amount of good, expensive devices and also unique ones developed by Luginin, that its condition put it at one of first places not only in Russia, but also in Western Europe. Scientists from Kharkov, Kazan' universities and also from abroad came here to make their research. Laboratory played an outstanding role in development of calorimetry and thermochemistry of organic compounds. Proud of being H.V. Regnault's scholar, Luginin in the first place strived to develop and to improve measures of constants, in the determination of which his instructor was engaged. As a result he improved methods of defining heat of liquids' evaporation and heat capacity of solids and liquids (his own designs of appliances were created). Being a close friend of Berthelot, Luginin took an active part in development and distribution of method of defining heats of burning of organic compounds proposed by the scientist, which he also improved. Earlier than other thermochemists Luginin noted that comparison of thermochemical properties for gaseous state of substances is more correct. As a result, determinations of combustion heat of organic compounds were supplemented by him with determinations of their vaporization heats at boiling temperature and of heat capacities from 0°□ to boiling point. Scientific heritage of this laboratory is indeed substantial by the evolving identity of chemistry.

The research is based on documents from several Moscow archives and on personal recollections of V.F.Luginin.

TEACHING CHEMISTRY THROUGH HISTORY: THE DEVELOPMENT OF THE PERIODIC TABLE.

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In prehistoric times chemistry was more an art than a science, after the chemical revolution of the 18th century it has became a real science and now it is an important part of our daily lives. In spite of chemical processes being in use from a long time ago, the history of chemistry is not usually taught in Spanish high secondary schools. We think that this absence is not good for chemistry social understanding.

High school students learn a variety of topics that include: structure of the atom and characteristics of matter, radioactivity, Lavoisier's law, the periodic table of elements, organic compounds, etc. However, they usually don't know who made or discovered that law neither when it happened or how it was found.

Students from Spanish high secondary school (>17 years-old), secondary school (15-16 years-old) and primary school (11-12 years-old) were asked to complete a questionnaire about chemistry and its history. Results showed us that interest in chemistry and also in science has been decreasing in Spanish younger students as it is also detected around Europe. In addition, we correlated these results with the amount of chemistry history in Spanish textbooks. Most of them neglected this subject but, some books contained a few illustrations or little words from a few scientists (e. g.: "*Marie Curie, she made some important discoveries related to radioactivity and several isotopes*"). This could be the reason why students have lost interest in chemistry.

Here we present a new way that was successfully applied in our schools to transform this situation. In order to bridge the gap between chemistry and its history, we proposed some changes in chemistry lessons for students in their first year of high secondary school. The aim of the project is to choose historic findings in chemistry which can help students to understand some concepts easily. Our pupils summarized the historical development of the periodic table of elements and then they have understood the concept of periodicity related to properties and reactivity of some chemistry elements. After that, a feedback was collected from students via a new questionnaire. Most students considered these classes valuable for increasing their chemistry knowledge and also said that this approach increased their interest in chemistry and changed their previous idea about chemistry.

The goal of this contribution is to show how chemistry lessons via its history can look again attractive for students. And we propose that this part of chemistry should be present in the Spanish science secondary school curricula.

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