CENTURIES OF RESEARCH IN CHEMISTRY

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Summary

Scientific research and above all alchemy has been supported frequently as early as in feudal ages, by lords and sovereigns. In the 17th—18th centuries, academies of science became the centres of scientific research. In some countries they were only scientific instances; Prussian and Russian academies, however, headed institutions too, among others chemical laboratories. These are the historical antecedents to the type of organization developed in the Soviet Union and followed by the other Socialist countries, namely that the academies of sciences are official authorities directing scientific research. In other countries this duty is usually performed by ministeries.

No important results were yet achieved at the universities of the 18th century in chemistry. It is characteristic that the great chemists of that period frequently practiced chemistry as a hobby only, making their living on some other profession, not on science. In the 19th century, universities became the primary workshops of chemical research. However, research did not, at the time, belong to their official functions and they did not dispose of funds for such purposes. The major driving force of research was the professors' ambition to achieve results that would promote their fame and career. Particularly after organic chemical industry had developed, the value of a good scientific record grew substantially, increasing the chances to enter higher regions of industrial management.

The first independent research institutes were established in the middle of the past century, in agriculture first, with chemistry always participating in them. The first purely scientific research institutes including chemical research institutes were the initiative of the end of the 19th century. Independent scientific research institutes have become of equal value to university research from the middle of the 20th century on.

The paper also deals with the history of chemical societies, international chemical organizations and chemical journals.

Chemistry is a *par excellence* experimental science; in all ages, its study required suitable apparatus and equipment, and a laboratory suited to house them, equipped with still and furnace. Even alchemists worked in laboratories, "made researches", if I may use this expression. Hence, chemistry is historically inseparable from research, and the research results in chemistry provide the history of chemistry. The stimuli for research are individual desire for knowledge, the desire for self-assertion and material success, but the possibilities for research have always been and still are controlled by external factors providing material and moral support. This support has turned more and more in the past centuries from individual patrons towards institutions and organizations sponsoring research for social-economical interests. Even alchemists' experimenting was frequently maintained by sovereigns and other feudal lords, and alchemists often took an unfair advantage of it. However, sometimes important results were born by such misuse. *Böttger* (1685—1719) misled August the Strong, king of Saxony and Poland for years with the promise that he was going to invent artificial gold. When the king began to clamour, more and more impatiently, the offset of the many advanced costs, the desperate alchemist attempted to escape, but was captured and subsequently had to experiment under strict surveillance. So, instead of gold, Böttger invented the manufacturing process of porcelain, which provided immense profits to the king.

Renaissance sovereigns did not only finance alchemists, but — in conformity with the enthusiasm for arts and sciences of the period, and frequently rivalling with one another — patronized scientific research aiming at the recognition of nature. They initiated the establishment of the first scientific societies and academies. The celebrated physicians of the period termed medical chemistry were frequently medical advisers to sovereigns, such as the two founders of the phlogiston theory, *Becher* in the court of the Bavarian prince-elector and *Stahl* in the court of the Prussian king, where they used their influence to promote university teaching and research, from which chemistry profited above all.

The great ideological battle of the 17th century for free research, for modern sciences, for the new concept of the universe, fought by researchers and scientists against dogmatists and the church took place primarily in the fields of philosophy, physics and astronomy; chemistry was little involved. The results of chemical research did not crash directly with dogmas and scholastic arguments. Aristotle's four elements did not interfere with chemical research, since *Boyle* fortunately separated the question of the primoridal elements from the practice of chemistry by stating that the chemist is unable to recognize the final components, he can only arrive to the chemical elements equivalent to the boundaries of separability. Not the philosophers, but the scientific appliers of the resuscitated atomic theory of antiquity, who used the concept to explain certain phenomena like evaporation and dissolution, solved the problem readily by a compromise. *Sennert*, for instance, simply used the term primary atoms for the atoms of the Aristotelean elements (fire, air, earth, water) which form the secondary atoms, the atoms of chemical elements; in the followings he limited his explanations to these atoms.

