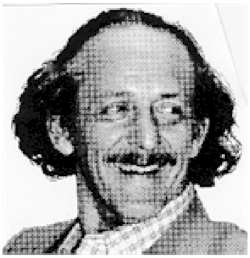
Essays of an Information Scientist, Vol:5, p.634-642, 1981-82 Current Contents, #32, p.5-13, August 9, 1982



Current Comments

The 1979 Articles Most Cited from 1979 to 1981. 2. Physical Sciences

Number 32 August 9, 1982

In a recent essay, I presented the 1979 life sciences papers that were among the most frequently cited in 1979-1980.[1] That study also included a list of papers that would be among the most cited if we had considered citations received in 1981. This essay presents the highly cited 1979 papers in the physical sciences. By examining papers that become highly cited soon after publication, one can often identify "hot spots" in science—areas of research that are currently of special interest to scientists.

Figure 1 lists the 105 physical sciences papers of 1979 that were among the most cited in 1979-1980. Their 1981 citations are listed as well. As always, papers are divided into broad subject areas, and listed alphabetically by first author below each subject heading. We use this arrangement, rather than citation frequency, to discourage invidious comparisons of individual papers. Articles published late in the year are at a disadvantage in studies of this kind. Therefore, we have listed in Figure 2 the 1979 papers that are among the most cited if 1981 citations are also counted.

Most of the 4,000,000 papers or books cited in *Science Citation Index*® (*SCI*®) receive one or two citations in a two-year period. The average for a five-year period is about five. But the average paper in Figure 1 received 41 citations—seven in 1979 and 34 in 1980. The most-cited paper received 96 citations, while the eight least-cited papers received 29 citations each.

As always, I must caution that the papers in this study do not necessarily represent the "best" research. One should not forget that many 1979 papers not included here will also become highly cited eventually. What makes the present group of papers interesting is the immediacy of their impact.

An interesting feature of this study is the inclusion of research front data. In previous essays, I have explained ISI®'s clustering technique for identifying new research fronts.[2] A research front is a group of current papers that cite one or more core papers in a co-citation cluster. Our clustering technique is the basis for "research front searching," available through our online *ISI/BIOMED*™, *ISI/CompuMath*™, and *ISI/GeoSciTech*™ systems.

We recently made research front searching available to users of our *Index to Scientific Reviews*™ (*ISR*™), as a future essay will describe in detail. To do so, we first had to cluster the entire *SCI* data base. We found that most of the papers in Figure 1, about 83 percent of them, are included in the core literature for *SCI*/*ISR* research fronts. The names of the research fronts which include two or more papers from this study within their cores are listed in Table 1.

Twenty-three papers in Figure 1 are single author works. Twenty-seven papers have two authors, 24 papers have three, and six have four. Five papers have five authors, one has six, one has seven, and 12 have between ten and 31

Figure 1: The 1979 physical sciences articles most cited in 1979-1980. Authors' affiliations follow each citation. A=1979 citations. B=1980 citations. C=combined 1979-80 citations. D=1981 citations.

The Physics of Condensed Matter

A	B	C	D	Bibliographic Data
13	67	80	102	Abrahams E, Anderson P W, Licciardello D C & Ramakrishnan T V. **Scaling theory of localization: absence of quantum diffusion in two dimensions.** *Phys. Rev. Lett.* 42:673-6, 1979. Rutgers Univ., Serin Phys. Lab., Piscataway, NJ; Princeton Univ., J. Henry Labs., Princeton, NJ.
4	32	36	44	Anderson P W, Abrahams E & Ramakrishnan T V. **Possible explanation of nonlinear conductivity in thin-film metal wires.** *Phys. Rev. Lett.* 43:718-20, 1979. Bell Labs., Murray Hill, NJ; Rutgers Univ., Serin Phys. Lab., Piscataway, NJ; Princeton Univ., J. Henry Labs., Princeton, NJ.
9	26	35	33	Baeri P, Campisano S U, Foti G & Rimini E. **A melting model for pulsing-laser annealing of implanted semiconductors.** *J. Appl. Phys.* 50:788-97, 1979. Univ. Catania, Inst. Struct. Mater., Catania, Italy.
4	26	30	26	Beasley M R, Mooij J E & Orlando T P. **Possibility of vortex-antivortex pair dissociation in two-dimensional superconductors.** *Phys. Rev. Lett.* 42:1165-8, 1979. Stanford Univ., Dept. Appl. Phys. & Dept. Phys., Stanford, CA.
5	29	34	32	Blount E I & Varma C M. **Electromagnetic effects near the superconductor-to-ferromagnet transition.** *Phys. Rev. Lett.* 42:1079-82, 1979. Bell Labs., Murray Hill, NJ.
5	34	39	23	Bolts J M, Bocarsly A B, Palazzotto M C, Walton E G, Lewis N S & Wrighton M S. **Chemically derivatized n-type silicon photoelectrodes.** *J. Amer. Chem. Soc.* 101:1378-85, 1979. Mass. Inst. Technol., Dept. Chem., Cambridge, MA.
5	27	32	41	Dolan G J & Osheroff D D. **Nonmetallic conduction in thin metal films at low temperatures.** *Phys. Rev. Lett.* 43:721-4, 1979. Bell Labs., Murray Hill, NJ.
5	24	29	22	Fincher C R, Ozaki M, Heeger A J & MacDiarmid A G. **Donor and acceptor states in lightly doped polyacetylene, $(CH)_x$.** *Phys. Rev. B* 19:4140-8, 1979. Univ. Pennsylvania, Lab. Res. Struct. Matter, Philadelphia, PA.
7	25	32	22	Goldberg I B, Crowe H R, Newman P R, Heeger A J & MacDiarmid A G. **Electron spin resonance of polyacetylene and AsF_5-doped polyacetylene.** *J. Chem. Phys.* 70:1132-6, 1979. Rockwell Internatl. Sci. Ctr., Thousand Oaks, CA; Univ. Pennsylvania, Lab. Res. Struct. Matter, Philadelphia, PA.
2	29	31	8	Grant P M & Batra I P. **Band structure of polyacetylene, $(CH)_x$.** *Solid State Commun.* 29:225-9, 1979. IBM Res. Lab., San Jose, CA.
7	45	52	28	Grimes C C & Adams G. **Evidence for a liquid-to-crystal phase transition in a classical, two-dimensional sheet of electrons.** *Phys. Rev. Lett.* 42:795-8, 1979. Bell Labs., Murray Hill, NJ.
0	33	33	26	Himpsel F J, Knapp J A & Eastman D E. **Experimental energy-band dispersions and exchange splitting for Ni.** *Phys. Rev. B* 19:2919-27, 1979. IBM T.J. Watson Res. Ctr., Yorktown Heights, NY.
3	28	31	28	Kaufman F B & Engler E M. **Solid-state spectroelectrochemistry of cross-linked donor bound polymer films.** *J. Amer. Chem. Soc.* 101:547-9, 1979. IBM T.J. Watson Res. Ctr., Yorktown Heights, NY.
2	31	33	28	Lee P A. **Real-space scaling studies of localization.** *Phys. Rev. Lett.* 42:1492-4, 1979. Bell Labs., Murray Hill, NJ.
4	28	32	33	Lehn J M, Sauvage J P & Ziessel R. **Thermal and photoinduced oxidation of water.** *Nouv. J. Chim.* 3:423-7, 1979. Louis Pasteur Univ., Inst. Le-Bel, Strasbourg, France.
7	25	32	18	Louie S G. **Hydrogen on Pd(111): self-consistent electronic structure, chemical bonding, and photoemission spectra.** *Phys. Rev. Lett.* 42:476-9, 1979. IBM T.J. Watson Res. Ctr., Yorktown Heights, NY.
3	27	30	47	Lucovsky G, Nemanich R J & Knights J C. **Structural interpretation of the vibrational spectra of a-Si:H alloys.** *Phys. Rev. B* 19:2064-73, 1979. Xerox Palo Alto Res. Ctr., Palo Alto, CA.
6	24	30	17	Maletta H & Convert P. **Onset of ferromagnetism in $Eu_xSr_{1-x}S$ near $x=0.5$.** *Phys. Rev. Lett.* 42:108-11, 1979. Julich Nuclear Res. Ctr., Julich, FRG; Inst. Laue-Langevin, Grenoble, France.
14	73	87	82	Miya T, Terunuma Y, Hosaka T & Miyashita T. **Ultimate low-loss single-mode fibre at 1.55 μm.** *Electron. Lett.* 15:106-8, 1979. Nippon Telegr. Teleph. Publ. Corp., Ibaraki Elect. Commun. Lab., Tokyo, Japan.
5	43	48	63	Muetterties E L, Rhodin T N, Band E, Brucker C F & Pretzer W R. **Clusters and surfaces.** *Chem. Rev.* 79:91-137, 1979. Cornell Univ., Cornell Mater. Sci. Ctr., Ithaca, NY.
6	41	47	56	Nelson D R & Halperin B I. **Dislocation-mediated melting in two dimensions.** *Phys. Rev. B* 19:2457-84, 1979. Harvard Univ., Dept. Phys., Cambridge, MA.
8	25	33	16	Oyama N & Anson F C. **Facile attachment of transition metal complexes to graphite electrodes coated with polymeric ligands.** *J. Amer. Chem. Soc.* 101:739-41, 1979. Calif. Inst. Technol., A.A. Noyes Lab., Pasadena, CA.
8	29	37	26	Penn D R. **Effect of bound hole pairs on the *d*-band photoemission spectrum of Ni.** *Phys. Rev. Lett.* 42:921-5, 1979. Natl. Bur. Standards, Washington, DC.
4	37	41	70	Rice M J. **Charged Π-phase kinks in lightly doped polyacetylene.** *Phys. Lett. A* 71:152-4, 1979. Xerox Webster Res. Ctr., Webster, NY; Nordita, Nordisk Inst. Theor. Atom. Phys., Copenhagen, Denmark.
1	40	41	57	Stauffer D. **Scaling theory of percolation clusters.** *Phys. Rep.* 54:1-74, 1979. Cologne Univ., Inst. Theor. Phys., Cologne, FRG.
1	48	49	88	Su W P, Schrieffer J R & Heeger A J. **Solitons in polyacetylene.** *Phys. Rev. Lett.* 42:1698-701, 1979. Univ. Pennsylvania, Dept. Phys., Philadelphia, PA.
3	31	34	29	Tsai C C & Fritzsche H. **Effect of annealing on the optical properties of plasma deposited amorphous hydrogenated silicon.** *Solar Energ. Mater.* 1:29-42, 1979. Univ. Chicago, Dept. Phys. & J. Franck Inst., Chicago, IL.
3	31	34	34	Tsang C & Street R A. **Recombination in plasma-deposited amorphous Si:H. Luminescence decay.** *Phys. Rev. B* 19:3027-40, 1979. Xerox Palo Alto Res. Ctr., Palo Alto, CA.

