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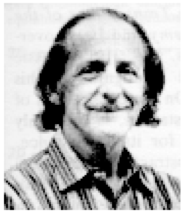

Current Comments®

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The Most-Cited 1983 Chemistry Articles Focus on NMR but the Increasing Impact of Materials Science and Computer Methods Is Evident

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This essay focuses on the list of 1983 "chemistry" papers most cited from 1983 to 1985 in the *Science Citation Index*® (*SCI*®) (see the Bibliography). This is the fourth group of highly cited chemistry papers that we have analyzed since 1983, when we examined papers published in 1980.[1]

Methodology

Once again the task of classifying the chemistry papers proved to be problematic. Although we used the *Chemistry Citation Index* (*CCI*), a subset of the *SCI* that covers the chemistry literature from 1978 to 1983, to select 98 papers, the list includes articles from other, often tangential fields such as biochemistry, earth sciences, and physics. Papers from such fields are included in the *CCI* if they give out at least five references to chemistry journals covered in the *CCI* and contain content that could be related to chemistry. Often these articles appear in physics or multidisciplinary journals.

A close examination of the Bibliography reveals 10 articles that probably should not have been selected for our chemistry group. They are by first authors C.J. Allègre, G. Binnig, A.Y. Cho, V. Dose, J.C. Fuggle, R.R. Garcia, S. Kirkpatrick, M.G. Mason, A.K. Niessen, and I.K. Robinson. Two of these articles are from the geosciences; the rest are in the physical sciences, including an article by 1986 physics Nobelists Gerd Binnig and Heinrich Rohrer, IBM Zurich Research Laboratory, Rüschlikon, Switzerland. Their article in the Bibliography is on scanning tunneling microscopy; they won the Nobel for their development of the microscope that allows scientists to see individual atoms. Ernst Ruska, now retired, shared the award with them for his work in electron optics and design of the first electron microscope, built in 1933.[2]

The Bibliography also includes a biochemistry paper on iron-sulfur proteins. It is of interest to chemists and biochemists, according to its first author, Helmut Beinert, then at the Institute for Enzyme Research and Department of Biochemistry, University of Wisconsin, Madison, and now at the Medical College of Wisconsin, Milwaukee, because iron-sulfur proteins are vital to biological processes such as cellular respiration, photosynthesis, and nitrogen fixation. However, these proteins also interest inorganic chemists and crystallographers.[3]

Biochemistry papers are usually included in the annual lists of highly cited life-sciences papers we study. Those lists and their counterparts, the annual lists of physical-sciences articles, contain papers most cited in the *SCI* during their first *two* years of publication. We wait for an additional year of citations to accumulate for chemistry papers because past studies have shown us that it takes at least three years for chemistry papers to achieve "critical" thresholds. A comparison of citation frequencies from the three studies of 1983 most-cited *SCI* papers—life[4] and physical sciences[5] and chemistry—clearly illustrates this point. In the Bibliography at the end of this essay, the three-year citation counts range from 36 to 141; the average for all three years is 49—3 in 1983, 18 in 1984, and 28 in 1985. For the *two-year* 1983 life-sciences study, the range was much higher, with papers having 64 to 200 citations; for most-cited 1983 physical-sciences papers, citations for two years ranged from 32 to 170.

The Papers

Nigel Walker and David Stuart, Queen Mary College, University of London, UK, authored the most-cited 1983 chemistry article. A methods paper, it proposes an improved empirical method for correcting diffractometer data distorted by absorption by crystals of foreign substances (such as mounting adhesive).[6]

A work comparable to Walker's paper because of its broad applicability to a specific group of researchers is the Soviet article by R.G. Gerr and colleagues, A.N. Nesmeyanov Institute of Heteroorganic Compounds of the Academy of Sciences of the USSR, Moscow. This work reports on improvements to a set of computer programs that automatically determine crystal structures. These programs are widely used by Soviet crystallographers—since 1983 the paper has been quoted over 76 times, almost exclusively by Russian authors. In general, and as we have often noted, highly cited methods papers are often cited out of proportion to other highly cited articles. But this is not a generalization that applies to all methods papers, most of which, like other types of papers, are rarely cited.

