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## **Structural Changes in International Scientific Communication: The Case of Chemistry (\*\*)**

Scientific communities are social units that produce, select and channel information. They are demarcated and structured by networks of communication. Communication is therefore one of the most important functions in any science. If groups of scientists begin to cluster and interact in a new way, if they redefine themselves in disciplinary, professional, institutional, local or national boundaries, a corresponding re-structuring of their communications network should be expected.

Communication in science operates in two ways. First, it transfers and preserves the stock of accepted knowledge from one generation to the next. This happens in textbooks, handbooks, the various forms of apprenticeship, scientific schools and other forms of transmission related to teaching. Second, modern science has created new channels of information that enable rapid exchange and critical feedback, provided e.g. by meetings, correspondence, preprints, and journals.<sup>1</sup> For the historian journals are the most easily accessible remains of the entire communications structure in science and an authentic mirror of its vicissitudes. The medium itself, however, has received relatively little attention.<sup>2</sup>

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(\*\*) Presented at the V National Meeting «Storia e Fondamenti della Chimica» (Perugia, 27-30 ottobre 1993).

<sup>1</sup> Cf. R.G.A. DOLBY, *The Transmission of Science*, «History of Science», 15, 1977, pp. 1-43; A.J. MEADOWS, *Communication in Science*, London, 1974; R. v. GIZYCKI, *Centre and Periphery in the International Scientific Community: Germany, France and Great Britain in the 19th Century*, «Minerva», 11, 1973, pp. 474-494.

<sup>2</sup> Cf. W.H. BROCK, A.J. MEADOWS, *The Lamp of Learning*, London, 1984; A.J. MEADOWS (ed.), *Development of Science Publishing in Europe*, Amsterdam, 1980; A.J. MEADOWS (ed.), *The Scientific Journal*, London, 1979; D.A. KRONICK, *A History of Scientific and Technical Periodicals: The Origins and Development of the Scientific and Technical Press, 1665-1790*, 2nd. ed., Metuchen/N.J., 1976; B. HOUGHTON, *Scientific Periodicals: Their Historical Development, Characteristics and Control*, London, 1975.

The aim of this sketch is to explore the role scientific journals played in providing a network of communication in nineteenth-century Europe. We shall ask how this network was established, improved, and diversified to meet the needs of the emerging discipline; we shall ask how efficient it was and where its limitations were; and we shall ask for the reasons of its vicissitudes which can be interpreted as a transition from a highly personal trans-national pattern to a communications system that operated on the national level and was connected internationally through organizations.

Chemistry offers an especially rewarding case.<sup>3</sup> At a very early stage chemists developed a highly competitive system of specialized journals which soon almost completely superseded competing means of communication. Already the decisive debates over the antiphlogistic chemistry took place in journals rather than in letters or textbooks. Chemistry was in fact the first non-medical science to have, since 1778, a successful, discipline-oriented journalism.

There are various reasons for this success. One could point to the early formation of an autonomous academic discipline, its increasing professionalization, and the creation of a «market» for specialized periodicals. One should also mention the very nature of chemical laboratory research the results of which were scarcely «useful» or «diverting» enough to meet the standards of periodicals addressed to the general public, nor were they substantial enough to be published separately as a book.

### *Formative years*

In the eighteenth century scientific communication operated on two levels: day-to-day business was done in letters, and the prestigious journals of learned societies were used to store lasting results. The new specialized, discipline-oriented journal emerged in open criticism of the traditional journals of the Academies. The latter ones were accused of being too exclusive and too expensive for most amateurs and practitioners. They were also blamed for their slow appearance. Publication times of two or three years were not unusual.

In 1773 the prototype of the private scientific journal, Rozier's *Observations sur la physique* proclaimed the program of the new medium: speed, competitiveness, social openness, complete coverage, and a fair price-utility-ratio.<sup>4</sup> The

<sup>3</sup> H. HARFF, *Die Entwicklung der deutschen chemischen Fachzeitschrift*, Berlin, 1941; S. WOLF, *Das deutsche pharmazeutische Reformschrifttum und Zeitschriftenwesen im 19. Jahrhundert*, Dissertation, Marburg, 1971.

