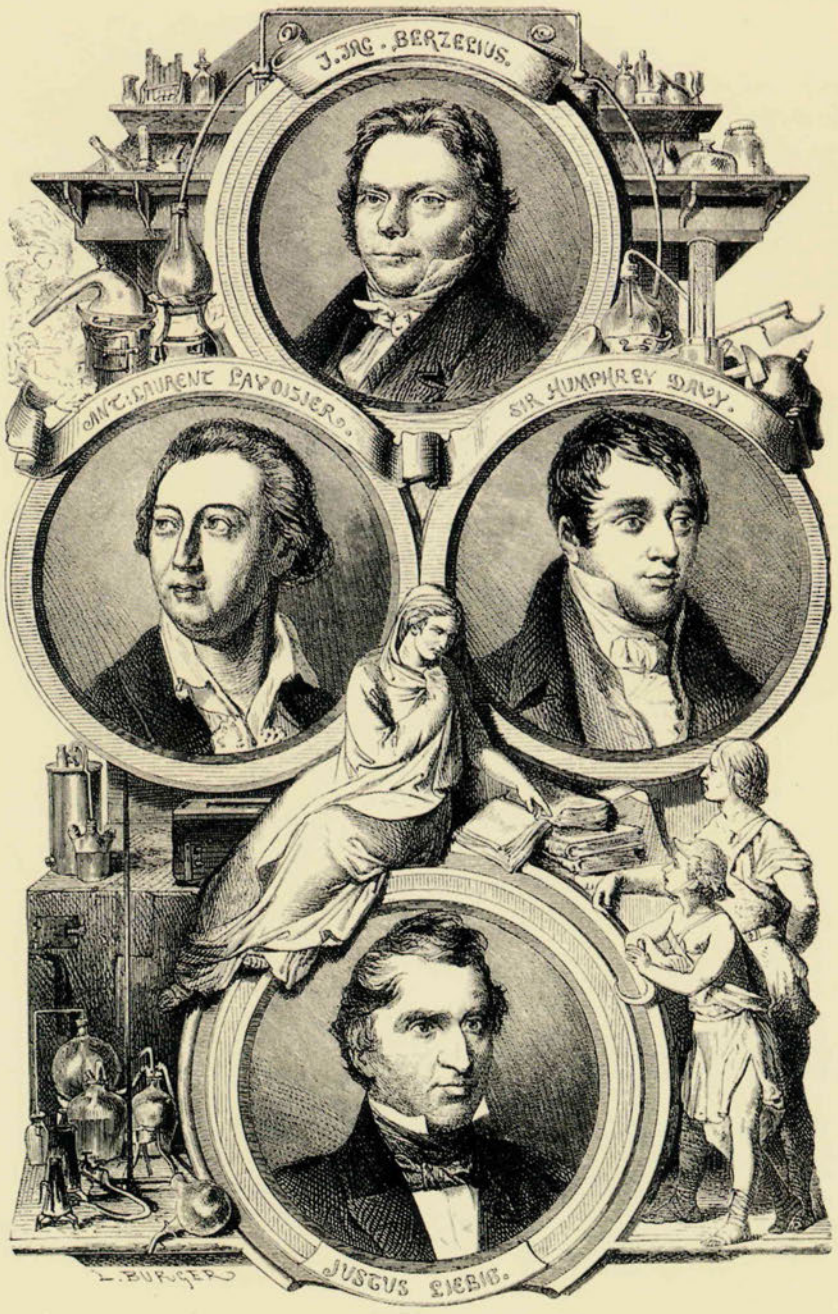
Final report

The Evolution of Chemistry in Europe 1789-1939



An ESF humanities programme

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The Evolution of Chemistry in Europe 1789-1939

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1. Origins of the project and initial aims

One of the peculiarities of this ESF history of chemistry programme is the fact that it was conceived of jointly by the European Science Research Councils *and* the ESF Standing Committee for the Humanities. Consequently, the programme was expected to link the 'two cultures' in a co-operative venture and to produce results that would be meaningful to historians and to the chemical community alike. In the beginning, chemists thought that something ought to be done to improve the public appreciation of chemistry and to integrate the discipline more fully into our concept of modern culture and civilisation. Members of the Humanities Committee suggested that historians of science should take up the challenge, as they would be able to contextualise chemistry and to provide, thereby, the means for a better understanding of science and its role in the modern world.

The history of chemistry was seen as a particularly appropriate subject for several reasons: First of all, no other science is so intimately connected with industry, economy, the state, the material basis of modern civilisation and the very conditions of living. This high contextuality makes chemistry an especially rewarding subject for historians. Second, ever since modern chemistry emerged in the late eighteenth century it has been part of the European scientific heritage – well worth studying from a European perspective. By combining comparative studies with those related to the transmission and exchange of knowledge new insights could be gained into the mechanism of the evolution of a scientific discipline, its cultural conditions and material requirements, the emergence of different national or regional patterns, the reasons for shifting centres of excellence, and the relationship between developing nations and those more advanced.

A working assumption behind this approach was that historical research strives at explaining the patterns and mechanisms of the complex interplay between science and economy, and will ultimately make us better prepared to solve the even more complex, if structurally similar, problems of our own scientific and technological culture in Europe.