Gerr's article is the only Soviet paper in the list. All but an additional 2 of the 98 papers were originally published in English. These two are the German papers by Wolfgang A. Herrmann, Institute for Inorganic Chemistry, Frankfurt University, Federal Republic of Germany (FRG), and Dieter Seebach and colleagues, Organic Chemistry Laboratory, Swiss Federal Institute of Technology, Zurich, Switzerland. Of course we cannot say if papers that appeared in *Angewandte Chemie—International Edition in English* were originally written in English or German since this journal publishes in both languages. An article originally written in German may have been translated into English for publication in the international edition. Both Herrmann and Seebach appeared in our recent primary-authors study.[7]

Seebach is an organic chemist. He authored two papers in the Bibliography, one with first author Beat Weidmann, also at the Swiss Federal Institute of Technology. That paper is the fourth most-cited article in the Bibliography and is a review on organometallic compounds used as reagents in organic synthesis. Organometallic compounds contain chemical bonds from carbon atoms to metal atoms and are thus considered "at the crossroads of inorganic and organic chemistry."[8] (p. 416) Work concerning organometallic molecules is also represented in the Bibliography in papers by M. Brookhart and M.L.H. Green, Inorganic Chemistry Laboratory, University of Oxford, UK; Brookhart, J.R. Tucker, and G.R. Husk, Department of Chemistry, University of North Carolina, Chapel Hill, and US Army, Research Office, Research Triangle Park, North Carolina; A.H. Janowicz and R.G. Bergman, Department of Chemistry, University of California, and Materials and Molecular Research Division, Lawrence Berkeley Laboratory, Berkeley, California; W.D. Jones and F.J. Feher, Department of Chemistry, University of Rochester, New York; and P.L. Watson, Dupont Company, Central Research and Development Department, Wilmington, Delaware.

Much of the work by the aforementioned authors focuses on a smaller subfield of organometallics known as C-H activation, which is the breaking of carbon-hydrogen bonds in organic compounds. These bonds make hydrocarbons extremely stable, in fact, "saturated hydrocarbons are among the most...chemically stable of all organic materials...."[9] Understanding C-H activation would allow chemists to change hydrocarbons into "compounds more easily utilized in chemical conversions."[9] According to Roald Hoffmann, Cornell University, Ithaca, New York, tremendous advances have occurred in C-H activation over the last few years.[10] It is not surprising then that

Table 1: The four C2-level research fronts contained in C3 front "NMR, computed tomography, and other techniques for the study of compounds, biological specimens, and other materials" (#85-0027). Several papers in the Bibliography belong to C1 fronts contained in these C2 fronts.

85-0061	Laser interferometry and other investigations of the photoreactive effects, phase conjugations, and other properties of crystal mirrors and other systems
85-0088	Magnetic resonance and computed tomography imaging for the study of biological specimens *in vivo* and studies of viscoelasticity and other properties of polymers
85-0300	Structure dynamics and spectroscopic relaxation studies of metal complexes, polymers, and organic and other compounds
85-0538	Carbon-13, phosphorous-31, and other two-dimensional NMR spectroscopy of carbohydrates, alkaloids, and other compounds

the Brookhart-Green paper on "Carbon-hydrogen-transition metal bonds" is the third most-cited work in the Bibliography. It received 99 citations from 1983 to 1985, 60 of these in 1985 alone.

In addition to Seebach and Brookhart, 17 of the 237 unique authors of the 98 papers are also represented by two or more articles. John Taylor Groves, Department of Chemistry, University of Michigan, Ann Arbor, wrote three papers, all concerned with iron porphyrins. Richard R. Ernst, a physical chemist at the Swiss Federal Institute of Technology, has two papers in the Bibliography (see L. Braunschweiler and O.W. Sorensen, both at the Physical Chemistry Laboratory, Swiss Federal Institute of Technology) that discuss different applications of nuclear magnetic resonance (NMR), a field that is currently very active.

In a 1983 *Citation Classic*® commentary, Ernst discussed NMR in relation to a highly cited 1966 paper he coauthored with W.A. Anderson, then at the Analytical Instrument Division, Varian Associates, Palo Alto, California. The paper described the application of Fourier transform spectroscopy to NMR, a "simple" concept that revolutionized this field. The method is now an accepted technique for recording NMR spectra in liquids and solids.[11] Ernst is considered to be the leading theoretician behind the recent surge of excitement in NMR research.[10] He rarely appears as a first author on the many articles he has written, however.

The second most-cited article in the Bibliography, by Reinhard Benn, Institute for Coal Research, Max Planck Society for the Advancement of Science, Mülheim, and Harald Gunther, Faculty of Organic Chemistry, Siegen University, FRG, also concerns NMR. It was referenced 116 times from 1983 to 1985 and reviews modern pulse methods in high-resolution NMR spectroscopy. It is 1 of 15 papers in the Bibliography that discusses some aspect of NMR. Nine of these are core documents in three of the four 1985 C2-level ISI® research fronts contained in the higher-level 1985 C3-level front entitled "NMR, computed tomography, and other techniques for the study of compounds, biological specimens, and other materials" (#85-0027). These 4 C2 fronts in turn comprise 57 C1 fronts. C1-level research fronts comprise all the papers published in one specific year that cite a common core group of older papers. Thus, a 1985 C1 research front consists of a group of core papers published in any prior year and the 1985 papers that cited them. C2 fronts are higher-level fronts formed from C1 fronts, rather than individual papers. And C3 fronts consist of C2 fronts.