Elementary Particle Physics (Theoretical)

A	B	C	D	Bibliographic Data
1	31	32	29	Altarelli G, Ellis R K & Martinelli G. **Large perturbative corrections to the Drell-Yan process in QCD.** *Nucl. Phys. B* 157:461-97, 1979. Univ. Rome, Inst. Phys., Rome, Italy; Mass. Inst. Technol., Ctr. Theor. Phys., Cambridge, MA; Natl. Inst. Nucl. Phys., Natl. Lab. Frascati, Frascati, Italy.
0	29	29	18	Brooks B R & Schaefer H F. **The graphical unitary group approach to the electron correlation problem.** *J. Chem. Phys.* 70:5092-106, 1979. Univ. Calif., Dept. Chem., Berkeley, CA.
10	49	59	45	Callan C G, Dashen R F & Gross D J. **A theory of hadronic structure.** *Phys. Rev. D* 19:1826-55, 1979. Princeton Univ.; Inst. Adv. Study, Princeton, NJ.
12	39	51	42	Ellis J, Gaillard M K & Nanopoulos D V. **Baryon number generation in grand unified theories.** *Phys. Lett. B* 80:360-4, 1979. CERN, Geneva, Switzerland; Harvard Univ., Dept. Physics, Cambridge, MA.
9	57	66	41	Ellis R K, Georgi H, Machacek M, Politzer H D & Ross G G. **Perturbation theory and the parton model in QCD.** *Nucl. Phys. B* 152:285-329, 1979. Mass. Inst. Technol., Ctr. Theor. Phys.; Harvard Univ., Lyman Lab. Phys., Cambridge, MA; Calif. Inst. Technol., C.C. Lauritsen Lab. High Energy Phys., Pasadena, CA.
7	30	37	22	Floratos E G, Ross D A & Sachrajda C T. **Higher-order effects in asymptotically free gauge theories.** *Nucl. Phys. B* 152:493-520, 1979. CERN, Geneva, Switzerland.

A	B	C	D	Bibliographic Data
12	19	31	5	Floratos E G, Ross D A & Sachrajda C T. **Detailed description of the violations of Bjorken scaling in QCD (including higher-order corrections).** *Phys. Lett. B* 80:269-74, 1979. CERN, Geneva, Switzerland
4	45	49	52	Georgi H & Nanopoulos D V. **Ordinary predictions from grand principles: t-quark mass in 0(10).** *Nucl. Phys. B* 155:52-74, 1979. Harvard Univ., Lyman Lab. Phys., Cambridge, MA.
10	24	34	17	Georgi H & Nanopoulos D V. **t-quark mass in a super-unified theory.** *Phys. Lett. B* 82:392-4, 1979. Harvard Univ., Lyman Lab. Phys., Cambridge, MA.
4	45	49	35	Goldman T J & Ross D A. **A new estimate of the proton lifetime.** *Phys. Lett. B* 84:208-10, 1979. Calif. Inst. Technol., Pasadena, CA.
3	39	42	58	Harari H. **A schematic model of quarks and leptons.** *Phys. Lett. B* 86:83-6, 1979. Stanford Univ., SLAC, Stanford, CA.
4	26	30	46	Linde A D. **Phase transitions in gauge theories and cosmology.** *Rep. Progr. Phys.* 42:389-437, 1979. Acad. Sci. USSR, P.N. Lebedev Phys. Inst., Moscow, USSR.
10	34	44	35	Nagels M M, Rijken T A, de Swart J J, Oades G C, Petersen J L, Irving A C, Jarlskog C, Pfeil W, Pilkuhn H & Jakob H P. **Compilation of coupling constants and low-energy parameters.** *Nucl. Phys. B* 147:189-276, 1979. Univ. Nijmegen, Nijmegen, the Netherlands; Univ. Aarhus, Aarhus, Denmark, Niels Bohr Inst., Copenhagen, Denmark; Univ. Liverpool, Liverpool, UK, Univ. Bergen, Bergen, Norway; Univ. Bonn, Bonn, FRG. Univ. Karlsruhe, Karlsruhe, FRG.
8	26	34	15	Newman C B, Anderson K J, Coleman R N, Hogan G E, Karhi K P, McDonald K T, Pilcher J E, Rosenberg E I, Sanders G H, Smith A J S & Thaler J J. **Determination of the pion structure function from muon-pair production.** *Phys. Rev. Lett.* 42:951-5, 1979. Univ. Chicago, Enrico Fermi Inst., Chicago, IL; Univ. Illinois, Urbana, IL; Princeton Univ., J. Henry Labs., Princeton, NJ.
8	42	50	71	Shifman M A, Vainshtein A I & Zakharov V I. **QCD and resonance physics. Theoretical foundations.** *Nucl. Phys. B* 147:385-447, 1979. Inst. Theor. Exper. Phys., Moscow, USSR.
5	27	32	57	Shifman M A, Vainshtein A I & Zakharov V I. **QCD and resonance physics. Applications.** *Nucl. Phys. B* 147:448-518, 1979. Inst. Theor. Exper. Phys., Moscow, USSR.
17	61	78	1	Toussaint D, Treiman S B, Wilczek F & Zee A. **Matter-antimatter accounting, thermodynamics, and black hole radiation.** *Phys. Rev. D* 19:1036-45, 1979. Princeton Univ., Princeton, NJ. Univ. Pennsylvania, Philadelphia, PA.
21	75	96	61	Weinberg S. **Cosmological production of baryons.** *Phys. Rev. Lett.* 42:850-3, 1979. Harvard Univ., Lyman Lab. Phys. and Harvard-Smithsonian Ctr. Astrophys., Cambridge, MA.
0	30	30	21	Wilczek F & Zee A. **Operator analysis of nucleon decay.** *Phys. Rev. Lett.* 43:1571-3, 1979. Princeton Univ., Dept. Phys., Princeton, NJ, Univ. Pennsylvania, Dept. Phys., Philadelphia, PA.