Although it has received considerable attention during recent decades, the history of science is a small and often novel subject in European universities. Historians of chemistry are even rarer birds in the academic world, and a European project in the

history of chemistry was therefore both a challenge and a somewhat uncertain venture. However, things have changed remarkably during the past few years: Since 1991 some twenty books on the history of the chemical sciences and chemical process industries have appeared, including four ambitious general textbooks on the history of chemistry. In 1992 the German chemical industry inaugurated a funding scheme for 'chemistry and humanities', including the history of chemistry. In spring 1993 two meetings were organised in London and Paris on writing and on teaching the history of chemistry and on the problems faced by contemporary authors in communicating this subject to diverse audiences of chemists, historians, students, and the general public. Interestingly enough, this revival of chemical history was soon followed by a rising interest in the philosophy of chemistry, a topic traditionally neglected by philosophers of science which in 1997 could boast of the inauguration of two specialised journals. To say that this new interest in chemistry as an important part of modern culture and history was an immediate outcome of the ESF programme on the emergence of modern chemistry, would of course be exaggerated. Yet, the coincidence is not just a matter of chance. At least it proves that the ESF programme was both timely and well chosen.

In February 1992 a first exploratory workshop met in Strasbourg, attended by Prof. Donnelly, representing the ESF Science Committee, Profs Dazzi and Shea representing the Humanities, and six historians of chemistry from Britain, France, Italy, Spain, Portugal, and Germany. The outlines of a project were drafted and a Steering Committee was set up. In November 1992 the ESF General Assembly accepted the research proposal on *The Evolution of Chemistry in Europe, 1789–1939* and provided a four-year grant of 1,9 million Francs.

2. Organisation

In December 1993 the programme was launched with a workshop in Canterbury, UK. Since then, 12 workshops and one final conference have been organised in various places, mainly in university towns where one of the participants could act as a local host and organiser. The total number of active participants in these workshops was 135 scholars from all over Europe [see 7.4.]. There was a fair mix of countries, some with a strong research tradition and others breaking new ground in the history of science; and most European countries

were represented, including Eastern Europe. From the very beginning, a few American historians of science took part in the programme, which, as time went on, also attracted other participants who came at their own expense. All workshops were open to PhD students and young researchers from local universities, who were not supported from the ESF budget but who in some cases received grants from their institutions.

The programme was organised under four themes of particular significance. The first one was the role and importance of new networks of communication and the establishment of a common language in nineteenth-century chemistry. This section was headed by Bernadette Bensaude-Vincent (Paris), Ferdinando Abbri (Florence) and Tore Frängsmyr (Uppsala, later replaced by Anders Lundgren, Uppsala). The second line of research dealt with the professionalisation of chemistry and the change in the academic and social status of the chemist, and was organised by David Knight (Durham) and Helge Kragh (Aarhus). The third section focused on chemical laboratories and the teaching of chemistry, and was lead by Javier Ordoñez (Madrid) and Ana Luísa Janeira (Lisbon). The fourth theme focused on the emergence of the chemical industry and the transfer of new technologies. It was chaired by Robert Halleux (Liège), Ernst Homburg (Maastricht) and Harm Schröter (Berlin).

Each of these sections acted more or less independently and developed its own working procedure and traditions. In this regard the section leaders, who had been appointed by the Steering Committee, were autonomous, even though some of them were also members of the Steering Committee. Some section leaders preferred to organise thematic conferences, the results of which could be published separately, as was the case with the conference on the reception of Lavoisier which was the first to be published. Sections II and III chose to pursue a common book project through a series of meetings with a core group of participants. Section IV took a chronological and systematic approach and the results will appear in a series of books. Again, editorial policy and negotiations with publishers was entirely the section leaders' responsibility.

Over the years a fair amount of expertise accumulated within each section and among the members. In order to share this experience among contributors in all sections, a final meeting was held in September 1997. It aimed

to bring together the chief results from the four sections in order to raise common issues and to evaluate the programme as a whole. This would also enable the authors and editors to take these discussions into consideration before the forthcoming proceedings of the programme are published.

3. Report on sections I–IV

3.1. Communication in chemistry (Section I)

Out of the multi-layered communication networks that constitute scientific communities two key features have been investigated on a European scale, viz. language and textbooks. The first workshop, held in Paris in May 1994, was entitled "Lavoisier in European Context: negotiating a new language for chemistry". It was innovative in two respects. First, it extended our knowledge from 'central' countries such as France, Britain, Germany and Spain, which had already received a considerable amount of attention from historians, to those at the margins of this great controversy, such as Poland, Portugal and Mexico. Thus issues of centre vs. periphery and of local styles were important. Second, the diffusion process of scientific innovation was seen in a new light. Most traditional accounts had viewed it as a passive reception or assimilation of both theory and practice which originated in Lavoisier's work. From this new perspective, the so-called reception is understood as a series of constructive responses influenced by the local context and local practice of chemistry, so that often the 'revolutionary' aspects of the new chemistry fade away. Universality was therefore not achieved by simple surrender to the 'better' method, but resulted from multiple responses and adaptations.

Additional results of this workshop confirm the formation and explain the coherence of a truly European chemical community around 1800. They explain the merging of local practices and contexts into a universal disciplinary matrix, and afford hints as to the speed of this process and to the role of language and politics. They also explain the changing geopolitical map of science in Europe, i.e. from decentralised local cultures, through polarised camps during the debate about the pro's and con's of the new French chemistry, to a reorientation in terms of centre and periphery. A similar reorientation took place in the disciplinary relations between chemistry, physics and pharmacy.

Bilingual proceedings [7.2.1.] of this workshop were published in

1995 by Science History Publications, Canton, Massachusetts.