In Table 1 we list the names of the four C2 fronts that make up C3 front #85-0027. Front #85-0061 includes two papers by A.J. Shaka, Physical Chemistry Laboratory, University of Oxford, UK, in its core of 111 cited papers, while articles by first authors M.R. Bendall, School of Science, Griffith University, Nathan, Australia; W.A. Edelstein, Corporate R&D Center, General Electric Company, Schenectady, New York; and A.A. Maudsley, Neurological Institute, Columbia University, New York, are cited in #85-0088. Front #85-0538 includes papers authored by A. Bax, Department of Chemistry, Colorado State University, Fort Collins; Benn; Braunschweiler; and Sorensen.

We often discover when we scan these annual chemistry lists that a particular topic such as NMR dominates. In last year's study

Table 2: Selected 1984 and 1985 *SCI®/SSCI®* research-front pairs with papers in the Bibliography. The 1984 front in each pair is the antecedent of the 1985 front. A = number of 1983 most-cited chemistry papers included in the core of each research front. B = number of core documents. C = number of 1984-1985 citing documents.

Number	Name	A	B	C
84-0234	Synthesis of DNA, cDNA, and nucleotides by the phosphotriester approach and other methods	2	24	268
85-0223	Synthesis of nucleotides using phosphoester and other intermediates	2	22	317
84-4238	Unimolecular decomposition and energy transfer in vibrationally excited molecules	2	11	209
85-6540	Energy-transfer parameters from unimolecular reactions of vibrationally highly excited molecules	2	3	36
84-4489	X-ray-photoelectron and other studies of supported noble-metal clusters	2	4	35
85-1027	Preparation, characterization, and catalytic reactions of metal-metal-oxide systems	5	29	276
84-4870	Activation of carbon-hydrogen bonds in saturated hydrocarbons by iridium, rhodium, and other transition-metal complexes	2	8	103
85-1641	Synthesis and polymerization reactions involving transition-metal complexes as catalysts for carbon-hydrogen activation	2	31	269

of the 1982 chemistry papers,[12] for example, there were at least six papers concerned with fast-atom bombardment. Another advantage to performing these studies on an annual basis is that we can often trace the progress of research from year to year. For example, Watson's work in organometallic molecules, such as lanthanide, is represented by a most-cited 1982 chemistry paper[13] (35 citations) and a 1983 article (53 citations). In 1982 Herrmann published a most-cited paper discussing methylene bridges;[14] his most-cited 1983 paper continued the discussion, describing preparation of organometallic methylene bridge bonds.

Another way we trace the growth of research is by examining the evolution of ISI research fronts. That is, we identify which fronts were carried over from the previous year (those that contained many of the same core documents in each year) and then see how they have changed. Often, a shift in a field's focus is easily discerned merely by comparing the research-front titles from the different years involved. In Table 2 we list in pairs those research fronts that carried over from 1984 to 1985 and that have at least two papers from the Bibliography in their core. "Synthesis of DNA, cDNA, and nucleotides by the phosphotriester approach and other methods" (#84-0234) became "Synthesis of nucleotides using phosphoester and other intermediates" (#85-0223), while "Activation of carbon-hydrogen bonds in saturated hydrocarbons by iridium, rhodium, and other transition-metal complexes" (#84-4870) was renamed "Synthesis and polymerization reactions involving transition-metal complexes as catalysts for carbon-hydrogen activation" (#85-1641). A change also occurred in "X-ray-photoelectron and other studies of supported noble-metal clusters" (#84-4489) from 1984 to 1985. Its 1985 title is "Preparation, characterization, and catalytic reactions of metal-metal-oxide systems" (#85-1027).

In Table 3 we list the research fronts in this study that are not part of a 1984-1985 research-front pair. Again, we provide the names of only those fronts having at least 2 papers from the Bibliography in their cores; however, 85 different fronts (topics) are represented by 77 of the papers in the Bibliography. Five fronts in Table 3 concern NMR, including the front with the greatest number of citing documents, "Structural assignments of carbohydrates, proteins, alkaloids, and other natural products by two-dimensional NMR" (#85-1361). Three papers from the Bibliography are in this front's core of 44 documents cited by 579 papers. Another NMR front, "High-resolution solid-state NMR spectroscopy studies of carbon-13 in organic compounds and of silicon-29 and other elements in glasses, zeolites, and other inorganic solids" (#85-0926), has the largest number of cited documents—54.