Astrophysics

A	B	C	D	Bibliographic Data
11	26	37	20	Abell G O & Margon B. **A kinematic model for SS433.** *Nature* 279:701-3, 1979. Univ. Calif., Dept. Astron., Los Angeles, CA.
13	28	41	42	Bridge H S, Belcher J W, Lazarus A J, Sullivan J D, McNutt R L, Bagenal F, Scudder J D, Sittler E C, Siscoe G L, Vasyliunas V M, Goertz C K & Yeates C M. **Plasma observations near Jupiter: initial results from Voyager 1.** *Science* 204:987-91, 1979. Mass. Inst. Technol., Ctr. Space Res. & Dept. Phys., Cambridge, MA, Goddard Space Flight Ctr., Lab. Extraterrestrial Phys., Greenbelt, MD; Univ. Calif., Dept. Atmospher. Sci., Los Angeles, CA, Max Planck Inst. Aeron., Katlenburg-Lindau, FRG; Calif. Inst. Technol., Jet Propulsion Lab., Pasadena, CA.
23	33	56	54	Broadfoot A L, Belton M J S, Takacs P Z, Sandel B R, Shemansky D E, Holberg J B, Ajello J M, Atreya S K, Donahue T M, Moos H W, Bertaux J L, Blamont J E, Strobel D F, McConnell J C, Dalgarno A, Goody R & McElroy M B. **Extreme ultraviolet observations from Voyager 1 encounter with Jupiter.** *Science* 204:979-82, 1979. Kitt Peak Natl. Observ.; Univ. S. Calif., Space Sci. Inst., Tucson Lab., Tucson, AZ; Planet. Sci. Inst., Jet Propulsion Lab., Pasadena, CA; Univ. Michigan, Ann Arbor, MI; Johns Hopkins Univ., Baltimore, MD; CNRS, Serv. Aeron., Paris, France, Naval Res. Lab., Washington, DC; York Univ., Ontario, Canada, Harvard Univ., Cambridge, MA.
16	43	59	77	Giacconi R, Branduardi G, Briel U, Epstein A, Fabricant D, Feigelson E, Forman W, Gorenstein P, Grindlay J, Gursky H, Harnden F R, Henry J P, Jones C, Kellogg E, Koch D, Murray S, Schreier E, Seward F, Tananbaum H, Topka K, Van Speybroeck L, Holt S S, Becker R H, Boldt E A, Serlemitsos P J, Clark G, Canizares C, Markert T, Novick R, Helfand D & Long K. **The *Einstein* (*HEAO 2*) X-ray observatory.** *Astrophys. J.* 230:540-50, 1979. Harvard-Smithsonian Ctr. Astrophys., Cambridge, MA; Goddard Space Flight Ctr., Lab. High Energy Astrophys., Greenbelt, MD, Mass. Inst. Technol., Ctr. Space Res., Cambridge, MA. Columbia Univ., Columbia Astrophys. Lab., New York, NY.
17	16	33	30	Hanel R, Conrath B, Flasar M, Kunde V, Lowman P, Maguire W, Pearl J, Pirraglia J, Samuelson R, Gautier D, Gierasch P, Kumar S & Ponnamperuma C. **Infrared observations of the Jovian system from Voyager 1.** *Science* 204:972-6, 1979. Goddard Space Flight Ctr., Greenbelt, MD; Paris Observ., Meudon, France, Cornell Univ., Ithaca, NY, Jet Propulsion Lab., Pasadena, CA; Univ. Maryland, College Park, MD
10	68	78	117	Kurucz R L. **Model atmospheres for G, F, A, B, and O stars.** *Astrophys. J. Suppl. Ser.* 40:1-340, 1979. Harvard-Smithsonian Ctr. Astrophys., Cambridge, MA
5	29	34	19	Linsky J L & Haisch B M. **Outer atmospheres of cool stars. I. The sharp division into solar-type and non-solar-type stars.** *Astrophys. J.* 229:L27-L32, 1979. Univ. Colorado and Natl. Bur. Standards, Joint Inst Lab. Astrophys., Boulder, CO
16	26	42	19	Margon B, Ford H C, Katz J I, Kwitter K B, Ulrich R K, Stone R P S & Klemola A. **The bizarre spectrum of SS 433.** *Astrophys. J.* 230:L41-L45, 1979. Univ. Calif., Dept. Astron., Los Angeles, CA, Univ. Calif., Lick Observ., Santa Cruz, CA.
5	28	33	25	Neugebauer G, Oke J B, Becklin E E & Matthews K. **Absolute spectral energy distribution of quasi-stellar objects from 0.3 to 10 microns.** *Astrophys. J.* 230:79-94, 1979. Calif. Inst. Technol. and Carnegie Inst. Washington, Hale Observ., Pasadena, CA
21	11	32	20	Peale S J, Cassen P & Reynolds R T. **Melting of Io by tidal dissipation.** *Science* 203:892-4, 1979. Univ. Calif., Dept. Phys., Santa Barbara, CA; NASA, Ames Res. Ctr., Theor. Planet. Stud. Branch, Moffett Field, CA.
5	26	31	34	Raymond J C. **Shock waves in the interstellar medium.** *Astrophys. J. Suppl. Ser.* 39:1-27, 1979. Univ. Wisconsin, Space Phys. Lab., Madison, WI.
8	29	37	19	Schechter P L & Gunn J E. **Observations of the internal dynamics of 12 elliptical galaxies.** *Astrophys. J.* 229:472-84, 1979. Univ. Arizona, Steward Observ., Tucson, AZ, Calif. Inst. Technol. and Carnegie Inst. Washington, Hale Observ., Pasadena, CA.
2	31	33	34	Scheuer P A G & Readhead A C S. **Superluminally expanding radio sources and the radio-quiet QSOs.** *Nature* 277:182-5, 1979. Mullard Radio Astron. Observ., Cambridge, UK, Calif. Inst. Technol., Pasadena, CA
42	30	72	50	Smith B A, Soderblom L A, Johnson T V, Ingersoll A P, Collins S A, Shoemaker E M, Hunt G E, Masursky H, Carr M H, Davies M E, Cook A F, Boyce J, Danielson G E, Owen T, Sagan C, Beebe R F, Veverka J, Strom R G, McCauley J F, Morrison D, Briggs G A & Suomi V E. **The Jupiter system through the eyes of Voyager 1.** *Science* 204:951-72, 1979. Univ. Arizona, Dept. Planet. Sci., Tucson, AZ; US Geolog. Survey, Flagstaff, AZ. Jet Propulsion Lab., Pasadena, CA, Univ. Coll. London, London, UK, US Geolog. Survey, Menlo Park, CA; Rand Corp., Santa Monica, CA, Smithsonian Astrophys. Observ., Cambridge, MA; SUNY, Dept. Earth Space Sci., Stony Brook, NY, Cornell Univ., Ithaca, NY, New Mexico State Univ., Dept. Astron., Las Cruces, NM, Univ. Hawaii, Inst. Astron., Honolulu, HI, NASA Headquarters, Washington, DC, Univ. Wisconsin, Space Sci. Eng. Ctr., Madison, WI.