<sup>4</sup> J.E. MCCLELLAN, *The Scientific Press in Transition: Rozier's Journal and the Scientific Societies in the 1770's*, «Annals of Science», 36, 1979, pp. 425-449; D. MCKIE, *The Observations of the Abbé François Rozier*, «Annals of Science», 13, 1957, pp. 73-89; cf. also S. LILLEY, *Nicholson's Journal, 1797-1813*, «Annals of Science», 6, 1948, pp. 78-101.

journal was not meant to be a repository; instead, its main duty was to speed up the rate of discovery.

Five years later, Lorenz von Crell created what was to become the first successful journal devoted exclusively to one particular science: chemistry.<sup>5</sup> Patriotism and scientific enthusiasm were the motives behind his *Chemisches Journal für Freunde der Naturlehre, Arzneygelahrtheit, Haushaltungskunst und Manufacturen*. Crell aimed at providing a platform for German chemists and at offering them, at the same time, every relevant piece of information from all over the world. The success of his venture is clearly demonstrated by almost 20 — if though unsuccessful — imitations. Even the French *Annales de chimie* originated in an attempt to get the *imprimatur* for a translation of Crell's journal.<sup>6</sup>

The new type of periodical was a private and competitive — sometimes even quite profitable — enterprise. Its success rested on a balance between speed and reliability, between originality and comprehensiveness. This meant, of course, that domestic as well as foreign information had to be covered adequately. Private subscribers, viz. doctors, pharmacists, manufacturers and administrators, expected to get, by means of translations, abstracts or reports, all the information they needed out of this single source. As a result, almost all of these early journals adapted between one and two thirds of their content from elsewhere, and again mainly from other journals.

### *Establishing a pattern*

The Napoleonic Wars brought a deep crisis to communication for scholars all over Europe. Journal editors began to experience the importance of reliable mechanisms of information processing, and they worked hard to reorganize the links with foreign countries as soon as the war came to an end. In 1813 Thomas Thomson, then an extra-mural lecturer of chemistry in Edinburgh, started his *Annals of Philosophy; or Magazine of Chemistry, Mineralogy ...* with the keen hope: «We may now confidently anticipate an unrestrained communication between Great Britain and all the other countries in Europe. ... proper means will be taken, as soon as the channels of communication are open, to secure a regular correspondence in these countries».<sup>7</sup>

The most efficient chemical journalism during this period emerged in the German states. Reasons for this success can be found in the country's decentra-

<sup>5</sup> K. HUFBAUER, *The Formation of the German Chemical Community, 1720-1795*, Berkeley, 1982, pp. 62-82.

<sup>6</sup> S. COURT, *The Annales de Chimie, 1789-1815*, «Ambix», 19, 1972, pp. 113-128.

<sup>7</sup> Preface, «Annals of Philosophy», 2, 1813.

lized structure with so many small universities and weak academies. University professors writing for a local or commercial public were the typical editors. A well established book trade supported the distribution. In addition, the increasingly professionalized pharmacists created a market for this new type of chemical information. Competition was high and required efficiency and diversification, but it also resulted in stabilizing, by 1830, a few market leaders such as Trommsdorff's *Journal der Pharmacie*, Scherer's *Allgemeines Journal der Chemie*, Gilbert's *Annalen der Physik*, and Liebig's *Annalen der Pharmacie*.

### *Speed*

Attempts to reduce the number of journals or to avoid overlap were bound to failure. On the contrary, multiple publication and multiple translation was the rule. Copyright restrictions did not yet exist, and authors used to send manuscripts to several editors at the same time. Thus, important foreign work appeared in independent translations at various places. Sometimes it lasted less than a month for a paper to come out in print after it had reached the editor, and foreign translations were often published within 3-8 months. In this way chemistry had established a truly European communications system with an efficiency astounding even today.