The smallest front in Table 3 concerns "Photoionization and electron-spin resonance studies of metal clusters, matrix-isolated atoms, and transition-metal molecules"

Table 3: The 1984 and 1985 *SCI®/SSCI®* research fronts that contain at least two of the papers in the Bibliography that were not part of a 1984-1985 research-front pair. (See Table 2.) A=number of 1983 most-cited chemistry papers included in the core of each research front. B=number of core documents. C=number of 1984-1985 citing documents.

Number	Name	A	B	C
84-0153	NMR in medical and biological studies	2	35	379
84-6403	High-resolution solid-state silicon-29 and aluminum-27 NMR characterization of silicon and other zeolites	2	8	83
84-7407	Photoionization and electron-spin resonance studies of metal clusters, matrix-isolated atoms, and transition-metal molecules	2	4	50
85-0325	Kinetics and mechanism for epoxidation and other oxidation reactions using metal-porphyrin complexes and other cytochrome-P-450 model compounds	3	19	234
85-0449	Synthesis and structure of high nuclearity organometallic clusters	2	41	556
85-0581	Carbon-13 NMR and effects of NMR and laser pulses on population inversion and coherence	2	35	383
85-0911	Theoretical and experimental studies of photoemission and surface states in solids	2	33	272
85-0926	High-resolution solid-state NMR spectroscopy studies of carbon-13 in organic compounds and of silicon-29 and other elements in glasses, zeolites, and other inorganic solids	2	54	507
85-0967	Stereoselective synthesis using the Aldol condensation of chiral aldehydes with the enolates of ketones and esters and other reactions	2	50	484
85-1361	Structural assignments of carbohydrates, proteins, alkaloids, and other natural products by two-dimensional NMR	3	44	579
85-1805	Theory and applications of scanning tunneling microscopy	2	13	161
85-1860	Structure, formation, and reactions of molecular, atomic, and ion clusters	2	46	348
85-1984	Electrochemical synthesis of polymers	2	30	243
85-2693	Electro-optic properties of polymers	2	33	372
85-4405	Synthesis, molecular structure, conductivity, and other chemical and physical properties of phthalocyanines and other metallomacrocyclic compounds	3	7	65

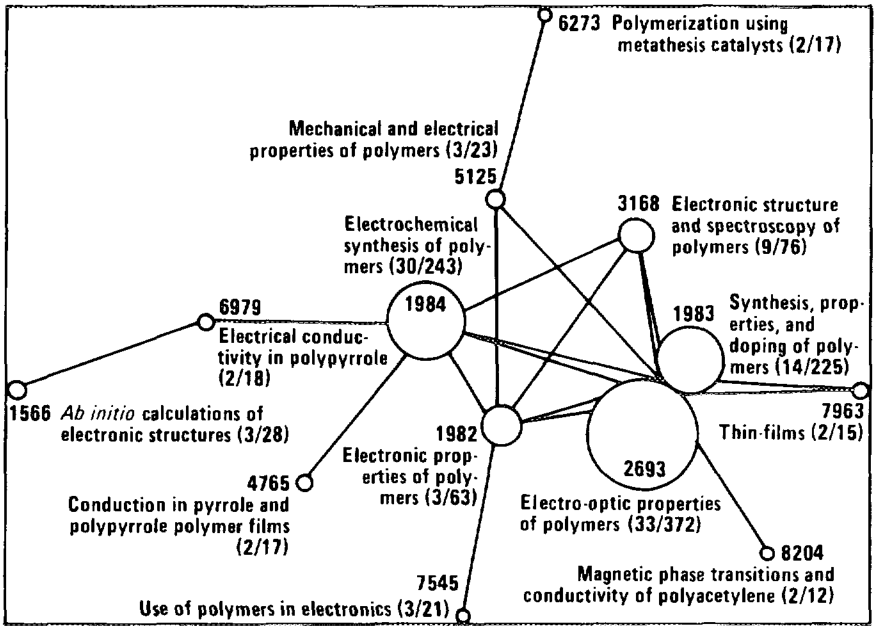
(#84-7407) and has 4 documents cited by 50 papers published in 1984. Two of these cited papers are in the Bibliography (see J.B. Hopkins and D.E. Powers). The second smallest front contains 7 cited documents and 65 citing papers. "Synthesis, molecular structure, conductivity, and other chemical and physical properties of phthalocyanines and other metallomacrocyclic compounds" (#85-4405) is represented by three papers in this study, including one article by B.N. Diel, Northwestern University, Evanston, Illinois, and another by C.W. Dirk, also at Northwestern. These were published consecutively in one 1983 issue of the *Journal of the American Chemical Society* and were co-cited in 27 papers from 1983 to 1985.