A	B	C	D	Bibliographic Data
14	26	40	17	Taylor J H, Fowler L A & McCulloch P M. **Measurements of general relativistic effects in the binary pulsar PSR1913 + 16.** *Nature* 277:437-40, 1979. Univ. Mass., Dept. Phys. Astron., Amherst, MA.
10	21	31	27	Walsh D, Carswell R F & Weymann R J. **0957 + 561 A, B: twin quasistellar objects or gravitational lens?** *Nature* 279:381-4, 1979. Univ. Manchester, Nuffield Radio Astron. Labs., Cheshire, UK; Inst. Astron., Cambridge, UK; Univ. Arizona, Steward Observ., Tucson, AZ.
10	26	36	41	Warwick J W, Pearce J B, Riddle A C, Alexander J K, Desch M D, Kaiser M L, Thieman J R, Carr T D, Gulkis S, Boischot A, Harvey C C & Pedersen B M. **Voyager I planetary radio astronomy observations near Jupiter.** *Science* 204:995-8, 1979. Sci. Applications Inc., Lab. Appl. Plasma Stud., Boulder, CO; Goddard Space Flight Ctr., Lab. Extraterrestrial Phys., Greenbelt, MD; Univ. Florida, Dept. Phys. Astron., Gainesville, FL; Jet Propulsion Lab., Pasadena, CA; Paris Observ., Sect. Astrophys., Meudon, France.
7	34	41	20	Woody D P & Richards P L. **Spectrum of the cosmic background radiation.** *Phys. Rev. Lett.* 42:925-9, 1979. Univ. Calif., Dept. Phys. & Lawrence Berkeley Lab., Berkeley, CA.

Field Theory

A	B	C	D	Bibliographic Data
6	39	45	21	Barger V, Long W F & Pakvasa S. **Constraints on weak-current angles of the six-quark model from the K°-K° system.** *Phys. Rev. Lett.* 42:1585-8, 1979. Univ. Hawaii, Dept. Phys. Astron., Honolulu, HI; Univ. Wisconsin, Dept. Phys., Madison, WI.
3	26	29	45	Creutz M, Jacobs L & Rebbi C. **Experiments with a gauge-invariant Ising system.** *Phys. Rev. Lett.* 42:1390-3, 1979. Brookhaven Natl. Lab., Dept. Phys., Upton, NY.
3	29	32	52	Dimopoulos S & Susskind L. **Mass without scalars.** *Nucl. Phys. B* 155:237-52, 1979. Columbia Univ., Dept. Phys., New York, NY; Stanford Univ., Dept. Phys., Stanford, CA.
3	32	35	34	Elitzur S, Pearson R B & Shigemitsu J. **Phase structure of discrete Abelian spin and gauge systems.** *Phys. Rev. D* 19:3698-714, 1979. Inst. Adv. Study, Princeton, NJ.
2	27	29	36	Georgi H. **Towards a grand unified theory of flavor.** *Nucl. Phys. B* 156:126-34, 1979. Harvard Univ., Lyman Lab. Phys., Cambridge, MA.
11	31	42	21	Gervais J L & Neveu A. **The quantum dual string wave functional in Yang-Mills theories.** *Phys. Lett. B* 80:255-8, 1979. Ecole Normale Superieure, Lab. Phys. Theor., Paris, France.
2	49	51	47	Marciano W J. **Weak mixing angle and grand unified gauge theories.** *Phys. Rev. D* 20:274-88, 1979. Rockefeller Univ., New York, NY.
12	40	52	32	Nambu Y. **QCD and the string model.** *Phys. Lett. B* 80:372-6, 1979. Univ. Chicago, Enrico Fermi Inst. & Dept. Phys., Chicago, IL.
7	45	52	76	Polyakov A M. **String representations and hidden symmetries for gauge fields.** *Phys. Lett. B* 82:247-50, 1979. Landau Inst. Theor. Phys., Moscow, USSR.
8	38	46	20	Shrock R E, Treiman S B & Wang L L. **Bounds on quark mixing angles in the standard six-quark model.** *Phys. Rev. Lett.* 42:1589-92, 1979. Princeton Univ., Dept. Phys., Princeton, NJ; Brookhaven Natl. Lab., Dept. Phys., Upton, NY.
0	32	32	29	t'Hooft G. **A property of electric and magnetic flux in non-Abelian gauge theories.** *Nucl. Phys. B* 153:141-60, 1979. Univ. Utrecht, Inst. Theor. Phys., Utrecht, the Netherlands.
0	30	30	29	Weinberg S. **Baryon- and lepton-nonconserving processes.** *Phys. Rev. Lett.* 43:1566-70, 1979. Harvard Univ., Lyman Lab. Phys. & Harvard-Smithsonian Ctr. Astrophys., Cambridge, MA.
8	38	46	25	Weinberg S. **Gauge hierarchies.** *Phys. Lett. B* 82:387-91, 1979. Harvard Univ., Lyman Lab. Phys., Cambridge, MA.
9	35	44	27	Wilczek F & Zee A. **Horizontal interaction and weak mixing angles.** *Phys. Rev. Lett.* 42:421-5, 1979. Princeton Univ., Dept. Phys., Princeton, NJ; Univ. Pennsylvania, Dept. Phys., Philadelphia, PA.
16	47	63	33	Witten E. **Instantons, the quark model, and the 1/N expansion.** *Nucl. Phys. B* 149:285-320, 1979. Harvard Univ., Lyman Lab. Phys., Cambridge, MA.

Elementary Particle Physics (Experimental)