Chemistry was taught at universities in the 17th century, usually within medical science, independently at some universities. Eminent researchers were found among the professors, mostly, however, at Protestant universities where teaching regulations were not as rigid. Every detail of teaching at Catholic universities (mainly headed by Jesuits) was defined very thoroughly and rigidly by the Ratio Studiorum issued in 1599. This resulted in great uniformity at all Catholic universities, on the basis that "the professor shall not diverge in any only slightly important matter from Aristotle and St. Thomas of Aquino". Dogmatic rigidity characterized Jesuit universities up to the late 18th century, and for this reason they played no important part in the progress of sciences till the dissolution of the Jesuit order. At the same time, paradoxically, numerous Jesuit scientists achieved outstanding results in scientific research.

Among Protestant universities, from the view of chemistry, the universities of Halle, Wittenberg, Göttingen in Germany, Leyden in Holland and Uppsala in Sweden were of greatest importance at the time, due to the prominent scientists teaching there and producing novel chemical theories and results, such as *Stahl*, *Sennert*, *Hofmann*, *Boerhaave*, *Bergman* etc.

As mentioned above, scientific societies were founded in the 17th century by princes devoted to science. These societies were of great significance in further scientific progress. Earlier, scientists had been working alone, their statements spread slowly, only by their books. Although printing of a book took much less time in the 17th—18th centuries than in our days, its circulation was substantially slower. Scientists rarely had money for printing; they had to find an enterprising printer willing to grant credit, or an aristocrat backer. The role of scientific societies consisted in bringing scientists closer to one another. Their sessions ensured the possibility of reading papers and having discussions on them. They gave organized form to scientific research, and some of them provided material help and means of subsistence. By inventing scientific periodicals, they largely simplified exchange of informations. In these periodicals, partial results could rapidly be made public and other scientists were able to react rapidly. Up to the present, scientific periodicals have remained the usual and authentic means of publishing and spreading scientific results, although they appear to be more and more inadequate for the purpose; however, a novel form of scientific communication that could replace them effectively has not yet been found.

Some signs of scientific societies existed already before the 17th century, but the first actual societies were founded in that century. The Academia dei Lincei in Rome was founded by an Italian prince in 1603, but dwindled away after the founder's deaath, similarly to the Academia del Cimento founded in Florence by Ferdinand II, grand-duke of Toscana, in 1657. The latter academy was the more significant of the two: its members contributed to the progress of science by many valuable discoveries. They were not, however, engaged in chemistry.

From the view of chemistry, two of the early scientific institutions, both still active at present, were of greatest importance: the Royal Society in London and the Académie des Sciences in Paris. The former developed from private gatherings of scientist, from their systematizing meetings, into the famous institution by the deed of foundation signed by Charles II, king of England, in 1662. The latter was established in 1662 by Colbert, minister of finances in France.

The two societies were contemporaries and yet largely differed: they bore the stamp of their social environment. England, at the time, was already past the revolution, it was a constitutional monarchy; the king only provided the chart of foundation and the attribute "Royal"; the Royal Society elected its own members, sustained itself and still sustains itself independently, it is and always has been a loosely structured scientific institution. To be a member of the Royal Society, to read a paper at its session is a great honour, appreciation and privilege, but nothing else. In contrast, the Académie des Sciences was founded in the absolutistic monarchy of Louis XIV, with rigid constraints, detailed, statutes, hierarchical organization. To be its member was a great honour too, even greater than in England, because the number of members was closed for each branch of science. However, in addition of being a great honour it was a living, because the members of the Académie des Sciences received regular salaries. The institution was maintained by the state, and the scientists had to perform governmental tasks and to report yearly on their work. In a certain extent the Académie might be regarded a state institution of science and research.

These two types of scientific institutions still exist in the academies of our time, depending on the model chosen at their foundation. Many countries followed the lead of England and France by founding academies of science. The highest scientific institution of the Holy Roman Empire, the Academia Caesarea Leopoldina Naturae Curiosum founded by the emperor Leopold I in 1671 followed the English pattern, and the Hungarian Academy of Sciences, at its foundation, also was rather more similar to this type. The French model, that is, governmental-type institutions maintained by the state were implemented e.g. in the Prussian academy founded in Berlin in 1700 and in the Russian academy founded in St. Petersburgh on the pattern of the former by tsar Peter the Great in 1725.