"Theory and applications of scanning tunneling microscopy" (#85-1805) contains the paper by Nobelists Binnig and Rohrer as well as Robinson's *Physical Review Letters* paper on determining the gold-110 reconstructed surface by X-ray diffraction. And polymers are the subject of two fronts containing two papers each from the Bibliography. Polymers are substances made of giant molecules formed by the repeated linking of small simple molecules.[8] (p. 452) [15] (p. 1243) Examples of two natural polymers are proteins, which are polymers of amino acids, and nucleic acids, which are composed of nucleotides. Synthetic polymers include polyethylene, the polymer of ethylene, and polypropylene, the polymer of propylene.[16]

The two fronts on polymers (#85-1984, #85-2693) appear in the heart of the higher-level research front, "Synthesis and structure of conducting polymers" (#85-0587), mapped in Figure 1. It contains a total of 13 fronts. The smallest front on the map, according to the number of citing documents it contains, is "Magnetic phase transitions and conductivity of polyacetylene" (#85-8204); it has 12 citing papers. The largest front is #85-2693, with 372 citing papers.

"Electro-optic properties of polymers" (#85-2693) is represented in the Bibliography by the papers of K. Fesser and colleagues, Theoretical Division and Center for Nonlinear Studies, Los Alamos National

Figure 1: Multidimensional scaling map for C2-level research front #85-0587, "Synthesis and structure of conducting polymers," showing links between C1-level research fronts. The numbers of core/1985 citing items are given in parentheses following the research-front name on the map. Circles show relative sizes of the 1985 citing literature.



Laboratory, New Mexico, and J.C. Scott and colleagues, IBM Research Laboratory, San Jose, California. Two of the papers in "Electrochemical synthesis of polymers" (#85-1984) are also by IBM researchers. A.F. Diaz appears as a coauthor on both of these works (see E.M. Genies, CNRS, Grenoble, France; R.J. Waltman, IBM). The papers are electrochemical studies involving polymer films, such as polypyrrole films created by the electropolymerization of pyrrole, an organic compound "found in the green leaf pigment, chlorophyll, in the red blood pigment, hemoglobin, and in the blue dye, indigo,"[15] (p. 840) or in polythiophene films.

According to Diaz, his paper with Genies is one of three key articles that demonstrate a materials breakthrough in the area of conductive polymers; these articles also demonstrate a connection between conductive polymers and electrochemistry. (The other two papers, published in 1979 and 1980, were coauthored with K.K. Kanazawa and G.P. Gardini, and J.I. Castillo, respectively.[17,18]) Prior to the publication of these papers, the study of conductive polymers focused primarily on the physical properties of these materials. The Genies-Bidan-Diaz paper is highly cited probably because there is interest in the electrochemical preparation of these materials as well as their neutral-to-conducting switching properties.[19]

IBM researchers account for seven papers in the Bibliography, the most produced by any of the 93 organizations listed in Table 4. IBM produced only one paper among the 1982 most-cited chemistry papers. In that study the Massachusetts Institute of Technology, Cambridge, Massachusetts, had the greatest number of papers—10—while in this study it is represented only by 3 articles.

A new affiliation in these chemistry studies is the University of Cadi Ayyad, Marrakech, Morocco. This institution was founded in 1978. J.-L.M. Abboud is the researcher affiliated with this university. He appears as coauthor on the paper by first au-

Table 4: Institutional affiliations listed in papers in the Bibliography in descending order of number of appearances.