A	B	C	D	Bibliographic Data
4	26	30	14	Abrams G S, Alam M S, Blocker C A, Boyarski A M, Breidenbach M, Broll C H, Burke D L, Carithers W C, Chinowsky W, Coles M W, Cooper S, Dieterle W E, Dillon J B, Dorenbosch J, Dorfan J M, Eaton M W, Feldman G J, Franklin M E B, Gidal G, Goldhaber G, Hanson G, Hayes K G, Himel T, Hitlin D G, Hollebeek R J, Innes W R, Jaros J A, Jenni P, Johnson A D, Kadyk J A, Lankford A J, Larsen R R, Luke D, Luth V, Millikan R E, Nelson M E, Pang C Y, Patrick J F, Perl M L, Richter B, Russell J J, Scharre D L, Schindler R H, Schwitters R F, Siegrist J L, Strait J, Taureg H, Tonutti M, Trilling G H, Vella E N, Vidal R A, Videau I, Weiss J M & Zaccone H. **Observation of Cabibbo-suppressed decay $D^{\circ}\to\pi^-\pi^+$ and $D^{\circ}\to K^- K^+$.** *Phys. Rev. Lett.* 43:481-3, 1979. Stanford Univ., SLAC, Stanford, CA; Univ. Calif., Lawrence Berkeley Lab. & Dept. Phys., Berkeley, CA.
8	30	38	22	Anderson K J, Coleman R N, Hogan G E, Karhi K P, McDonald K T, Newman C B, Pilcher J E, Rosenberg E I, Sanders G H, Smith A J S & Thaler J J. **Production of muon pairs by 225-GeV/c $\pi^\pm$, K^+, $p^\pm$ beams on nuclear targets.** *Phys. Rev. Lett.* 42:944-7, 1979. Univ. Chicago, Enrico Fermi Inst., Chicago, IL; Univ. Illinois, Urbana, IL; Princeton Univ., J. Henry Labs., Princeton, NJ.
0	50	50	39	Barber D P, Becker U, Benda H, Boehm A, Branson J G, Bron J, Buikman D, Burger J, Chang C C, Chen H S, Chen M, Cheng C P, Chu Y S, Clare R, Duinker P, Fang G Y, Fesefeldt H, Fong D, Fukushima M, Guo J C, Hariri A, Herten G, Ho M C, Hsu H K, Hsu T T, Kadel R W, Krenz W, Li J, Li Q Z, Lu M, Luckey D, Ma D A, Ma C M, Massaro G G G, Matsuda T, Newman H, Paradiso J, Poschmann F P, Revol J P, Rohde M, Rykaczewski H, Sinram K, Tang H W, Tang L G, Ting S C C, Tung K L, Vannucci F, Wang X R, Wei P S, White M, Wu G H, Wu T W, Xi J P, Yang P C, Yu X H, Zhang N L & Zhu R Y. **Discovery of three-jet events and a test of quantum chromodynamics at PETRA.** *Phys. Rev. Lett.* 43:830-3, 1979. Rhine-Westphalia Tech. Univ., III. Phys. Inst., Aachen, FRG; German Electron-Synchrotron (DESY), Hamburg, FRG; Mass. Inst. Technol., Lab. Nucl. Sci., Cambridge, MA; Natl. Inst. Nucl. Phys. & High Energy Phys. (NIKHEF), Amsterdam, the Netherlands; Chinese Acad. Sci., Inst. High Energy Phys., Peking, China.
0	34	34	39	Berger C, Genzel H, Grigull R, Lackas W, Raupach F, Klovning A, Lillestol E, Lillethun E, Skard J A, Ackermann H, Alexander G, Barreiro F, Burger J, Criegee L, Dehne H C, Devenish R, Eskreys A, Flugge G, Franke G, Gabriel W, Gerke C, Knies G, Lehmann E, Mertiens H D, Pape K H, Reich H D, Stella B, Ranga Swamy T N, Timm U, Wagner W, Waloschek P, Winter G G, Zimmermann W, Achterberg O, Blobel V, Boesten L, Kapitza H, Koppitz B, Luhrsen W, Maschuw R, van Staa R, Spitzer H, Chang C Y, Glasser R G, Kellogg R G, Lau K H, Sechi-Zorn B, Skuja A, Welch G, Zorn G T, Backer A, Brandt S, Derikum K, Diekmann A, Grupen C, Meyer H J, Neumann B, Rost M, Zech G, Azemoon T, Daum H J, Meyer H, Meyer O, Rossler M, Schmidt D & Wacker K. **Evidence for gluon bremsstrahlung in e^+e^- annihilations at high energies.** *Phys. Lett. B* 86:418-25, 1979. Rhine-Westphalia Tech. Univ., I. Phys. Inst., Aachen, FRG; Univ. Bergen, Bergen, Norway; German Electron-Synchrotron (DESY), Univ. Hamburg, II. Inst. Exper. Phys., Hamburg, FRG; Univ. Maryland, College Park, MD; Siegen Univ., Siegen, FRG; Wuppertal Univ., Wuppertal, FRG.

A	B	C	D	Bibliographic Data
5	30	35	21	Berger C, Genzel H, Grigull R, Lackas W, Raupach F, Wagner W, Klovning A, Lillestol E, Lillethun E, Skard J A, Ackermann H, Alexander G, Barreiro F, Burger J, Criegee L, Dehne H C, Devenish R, Flugge G, Franke G, Gabriel W, Gerke C, Horlitz G, Knies G, Lehmann E, Mertiens H D, Neumann B, Pape K H, Reich H D, Stella B, Timm U, Waloschek P, Winter G G, Wolff S, Zimmermann W, Achterberg O, Blobel V, Boesten L, Kapitza H, Koppitz B, Luhrsen W, Maschuw R, van Staa R, Spitzer H, Chang C Y, Glasser R G, Kellog R G, Lau K H, Sechi-Zorn B, Skuja A, Welch G, Zorn G T, Backer A, Brandt S, Derikum K, Grupen C, Meyer H J, Rost M, Zech G, Azemoon T, Daum H J, Meyer H, Meyer O, Rossler M, Schmidt D & Wacker K. **First observation of hadron production in e^+e^- collisions at 13 and 17 GeV CMS energy with the PLUTO detector at PETRA.** *Phys. Lett. B* 81:410-5, 1979. Rhine-Westphalia Tech. Univ., I. Phys. Inst., Aachen, FRG; Univ. Bergen, Bergen, Norway; German Electron-Synchrotron (DESY), Univ. Hamburg, II. Inst. Exper. Phys., Hamburg, FRG; Univ. Maryland, College Park, MD; Siegen Univ., Siegen, FRG; Wuppertal Univ., Wuppertal, FRG.
0	47	47	41	Brandelik R, Braunschweig W, Gather K, Kadansky V, Lubelsmeyer K, Mattig P, Martyn H U, Peise G, Rimkus J, Sander H G, Schmitz D, Schultz von Dratzig A, Trines D, Wallraff W, Boerner H, Fischer H M, Hartmann H, Hilger E, Hillen W, Knop G, Korbach W, Leu P, Lohr B, Roth F, Ruhmer W, Wedemeyer R, Wermes N, Wollstadt M, Buhring R, Fohrmann R, Heyland D, Hultschig H, Joos P, Koch W, Kotz U, Kowalski H, Ladage A, Luke D, Lynch H L, Mikenberg G, Notz D, Pyrlik J, Riethmuller R, Schliwa M, Soding P, Wiik B H, Wolf G, Holder M, Poelz G, Ringel J, Romer O, Rusch R, Schmuser P, Binnie D M, Dornan P J, Downie N A, Garbutt D A, Jones W G, Lloyd S L, Pandoulas D, Pevsner A, Sedgebeer J, Yarker S, Youngman C, Barlow R J, Cashmore R J, Illingworth J, Ogg M, Salmon G L, Bell K W, Chinowsky W, Foster B, Hart J C, Proudfoot J, Quarrie D R, Saxon D H, Woodworth P L, Eisenberg Y, Karshon U, Kogan E, Revel D, Ronat E, Shapira A, Freeman J, LeComte P, Meyer T, Wu S L & Zobernig G. **Evidence for planar events in e^+e^- annihilation at high energies.** *Phys. Lett. B* 86:243-9, 1979. Rhine-Westphalia Tech. Univ., I. Phys. Inst. Aachen, FRG; Univ. Bonn, Phys. Inst., Bonn, FRG; German Electron-Synchrotron (DESY); Univ. Hamburg, II. Inst. Exper. Phys., Hamburg, FRG; Imperial Coll., Dept. Phys., London, UK; Oxford Univ., Dept. Nucl. Phys., Oxford, UK; Rutherford Lab., Chilton, UK; Weizmann Inst., Rehovot, Israel; Univ. Wisconsin, Dept. Phys., Madison, WI.
1	29	30	22	Brandelik R, Braunschweig W, Gather K, Jaax B, Kadansky V, Lubelsmeyer K, Martyn H U, Peise G, Rimkus J, Sander H G, Schmitz D, Schultz von Dratzig A, Trines D, Wallraff W, Boerner H, Fischer H M, Hartmann H, Hilger E, Hillen W, Knop G, Korbach W, Lohr B, Roth F, Ruhmer W, Wedemeyer R, Wermes N, Wollstadt M, Buhring R, Heyland D, Hultschig H, Joos P, Koch W, Kotz U, Kowalski H, Ladage A, Luke D, Lynch H L, Mikenberg G, Notz D, Pyrlik J, Riethmuller R, Schliwa M, Soding P, Wiik B H, Wolf G, Fohrmann R, Poelz G, Ringel J, Romer O, Rusch R, Schmuser P, Binnie D M, Dornan P J, Downie N A, Garbutt D A, Jones W G, Lloyd S L, Pandoulas D, Youngman C, Barlow R J, Cashmore R J, Illingworth J, Ogg M, Salmon G L, Bell K W, Chinowsky W, Foster B, Hart J C, Proudfoot J, Quarrie D R, Saxon D H, Woodworth P L, Eisenberg Y, Karshon U, Kogan E, Revel D, Ronat E, Shapira A, Freeman J, LeComte P, Meyer T, Wu S L & Zobernig G. **Properties of hadron final states in e^+e^- annihilation at 13 GeV and 17 GeV center of mass energies.** *Phys. Lett. B* 83:261-6, 1979. Rhine-Westphalia Tech. Univ., I. Phys. Inst. Aachen, FRG; Univ. Bonn, Phys. Inst., Bonn, FRG; German Electron-Synchrotron (DESY); Univ. Hamburg, II. Inst. Exper. Phys., Hamburg, FRG; Imperial Coll., Dept. Phys., London, UK; Oxford Univ., Dept. Nucl. Phys., Oxford, UK; Rutherford Lab., Chilton, UK; Weizmann Inst., Rehovot, Israel; Univ. Wisconsin, Dept. Phys., Madison, WI.
6	35	41	16	Conti R, Bucksbaum P, Chu S, Commins E & Hunter L. **Preliminary observation of parity nonconservation in atomic thallium.** *Phys. Rev. Lett.* 42:343-6, 1979. Univ. Calif., Dept. Phys. & Lawrence Berkeley Lab., Berkeley, CA.
16	18	34	17	LaRue G S, Fairbank W M & Phillips J D. **Further evidence for fractional charge of 1/3e on matter.** *Phys. Rev. Lett.* 42:142-5, 1979. Stanford Univ., Dept. Phys., Stanford, CA.
1	28	29	24	Prescott C Y, Atwood W B, Cottrell R L A, DeStaebler H, Garwin E L, Gonidec A, Miller R H, Rochester L S, Sato T, Sherden D J, Sinclair C K, Stein S, Taylor R E, Young C, Clendenin J E, Hughes V W, Sasao N, Schuler K P, Borghini M G, Lubelsmeyer K & Jentschke W. **Further measurements of parity non-conservation in inelastic electron scattering.** *Phys. Lett. B* 84:524-8, 1979. Stanford Univ., SLAC, Stanford, CA; Yale Univ., New Haven, CT; CERN, Geneva, Switzerland; Rhine-Westphalia Tech. Univ., Aachen, FRG; Univ. Hamburg, II. Inst. Exper. Phys., Hamburg, FRG.
6	28	34	27	Stricker K, McManus H & Carr J A. **Nuclear scattering of low energy pions.** *Phys. Rev. C* 19:929-47, 1979. Michigan State Univ., Depts. Phys. & Astron., East Lansing, MI.
4	27	31	12	Ueno K, Brown B C, Brown C N, Innes W R, Kephart R D, Yamanouchi T, Herb S W, Hom D C, Lederman L M, Snyder H D, Yoh J K, Fisk R J, Ito A S, Jostlein H & Kaplan D M. **Evidence for the Υ' and a search for new narrow resonances.** *Phys. Rev. Lett.* 42:486-9, 1979. Fermi Natl. Accel. Lab., Batavia, IL; Columbia Univ., New York, NY; SUNY, Stony Brook, NY.