Chemists had a role in the life of all academies. Among the founding members of the Royal Society we find *Boyle*, *Hooke*, *Mayow*; later, up to our days, all significant British chemists were elected members. In the French Academy of Science a particular section for chemistry was established from the beginning on. It was more difficult to become a member here, since — owing to the closed number — some member had to die in order to make place for a new member, and besides, the benevolence of the king was required, since it was he who appointed the member whom he preferred among the candidates. However, French chemists playing a part in the history of chemistry were none the less, in their majority, members of the Académie. *Lavoisier* and *Dumas* were both directors of the institution.

The academies in Berlin and in St. Petersburgh had laboratories for research, headed from time to time by famous chemists like *Marggraf* and *Klaproth* in Berlin and *Lomonosov* in St. Petersburgh, who attained most of their scientific achievements in these laboratories.

Chemistry in the 18th century had an interesting feature: it might be called the science of amateurs full of genius, in the best sense of the word. In this age of enlightment, the upper classes turned increasingly towards science; scientific subjects were discussed and experiments were demonstrated in fashionable gatherings. The lectures in chemistry of the Royal Institution in London (a still active institution for research and propagation of sciences, founded towards the end of the 18th century by Lord Rumford) were and still are social events, attended in evening dress. To Davy's lectures, for instance, who was active in this institution, it was as difficult to obtain a ticket as to a concert of some famous, fashionable conductor.

For the greatest chemists of the 18th century, chemistry was not a profession but a hobby. When they had studied at a university, it was not medicine or chemistry. They never made a living of chemistry; instead, it rather cost them money. *Priestley* had studied theology and was a priest; *Cavendish* and *Kirwan* were immensely rich English peers; *Lavoisier* had studied law and made a very good living by his position as general tenant (fermier) of taxes; *Richter* made a rather poor living by land surveying; *Dalton* gave private lessons in mathematics, and so on.

In the great progress of chemistry in the 18th century, and particularly in the rapid development of analytical procedures, the most decisive factor was that among all branches of sciences chemistry was the first to attain direct industrial importance, its assistance being demanded for in industrial production.

The 18th century was the starting period of the industrial revolution. The steam engine, spinning machines and mechanical weaving looms were invented. Mechanized production raised a number of questions whose solution required the application of chemistry. Iron production rose dramatically; this needed exploration of new iron ore deposits, and this demand promoted the development of metal analysis. The centre of this development was — obviously — Sweden, the largest iron-producer country. Novel analytical methods much more sensitive than any earlier procedures were developed, for instance blowpipe analysis, and by means of this method, Swedish analysts discovered many metals unknown earlier, e.g. nickel, cobalt, manganese etc., thereby opening up new prospects for metallurgy. In England, iron manufacture utilizing coke instead of charcoal was invented. However, iron manufactured by this process was much poorer in quality than earlier. Again, the task of finding the reason fell to chemists. They demonstrated that poorer grade was due to the high carbon, sulfur and phosphorus content and found the means for improvement by reducing carbon content. Even the textile industry raised chemical problems: cloth bleaching. Earlier, weavers used sunlight for bleaching; mass production, however, needed chemical bleaching agents. It is astonishing how rapidly novel scientific discoveries in chemistry found their way into industry; chlorine was discovered in 1774 by *Scheele* in Sweden, and only four years later *Berthollet* in France experimented successfully in applying its alkaline solution (hypochlorite) for cotton bleaching. Some years later, he founded a hypochlorite factory and his agents travelled all over the country, presenting the product to textile manufacturers. Since too concentrated hypochlorite solutions destroy fabrics, a method had to be developed to control their concentration. It was the stimulus for the first titrimetric analytical procedure to be created, giving rise to the development of a novel branch of chemical analysis, still surviving at the present moment: volumetry.