The discovery of catalysis is an especially impressive example.<sup>8</sup> On 3 August, 1823, Johann Wolfgang Döbereiner in Jena, Saxony, discovered that a jet of hydrogen, directed at a platinum sponge, burst into flame — the Döbereiner lighter was invented. Immediately he sent a summary to four different journals. On 3 September, the article appeared in Schweigger's *Journal für Chemie und Physik* and almost simultaneously in Gilbert's *Annalen der Physik*, Trommsdorff's *Neues Journal der Pharmacie*, the *Bibliothèque Universelle*, and in Oken's *Isis*. — In the meantime foreign scientists had become aware of the discovery. Kastner from Erlangen informed Liebig, who was in Paris at the time, Liebig talked to Alexander von Humboldt, the latter to Louis Jacques Thenard, and Thenard reported the news to the *Académie des Sciences* on 26 August. Two days earlier the *Journal des Débats* already released a preliminary note. Immediately Thenard and Dulong began testing the new phenomenon and reported back to the *Académie* on 15 September. The next day, the physicist Hachette wrote to Michael Faraday in London, and Faraday began working on catalysis on 27 September. The October issue of the *Quarterly Journal of Sciences and Arts*, which he edited, contained his first results, while translations of Döbe-

<sup>8</sup> P. COLLINS, *Johann Wolfgang Döbereiner and Heterogeneous Catalysis*, «Ambix», 23, 1976, pp. 96-115.

reiner's papers and Thenard's and Dulong's reports appeared in the *Philosophical Magazine* of 31 October, the latter as a translation from the *Annales de Chimie et de Physique*. — Thus, by the end of 1823, Döbereiner's work was available in his four «original» German publications and in the leading French and British journals, not to mention short notices and abstracts that had appeared elsewhere.

Thus, by the first third of the 19th century chemistry possessed an information system typical of a mature discipline. Relevant work could be communicated and checked internationally, and controversies could be settled rapidly and efficiently.

There were even attempts to develop a truly international cooperative publications system. As early as 1830 Faraday made arrangements to publish Continental material simultaneously in his *Journal of the Royal Institution*.<sup>9</sup> In 1837 Liebig planned to transform his *Annalen* into a journal of general chemistry that ought to be published simultaneously in German, French, and English. Thomas Graham and Jean-Baptiste Dumas were named co-editors.<sup>10</sup> The bold project failed, but a few years later Charles Gerhardt in Montpellier and August Wilhelm Hofmann in London pursued a similar venture.

### *Experiments*

The growth of knowledge was soon to become a problem. Already in the 1840's editors would no longer have promised to render their journal «as complete a register as possible of all the improvements made in chemistry and the kindred sciences, not merely in Great Britain, but in every part of the world», as Thomas Thomson had done it for the *Annals of Philosophy* in 1813. The intrinsic dilemma of the journal to be, at the same time, a lasting repository and a rapid medium for current debates, required new solutions.

In the 1830's and 1840's we observe, therefore, a period of deliberate experimentation with new forms of chemical journalism. The most successful type was the abstract journal. Gustav Theodor Fechner's *Pharmaceutisches Centralblatt* of 1830 (which was to become the *Chemisches Zentralblatt* later on) was the first of this kind. Its working assumption was that scientific articles could be condensed to mere facts and data.

In general, however, nineteenth-century scientists were less positivistic than they sometimes appear. They enjoyed feeling the editor's personality, his predi-

<sup>9</sup> Cf. M. BERGMAN, *Social Change and Scientific Organisation: The Royal Institution, 1799-1844*, London, 1978, pp. 141-145.

<sup>10</sup> H.S. VAN KLOOSTER, *The Story of Liebig's Annalen der Chemie*, «Journal of Chemical Education», 34, 1957, pp. 27-30.

lections and even his oddities. A bit of polemics was almost indispensable to make a journal worth reading. The early chemical community was in fact an assembly of individuals. As a consequence, annual reports written by outstanding scientists enjoyed great popularity, and this just because of their selectivity and idiosyncrasy.

The reports given by the secretaries of the major Academies served as a model for this type of journalism. In the private journal annual reports feature only sporadically, mainly in order to keep up with developments abroad. Thus, in 1802 Scherer reviewed recent French publications in his *Allgemeines Journal der Chemie*; in 1814 Thomas Thomson's *Annals of Philosophy* summarized recent developments in chemistry on the Continent of Europe, and in 1817 Brande adopted this model in a regular «Analytical Review of the Scientific Journals published on the Continent» printed with the Royal Institution's *Journal of Science and the Arts*. Yet, the most influential of all these annual reports was the one Jöns Jacob Berzelius gave to the Swedish Academy every March from 1822 to his death in 1848.<sup>11</sup> Delivered in Swedish, his account was immediately translated into German, French, Italian and, with little success, into English. But it was the German version through which the genre became popular and gave birth to dozens of similar *Jahresberichte* for the various branches of science later in the century.