Organic & Organometallic Chemistry

A	B	C	D	Bibliographic Data
11	33	44	40	Corey E J & Schmidt G. **Useful procedures for the oxidation of alcohols involving pyridinium dichromate in aprotic media.** *Tetrahedron Lett.* 5:399-402, 1979. Harvard Univ., Dept. Chem., Cambridge, MA.
2	38	40	42	Jones R D, Summerville D A & Basolo F. **Synthetic oxygen carriers related to biological systems.** *Chem. Rev.* 79:139-79, 1979. Northwestern Univ., Dept. Chem., Evanston, IL.
6	35	41	35	Krasna A I. **Proflavin catalyzed photoproduction of hydrogen from organic compounds.** *Photochem. Photobiol.* 29:267-76, 1979. Columbia Univ., Coll. Physicians, Dept. Biochem., New York, NY.
12	27	39	33	Reich H J. **Functional group manipulation using organoselenium reagents.** *Account. Chem. Res.* 12:22-30, 1979. Univ. Wisconsin, Dept. Chem., Madison, WI.
5	24	29	33	Schrock R R. **Alkylidene complexes of niobium and tantalum.** *Account. Chem. Res.* 12:98-104, 1979. Mass. Inst. Technol., Dept. Chem., Cambridge, MA.
8	25	33	41	Seebach D. **Methods of reactivity umpolung.** *Angew. Chem. Int. Ed.* 18:239-58, 1979. Swiss Fed. Inst. Technol. (ETH), Lab. Org. Chem., Zurich, Switzerland.
6	23	29	25	Torrance J B. **The difference between metallic and insulating salts of tetracyanoquinodimethane (TCNQ): how to design an organic metal.** *Account. Chem. Res.* 12:79-86, 1979. IBM Res. Lab., San Jose, CA.

Physical Chemistry

A	B	C	D	Bibliographic Data
5	27	32	26	Almgren M, Grieser F & Thomas J K. **Dynamic and static aspects of solubilization of neutral arenes in ionic micellar solutions.** *J. Amer. Chem. Soc.* 101:279-91, 1979. Univ. Notre Dame, Radiat. Lab., Notre Dame, IN.
2	39	41	23	Efrima S & Metiu H. **Classical theory of light scattering by an adsorbed molecule. I. Theory.** *J. Chem. Phys.* 70:1602-13, 1979. Univ. Calif., Dept. Chem., Santa Barbara, CA.
2	28	30	19	Efrima S & Metiu H. **Light scattering by a molecule near a solid surface. II. Model calculations.** *J. Chem. Phys.* 70:2297-309, 1979. Univ. Calif., Dept. Chem., Santa Barbara, CA.
1	33	34	13	Efrima S & Metiu H. **Resonant Raman scattering by adsorbed molecules.** *J. Chem. Phys.* 70:1939-47, 1979. Univ. Calif., Dept. Chem., Santa Barbara, CA.
8	21	29	20	Sudbo A S, Schulz P A, Grant E R, Shen Y R & Lee Y T. **Simple bond rupture reactions in multiphoton dissociation of molecules.** *J. Chem. Phys.* 70:912-9, 1979. Univ. Calif., Lawrence Berkeley Lab., Berkeley, CA.

Earth Science

A	B	C	D	Bibliographic Data
12	37	49	49	Corliss J B, Dymond J, Gordon L I, Edmond J M, von Herzen R P, Ballard R D, Green K, Williams D, Bainbridge A, Crane K & van Andel T H. **Submarine thermal springs on the Galapagos rift.** *Science* 203:1073-83, 1979. Oregon State Univ., Sch. Oceanogr., Corvallis, OR; Mass. Inst. Technol., Dept. Earth Planet. Sci., Cambridge, MA; Woods Hole Oceanogr. Inst., Woods Hole, MA; US Geolog. Survey, Fed. Ctr., Denver, CO; Scripps Inst. Oceanogr., La Jolla, CA. Stanford Univ., Dept. Geol. Geophys., Stanford, CA.

Figure 2: The 1979 physical sciences articles which are among the 100 most cited in 1979-1981, and which do not appear in the original list mainly because of late publication dates. A=1979 citations. B=1980 citations. C=1981 citations. D=total 1979-81 citations.