Potassium carbonate was of high importance for scouring cotton fabrics. It was manufactured from wood ash and mainly supplied to France from its Canadian dominions. The English—French wars cut off this source. Potassium carbonate might, of course, be replaced by sodium carbonate (soda), but this compound is rare in nature. It needed a chemist's brain to conceive the idea that common salt, sodium chloride, occurring abundantly, might eventually be transformed into soda. Science turned into social demand is reflected in the fact that the French Academy of Sciences, in 1775, offered a high prize for developing an industrial process to manufacture soda from common salt. This was the first example of scientific research being a matter of public concern, the first occasion that the state materially prompted scientific research in a strictly confined subject, out of industrial-economical interest; applied research oriented to a defined purpose was born. By this incentive, zealous work was started all over France to find a process for synthetic soda. However, the solution of the problem took more time than expected, and was finally found simultaneously with the outbreak of the Great French Revolution. For this reason *Leblanc*, the inventor never got the prize; he was ruined by the political events and committed suicide. (He was not the only inventor whose success was reaped by others.) Anyhow, the Leblanc soda process remained, for hundred years, one of the first and most important manufacturing processes of the chemical industry.

Towards the middle of the 19th century, with the development of organic chemical industry, the relations between chemical research and industrial production became even more close. At that stage chemical research was performed almost exclusively at universities. Almost all great discoveries of the past century were made at universities, apart from early 19th century England. It appears that university-centred research spread in Europe from East towards the West, presumably because in the former, bourgeoisie were less developed and state more centralized, its cameralistic economics being responsive to technological innovation. In Central Europe and in the small German states, universities were the centres of science and research as early as the 18th century. In England they took over this role only from the middle of the 19th century.

Apparently, the increased cost of research was one of the reasons why universities came to play the leading or even exclusive part in research. This took place only after laboratories were established for the students, where the necessary rooms, equipment and chemicals were at disposal for research and students working on their doctoral theses moant unpaid scientific auxiliary staff to their professor. In this respect *Liebig's* activity was of outstanding significance. He provided his students and assistants with numerous research subjects. He was unbelievably exacting towards them, demanding hard work prolonged usually into late night hours. However, those concerned were well aware that it was worth to be "exploited" by Liebig: to have been his assistant, to have taken a doctor's degree from his department was a sure introduction to a successful scientific career, to a professorship at some smaller university.

In big countries with many universities, a sort of hierarchy rules them; besides illustrious universites with long historical pasts, small, modest universities exist. Hierarchy was particularly sharp in the Germany of the past century consisting of many smaller and larger, poorer and richer kingdoms and princedoms. This hierarchy between universities is one explanation for the arduous and persistent research work of the majority of professors. At that time research was no official duty of universities, no higher authority obliged professors to carry out research work. It was, however, the only opportunity to get an appointment to some more famous, more renowned university. Vacancies at universities were usually filled by invitation, the major argument being previous scientific activity of the candidates. Particularly in the past century and in big countries one can follow the path on which a young chemist graduating and taking a doctor's degree from the school of some famous professor obtained a chair at a small university, and subsequently rising to more and more illustrious universities eventually reached the peak, Paris in France, Berlin, Heidelberg or Leipzig in Germany, Oxford or Cambridge in England, Yale, Princeton or Harvard in the USA, St. Petersburgh in Russia. These top universities never accepted beginners, only professors who had already made a name in their branch. Paid assistants being few, usually one or two only, the professor built up his school from unpaid researchers, post-graduate students working at their doctoral thesis under his guidance. It depended on the goodwill of the professor whether the resulting publication appeared under both names; in many cases he satisfied himself by expressing his gratitude to his co-worker in a single sentence. If, however, the name of the young assistant appeared as co-author, he would cite this with great satisfaction even in late life. The past century, and to a certain extent our century too was the period of famous schools of great scientists. Such schools were of particular importance in chemistry, since in sciences like mathematics that could be practiced without laboratories, the young researcher at the start of his career was less tied to his professor. Chemical research can, however, only be done in laboratories and the professor had full authority to dispose of them. This system of university research might certainly be criticized from the sociological view, but it cannot be denied that it worked very efficiently, particularly in chemistry.