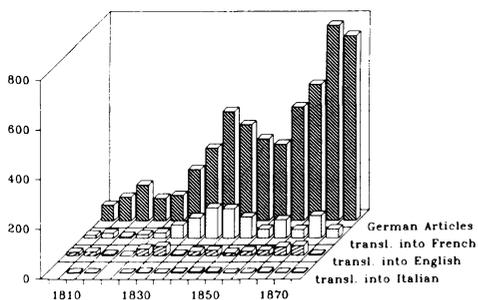
### *Comparisons and differences*

A rough quantitative estimate of the efficiency of chemical communication during that period might be useful. For this purpose the transfer of information across language barriers can be used as an indicator. The following analysis (see figures) is based on the total of chemical papers by the 200 nineteenth-century chemists included in the *Dictionary of Scientific Biography* (New York, 1970-1990), and the subsequent translations of these papers into other languages. The papers are those listed in the *Royal Society Catalogue of Scientific Papers* (London, 1867-1925) which covers a fairly complete choice of journals.

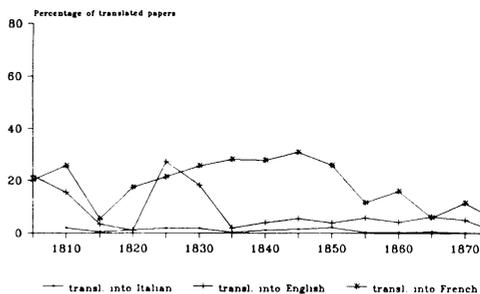
Using statistics historians will not need to be warned against over-interpretation. Chemical papers are not like peas or dryophila flies. Exchange of information does not work mechanically. Each step, from publication of a paper in a particular journal, its recognition as a relevant paper, up to its transmission and subsequent reception abroad, all of this is part of a complex process of both scientific and social selection and evaluation. The status of the field, expec-

<sup>11</sup> W. ODELBERG, *Berzelius as Permanent Secretary*, in «Science in Sweden: The Royal Swedish Academy of Science, 1739-1989», Canton/MA, 1989, pp. 124-147.