The second workshop, on "Chemical Textbooks, 1800–1930", met in Uppsala in February 1996. It dealt with one of the main means of communication in science which had a tremendous expansion in the nineteenth century. The textbook was selected in order to understand the development of chemistry through the ways it was taught, professionalised and institutionalised. The workshop chose a comparative approach to understand the process of standardisation and consensus through which chemical knowledge became shared knowledge.

Unlike the Lavoisier case, this topic could not rely upon established research traditions. Instead it had to break new ground. The very definition of a textbook needed to be defined in terms of content, use, and readership; the relationship between textbooks and discipline formation was examined. The results could be summarised by identifying a two-step process: first, inner institutionalisation as the constitution of a new cognitive field or research area, usually within an existing discipline; second, outer institutionalisation by which a field organised itself more formally, creating institutions and chairs, or by producing journals and textbooks.

Several related issues were raised in this context, including the various readers and uses of textbooks, the relationship between practical skills and the literary tradition, and the differences between lecture hall teaching and teaching through texts. Other papers looked at the role of translations and translators, or at the pedagogical ideals behind textbooks and their role in popularising science.

Because this part of the programme could not build upon existing research, a complete coverage of the European textbook tradition in chemistry has not been achieved, nor was it ever intended. However, complete bibliographical surveys on the chemical textbook literature have been prepared for France, Spain, and Sweden, which in turn can be used as a basis for quantitative and comparative studies. For the publication of the results and in order to fill some of the more urgent lacunæ, a few additional papers that had not been presented at the workshops have been commissioned and will be included in the final volume entitled *Communication in Chemistry: textbooks and their audiences, 1789–1939*, scheduled

for publication by Science History Publications in 1999 [7.2.9.].

3.2. The making of the chemist (Section II)

Section II was set up to focus on the social history of chemistry, including processes of professionalisation, education, and career opportunities for chemists both in academia, industry, and elsewhere. The idea was to map these processes for individual countries and discuss similarities and differences. The section has followed the original plan rather closely. In contrast to other sections, it largely worked with the same group of people, and the same nations, throughout the four years. For the last workshop, however, a number of younger researchers joined the group.

The section workshops were as follows: December 1993 in Canterbury "The Making of the Chemist: the social history of a profession"; September 1994 in Dublin "The Development of Chemistry within National Boundaries"; May 1995 in Delphi "The Making of the Chemist: the social history of a profession", and September 1996 in Rome "From one War to another: social and other aspects of chemistry in Europe, 1910–1940".

For the 'long' nineteenth century (1789–1914) the section succeeded in bringing together material from a large number of European countries that allows a comparative analysis. For the period 1910–1940 this turned out to be more difficult, and a number of important issues had to be left aside, e.g. the role of chemistry in the First World War or the changing relationship of science, economy, politics, and the job market, in its aftermath. Likewise the important twentieth-century links between chemistry in Europe and the United States, which at this time rose to become a dynamic centre of both academic and industrial power, had to remain outside the scope of this programme. Complementary aspects concerned the intellectual status of chemistry in relation to other sciences, especially physics. Thus in the 1920's, due to the rise of atomic and theoretical physics, chemistry was no longer considered the fundamental science of high cognitive value as it had been in the nineteenth century. At the same time, however, chemistry and physics became ever more closely associated through interdisciplinary fields such as chemical physics and quantum chemistry.

With regard to the nineteenth century our work did lead to some new and interesting results. For one thing, in many of the smaller countries there simply did not exist any investigations

concerning the social history of local chemical communities: Denmark, Norway, Lithuania, Portugal, Greece, and Belgium have for the first time appeared on the agenda of the international history of chemistry community. The results will now be accessible in English and can hence serve as a basis for comparative work. From this, the following aspects are worth mentioning.

First, the diversity of the European chemical communities is so marked that 'comparison' cannot mean a reduction to sheer quantity. The differences between 'centres' and 'peripheries' of chemical excellence need to be analysed in terms of historical context. There are examples of so-called peripheral countries that benefited from their position, but without threatening the hegemony of the three major nations which continued to dominate world chemistry throughout the century. And there are also many examples of failed transmission from centre to periphery, because local conditions did not support the kind of chemistry practised elsewhere.

Second, the formation of national chemical communities required a critical density of chemists, multiplied, so to speak, by a mobility factor that depended on infrastructure technologies. Printed means of communication were as important as the railway, mail and telegraph systems.

Third, much attention was given to the establishment of national chemical societies as an indicator of the professional status of the chemist. Recurring themes were regional competition and the often uneasy relationship between industries and academia. Fourth, some attention was paid to the employment opportunities for chemists, since if there were no demands for chemical knowledge and skills that went beyond the purely academic level, the various chemical professions might never have emerged. The diversity of jobs created at different times in different countries, accounts for the different dates at which national chemical communities can be said to have come into existence.

The proceedings of the series of workshops organised under Section II are planned to be published by Cambridge University Press under the title *The Making of the Chemist* [7.2.7.] in the spring of 1998. Another collection of papers dealing with twentieth-century chemistry was issued as a special number of the international history of science journal *Centaurus* in October 1997.

3.3. Laboratories and the teaching of chemistry (Section III)

In the original proposal of 1992, Section III of the programme was meant to deal with the impact of new materials and the contribution of chemistry to human welfare. Agriculture and medicine were the obvious fields of chemical improvements, but the new world of fibres and plastics were equally important in transforming the very conditions of human life. It was assumed that by focusing on materials the expertise of business and economic historians, historians of chemistry, museum people and working chemists would arrive at a point of reference that would enable these different communities to share their experiences. And as the whole programme had been initiated by ESF chemists in the very beginning, it was taken for granted that the chemical and industrial community would be particularly happy with this approach. The contrary, however, was the case. Despite repeated attempts at bringing chemists or chemical industrialists into this part of the project, the topic did not attract these groups, nor were historians of science particularly keen on it.