Organic chemical industry, started by the incidental discovery of synthetic dyestuffs from coal tar (1857) developed dramatically and grew into a powerful industry within only a few decades. Its novel feature was that it had no historical antecedents; organic chemical technology could not be based on empirism, but on high-level chemical knowledge only. To keep up with fashion, new dyes had to be commercialized constantly, and sharp competition between the many newly founded companies forced them to bring new products to the market perpetually. Consequently, from this time on academic careers were not the only alternatives for talented, well-trained chemists but (usually better-paid) industrial careers stood open to them too. Other, older-established branches of industry, e.g. metallurgy, also regularly engaged chemists by that time; however, in general only for analytical, quality control work. In organic chemical plants, in contrast, chemists had direct control of production and development. Such plants needed many chemists for their newly established research and development departments, and were eager to accept young men coming from the schools of famous professors, recommended by them. Many of these young men became, with time, all-powerful managers of large companies and concerns. They remained in contact with their *alma mater*, with their former professors or colleagues now professors, turning to them for advice or asking their contribution to solve some problem (duly remunerating them, of course). In this manner, cooperation in research between universities and industry was started. It was fruitful to universities, since it increased their material resources, and to industry, since it helped to develop new, competitive products. Such cooperation was closest in Germany and had a great part in turning this country into the centre of chemical science and into the leading power in organic chemical industry, a position Germany was able to keep up till World War I. In fact, the phenomenon nowadays termed scientific and technological revolution, when science becomes an indispensable precondition and simultaneously the major driving force of industrial progress, took shape first in the early decades of the developing organic chemical industry.

Academies of sciences and similar institutions were exclusive instances with a small number of select members. Chemistry, however, was no exclusive profession from the second half of the 19th century on. Chemists were active in many different fields, in teaching, in industry, in quality control institutions, in various organizations on an international scale, e.g. those for measures, standards, transport etc. It was the need of chemists working in very different domains of life for some sort of organization that led to the creation of chemical societies in most countries. Initially the primary objective of these societies was to safeguard material and moral interests of their members. Soon, however, they also started various scientific activities: they organized scientific sessions, conferences, congresses ensuring wide audiences to the participants. They published high-level journals, largening the potential for scientific publication. The first such society was founded in England: the Chemical Society (London, 1841); it was followed by the Société Chimique de France (1857), the Khimicheskoe Obshchestvo in Russia (1868), the Deutsche Chemische Gesellschaft (1867), the Verein Österreichischer Chemiker (1897). Due to their wide social basis, their large membership and their close industrial contacts, chemical societies — towards the end of the 19th century — became centres of chemical scientific public life to a much greater extent that the academies of sciences.

In Hungary, where sciences (as compared to arts) had little weight in the activities of the Academy, the centre of chemical scientific life till World War I was the Chemical Section of the Royal Society for Natural Sciences (Természettudományi Társulat). A society of Hungarian chemists (Magyar Chemikusok Egyesülete) was founded in 1907, but it developed into a true centre only in the period between the two wars.

National chemical organizations attempted to find ways for international scientific exchange of ideas. This first took shape systematically by the organization of International Congresses of Applied Chemistry. The first congress was organized in 1891, and subsequently took place every third year in alternating cities. Hungary was first represented officially at the 7th congress in London, where two Hungarian chemists read scientific reports. The International Organization of Chemical Societies was established in 1912, but broke up during World War I. It was reorganized in the 'twenties into the International Union of Chemistry, continuing its activities after the end of World War II as International Union of Pure and Applied Chemistry (IUPAC) under the auspices of UNESCO.

The precursors of modern scientific research institutes appeared in the 19th century, first of all in the field of agriculture and agricultural chemical industry. They were usually established by governments, particularly in countries where feudalism continued to exist during capitalism in the form of latifundia, because the great landlords, possessing strong political influence, were able to charge the state with the expenses of research, while profiting from its results. However, state subsidies were granted to research institutions in all countries, even in England and the USA. In Hungary — compared to the size of the country — a large number of agricultural research stations were established by the state. Chemistry played an important part in these stations, since agricultural and chemical science and technology are closely related.

The first agricultural research institution was established in England in the form of a private enterprise on the estate of Sir John Lawes in Rothamsted, 1843. The first agricultural research station in Germany was founded in 1851, in Möckern (Saxony); ten years later already 11 similar stations were active. In Austria, a sugar research station was the first to be established in 1859. In Hungary, the first chemical research station was founded in 1869, in Debrecen on a private incentive, but soon taken over by the state.