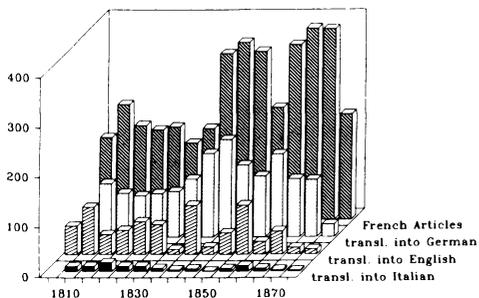
### Articles from German Journals



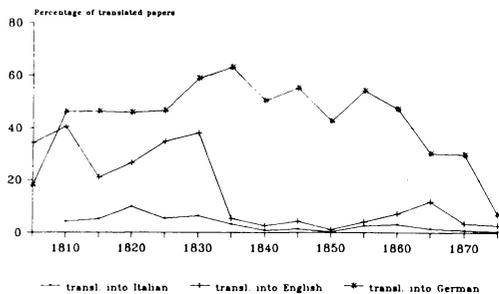
### Articles from German Journals



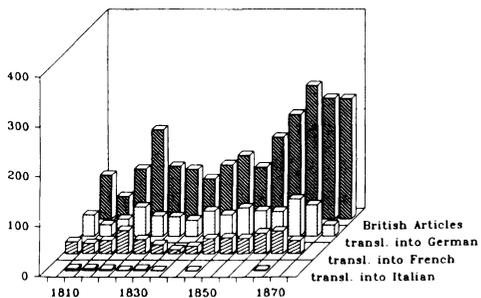
### Articles from French Journals



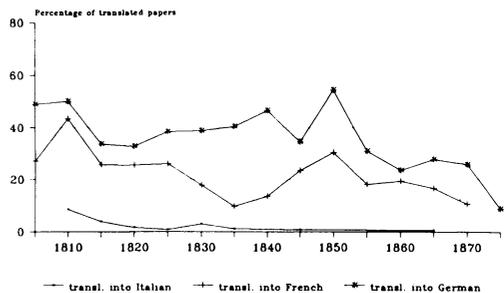
### Articles from French Journals



### Articles from British Journals



### Articles from British Journals



tations of the scientific community, the author's fame, personal ties, local and institutional factors, and even pure chance do make a difference. If I am using translations, I take them as mere indicators of awareness and reception, but by no means as the only mechanism by which knowledge is transferred across language barriers. Therefore my analysis displays but tendencies, patterns of change, and national differences.

Let us now turn to the graphs. On the left, chemical papers published within each five-year period are listed in absolute figures. The graphs display articles that were published in German, French, and British journals. In each graph the rear pillars represent the number of «source» articles in the respective original language, the front pillars display their translations into other languages. Note that, due to the great number of German papers, the respective vertical scale has been reduced, and multiple translations of the same paper into one language are counted but once. — On the right, the same information is given in relative figures (number of «source» articles = 100%).

First of all we observe the take-off of German publications in the 1840's and, correspondingly, the great proportion of papers translated into German. In fact, an average of 30-50% of all English and French papers included in our sample were soon available in German. Most of these appeared in no less than three competing journals: Liebig's *Annalen der Chemie und Pharmacie*, Poggendorff's *Annalen der Physik und Chemie*, and Erdmann's *Journal für praktische Chemie*. Competitiveness, speed, efficiency and geographical position gave these journals a key role in transmitting information to the European chemical community. As a consequence, they also received a great number of original contributions from abroad, and were deliberately chosen by e.g. Scandinavian or Russian authors who wished to make themselves known to the rest of Europe. To some extent German served even as an intermediate language between more «distant» communications networks.

The French journals, on the other hand, continued to receive the highest attention from abroad, but contained a much lower proportion of foreign information themselves. This is especially true for the prestigious *Annales de chimie*. Prior to 1815 the *Annales* used to have an average of 20% translations and additional 15% extracts from letters received by the editors. But they abandoned this policy when the new series *Annales de chimie et de physique* began in 1816. As a consequence, less renowned journals catered for the demand, chiefly the *Journal de pharmacie*, run by two Alsacians and former students of Liebig's, Charles Gerhardt and Adolphe Wurtz. On the applied side of chemistry was the *Revue scientifique et industrielle* that was continued by the fortnightly *Moniteur scientifique du chimiste et du manufacturier*, edited by the chemical industrialist Gustave Augustin Quesneville from 1840. An interesting, if shortlived, journal was the *Comptes rendus mensuels des travaux chimiques à l'étranger* by the *enfants terribles* Auguste Laurent and Charles Gerhardt who

used this medium to give their own theories greater publicity. In general, however, the official, Paris-centred French chemistry was increasingly inward-bound and less concerned with foreign developments.

Turning to Britain, we are struck by the low awareness of foreign work. The few attempts to compensate for the neglect of «foreign intelligence» were bound to failure — a recurrent theme during the «Decline Debates» of the 1830's. Robert Thomson's *Records of General Science*, established in 1835 «to afford information in reference to the progress of science abroad», lasted for only two years. William Sturgeon's *Annals of Electricity, Magnetism & Chemistry*, published from 1836 through 1843, was explicitly aimed at printing translations, but the editor seems to have misunderstood the very nature of a journal, for some of the papers he reprinted were as old as 45 years. A market for discipline-oriented, specialized scientific journals did hardly exist in Britain during the first half of the century. In chemistry the situation improved only from 1842, when William Francis and Henry Croft started their fortnightly *Chemical Gazette* which soon became the only reliable source of information about Continental chemistry available in English for some 17 years.<sup>12</sup>

#### *Nationalization — internationalization*

In the second half of the century the structure of the European chemical community changed considerably. As the nation-state emerged and national organizations were founded all over Europe, in scientific communities too a transition took place from the earlier trans-national pattern of personal exchange to a communications system that was organized on the national level and connected internationally through national societies.