It was therefore decided to replace the "New Materials" section by another topic that had emerged as a focus of interest and a bridging subject relevant to all other sections namely "Laboratories and the Teaching of Chemistry". In Section I the laboratory emerged as the non-verbal counterpart to the textbook tradition; in Section II it was identified as a core structure in the process of professionalisation; and from Section IV the laboratory served as a link between research and production.

Two workshops were organised in this redefined Section III, one in December 1994 in Madrid and the other in November 1996 in Lisbon. From the beginning there was a major involvement from a Portuguese school of epistemology based in Lisbon. Since one organiser of this section was head of this school, the peculiar approach favoured in this group was strongly felt in the conferences. From this perspective laboratories and instruments were seen as spatial arrangements that interact with human actions and thereby produce meaning. Thus the changes in design, equipment and layout of chemical laboratories were interpreted as inscriptions of the changing nature and function of chemistry. The existing literature on the subject had concentrated on the study of exemplary research laboratories such as Liebig's. Section III extended this approach to the more typical laboratory,

including pure teaching and industrial laboratories. The examples from Portugal emphasised the role of space in the building of the laboratories and its different uses for various purposes.

A second group of studies focused on the laboratory as the place where the values of precision and accuracy were established and controlled. Regnault's Paris laboratory was presented as an example of how this "stage of precision" was used in obtaining public support for this new programme. The question of how instrumentation changed the laboratory was raised several times, but chemical laboratory instruments were not studied as such in this section. Other authors looked at the vicissitudes of industrial laboratories and confronted late eighteenth-century natural dyestuff workshops with industrial explosives laboratories in the late 19th and early 20th centuries.

A third group of papers discussed the relationship between research laboratories and the transformation of chemical education in the nineteenth century. The teaching laboratories of Bologna, Paris, Sardinia, Germany, Poland, Portugal and Russia were examined in greater detail. Seven subsequent steps in their development have been distinguished: 1. The laboratory as operations-oriented schools of a practice with mainly pharmaceutical ends; 2. the transformation of pharmaceutical boarding schools into new elements of the university structure; 3. the birth of the research group out of a new instrumental method; 4. strategies of legitimisation for the new research-oriented curriculum; 5. the consolidation of university institutes as schools of research; 6. the re-definition of the role of research schools by means of the notion of synthesis as a future-oriented endeavour; and 7. the beginnings of a breaking apart of the laboratory as the single integrating space for teaching and research.

On the whole, Section III was not overly well balanced as far as intellectual homogeneity and organisation were concerned. To present the respective approaches more adequately, it was decided to publish the studies of the Portuguese group in a book on *The Mineral Chemistry Laboratory of the Polytechnic School of Lisbon, 1884–1894* published by Lisbon University Press (Livraria Escolar Editora) in 1996 [7.2.3.]. Papers that did not really meet the epistemological framework of spatial organisation and knowledge production will appear in a volume on *Research Laboratories and the Teaching of Chemistry* [7.2.10.].

3.4. Strategies of chemical industrialisation (Section IV)

That Section IV of the programme has been the most productive in terms of publications, and to some extent the most sophisticated in terms of approach, reflects the fact that the history of the chemical industry recently has received considerable attention from historians. In addition the field has particularly profited from input by business and economic historians.

The working format of this section was a series of three workshops that were defined both chronologically and thematically. There was not only a succession of periods but also of scholars taking part, with a core group of people active throughout the series. Whereas the earlier periods attracted mainly historians of science and technology, the later ones had strong contributions from economic and business historians. One of the major breakthroughs of this Section was indeed the bringing together of these groups that otherwise rarely meet.

The first workshop entitled "From Lavoisier to Bessemer, 1789–1856" was held in Liège in 1994. It focused on the role of chemistry in the development of industrial sectors. Special attention was paid to the 'traditional' mass production technologies of metal, glass and coal, and the features observed here were confronted with the chemically more sophisticated 'new' technologies of the alkali industry and the making of gunpowder and dyestuffs. The interpretative framework marked the distinction between ecotechnique (local production, small-scale extraction leading to a single product, high pollution per output but small factories, practical know-how) and paleotechnique (transport of raw materials, larger-scale synthesis, range of end products, lower pollution per output but large factories, chemical know-how).

A selection of papers from this first workshop were published in Rome in 1996 as a special issue of the *Archives Internationales d'Histoire des Sciences* [7.2.2.].

The second workshop in this series was held in Maastricht in March 1995. It dealt with the period "From Perkin to Bosch, 1856–1918", i.e. with the beginnings of industrial research, the transition from research to production and the problems involved in scaling up and market entry. Foci of interest were: case studies on high-tech companies in a heterogeneous environment as exemplified by the dyes and pharmaceuticals industries; the interplay and knowledge transfer between science and industry;

typical patterns in national strategies of chemical industrialisation; the problems and challenges caused by pollution and environmental concern; methods of process control in chemical firms; and, finally, the professional and economic roles of chemists and chemical engineers.

