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Current Comments

1978 Articles Most Cited in 1978 and 1979. 1. Physical Sciences

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This is the latest in a series of essays in which we identify "hot disciplines" of science by listing a select group of papers that are well cited shortly after publication. In previous essays this year, we published data on the most-cited papers of 1977.[1,2] Now we've compiled similar data for 1978 papers. This essay discusses the physical sciences articles most cited in 1978 and 1979. The next part will cover the life sciences. Our past experience indicates that virtually all of the papers presented here will continue to be heavily cited for some time to come.

One would expect the average paper cited in the *Science Citation Index®* (*SCI®*) to receive a citation or two in a two year period. Even the higher impact articles listed in *Current Contents®* will be cited only twice as much. But the least cited paper in the present study received 29 citations in 1978-1979—the most cited, 104 citations. The average paper received about 43 citations, 9.6 in 1978, and 33.3 in 1979. In the forthcoming list of life sciences papers, we can expect the average to be much greater. This reflects primarily the greater size of the life sciences literature, which increases the probability for superstar papers. We don't know yet whether the trend in biochemistry towards a higher number of references per paper[3] is also a factor. A comparable study of the physical sciences needs to be done.

The 100 papers in this study were published in the 28 journals listed in Table 1. *Physical Review Letters* accounted for 21 papers, more than any other journal. *Physical Review Letters* also led all other journals in our study of the 1977 physical sciences papers. *Physical Letters B* contributed 18 papers to the list, and *Physical Reviews D* contributed 11. Together, these three journals accounted for half of the papers. It is interesting to note that *Applied Physics Letters* contributed eight papers to this study. This journal had just one in our study of the 1977 papers.[2]

Ninety-nine different institutions helped produce the papers on our list. They are identified in Table 2. The US again tops all countries with 44 institutions. The Federal Republic of Germany has ten, the UK nine, Italy seven, France six, Canada four, and the USSR three. Australia, The Netherlands, Israel, and Japan each have two institutions. Switzerland also has two, although the European Organization for Nuclear Research (CERN) is actually a consortium of 12 Western European nations. It is most interesting to note that CERN tops the list of institutions, accounting for 19 papers. In our study of the 1977 papers, CERN was in sixth place with seven papers.[2] Austria, Belgium, Denmark, India, Norway, and Sweden are each represented by one institution. Without exception, all of the papers on the list were published in English.

Nineteen papers were single-author works. Twenty-four papers had two authors, and 19 had three. Nine papers had four authors, four papers had five,

Table 1: The 28 journals represented on the list of 1978 physical science papers most cited in 1978-79. The numbers in parentheses are the impact factors for the journals. (Impact equals average number of citations received by articles published in that journal.) Data were taken from the 1978 *Journal Citation Reports®*, which is volume 13 of the *SCI®*. The figures at the right indicate the number of papers from each journal which appear on the list.

Phys. Rev. Lett.	(6.573)	21
Phys. Lett. B	(4.037)	18
Phys. Rev. D	(2.982)	11
Appl. Phys. Lett.	(3.244)	8
Nucl. Phys. B	(3.670)	8
Account. Chem. Res.	(7.842)	3
Astrophys. J.	(4.348)	3
J. Amer. Chem. Soc.	(5.327)	2
Mon. Notic. Roy. Astron. Soc.	(2.707)	2
Nature	(5.409)	2
Nucl. Phys. A	(2.813)	2
Phys. Rep. (Sec. C Phys. Lett.)	(7.580)	2
Phys. Rev. C	(2.268)	2
Science	(5.927)	2
Appl. Optics	(1.934)	1
Astron. Astrophys.	(2.313)	1
Chem. Rev.	(10.471)	1
Chem. Soc. Rev.	(3.289)	1
IEEE J. Quantum Electron.	(2.992)	1
Inorg. Chem.	(2.652)	1
J. Appl. Phys.	(1.670)	1
J. Chem. Phys.	(3.043)	1
J. Geophysical Res.	(7.041)	1
J. Luminesc.	(1.243)	1
Phys. Lett. A	(1.246)	1
Phys. Today	(2.041)	1
Rev. Mod. Phys.	(19.213)	1
Tetrahedron	(1.843)	1

Table 2. The institutional affiliations of authors on the list. Institutions are in descending order of number of papers produced. The number of authors from each institution is shown in parentheses.