The earliest chemical societies still bear the hallmark of the old cosmopolitan idea of a supra-national *république des hommes de lettres*. In the London *Chemical Society* of 1841, the earliest of its kind, strong transnational ties were part of the Society's identity. Group cohesion on a local level and communication abroad were complementary tasks. This was even more so when, in 1857, the *Société Chimique de Paris* was founded. Its statutes say that this society should be «un moyen d'établir un lien entre la chimie française et la chimie étrangère», «une association scientifique de chimistes tant de la France que de l'Etranger».<sup>13</sup> A Swede was the second president, and 32 out of 191 members lived abroad.

<sup>12</sup> W.H. BROCK, *The Fontana History of Chemistry*, London, 1992, pp. 436-461.

<sup>13</sup> «Société Chimique de Paris, Bulletin», 1858-1860, p. 1 [1857]; see *Cinquantenaire de la Société Chimique de France*, Paris, 1908; cf. T.S. MOORE, J.C. PHILIPP, *The Chemical Society, 1841-1941*, London, 1947.

During the 1860's, however, the national character of these societies became more prominent. The *Deutsche Chemische Gesellschaft*, founded in 1868, was the first chemical society to explicitly claim being *the* representative of German chemistry.<sup>14</sup> This did not go unchallenged as the older generation of chemists still thought in terms of a *république des lettres* and disliked the idea of national representation. After all, there was no political unit «Germany» in 1868. Yet, by the turn of the century Britain, France, Germany, Denmark, Sweden, Belgium, Finland, and Norway, all had their own national chemical societies.

The impact on the communications system was immediate. The national societies now became the switchboards for information. They nominated delegates to international conferences and named juries at World Exhibitions. They also took over some of the formerly private journals or established their own periodicals.

London's *Chemical Society* was the first to launch its own journal. From 1849, it had a special supplement with abstracts and translations of foreign papers. In 1871 this was re-organized to become a separate abstract section, and as a consequence, translations virtually disappeared from the *Journal of the Chemical Society*. In 1858 the *Bulletin de la Société Chimique de Paris* took over two formerly private abstract journals, viz. Adolphe Wurtz's *Répertoire de Chimie Pure* and Charles Barresvil's *Répertoire de Chimie Appliquée*. In Berlin the *Deutsche Chemische Gesellschaft* issued its *Berichte* from 1868. Five years later they included an index to papers from other journals which developed into a full abstract section in 1878. This practice was discontinued in 1897 when the Society took over the *Chemisches Centralblatt*, that had been run as a private commercial journal since 1830.

Compared to their private competitors the society journals provided much greater efficiency and continuity, as they could rely on a powerful organization and on a more stable subscription basis. Facing an ever increasing flood of publications all over the world, the service they offered surpassed the means of any private editor-entrepreneur. Thus the journals, reports and abstract services issued by the national chemical societies quickly defeated their private rivals. The societies monopolized at least parts of the market. As a result, the remaining commercial journals came under pressure and almost all of them abolished full-length translations and reprints of articles that had appeared elsewhere. The first journal to adopt this new policy was Hermann Kolbe's *Journal für praktische Chemie* in 1870. By the end of the decade, multiple publications and translations — so typical for the medium up to then — had almost entirely disappeared or were restricted to languages such as Russian. The decline can be seen in our graphs (see above) and this explains why no figures are given after 1875.

<sup>14</sup> W. RUSKE, *100 Jahre Deutsche Chemische Gesellschaft*, Weinheim, 1967.

An efficient and reliable abstract service published as a separate journal is of course a good alternative to translations that were published in between «original» articles. Yet, if foreign information was relegated to a «secondary» level, filtered through an impersonal abstract service provided by a national organization, the way a chemist perceived the chemical world had become very different. The supra-national republic of letters, in which each scientist enjoyed direct civil rights, transformed itself into a more federal system, characterized by a fusion on the national level and outward representation through national organizations. Whereas cosmopolitan scientists used to believe that science should be advanced through immediate, personal contacts and the joint effort of individuals, it was now felt that strong national organizations were needed to keep up with the progress of science abroad and to survive in the struggle for national superiority. The social structure of European chemistry had thus changed from an individualized trans-national relationship to an institutionalized form of organized international relations.<sup>15</sup>

The cumbersome business of corresponding in a foreign language, searching foreign journals, and representing one's interests abroad, could now be left to one's national chemical society. Thus even scientists with European reputation such as Henry Edward Armstrong, Louis Pasteur or Emil Fischer could easily do without much personal contact to colleagues abroad — an attitude that would have been hardly possible 50 years earlier.