A book containing papers from this workshop, *Chemical Technology and the Second Industrial Revolution*, will be published by Kluwer of Dordrecht in 1998 [7.2.5.].
The third workshop on "Determinants in the Evolution of Chemistry: political framework, markets and companies, 1900–1930" took place in Strasbourg in October 1996. It was explicitly aimed at establishing new standards of European comparative studies on chemical history. This was achieved on several levels: by a global analysis of technological progress and its interplay with science, economy, and society; by in-depth case studies of actions and reactions at the microeconomics level; by examining the role of the state and legislation, especially patent law; and finally by comparing national patterns of chemical industrialisation.

Particularly significant was the emphasis on fertiliser production, which stimulated research into electrochemical and high pressure processes, and polymer chemistry. The main focus was on the interwar period, when political factors and the lessons of World War I, particularly strategies for self-sufficiency, dictated that innovations were based on the availability of raw materials and the needs of new user industries. Commercial factors also played important roles, for instance the mergers that led to the formation of companies such as I.G. Farben and Imperial Chemical Industries. Nevertheless, many novel products emerged from the laboratories of small and independent companies. In some countries, perceived needs of the chemical industry were linked to academic and government debates. While much of the European chemical industry was dependent upon coal and coal tar products, there were strong moves towards the foundation of science-based biochemical industries. The quest for national autarky was a driving force in almost all countries.

The papers of this third workshop are planned to be published in 1998 by Kluwer of Dordrecht as *Determinants in the Evolution of the European Chemical Industry, 1900–1939: new technologies, political framework, markets and companies* [7.2.6.].

In addition to this series, a fourth and more specialised workshop on "Natural Dyestuffs in Europe, 1750–1880" was brought into the programme at a somewhat later stage. It took place in Oxford in January 1996. In terms of participants there was some overlap with other workshops of this section, but thematically this one was independent. It aimed to mark the transition from natural to synthetic products and the resulting competition of scientific expertise, technical skills, markets and professional groups. The areas studied were bleaching, dyeing and printing. This included the chemical processes involved, the role of raw materials, the manner working processes were organised in the factory, and how various professional groups interacted. The topic enabled collaboration between the domains of economic historians, historians of technology and historians of chemistry.

The outcome of this workshop will be a book on *Natural Dyestuffs in Europe, 1750–1850* to be published by Science History Publications in 1998 [7.2.8.].

In general, the series of four workshops resulted in a fairly balanced treatment of the transition from simple extraction processes to more sophisticated industrial production, and from practical expertise to applied research to plant operation. Further historical research would be needed on product and process development as an intermediate between research and production, and plant and apparatus design. Another aspect that was not sufficiently developed within these workshops but would need to be studied in greater depth from a comparative European perspective concerns the role of the state.

4. General evaluation

4.1. Achievements

The evaluation of the scholarly achievement of the ESF research programme *The Evolution of Chemistry, 1789–1939* was made during a final conference held in Delphi in September 1997. For this conference the section leaders of the four sections had been asked to propose as contributors up to 10 of the most active and innovative participants from their respective sections. In this way an attempt was made to bring together the results that had been achieved within the four sections separately, so that common issues could be raised and critical questions asked. No formal papers were read. Instead, the section leaders gave detailed reports on the work done in their respective sections. These reports had three parts: 1) a summary of the workshops, topics discussed

and results obtained, including publications; 2) a discussion of methodological issues, open questions which might link to items dealt with in other sections, and also failures and research deficiencies; 3) and topics that had emerged as unsolved questions worthy of study in the future. The section leaders' reports were then discussed among all participants.

As a second step of the evaluation the Steering Committee members and the section leaders met separately. Particular attention was paid to how the results obtained refer to the original intention laid out in the 1992 proposal. This was followed by a report on the budget.

On the whole the programme was regarded as highly successful. For the many scattered and often isolated historians of chemistry all over Europe it was a unique opportunity to join efforts on an international scale and to thereby achieve momentum and visibility they would not have otherwise achieved. The concrete scholarly outcome of the project has already been dealt with under heading 3.1–4. of this report. Further and more objective indicators for the success of the programme can be given:

- ***Publications:*** An impressive number of contributions have been, or are scheduled to be, printed [see 7.2.]. Two volumes have already appeared, four more volumes are scheduled for 1998, and still two more volumes for 1999, making a total of eight volumes. Three of them are produced by Science History Publications in the US, a major international publisher specialising in the history of science which, for the first time, agreed to accept contributions in either English or French. Two other volumes will be published by Kluwer (a major international publisher of scholarly books) and the volume on the social history of chemistry by Cambridge University Press. Two components of workshops that would not make a whole volume were published as special issues of well established international history of science journals. The spreading of results through various publishers was deliberately chosen in order to reach a much wider audience than it would have been possible through one uniform series.

- ***Research network:*** When we started to collaborate five years ago the history of chemistry was hardly a well-defined discipline. There were a dozen scholars who knew each other, and there were two specialised journals in the field in the world, but on the whole activity was local, communication weak, and the

smaller countries and those at the fringes were literally cut off.

This situation has completely changed as a result of the programme. There is now a core group of some 120 people active in the history of chemistry who share the experience of working together. Scholars from almost every part of Europe, including the East European countries, were involved, and – as one participant observed – the programme itself became a truly European venture [see 7.4.1.]. It was striking to see how intensively the history of chemistry is being studied in places such as Greece, Portugal, and Italy – countries that would never have reached the present level of international recognition without the ESF programme.

The formation of the research network that was initiated through the ESF programme is already beginning to establish firmer and more permanent structures. In February 1997 an electronic mailing list and news bulletin called CHEM-HIST was set up at the University of Regensburg. It has now some 350 subscribers from all over the world and is being used extensively to discuss topics, or to announce news, relevant to historians of chemistry. It goes without saying that the ESF programme and its results were given, and will continue to be given, wide international publicity through this medium.