A	B	C	D	
7	21	28	56	Brown G M, Brunschwig B S, Creutz C, Endicott J F & Sutin N. **Homogeneous catalysis of the photoreduction of water by visible light. Mediation by a tris(2,2′-bipyridine)ruthenium(II)-cobalt(II) macrocycle system.** *J. Amer. Chem. Soc.* 101:1298-300, 1979. Brookhaven Natl. Lab., Dept. Chem., Upton, NY.
3	25	30	58	DeLaive P J, Sullivan B P, Meyer T J & Whitten D J. **Applications of light-induced electron-transfer reactions. Coupling of hydrogen generation with photoreduction of ruthenium(II) complexes by triethylamine.** *J. Amer. Chem. Soc.* 101:4007-8, 1979. Univ. N. Carolina, Dept. Chem., Chapel Hill, NC.
1	27	34	62	Evans D A, Vogel E & Nelson J V. **Stereoselective aldol condensations via boron enolates.** *J. Amer. Chem. Soc.* 101:6120-3, 1979. Calif. Inst. Technol., Labs. Chem., Pasadena, CA.
0	26	47	73	Faber S M & Gallagher J S. **Masses and mass-to-light ratios of galaxies.** *Annu. Rev. Astron. Astrophys.* 17:135-87, 1979. Univ. Calif., Board Stud. Astron. Astrophys., Santa Cruz, CA; Univ. Illinois, Dept. Astron., Urbana, IL.
1	25	36	62	Kalyanasundaram K & Gratzel M. **Cyclic cleavage of water into H_2 and O_2 by visible light with coupled redox catalysts.** *Angew. Chem. Int. Ed.* 18:701-2, 1979. Ecole Polytech. Fed., Inst. Chem. Phys., Lausanne, Switzerland.
12	15	41	68	Ness N F, Acuna M H, Lepping R P, Burlaga L F, Behannon K W & Neubauer F M. **Magnetic field studies at Jupiter by Voyager 1: preliminary results.** *Science* 204:982-7, 1979. Goddard Space Flight Ctr., Greenbelt, MD; Tech. Univ., Braunschweig, FRG.
4	24	32	60	Pfeffer P E, Valentine K M & Parrish F W. **Deuterium-induced differential isotope shift ^{13}C NMR. 1. Resonance reassignments of mono- and disaccharides.** *J. Amer. Chem. Soc.* 101:1265-74, 1979. US Dept. Agr., Eastern Region. Res. Ctr., Philadelphia, PA.
1	27	50	78	Shupe M A. **A composite model of leptons and quarks.** *Phys. Lett. B* 86:87-92, 1979. Univ. Illinois, Dept. Phys., Urbana, IL.
0	27	76	103	Susskind L. **Dynamics of spontaneous symmetry breaking in the Weinberg-Salam theory.** *Phys. Rev. D* 20:2619-25, 1979. Stanford Univ., SLAC, Stanford, CA.
7	20	37	64	Sutin N. **Light-induced electron transfer reactions.** *J. Photochem.* 10:19-40, 1979. Brookhaven Natl. Lab., Dept. Chem., Upton, NY.
3	24	26	53	Teo B K & Lee P A. **Ab initio calculations of amplitude and phase functions for extended X-ray absorption fine structure spectroscopy.** *J. Amer. Chem. Soc.* 101:2815-32, 1979. Bell Labs., Murray Hill, NJ.

authors. Six papers have more than 50 authors—among them, one paper has 88 authors, while another has 83. All of the papers with more than 50 authors are from the field of experimental elementary particle physics.

One hundred and thirty-eight authors have two papers in Figure 1, but only 11 have three. They are: J. Bürger, S. Efrima, A.J. Heeger, K. Lübelsmeyer, D. Lüke, H. Metiu, D.V. Nanopoulos, D.A. Ross, S. Weinberg, F. Wilczek, and A. Zee. One author, H. Georgi, has four papers on the list.

The papers were published in the 24 journals listed in Table 2. The top three journals published just less than half of the papers. These journals are *Physical Review Letters*, *Physics Letters B*, and *Nuclear Physics B*. *Physical Review Letters* has topped the journal list each year since we examined the highly cited physical sciences articles of 1976.[3-5]

The authors in this study came from the 86 institutions listed in Table 3. Forty-eight of these institutions are in the US. In our study of the 1978 physical sciences papers, the US had 44 institutions.[5] The Federal Republic of Germany has ten institutions, the UK has six, and France has five. Denmark, Italy, and the Netherlands each have three institutions. Switzerland has two, although one of these, CERN, is actually a consortium of 12 European nations. Canada, China, Israel, Japan, Norway, and the USSR each have one institution in this study. All of the papers in Figure 1 were published in English.

Harvard University produced more papers, 15, than any other institution. The University of California produced

Table 1: 1981 *ISR*™ research fronts which contain two or more 1979 most-cited physical sciences papers as core documents. A = research front number. B = research front name. C = number of 1979 most-cited physical sciences papers included in the core of each research front.

A	B	C
81-0181	*Perturbative quantum chromodynamics, hadron jets, structure functions, and quarks*	9
81-0257	Radio observations, kinematical analysis, and the structure of the galactic radio source SS433	2
81-0306	Effects of Anderson localization in disordered systems on magnetoresistance, conductance, and Zeeman splitting	4
81-0312	Grand unified theories, proton decay, neutrino masses, flavor dynamics, and Higgs boson in the SO(10) model	9
81-0313	Relations between cosmology and grand unified theories, elementary particles, phase transitions, and black hole production	4
81-0314	Lattice gauge theory, quark confinement, and strong and weak coupling	3
81-0315	Flavor dynamics of quarks and leptons, Higgs particle mixing, and the structure of neutral currents	2
81-0316	Quantum chromodynamics as a dynamics of loops, the loop space solution of 2-dimensional quantum chromodynamics, and the large N limit for Euclidean field theories	3
81-0421	Surface-enhanced Raman scattering	2
81-0470	Water cleavage into hydrogen and oxygen by visible light	3
81-0498	Kosterlitz-Thouless phase transitions, renormalization, and the 2-dimensional ferromagnetic planar model	3
81-0508	Properties of amorphous hydrogenated silicon, with emphasis on preparation by sputtering	2
81-0554	Electronic structure and magnetism of iron clusters	2
81-0646	Composition and flow of ions in Jupiter's magnetosphere and Io's plasma torus	6
81-0704	Neutral currents, structure and relationship to muon electron scattering and nuclear dynamic resonance	2
81-0731	Solitons in doped polyacetylene	4
81-0932	Studies of electrodes coated with polymer-bound complexes	2
81-2230	Sum rules, duality, chiral symmetry breaking, and phase transitions in quantum chromodynamics	2

13. Interestingly, CERN accounts for just four papers this time. In our study of 1977 papers, CERN produced seven.[4] And in 1978, CERN produced 19![5]

The papers in Figure 1 fall under eight broad subject headings: the physics of condensed matter, elementary particle physics (theoretical), astrophysics, field theory, elementary particle physics (experimental), organic and organometallic chemistry, physical chemistry, and earth science. Clearly, papers in chemistry are not as well represented because there is a longer "incubation period." Eventually, many of these papers will go on to have even greater impact. This will be demonstrated in a separate study of chemistry papers.

Twenty-eight papers in Figure 1 are from condensed matter physics, a subject field that includes what used to be called solid-state physics. The heavy representation of condensed matter physics in this study comes as no surprise since, according to Theodore Geballe, Center for Materials Research, Stanford University, more than 25 percent of all American physicists are condensed matter physicists.[6] The paper by T. Miya and colleagues, the second most cited on the list, received 87 citations in the two-year period. It discusses the development of a highly efficient optical fiber. The third most-cited paper, by E. Abrahams and colleagues, received 80 citations. It is concerned with scaling theories, which describe changes in matter states at extremes of temperature and in magnetic fields.

Incidentally, the paper by D. Stauffer describes "percolation clusters." In the introduction to this long review, Stauffer used the Permuterm® Subject Index of *SCI* and the Weekly Subject Index of *Current Contents*® (*CC*®) to describe the recent growth in the literature on percolation.

Theoretical papers in elementary particle physics account for 19 papers. This group includes the most-cited paper on the list, by Nobel laureate S. Weinberg, which received 96 citations. The one by

Table 2: The 24 journals represented on the list of 105 physical sciences papers most cited in 1979-1980. The numbers in parentheses are the impact factors for the journals. (Impact equals the average number of citations received by articles published in that journal.) Data were taken from the 1979 *Journal Citation Reports®* of *SCI®*. The figures at the right indicate the number of papers from each journal which appear on the list.