IBM		7
Ruschlikon, Switzerland	1	
San Jose, CA	4	
Yorktown Heights, NY	2	
Swiss Fed. Inst. Technol., Zurich, Switzerland		5
Univ. California, CA		4
Berkeley	3	
Irvine	1	
AT&T Bell Labs., Murray Hill, NJ		3
Caltech, Pasadena, CA		3
CNRS, France		3
Grenoble	1	
Montpellier	1	
Orsay	1	
Max Planck Soc. Adv. Sci., FRG		3
Inst. Coal Res., Mulheim	1	
Inst. Exp. Med., Gottingen	1	
Inst. Solid-State Res., Stuttgart	1	
MIT, MA		3
Cambridge	2	
Lexington	1	
Northwestern Univ., Evanston, IL		3
Purdue Univ., West Lafayette, IN		3
Univ. Michigan, Ann Arbor, MI		3
Univ. Oxford, UK		3
Univ. Wisconsin, Madison, WI		3
Paris Univ., France		2
Orsay	1	
Paris	1	
Los Alamos Natl. Lab., NM		2
Rice Univ., Houston, TX		2
Univ. Chicago, IL		2
Univ. Colorado, Boulder, CO		2
Univ. Houston, TX		2
Univ. North Carolina, Chapel Hill, NC		2
Yale Univ., New Haven, CT		2
Amsterdam Univ., The Netherlands		1
Argonne Natl. Lab., IL		1
Berlin Tech. Univ., FRG		1
Berne Univ., Switzerland		1
Bielefeld Univ., FRG		1
Bonn Univ., FRG		1
City Univ. New York, NY		1
Colorado State Univ., Fort Collins, CO		1
Columbia Univ., New York, NY		1
Darmstadt Inst. Technol., FRG		1
Dupont Co., Wilmington, DE		1
Eastman Kodak Co., Rochester, NY		1
Exxon Res. Eng. Co., Linden, NJ		1
Ford Motor Co., Dearborn, MI		1
Frankfurt Univ., FRG		1
Friedrich Alexander Erlangen-Nuremberg Univ., Erlangen, FRG		1
General Electric Co., Schenectady, NY		1
Gottingen Univ., FRG		1
Griffith Univ., Nathan, Australia		1
Guelph-Waterloo Ctr. Grad. Work Chem., Guelph, Canada		1
Harvard Univ., Cambridge, MA		1
Indiana Univ., Bloomington, IN		1
Johannes Gutenburg Univ. Mainz, FRG		1
Julich Nucl. Res. Ctr., FRG		1
Michigan State Univ., East Lansing, MI		1
Mobil Res. Dev. Corp., Princeton, NJ		1
Monsanto Co., St. Louis, MO		1
NASA, Moffet Field, CA		1
Natl. Ctr. Atmospher. Res., Boulder, CO		1
Natl. Oceanic Atmospher. Admin., Boulder, CO		1
Natl. Sci. Fnd., Washington, DC		1
NBS, Washington, DC		1
NRC Canada, Ottawa, Canada		1
Oak Ridge Natl. Lab., TN		1
Osaka City Univ., Japan		1
Oxford Res. Syst. Ltd., UK		1
Paris Inst. Earth Phys., France		1
Pennsylvania State Univ., University Park, PA		1
Philips Res. Labs., Eindhoven, The Netherlands		1
Polyatomics Res. Lab., Mountain View, CA		1
Res. Lab., Hoogovens, The Netherlands		1
Siegen Univ., FRG		1
Soreq Nucl. Res. Ctr., Yavne, Israel		1
SRI Intl., Menlo Park, CA		1
Stanford Univ., CA		1
Tel Aviv Univ., Israel		1
Thomson CSF, Orsay, France		1
Univ. Cadi Ayyad, Marrakech, Morocco		1
Univ. Cambridge, UK		1
Univ. East Anglia, Norwich, UK		1
Univ. Florida, Gainesville, FL		1
Univ. Groningen, The Netherlands		1
Univ. Guelph, Canada		1
Univ. Hamburg, FRG		1
Univ. Illinois, Urbana, IL		1
Univ. Kansas, Lawrence, KS		1
Univ. Leiden, The Netherlands		1
Univ. London, UK		1
Univ. Manitoba, Winnipeg, Canada		1
Univ. Minnesota, Minneapolis, MN		1
Univ. Pennsylvania, Philadelphia, PA		1
Univ. Rochester, NY		1
Univ. Surrey, Guildford, UK		1
Univ. Tokyo, Japan		1
Univ. Washington, Seattle, WA		1
Univ. Western Ontario, London, Canada		1
Univ. Wurzburg, FRG		1
US Army, Research Triangle Park, NC		1
USSR Acad. Sci., Moscow, USSR		1
Wayne State Univ., Detroit, MI		1
Weizmann Inst. Sci., Rehovot, Israel		1
White Oak Lab., Silver Spring, MD		1

thor M.J. Kamlet, Naval Surface Weapons Center, White Oak Laboratory, Silver Spring, Maryland, with M.H. Abraham, Department of Chemistry, University of Surrey, Guildford, UK, and R.W. Taft, Department of Chemistry, University of California, Irvine.

The US is represented in 66 papers in the Bibliography; 6 of these were also coauthored with researchers at institutions in Canada, France, and Israel, in addition to

Table 5: National locations of the institutional affiliations listed by authors in the Bibliography, according to total appearances (column A). B = number of papers coauthored with researchers affiliated with institutions in other countries. C = national locations of institutions listed by coauthors.