In the summer of 1997 we discussed the feasibility of merging two existing history of chemistry journals into one truly European journal that would accept papers in the main European languages. So far the plan has not yet materialised, but the option needs further discussion and negotiation.

- ***Participation:*** The project was particularly successful in its ability to recruit scholars from almost all European nations, including a fair number of excellent young researchers. In the beginning, the Steering Committee was inclined to make the PhD the condition for participation. This policy was abandoned as it became clear how much exciting and innovative research was, and is, being done at the doctoral level. The participation of so many bright young minds was probably one of the most rewarding features of the project, and the project itself may have drawn them into the history of chemistry as a thriving and intellectually promising field of research.

- ***Follow-up projects:*** At least two follow-up projects immediately related to the ESF programme are already under-way. First, in Britain and Italy

extensive historical databases on the nineteenth- and twentieth-century chemical community are currently being created and will provide valuable material for prosopographical research. Second, a new Commission on the History of Modern Chemistry has been set up by the International Union of History and Philosophy of Science / Division of History of Science (a body linked to UNESCO through the International Council of Scientific Unions). The Commission on the History of Modern Chemistry was proposed by representatives of the ESF history of chemistry programme and was conceived as a continuation and extension of what had been achieved during the ESF project. The chief aim of the new Commission is to create a platform for research on twentieth-century chemistry including its relationship to the biomedical sciences, physics, instrumentation, and technology.

4.2. Deficiencies

The 1992 proposal presented a framework of topics worth studying, but with no detailed knowledge as to who might be prepared and willing to engage in research of this kind. The proposal was thus an attempt at initiating and focusing research, rather than an agenda that needed to be worked through item by item. Therefore lacunae and deficiencies were inevitable once the results were compared with the initially defined aims. Evaluation has revealed the following shortcomings:

- Comparative approaches were strongly encouraged during the programme, but truly comparative studies were in the minority. There are many reasons for this: *state-of-the-art-reasons* as the history of chemistry is an emerging field with limited literature to date; *material reasons* due to the availability of sources and the feasibility of comparative work; *personal reasons* as only a few people have a chance to become really familiar with more than one country or historical context; and finally *methodological reasons* as comparison typically requires a more quantitative approach, but the entities being compared such as professional groups, societies, laboratories, innovations etc., differ in so many ways that they are difficult to compare unless detailed and reliable case studies have been made. The solution was to confront thorough case studies and to pay particular attention to transmission processes and their accompanying changes on conceptual, institutional or social levels. For the vicissitudes of practice and knowledge arising from transmission often reveal differences of the respective local contexts, and thus can be used as a key for comparison.

- Although there was considerable interest in the programme among chemists, it largely failed to draw active chemists into the programme and to direct their attention towards the history of science, as hoped for in the beginning. Several participants teach chemistry, and a few are retired chemists, but as far as their research is concerned, nearly all of them had already become historians of chemistry. In a way this testifies to the fact that the history of science – at least in some countries – has indeed reached a degree of professionalisation and academic independence that makes it difficult to keep the traditional ties with the physical sciences. Yet, there are signs that the scientific community is beginning to appreciate that historians of science are offering a kind of knowledge that is different from the scientists' knowledge, which is vitally important for a better understanding of the role science and scientists play in the modern world.

4.3. Structural aspects

On the whole, the division of responsibilities between Steering Committee and Section Leaders has worked quite well, the only problem being the lack of electronic mail with Eastern European and Portuguese colleagues. The series of workshops created a good mixture of continuity and novelty. A few minor problems that have arisen may be typical for this type of project:

- The initial phase of the programme would have been more efficient and better balanced had it been given the chance of a 'Year Zero'. An exploratory period would have enabled the Steering Committee to improve the publicity and to optimise responsibilities. Without it there was a rather slow beginning in the first year.

- A series of workshops is an ideal way to network local research groups and to initiate new areas of research. Disciplines, however, which are just beginning to take shape and can not yet rely upon a wealth of published research, would need additional means of supporting research, e.g. through scholarships for young researchers. This is not part of ESF policy, but many participants felt sorry that it was not possible to mobilise such additional means.

- Language is likely to be a recurrent problem in ESF programmes. In this case, English, French, Spanish and Italian were spoken during the workshops. For publications, however, only English and French were accepted,

and we even succeeded in convincing an American publisher to accept these two languages – by the way a major breakthrough from a European point of view! Yet, only a small minority of authors were native speakers of any one of them. As a consequence, the editing and polishing-up of the papers was, and still is, a tremendous task and difficult to cope with in the absence of additional financial support for professional copyediting.

5. Publicity

During the past years history of science newsletters and the chemical press have paid considerable attention to the project [see 7.3.]. The programme has also been presented at the annual meeting of the American History of Science Society in Atlanta in October 1996. To enhance the impact of the programme and to secure its long-term effect the results will be given wide publicity on various levels: A copy of this report shall be sent to every scholar actively involved in the programme and anybody else on request. An electronic version will be made available on the internet, and forthcoming publications coming from this ESF programme will be announced through the e-mail listserver CHEM-HIST. Shorter versions of this report will be offered to various newsletters and professional journals, both in the history of science and in the scientific community. Several of these have already expressed their interest. More lasting and more important, however, will be the offspring in terms of the workshop proceedings [see 7.2.]. Therefore, to achieve publishable results was a high priority from the very beginning of the programme, and a corresponding amount of the budget was reserved for this very purpose.