CERN, Switzerland			19	(86)*
California Institute Technology			9	(16)*
University of California			8	(35)
Berkeley	3	(14)		
Davis	1	(1)		
Irvine	1	(8)		
Livermore	1	(1)		
Los Alamos, NM	1	(2)		
Los Angeles	1	(9)		
Stanford University[1]			8	(37)
Harvard University[2]			7	(22)*
Rhine-Westphalia Tech. Univ., FRG			6	(36)
Bell Labs., NJ			6	(12)
Murray Hill	4	(10)		
Holmdel	2	(2)		
CENS, Gif-sur-Yvette, France			4	(24)
Imperial College, London, UK			4	(15)
Columbia University, NY			3	(8)*
Cornell University, NY			3	(6)
German Electron Synchrotron (DESY), Hamburg, FRG			3	(49)
Institute for Advanced Study, NJ			3	(5)*
Oxford University, UK			3	(22)
University Hamburg, FRG			3	(22)
University Milan, Italy			3	(10)
University Wuppertal, FRG			3	(7)*
Brookhaven National Lab., NY			2	(4)
CNRS, Ecole Norm. Super., France			2	(2)
IBM, T.J. Watson Research Ctr., NY			2	(4)
Oak Ridge National Lab., TN			2	(12)
Rockefeller University, NY			2	(3)
Rome University, Italy			2	(2)
State University New York, Stony Brook			2	(9)
Texas A & M University			2	(4)
University Bonn, FRG			2	(18)
University College, UK			2	(5)
University Dortmund, FRG			2	(7)
University Heidelberg, FRG			2	(8)
University Leicester, UK			2	(15)
University Louis Pasteur, France			2	(9)*
University Pennsylvania			2	(9)
University Southern California, Los Angeles			2	(2)
University Texas			2	(5)
University Washington, Seattle, WA			2	(5)
Western Electric Engineering Research Center, NJ			2	(2)
Academy Sciences, Steklov Institute, Moscow, USSR			1	(2)
Academy Sciences, L.D. Landau Institute, Moscow, USSR			1	(1)
Advanced Research Applications Corporation, CA			1	(2)
Anglo-Australian Observatory, Australia			1	(2)
Argonne National Lab., IL			1	(2)
Bari University, Italy			1	(6)
Carnegie-Mellon University, PA			1	(2)
Carnegie Institution, Washington, DC			1	(1)*
Center of Nuclear Research, Strasbourg, France			1	(8)*
Dartmouth College, NH			1	(1)
Ecole Polytech., LPNHE, France			1	(7)
Ecosystems Center, Woods Hole, MA			1	(2)
Fermi National Accelerator, IL			1	(7)
Florida State University			1	(2)
Hitachi Ltd., Japan			1	(7)
Indian Institute Science, Bangalore, India			1	(1)
International Center Theoretical Physics, Trieste, Italy			1	(1)
Inter-University Brussels, Belgium			1	(4)
Joint Institute Nuclear Research, Moscow, USSR			1	(1)
Karlsruhe University, FRG			1	(1)
Kings College, UK			1	(1)
Kitt Peak National Observatory, AZ			1	(1)
Linear Accelerator Lab., Orsay, France			1	(5)
Max-Planck-Inst., Munich, FRG			1	(8)
MIT, Cambridge, MA			1	(1)
McGill University, Montreal, Canada			1	(3)
NOAA Environmental Research Lab., Boulder, CO			1	(3)*
National Bureau Standards, Wash., DC			1	(4)
National Center Atmospheric Research, Boulder, CO			1	(1)*
Northwestern University, IL			1	(7)
Padova University, Italy			1	(1)
Princeton University, NJ			1	(1)
Queen Mary College, London, UK			1	(1)
Rijks University, The Netherlands			1	(2)
Royal Signals & Radar Establishment, Worcester, UK			1	(5)
Siegen University, FRG			1	(5)
Tel-Aviv University, Israel			1	(1)
University Alberta, Canada			1	(1)
University Bergen, Norway			1	(4)
University Bern, Switzerland			1	(1)
University Bologna, Italy			1	(1)
University Calgary, Canada			1	(2)
University Catania, Italy			1	(4)
University Chicago, Fermi Institute			1	(3)
University Copenhagen, Denmark			1	(1)*
University Glasgow, UK			1	(1)
University Hawaii			1	(7)
University Illinois			1	(3)
University Lund, Sweden			1	(2)
University Massachusetts			1	(2)
University Michigan			1	(1)
University North Carolina			1	(1)