Country	A	B	C
US	66	7	Canada, France, Israel, Morocco, UK
FRG	11	0	
UK	8	4	Australia, Canada, Morocco, US
Switzerland	6	0	
France	5	2	US
Canada	4	2	UK, US
Israel	2	2	US
The Netherlands	2	0	
Australia	1	1	UK
Japan	1	0	
Morocco	1	1	UK, US
USSR	1	0	

the UK and Morocco. (See Table 5.) Twelve countries in all appear in the Bibliography. Canada, which had 10 listings in the study of 1982 papers, has 4 here, but the FRG increased from 7 to 11. As always, we caution our readers that the institutional and geographical tabulations are based solely on the affiliations listed by researchers in their papers. These may not reflect the countries where they are citizens or where they were born.

Journals

Our final analysis of the 98 papers is by the journals that published them. (See Table 6.) *Angewandte Chemie—International Edition in English* published seven articles, including the second and fourth most-cited papers already mentioned. This journal publishes both review and original articles, but most of its highly cited items are reviews. For example, five of the seven articles in the Bibliography are surveys in specific chemical areas. The review by E.L. Muetterties and M.J. Krause, both of the Department of Chemistry, University of California, Berkeley, covers catalysis by molecular metal clusters. Muetterties died recently.

About 25 papers in the Bibliography are reviews. As a general rule review articles are well cited because they become surrogates for many original articles that might be cited. *Accounts of Chemical Research* and *Analytical Chemistry* each published two reviews listed in the Bibliography. Other journals in which reviews appeared are *Catalysis Reviews—Science and Engineering*, *Annual Review of Physical Chemistry*, *Physical Review B—Condensed Matter*, *Mass Spectrometry Reviews*, and *Chemical Society Reviews*. Several of these latter five journals are committed to publishing surveys of the chemical-physical literature; some publish both review and original-research articles. I've discussed the importance of review papers extensively. It should not be forgotten that many of these include important original experimental and theoretical observations.

The *Journal of the American Chemical Society* (*JACS*) accounts for the greatest number of the 98 articles—18; it had 21 papers in the list of 1982 chemistry papers. Nine 1983 articles appeared in the *Journal of Chemical Physics* and seven in *Physical Review B—Condensed Matter*, although two of these articles are the physics papers by Fuggle and Mason. The *Journal of Magnetic Resonance* has the fifth highest number of articles in the Bibliography—five. Among the 1982 papers it accounted for only two most-cited articles. However, there are many more NMR papers in this study. *Analytical Chemistry*, on the other hand, dropped from nine papers in the 1982 list to just two in the 1983 table. The Russian-language journal *Kristallografiya* is represented by one paper in the Bibliography; its English translation is *Soviet Physics—Crystallography*. It was not represented in the study of 1982 most-cited chemistry papers. In all, a total of 44 journals are listed in Table 6 along with each journal's 1983 impact factor.

Conclusion

This analysis of 1983 chemistry papers has highlighted active areas of chemical re-

Table 6: The 44 journals represented in the list of 1983 chemistry papers most cited in the *SCI*®, 1983-1985. The numbers in parentheses are the 1983 impact factors for the journals. (The 1983 impact factor equals the number of 1983 citations received by the 1981-1982 articles in a journal divided by the number of articles published by the journal from 1981 to 1982.) Data were taken from the 1983 *JCR*®. The figures at the right indicate the number of papers from each journal that appear in the Bibliography.

Journal	**Number of Papers**
J. Amer. Chem. Soc. (4.5)	18
J. Chem. Phys. (3.0)	9
*Angew. Chem. Int. Ed. (3.9)	7
Phys. Rev. B—Condensed Matter (3.3)	7
J. Magn. Resonance (2.8)	5
J. Phys. Chem. (2.7)	4
J. Catal. (2.4)	3
Account. Chem. Res. (8.2)	2
Anal. Chem. (3.4)	2
J. Comput. Chem. (2.0)	2
J. Organometal. Chem. (2.2)	2
Nature (9.3)	2
Organometallics (2.9)	2
Phys. Rev. Lett. (6.5)	2
Science (7.4)	2
Acta Crystallogr. A—Found. Crys. (2.0)	1
Advan. Phys. (12.8)	1
Annu. Rev. Phys. Chem. (7.1)	1
CALPHAD—Comput. Coup. Phase Dia. (0.8)	1
Catal. Rev.—Sci. Eng. (3.4)	1
Chem. Phys. Lett. (2.2)	1
Chem. Soc. Rev. (5.7)	1
Colloid Polym. Sci. (0.8)	1
Environ. Health Perspect. (1.0)	1
Helv. Chim. Acta (1.9)	1
J. Comput. Assist. Tomogr. (2.2)	1
J. Electroanal. Chem. (1.9)	1
J. Electron. Mater. (1.8)	1
J. Geophys. Res. (3.7)	1
J. Mol. Biol. (6.7)	1
J. Org. Chem. (2.0)	1
J. Vac. Sci. Technol. B (3.0)	1
**Kristallografiya SSSR (0.4)	1
Mass Spectrom. Rev. (5.0)	1
Mol. Phys. (2.0)	1
Polyhedron (0.8)	1
Proc. Nat. Acad. Sci. USA (8.7)	1
Prog. Nucl. Magn. Reson. Spectros. (13.3)	1
Prog. Surf. Sci. (5.0)	1
Pure Appl. Chem. (2.0)	1
Surface Sci. (4.0)	1
Tetrahedron (1.7)	1
Tetrahedron Lett. (2.0)	1
Thin Solid Films (1.3)	1