6. Budget and timetable

The programme received a total budget of 1,898,000 French Francs for four years. Financial support came from the following Member Organisations: Fonds National de la Recherche Scientifique / Fonds voor Wetenschappelijk Onderzoek - Vlaanderen, Belgium; Statens Humanistiske Forskningsråd, Denmark; Suomen Akatemia/ Finlands Akademi, Finland; Centre National de la Recherche Scientifique, France; Deutsche Forschungsgemeinschaft, Germany; Royal Irish Academy, Ireland; Consiglio Nazionale delle Ricerche, Italy; Nederlandse Organisatie voor

Wetenschappelijk Onderzoek, the Netherlands; Humanistisk Samhällsvetenskapliga Forskningsrådet, Sweden; Schweizerischer Nationalfonds zur Förderung der wissenschaftlichen Forschung, Switzerland.
Due to the missing 'year zero' and an accordingly slower initial phase, the Standing Committee for the Humanities agreed to grant us an additional year within the original financial limits, i.e. without additional budget.

The money was used as follows:

• Steering Committee meetings	110,000 FF
• Workshops of the 4 Sections	1,025,000 FF
• Final Conference	240,000 FF
• Publicity, Publications (incl. forthcoming volumes)	494,000 FF
• Miscellaneous	6,000 FF
• Administrative costs ESF	23,000 FF
Total	**1,898,000 FF**

Compared to the original plans, the proportion of money spent on publications was higher than expected, since the programme produced a total of 8 books and 2 special journals issues, whereas in the original budget provision was made only for one publication from each of the four sections. On the whole, scholarly results and the structural impact of the programme were achieved at a very reasonable financial investment.

7. Appendix

7.1. Meetings and reports on meetings

- 1993, Dec 20–22
The Making of the Chemist: The Social History of a Profession (Canterbury, United Kingdom, 18 participants)
Reports: Ambix 41 (1994), 42–44 (D. Knight); Royal Society of Chemistry Historical Group Newsletter (July 1995), 9–10 (P. Reed)

- 1994, Apr 7–8
Strategies of Chemical Industrialisation: From Lavoisier to Bessemer, 1789–1856 (Liège, Belgium, 23 participants)
Reports: Royal Society of Chemistry Historical Group Newsletter (July 1995), 10–11 (P. Reed); Gewina Tijdschrift voor de Geschiedenis der Geneeskunde, Natuurwetenschappen, Wiskunde en Techniek 20 (1997), 106–108

- 1994, May 9–10
Lavoisier in European Context: Negotiating a New Language for Chemistry (Paris, France, 22 speakers, numerous guests since members of the French Club d'Histoire de la Chimie were invited)
Report: Chemical Heritage 12:1 (1994/95), 28–29 (J.-P. Poirier)

- 1994, Sept 18–20
The Development of Chemistry within National Boundaries (Dublin, Ireland, 16 participants)

- 1994, Dec 2–3
The Role of Space and Instruments in the Making of Chemistry in Europe, 1789–1939 (Madrid, Spain, 14 participants)

- 1995, Mar 23–25
Strategies of Chemical Industrialisation: From Perkin to Bosch, 1856–1918 (Maastricht, Netherlands, 22 participants)
Reports: Royal Society of Chemistry Historical Group Newsletter (July 1995), 11 (P. Reed); Gewina Tijdschrift voor de Geschiedenis der Geneeskunde, Natuurwetenschappen, Wiskunde en Techniek 20 (1997), 106–108

- 1995, May 21–24
The Making of the Chemist: The Social History of a Profession (Delphi, Greece, 18 participants)

- 1996, Jan 4–6
Natural Dyestuffs and Industrial Culture in Europe, 1750–1880 (Oxford, United Kingdom, 22 participants)

- 1996, Feb 15–16
Chemical Textbooks, 1800–1930 (Uppsala, Sweden, 20 speakers)
Report: Lychnos 1996, 376

- 1996, Sept 14–18 *From the First World War to the Second: Social and other Aspects of Chemistry in Europe, 1910–1940* (Rome/ Frascati, Italy, 26 participants)

- 1996, Oct 3–4
Determinants in the Evolution of the European Chemical Industry, 1900–1939 (Strasbourg, 21 participants)
Report: Royal Society of Chemistry Historical Group Newsletter (July 1997), 15–16 (P. Morris)

- 1996, Nov 26–27
Chemistry Laboratories, Instruments, New Technologies and Education (Lisbon, Portugal, 32 participants)
Report: Royal Society of Chemistry Historical Group Newsletter (July 1997), 16 (D. Knight)

- 1997, Sep 17–22
The Evolution of Chemistry in Europe: Final Conference (Delphi, Greece, 50 participants)
Report: Detailed minutes were prepared and sent to all participants for comments and criticism, but they are not being published as such.