The history of the congresses on chemical nomenclature also attests to this change. The Karlsruhe Conference of 1860 was organized under the scheme that, if possible, each professor of chemistry from every European university should be invited individually. In 1892, however, the Geneva Conference was organized according to a balanced representation of the nine most important central European countries.<sup>16</sup> In Karlsruhe it was taken for granted that decisions could only be made by the entire chemical community, and voting at the conference was therefore expressly avoided; in Geneva, however, national delegates voted on a majority basis. The subsequent conferences on chemical nomenclature from Saint-Etienne (1897) to Liège (1930) testify that their success depended on the support given by influential national organizations.

<sup>15</sup> F.S.L. LYONS, *Internationalism in Europe, 1815-1914*, Leiden, 1963; B. SCHRÖDER, *Caractéristiques des relations scientifiques internationales, 1870-1914*, «Journal of World History», 10, 1966, pp. 161-177.

<sup>16</sup> P.E. VERKADE, *La naissance de la nomenclature de Genève*, «Bulletin de la Société Chimique de France», 1966, pp. 1807-1812; M.P. CROSLAND, *Historical Studies in the Language of Chemistry*, London, 1962, pp. 347.

### *Limits*

By the turn of the century the sheer amount of information was calling for new solutions. E.g. the abstract section of the *Journal of the Chemical Society* grew from 604 pages in 1871 to 3250 pages in 1925. The *Jahresbericht über die Fortschritte der Chemie* — the main rival of the German Chemical Society's *Chemisches Zentralblatt* — grew from 3370 pages in 1888 (compiled by 13 people) to more than 5000 pages in 1897 (compiled by 54 people). And when the ultimate volume for 1905/08 came out in 1912 it amounted to more than 9400 pages. In the end the editors had to admit that this kind of journalism was no longer feasible.

The idea of producing just one, truly international abstract service composed by the chemical societies of various nations would have been a way out of this dilemma. Yet, all of these societies were part of their country's quest for prestige and power, and cooperation turned out to be a political issue. As early as 1869, Alexander William Williamson, a former student of Giessen and Paris, submitted a proposal to the *Deutsche Chemische Gesellschaft*, aimed at creating a monthly abstract service published jointly by the British, the French, and the German chemical societies. Yet in the turmoil of the Franco-Prussian War the suggestion came to nothing. Williamson had to content himself with establishing the abstract section of the *Journal of the Chemical Society*. In 1882 a similar suggestion by William Ramsay failed again since nationalistic objections were believed to be insurmountable.

### *Mature and emerging fields*

Besides nationalism there was also the influence of size and self-sufficiency of major communities. Earlier in the century, the chemical community was small and it was necessary to contact fellow-chemists disregarding national and language boundaries. But in the 1870's chemistry had become almost a mass discipline.

It is interesting, therefore, to compare mainstream chemistry with its younger subdisciplines to see if there is a difference between mature and emerging fields. When Wilhelm Ostwald, in 1887, founded the *Zeitschrift für Physikalische Chemie*, physical chemistry was still a disputed subject with little hope for support by the organic chemists who dominated the *Deutsche Chemische Gesellschaft*. Thus it was only natural for Ostwald to resume the old pattern of transnational cooperation between individual scholars instead of relying on national organizations. Consequently the *Zeitschrift für Physikalische Chemie*, edited by Ostwald and van't Hoff, displayed the names of 22 well-known scientists from

10 countries on the titlepage. In fact the *Zeitschrift* continued to be *the* international journal for physical chemistry for quite some time.<sup>17</sup>

Inorganic chemistry offers a similar case. The branch had suffered particularly from the predominance of organic chemistry. Its publishing possibilities were poor. As a consequence, Gerhard Krüss, an Extraordinarius of inorganic chemistry from Munich, negotiated with almost all his colleagues at home and abroad to solicit support for a new journal exclusively devoted to pure, inorganic chemistry. As a result the *Zeitschrift für anorganische Chemie* was created in 1892 and boasted an impressive list of 28 inorganic chemists from 11 countries as co-editors.