Phys. Rev. Lett. (5.9)	26
Phys. Lett. B (3.9)	14
Nucl. Phys. B (3.9)	11
Astrophys. J. (4.1)	7
Science (5.9)	7
J. Chem. Phys. (2.8)	6
Phys. Rev. B-Condensed Matter (2.8)	5
J. Amer. Chem. Soc. (5.1)	4
Nature (5.9)	4
Phys. Rev. D-Part. Fields (2.5)	4
Account. Chem. Res. (8.2)	3
Chem. Rev. (10.7)	2
Angew. Chem. Int. Ed. (5.0)	1
Electron. Lett. (0.9)	1
J. Appl. Phys. (1.7)	1
Nouv. J. Chim. (2.1)	1
Photochem. Photobiol. (2.4)	1
Phys. Lett. A (1.2)	1
Phys. Rep. (6.9)	1
Phys. Rev. C-Nucl. Phys. (1.4)	1
Rep. Progr. Phys. (4.2)	1
Solar Energ. Mater. (1.1)	1
Solid State Commun. (1.9)	1
Tetrahedron Lett. (2.1)	1
Total	105

Table 3: The institutional affiliations of authors on the list, and the number of papers produced by each institution.

Acad. Sci. USSR, Moscow, USSR		4
L.D. Landau Inst. Theor. Phys.	3	
P.N. Lebedev Phys. Inst.	1	
Bell Labs., Murray Hill, NJ		5
Brookhaven Natl. Lab., Upton, NY		2
California Inst. Technology, Pasadena, CA		11
Carnegie Inst. Washington, Pasadena, CA		2
CERN, Geneva, Switzerland		4
Chinese Acad. Sci., Peking, China		1
Cologne Univ., FRG		1
Columbia Univ., New York, NY		4
Cornell Univ., Ithaca, NY		4
CNRS, Paris, France		2
Ecole Normale Supérieure, Paris, France		1
Fermi Natl. Accelerator Lab., Batavia, IL		1
German Electron-Synchrotron (DESY), Hamburg, FRG		5
Harvard Univ., Cambridge, MA[1]		15
IBM		5
Res. Lab., San Jose, CA	2	
Thomas J. Watson Res. Ctr., Yorktown Heights, NY	3	
Inst. Advanced Study, Princeton, NJ		2
Inst. Laue-Langevin, Grenoble, France		1
Johns Hopkins Univ., Baltimore, MD		1
Jülich Nuclear Res. Ctr., FRG		1
Kitt Peak Natl. Observ., Tucson, AZ		1
Louis Pasteur Univ., Strasbourg, France		1
Massachusetts Inst. Technol., Cambridge, MA		8
Max Planck Inst. Aeron., Katlenburg-Lindau, FRG		1
Michigan State Univ., East Lansing, MI		1
NASA		6
Ames Res. Ctr., Moffett Field, CA	1	
Goddard Space Flight Ctr., Greenbelt, MD	4	
Headquarters, Washington, DC	1	
Natl. Bureau Standards		2
Boulder, CO	1	
Washington, DC	1	
Natl. Inst. Nucl. Phys., Frascati, Italy		1
Natl. Inst. Nucl. Phys. & High Energy Phys. (NIKHEF), Amsterdam, the Netherlands		1
Naval Res. Lab., Washington, DC		1
New Mexico State Univ., Las Cruces, NM		1
Niels Bohr Inst., Copenhagen, Denmark		1
Nippon Telegraph & Telephone Public Corp., Tokyo, Japan		1
Nordisk Inst. Theor. Atomic Phys. (Nordita), Copenhagen, Denmark		1
Northwestern Univ., Evanston, IL		1
Oregon State Univ., Corvallis, OR		1
Oxford Univ., UK		2
Paris Observ., Meudon, France		2
Planet Sci. Inst., Pasadena, CA		1
Princeton Univ., NJ		9
Rand Corporation, Santa Monica, CA		1
Rhine-Westphalia Tech. Univ., FRG		6
Rockefeller Univ., New York, NY		1
Rockwell Internatl. Sci. Ctr., Thousand Oaks, CA		1
Rutgers Univ., Piscataway, NJ		2
Rutherford Lab., Chilton, UK		2
Science Applications Inc., Boulder, CO		1
Scripps Inst. Oceanography, La Jolla, CA		1
Siegen Univ., FRG		2
Stanford Univ., CA[2]		7
SUNY, Stony Brook, NY		2
Swiss Fed. Inst. Technol. (ETH), Zurich, Switzerland		1
Univ. Aarhus, Denmark		1
Univ. Arizona, Tucson, AZ		3
Univ. Bergen, Norway		3
Univ. Bonn, FRG		3
Univ. California, CA		13
Berkeley	5	
Los Angeles	3	
Santa Barbara	4	
Santa Cruz	1	
Univ. Cambridge, UK		2
Univ. Catania, Italy		1
Univ. Chicago, IL		4
Univ. Colorado, Boulder, CO		1
Univ. Florida, Gainesville, FL		1
Univ. Hamburg, FRG		5
Univ. Hawaii, Honolulu, HI		2
Univ. Illinois, Urbana, IL		2
Univ. Karlsruhe, FRG		1
Univ. Liverpool, UK		1
Univ. London		3
Univ. Manchester, Cheshire, UK		1
Univ. Maryland, College Park, MD		3
Univ. Massachusetts, Amherst, MA		1

Univ. Michigan, Ann Arbor, MI		1
Univ. Nijmegen, the Netherlands		1
Univ. Notre Dame, IN		1
Univ. Pennsylvania, Philadelphia, PA		6
Univ. Rome, Italy		1
Univ. S. California, Tucson, AZ		1
Univ. Utrecht, the Netherlands		1
Univ. Wisconsin, Madison, WI		6
US Geological Survey		3
Denver, CO	1	
Flagstaff, AZ	1	
Menlo Park, CA	1	
Weizmann Inst., Rehovot, Israel		2
Woods Hole Oceanographic Inst., MA		1
Wuppertal Univ., FRG		2
Xerox		3
Palo Alto Res. Ctr., CA	2	
Webster Res. Ctr., NY	1	
Yale Univ., New Haven, CT		1
York Univ., Ontario, Canada		1

[1]Includes Harvard-Smithsonian Ctr. for Astrophysics
[2]Includes SLAC

D. Toussaint and colleagues received 78 citations and is tied for the fourth most cited with the astrophysics paper by R.L. Kurucz. Both the Weinberg and the Toussaint papers discuss the number of baryons (protons and neutrons) in the universe, with a view toward explaining why there is more matter than antimatter. Five other papers in this group deal with quantum chromodynamics (QCD). The "strong force" which holds the nucleus of an atom together is described in terms of QCD.

The field of astrophysics produced 18 papers. The one by Kurucz, which received 78 citations in the two-year period, discusses the atmosphere of certain types of stars. Five astrophysics papers discuss observations made as a result of the *Voyager 1* mission to Jupiter.

Fifteen papers in Figure 1 are concerned with field theory. Field theory attempts to explain the fundamental forces of nature in terms of a single theoretical framework, or unified field theory. Five papers in this group are concerned with gauge theories, which provide a common form for describing the four known forces of nature.

Experimental elementary particle physics contributed 12 papers to the list. Much research in this field requires the use of gigantic particle accelerators, which shoot particles into bubble chambers where their behavior can be recorded and studied. These experiments require enormous collaborative effort. The *average* number of authors for papers in this group is a whopping 39. In our study of the 1978 physical sciences papers, experimental particle physics papers averaged "only" 24 authors.[5]

Seven papers are on various topics in organic and organometallic chemistry, and five are from physical chemistry. The three physical chemistry papers by S. Efrima and H. Metiu discuss a theory which they've developed concerning the scattering of light by molecules on the surface of a solid.

Only one paper in Figure 1 is from the earth sciences. We will do a separate study of this field in the future.

We have now published lists of the most-cited articles in the life and physical sciences for each year since 1970. This series will continue when data are available for the 1980 articles that were among the most cited in 1980-1982.

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My thanks to Thomas Di Julia and Dorothy Silver for their help in the preparation of this essay.

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