7.2. Publications

- *Lavoisier in European Context: Negotiating a New Language for Chemistry*, ed. by Ferdinando Abbri and Bernadette Bensaude-Vincent (Canton: Science History Publications, 1995), X + 303 pp. [16 contributions: 13 in English and 3 in French]
Reviews and Notices: Isis 86 (1995), 693; Ambix 43 (1996), 121–122 (W.A. Smeaton); Nuncius 11 (1996), 377–379 (M. Ciradi); Annals of Science 54 (1997), 215–216 (P. Bret); Scientiarum Historia 22 (1996), 114 (G. Vanpaemel); Lychnos 1996, 326–327 (L. Tansjö); History and Philosophy of the Life Sciences 18 (1996), 383; Centaurus 39 (1997), 285; Chemical Heritage 14/2 (1997), 46 (J. Simon); Revue de Synthèse, 4e sér., 1997, 150–152 (J.-P. Poirier); Mitteilungen GDCh-Fachgruppe Geschichte der Chemie 12 (1996), 113

- "Strategies of Chemical Industrialisation: From Lavoisier to Bessemer," *Archives Internationales d'Histoire des Sciences* [Rome] 46 (1996), no. 136, pp. 1–125 [8 papers: 5 in English and 3 in French]

- *Demonstrar ou Manipular? O Laboratório de Química Mineral de Scola Politécnica de Lisboa na sua Época, 1884–1894 / Demonstrate or Manipulate? The Mineral Chemistry Laboratory of the Polytechnic School of Lisbon in its Age, 1884–1894*, ed. by Ana Luísa Janeira *et al.* (Lisbon: Escolar, 1996), pp. [6 contributions, text in English and Portuguese]
Reviews and Notices: Mitteilungen GDCh-Fachgruppe Geschichte der Chemie 13 (1997), 192

- ["Aspects of European Chemistry, 1900–1940"] *Centaurus* [Copenhagen] 39 (1997), no. 4, pp. 291–381 [6 papers in English]

- *Chemical Technology and the Second Industrial Revolution*, ed. by Ernst Homburg, Harm Schröter, Anthony Travis and Robert Halleux (Dordrecht: Kluwer, in print), ca. 320 pp. [17 contributions]

- *Determinants in the Evolution of the European Chemical Industry: New Technologies, Political Framework, Markets and Companies*, ed. by Anthony Travis, Harm Schröter and Ernst Homburg (Dordrecht: Kluwer, in print), ca. 365 pp. [16 contributions]

- *The Making of the Chemist*, ed. by David Knight and Helge Kragh (Cambridge: Cambridge University Press, in print), ca. 350 pp. [15 contributions]

- *Natural Dyestuffs: An Industrial Culture in Europe*, ed. by Robert Fox and Agusti Nieto-Galan (Canton: Science History Publications, in preparation)

- *Communication in Chemistry: Textbooks and their Audiences, 1789–1939*, ed. by Bernadette Bensaude-Vincent and Anders Lundgren (Canton: Science History Publications, in preparation)

- *Research Laboratories and the Teaching of Chemistry*, ed. by Christoph Meinel (Canton: Science History Publications, in preparation)

7.3. Reports on the ESF Programme as a whole

Ambix 40 (1993), 26 (D. Knight); *Chemistry in Britain* (1993), 370; *Chemistry and Industry* (July 1993), 545 (D. Knight); *Mitteilungen GDCh-Fachgruppe Geschichte der Chemie* 8 (1993), 77–80; *Royal Society of Chemistry Historical Group Newsletter* (July 1993), 23–24; *Chemical Heritage* 11:1 (1993/94), 23; *Ambix* 41 (1994), 42–44 (D. Knight); *International History of Science Newsletter* 2 (1994), 11 (H. Kragh); *Royal Society of Chemistry Historical Group Newsletter* (Jan 1995), 8 (J. Green); *Royal Society of Chemistry Historical Group Newsletter* (July 1995), 8–11 (P. Reed); *Royal Society of Chemistry Historical Group Newsletter* (Spring 1998), 11 pp. (C. Meinel).

7.4. Participants

135 scholars have actively participated in the workshops, including those whose participation was paid from sources other than ESF.

7.4.1. Participants by country

ESF Member Countries

Austria	1	Italy	12
Belgium	8	Norway	1
Denmark	3	Poland	2
Finland	1	Portugal	15
France	13	Spain	12
Germany	17	Sweden	3
Greece	2	Switzerland	4
Hungary	1	The Netherlands	3
Ireland	1	United Kingdom	22

Associated and Overseas Countries

Australia	1	Lithuania	1
Brazil	2	Mexico	1
Czech Republic	1	USA	7
Israel	1		

7.4.2. Participants by name

Prof. Ferdinando Abbri, Università di Siena, Arezzo, Italy

Prof. Patricia Aceves, Universita Autonoma metropolitana, Mexico, Mexico

Dr. Maria Luísa Alves, Escola D. Fernando II, Sintra, Portugal

Prof. Paolo Amat di San Filippo, Università degli Studi di Cagliari, Italy

Dr. Arne Andersen, Universität Basel, Switzerland

Dr. Robert G.W. Anderson, The British Museum, London, United Kingdom

Dr. Theodore Arabatzis, Panepistemonion tis Athinas, Athens, Greece

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Prof. Stuart Bennett, University of Sheffield, United Kingdom

Prof. Bernadette Bensaude-Vincent, Université Paris X, Nanterre, France

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Prof. Nathan M. Brooks, New Mexico State University, Las Cruces, USA

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Prof. Alec Campbell, Newcastle upon Tyne, United Kingdom

Ana Maria Cardoso de Matos, Universidade de Évora, Portugal

Prof. François Caron, Université de Paris IV, Paris, France

Prof. Manuel Castillo Martos, Universidad de Sevilla, Spain

Prof. Luigi Cerruti, Università di Torino, Italy

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Dr. Isabel Cruz, Universidade de Lisboa, Portugal

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Dr. Brian Dolan, University of Cambridge, United Kingdom

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Dr. Danielle Fauque, Université Paris, France

Ulrike Fell, Paris, France

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Prof. Frederic L. Holmes, Yale University, New Haven, USA

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