In the last third of the past century all states established various chemical institutions for other purposes, such as forensic laboratories, police laboratories, custom laboratories, chemical stations of town councils etc. Their tasks were primarily official: expert evidence, control of goods, of food etc., but if some particular problem arose, they frequently performed scientific research.

Extensive introduction of the metric system and the international organization of metrology between 1870 and 1880 had a great influence on the establishment of purely scientific research institutes. It was Germany that took the lead: in 1887 the Physikalisch-Technische Reichsanstalt was founded for research in physics and electricity. German chemists urged the establishment of a similar in type chemical institution, which was realized within the scope of a wider project: in 1911 the Kaiser-Wilhelm-Gesellschaft zur Förderung der Wissenschaften, a state-subsidized association was founded with the objective to set up scientific research institutes. The first of these institutes was the Kaiser-Wilhelm-Institut für Chemie, which started its activities in 1912, in Berlin-Dahlem. Many scientific achievements of great importance were attained in this institute, the most significant of all in 1938 when *Otto Hahn* and *Fritz Strassmann* discovered uranium fission. Many other Kaiser-Wilhelm-Institutes followed, among them another for chemistry, the Kaiser-Wilhelm-Institute für physikalische Chemie und Elektrochemie, in 1913. (In the Federal Republic Germany, the organization continued its work after World War II, replacing the name of Emperor William by that of Max Planck, the great physicist, and establishing numerous research institutes.)

In the United States the National Research Council and in Great Britain the Department of Scientific Research were founded during World War I (1915), first to subsidize research, later to found research institutes. This activity became much accelerated during World War II. In the Soviet Union, ever since its existence, the importance of fundamental research has been emphasized. It was organized under the direction of the Academy of Sciences of the USSR. Many well-equipped research institutes belonging to the Academy of Sciences were created in the period between the two wars. It was here that research in institutes became on a par with research at universities, not only with respect to its high level, but also quantitatively, and even surpassed it in many respects, by its more modern objects and equipment.

Since World War II, in the age of the scientific and technological revolution, the importance of research institutes increased all over the world; in chemistry too, but in this field, perhaps owing to traditions, research institutes could not overcome superiority of universities. Or is it because in chemistry the concept that teaching and research are activities mutually complementing and stimulating one another, more successful if not separated from one another, asserted itself more than in other branches of science?

In Hungary one or two scientific research institutes were founded between the two world wars, but not in the domain of chemistry. However, the chemical industry was relatively significant, particularly the pharmaceutical industry made rapid progress. Thus, closer cooperation between industry and universities was instituted. An outstanding example for such cooperation was that of professor *Géza Zemplén* and his department, the Department of Organic Chemistry of the Technical University Budapest with the Hungarian pharmaceutical industry, resulting, on the one hand, in the development of this industry to an internationally acknowledged level, and on the other hand, in important progress of Hungarian organic chemical science.

After World War II, scientific and technological research gained increased significance in Hungary. It was organized after the Soviet pattern: fundamental research came under the direct authority of the Academy of Sciences, which — besides maintaining its scientific corporate character — became the supreme authority of state administration for science. The Academy of Sciences created numerous modern research institutes; beside them, the importance of university research decreased. Simultaneously, research departments of industrial companies were taken away from the companies and made independent as industrial research institutes. All this substantially promoted research in Hungary. It was, however, accompanied by less positive features. Fundamental research became overorganized, overspecialized for a country of the size of Hungary, overfragmented, although in the science of chemistry itself the signs of reintegration become more and more manifest, and integrated research has better chances at universities representing integrated science. For this reason, more support to university research has recently again come to the fore. On the other hand, independent industrial research institutes became more detached from industry, and the requirements of industry and the activities of the research institutes have, to a certain extent, moved apart.