It is clear from these cases that a certain size of a scientific community and a certain stage of its development are prerequisites for organizing itself within national rather than purely disciplinary boundaries.

### *Years of crisis*

By the end of the century, signs of a general crisis in chemical communication could no longer be ignored. A growing number of specialized and subspecialized journals, private abstract services, annual reports or yearbooks were competing with the huge and ponderous abstract services and journals of the national societies, and these in turn competed with each other. Complaints about the state of chemical journalism and proposals of how to improve the communications system were frequent in the years prior to World War I. Most of these arguments were targeted at the scientific journal.

Among the many proposals uttered in this context, Ostwald's bold vision was the most fascinating one.<sup>18</sup> What Ostwald had in mind was nothing less than a total abandonment of the traditional form of book and journal publishing. In his opinion, it was time to get rid of the idea that printed work deserved permanent storage. For books and journals carry a hotchpotch of soon outdated material. Only a minor proportion is actually used and permanently needed. Binding and shelving, however, preserves it for ever.

Positivist that he was, Ostwald wanted to keep just the essence of science, the facts and inventions, in a form that allows updating and modifying at any time according to the progress of science. For this purpose, he suggested publishing scientific results separately on loose sheets or as brochures, and in an

<sup>17</sup> T. HAPKE, *Die Zeitschrift für Physikalische Chemie. Hundert Jahre Wechselwirkung zwischen Fachwissenschaft, Kommunikationsmedium und Gesellschaft*, Herzberg, 1990.

<sup>18</sup> W. OSTWALD, *Die chemische Literatur und die Organisation der Wissenschaft*, Leipzig, 1919.

internationally standardized style, form and size. Out of this material scientists should be able to build up their personal stock of information. To exchange obsolete pages for up-to-date ones or to insert new material, all pieces had to be classified by a code determining their exact place within the overall system of scientific knowledge. In a way this was a combination of the modern principles of loose-leaf edition and publication on demand. According to Ostwald, this ought to be done in a «neutral», artificial language that would eliminate all national animosities and make translations superfluous. In fact, Ostwald himself had been busy in promoting Esperanto for this purpose, and in 1910 he developed Ido, a derivative of Esperanto, into a language tailored to meet the needs of chemical terminology.

In this way, Ostwald thought, a single international repository for all relevant discoveries and data could be built up by mere accumulation. It would eventually lead to what he called «the general handbook of science». Its methodological counterpart would form a problem-oriented «handbook of scientific techniques». And both these collections should be kept in an *International Institute for Chemistry*, the program of which Ostwald presented to the *International Association of Chemical Societies*, founded on his initiative in 1911.<sup>19</sup>

The War and the economic depression in its wake prevented these ideas from being discussed more widely, and it was only after the Second World War — then under the auspices of the American hegemony in science — that new forms and new technologies of information processing and scientific communication were proposed and developed.

### *Conclusion*

The way scientific information was transmitted in journals has helped us to discover structural changes within the European chemical community. We have seen how a specialized discipline-oriented journalism was established, improved, and diversified as chemistry emerged as an autonomous science. We have used translations as an indicator for the efficiency of the system, and we have met different national patterns to cope with this challenge. We have noticed the restructuring of communication in the 1870's as a consequence of the emergent national societies. And we have finally seen that the traditional form of information processing had reached its limits in the first decade of the twentieth century.

<sup>19</sup> N.R. HOLT, *Wilhelm Ostwald's 'The Bridge'*, «British Journal for the History of Science», 10, 1977, pp. 146-150.

The overall process can be interpreted as a transition from a trans-national pattern of communication between individuals to a communications system that was organized on the national level and connected internationally through powerful organizations.<sup>20</sup> In that regard the vicissitudes of the scientific community are but part of a much wider cultural and political process that restructured the whole of Europe during the nineteenth century.

<sup>20</sup> C. MEINEL, *Nationalismus und Internationalismus in der Chemie des 19. Jahrhunderts*, in «Perspektiven der Pharmaziegeschichte», ed. by P. Dilg, Graz, 1983, pp. 225-242.