University Pittsburgh, PA	1	(1)
University Rochester, NY	1	(6)
University Sussex, UK	1	(2)
University Sydney, Australia	1	(7)
University Tokyo, Japan	1	(4)
University Utrecht, The Netherlands	1	(1)
University Victoria, Canada	1	(1)
University Vienna, Austria	1	(1)*
University Wisconsin	1	(2)
Weizmann Institute Science, Israel	1	(1)*
Yale University, CT	1	(4)

[1]Includes SLAC
[2]Includes Harvard College Observatory and Smithsonian Astrophysical Observatory
*One or more of these authors represents a second affiliation for a single-authored paper.

five papers had six, and five had seven. Three papers had eight authors. One paper each had 13, 15, 17, 20, 26, 29, and 34 authors. Two papers had 47, one paper had 56, one had 58, and one had 63 authors.

Seventy-eight authors had two papers on the list. R.D. Field, H. Georgi, and J. Morfin each had three. R. Petronzio of CERN was a coauthor on four papers.

The 1978 physical sciences articles most cited in 1978-79 appear in Figure 1. We have divided the list into 12 subject areas. As always, I must caution that the most-cited papers appearing in Figure 1 are not necessarily the "best" papers. For that reason, we alphabetized the listings under each heading. We did this to discourage comparisons of citation rates between papers. Once a paper achieves a minimum threshold, the probability of significance is high. Additional citations may then indicate the activity which the discovery or method has stimulated.

The subject areas represented in this study are field theory, elementary particle physics (theoretical), elementary particle physics (experimental), nuclear physics, atomic and molecular physics, astronomy and astrophysics, lasers and optics, material sciences and condensed matter sciences, physical chemistry, inorganic and organometallic chemistry, organic chemistry, and geochemistry and geophysics.

Field theory only contributed eight papers to the list. In our study of the 1977 physical sciences papers, field theory contributed 21 papers.[2] Field theory is the study of the fundamental forces of the universe. The most-cited paper on the list, that by C.G. Callan and colleagues, is a theoretical discussion of the "strong force." The second most-cited paper also falls in this group. The paper by A.J. Buras and K.J.F. Gaemers received 92 citations. That paper provides an analytical expression for the distribution of partons, a hypothetical basic unit of matter.

Theoretical work in elementary particle physics accounts for 29 of the papers listed here. This branch of research studies the properties and interactions of various subatomic particles. At least 15 papers in this group deal with quantum chromodynamics (QCD). The so-called strong force that holds the nucleus of an atom together is described in terms of QCD. QCD theories, by the way, are an outgrowth of the work performed independently by Steven Weinberg and Abdus Salam, for which they shared the 1979 Nobel prize in physics.[4]

Ten papers are from the field of experimental elementary particle physics. Research in this field often involves the use of gigantic particle accelerators, which shoot particles into bubble chambers where their behavior can be studied. Such experiments require an enormous collaborative effort, which can be seen by the number of authors of the papers in this group. They average nearly 34 authors apiece!

Twelve papers deal with various aspects of nuclear physics. Researchers in this field study the structure, properties, and decay of the atomic nucleus. Several papers in this group report the results of "scattering" experiments. These involve destruction of the nucleus through collisions with other matter. Researchers can then draw inferences about the properties of nuclear particles by observing the manner in which they scatter. Applications of nuclear research include weaponry and civil power generation.