Scientific research is inseparable from scientific publication; through publication, research results become known and can become fruitful for science and frequently for society. Scientific journals, the means for publication originated in the 17th century: the first, simultaneously started (1665) and ever since appearing journals were the Philosophical Transactions and the Journal des Savants, published by the Royal Society and the French Academy of Sciences, respectively. They were open to all branches of science. One century later, in 1778, the first journal specialized in chemistry was started: Lorenz Crell's Chemisches Journal, later Chemische Annalen (referred to usually as Crell's Annalen). It was followed ten years later, in 1789, by Annales de chimie (Paris) initiated by Lavoisier and appearing ever since. In 1841, already 74 chemical journals existed, 38 in Germany, 8 each in England, France and Italy, 5 in Holland, 2 each in Belgium and the USA, one each in Russia and Sweden. Chemistry in general was treated by all of them; however, the time drew near when specialization within chemistry manifested itself in journals too. The first specialized chemical journal was in analytical chemistry: the Zeitschrift für analytische Chemie (1862). It was soon followed by other larger branches of chemistry. In our century, specialization of chemical journals continued; we now have, within analytical chemistry for instance, particular journals for electroanalysis, chromatography, thermal analysis, radioanalysis, microanalysis, spectral analysis etc. The situation is similar in other branches of chemistry and in the increasing number of border territories.

In Hungary, the first scientific journal (Tudományos Gyűjtemény) appeared from 1817 till 1841; it published papers in all branches of arts and sciences, on a rather popular level. In 1869, the journal Természettudományi Közlöny, for all branches of science, was started. The Hungarian Academy of Sciences had a scientific periodical Mathematikai és Természettudományi Értesítő from 1882 till 1944 and a German edition of this journal "Mathematische und naturwissenschaftliche Berichte aus Ungarn" (1882—1942), the latter with the objective to promote wider recognition of Hungarian scientific results. The first specialized chemical journal was started in 1882, at Kolozsvár (today Cluj, Roumania), but appeared for some years only. At the initiative of *Károly Than*, the Chemical Section of the Royal Society for Natural Sciences started the journal Magyar Kémiai Folyóirat in 1895; it still exists ever since. The journal of the Society of Hungarian Chemists (Magyar Kémikusok Lapja) was started in 1910, but its publication was discontinued from 1920 to 1940. After the end of the war several new chemical journals were started in Hungary; the journal Kémiai Közlemények (earlier MTA Kémiai Osztályának Közleményei), published by the Academy of Sciences, yields overall information on the development of individual fields of chemistry, while the Academy's other chemical journal, published in English, Acta Chimica Academiae Scientiarum Hungariae, started in 1952, serves the purpose to make known the results of Hungarian chemical research abroad. The chemical journal in foreign languages of the Technical University Budapest, Periodica Polytechnica Chemical Engineering was founded in 1957 with a similar objective.

The number of scientific journals in the world is at present in the order of 100.000, including about 10.000 chemical preiodicals. It is practically impossible for the researcher to survey them. For a long time this requirement was satisfied by chemical abstracting journals. The concept stems from Berzelius: from 1820 on he yearly published a Jahresbericht (yearly report), in which he critically surveyed all papers of the previous year on chemistry, physics and mineralogy. At that time, the number of papers was still so low that one man was able to achieve such a task! After Berzelius' death, German editors continued to publish Jahresberichte on the same principles, but restricted to chemistry only, up to 1912. The German abstracting journal Chemisches Zentralblatt was started in 1830; it gave short abstracts, non-critically, of the papers on chemistry in the world. It was closed down in 1969, because the editors were technically unable to follow chemical literature growing explosion-like in volume. The most general abstracting journal in chemistry is at present Chemical Abstracts, started in 1907 by the American Chemical Society; however, it is only capable of abstracting the chemical journals with constantly increasing delay. More rapid information is yielded by more recent types of journals, as e.g. Chemical Titles publishing only the author(s) and titles of the papers, and Current Contents communicating the tables of content of the individual journals. Expectations are attached by many to data banks working with large-memory computers. However, data banks can only store informations that are fed into them; as an example of the dramatic increase of information, let us have a look at the rise of the number of chemical scientific papers. Their number, from the beginnings to the present, totals 8 to 9 million. Berzelius, in 1820, reviewed 55 papers, Jahresberichte, in 1850, 700 papers. In subsequent years the corresponding numbers were: 1900: 4000; 1948: 32.000; 1965: 170.000; 1972: 340.000; 1980: 460.000. The opinion is frequently heard that it is simpler to rediscover something than to find it in the literature. Doubtlessly, the difficulty in surveying the vast flood of information is today's greatest problem in chemical research.

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