*also published in German as *Angew. Chem.*

**translated in *Sov. Phys.—Crystallogr.*

search concerning NMR, organometallics, carbon-hydrogen activation, and polymers. According to an August 1986 *Chemical & Engineering News* article, several of these areas have continued to advance through 1986.[20]

More slowly developing subfields of chemistry, or areas that are less research oriented and more theoretical, may be identified by papers in the Bibliography that have not yet appeared in ISI research fronts. For example, the paper by G.L. Long and J.D. Winefordner, Department of Chemistry, University of Florida, Gainesville, does not appear in the core of any 1983, 1984, or 1985 front. It examines the International Union of Pure and Applied Chemistry (IUPAC) definition of "limit of detection" values. "The ability to quantify a trace element or molecule in chemical and biological matrices using specific analytical methods is often viewed in terms of the limit of detection. This...is a number, expressed in units of concentration..., that describes the lowest concentration level...of the element that an analyst can determine to be statistically different from an analytical blank. Although this definition seems rather straightforward, significant problems have been encountered in expressing these values because of the various approaches to the term 'statistically different.' "[21]

Another paper that has not yet appeared in a research front is the report by B.R. Brooks, Department of Chemistry, Harvard University, on a computer program for modeling and analyzing macromolecular systems. Computer programs that aid scientists in their research have just recently begun appearing in our lists of most-cited *SCI* papers.

"Solvent influence on photoisomerization dynamics" by G. Rothenberger and colleagues, Department of Chemistry and Laboratory for Research on the Structure of Matter, University of Pennsylvania, Philadelphia, is also not in a research front yet; it was an early contribution to understanding how, both experimentally and theoretically, molecules isomerized in liquids. This field has now become quite large in chemical physics.[22]

In conclusion, this final part of our study of 1983 *SCI* papers once again illustrates the difficulties of separating chemistry papers from physical-sciences articles. Any attempt to divide the two fields may, in fact, be an exercise in futility. In this list of so-called chemistry papers we identified 10 articles that were not strictly chemical in nature. And many other papers in the Bibliography were published in physics journals such as the *Journal of Chemical Physics* (nine papers) and *Physical Review B—Condensed Matter* (seven articles). In future studies we may change our procedure for selecting chemistry papers to facilitate identification of more articles from synthetic organic chemistry, the types of papers that are mainly covered in *Index Chemicus*® (*IC*®), as well as *Current Chemical Reactions*® (*CCR*®). (For more information on *IC* and *CCR*, refer to our study of the 1981 most-cited chemistry papers.[23]) More than three years may often be required for the important papers in these fields to demonstrate their impact. Indeed, it may be instructive to examine the impact of papers published in 1980, for example, as reflected in the *SCI* cumulation for 1980-1984, which was published in early December.

* * * * *

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BIBLIOGRAPHY OF MOST-CITED 1983 CHEMISTRY PAPERS

The 1983 chemistry articles most cited in the *SCI*®, 1983-1985. Articles are listed in alphabetic order by first author. The authors' affiliations follow each citation. Code numbers indicate the 1983, 1984, and 1985 *SCI/SSCI*® research-front specialties for which these are core papers.

Citations 1983	1984	1985	Total	Bibliographic Data
7	30	33	70	**Adams S P, Kavka K S, Wykes E J, Holder S B & Galluppi G R.** Hindered dialkylamino nucleoside phosphite reagents in the synthesis of two DNA 51-mers. *J. Amer. Chem. Soc.* 105:661-3, 1983. Monsanto Co., Corp. Res. Lab., St. Louis, MO. 84-0234, 85-0223
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3	22	15	40	**Anson F C, Saveant J-M & Shigehara K.** New model for the interior of polyelectrolyte coatings on electrode surfaces. Mechanisms of charge transport through protonated poly(L-lysine) films containing Fe^{III}(edta) and $Fe^{II}(edta)^{2}$ as counterions. *J. Amer. Chem. Soc.* 105:1096-106, 1983. Caltech, Arthur Amos Noyes Labs., Pasadena, CA; Paris Univ., Electrochem. Lab., France.
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1983	1984	1985	Total	Bibliographic Data
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