Two papers were from the field of atomic and molecular physics, including the third most-cited paper on the list. That paper, by C.Y. Prescott and colleagues, received 91 citations. It describes the results of an experiment involving electron scattering.

There were eight papers from the field of astronomy and astrophysics. This group includes the fifth most-cited paper, by B.A. Cooke and colleagues. The paper, which received 87 citations, catalogs cosmic X-ray sources which may originate beyond our galaxy.

Five papers are on various topics in the field of lasers and optics. The paper by E.R. Grant and colleagues discusses a process called "multiphoton dissociation." There were four papers on this subject in our 1977 list. Briefly, multiphoton dissociation happens when a molecule loses one or more of its constituent atoms when exposed to a laser beam. Applications of this research include the synthesis of chemicals.

Thirteen papers are on materials sciences and condensed matter sciences. These broad subject areas include condensed liquids, superconductors, what used to be called solid state physics, metallurgy, crystallography, and other areas of study. The fourth most-cited paper on the list appears in this group. That paper, by R.T. Young and colleagues, was cited 88 times in the two year period. It discusses the use of lasers in annealing, a process that removes crystal imperfections in a solid by heating it and then allowing it to cool slowly.

There are four physical chemistry papers on the list. The paper by S.W. Benson on molecules that contain sulfur has application in the desulfurization of such fuels as coal and petroleum. Sulfur in fossil fuels is an insidious source of air pollution.

Four papers are from inorganic and organometallic chemistry. F. Albert Cotton of Texas A&M University appears as author on two of them. Both papers discuss the manner in which the atoms of metal molecules are bonded together.

Two papers, both reviews, are from organic chemistry. D.L.J. Clive's paper discusses the element selenium and its compounds. E.W. Colvin's paper reviews the subject of silicon compounds.

Three papers are from geochemistry and geophysics. Two of them deal with human-caused increases in the overall carbon content of the earth's atmosphere. The third paper discusses depletion of the atmospheric ozone layer due to chlorocarbon emissions.

It will be obvious from examining our list that certain fields are more heavily represented than the volume of literature or other factors would warrant. Part of this is due to the immediacy phenomenon. Another way of explaining it is to talk about half-lives. In any case, one has to classify papers by one means or another. Whether one uses *a priori* classification schemes, or *a posteriori* methods such as co-citation clustering,[5,6] the result will undoubtedly appeal to those in fields which are neglected by these "little" studies. The purpose of our *Atlas of Science*,[7] however, as I've often mentioned, is to identify all the important papers in every field, regardless of the citation peculiarities of the fields involved. Another way of selecting a sample of interesting papers is to select the most-cited one from each journal in the field, as we did recently in our study of the plant sciences.[8,9] Still another approach is to simply extend the list to several hundred papers. Even if we could afford the space, no matter how far we carried the exercise, some "small" fields would be neglected. It is interesting to note, however, that work which is considered *of Nobel class* rarely, if ever, falls into such fields.

If we had extended this study to include citation data for 1980, most of the papers would have continued to be highly cited. As in our earlier studies,

however, the relative standing of certain papers would have improved simply because of the artifact of publication date. A paper published late in 1978 would be at a distinct disadvantage in making our list. For that reason, we present in Figure 2 those 1978 physical sciences papers that would have made the list if we had counted only those citations received in 1979.

Next week we will look at the 100 1978 life sciences papers that were highly cited immediately after publication.

* * * *

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Figure 1: The 1978 physical sciences articles most-cited in 1978-79. Authors' affiliations follow each citation. Journals are often ambiguous about addresses. When we could not tell which author was at which organization, we have simply given the addresses without linking them to specific authors.

Field Theory

78	79	Total Citations	Bibliographic Data
26	66	92	Buras A J & Gaemers K J F. **Simple parametrizations of parton distributions with Q^2 dependence given by asymptotic freedom.** *Nucl. Phys. B* 132:249-67, 1978. CERN, Geneva, Switzerland.
5	61	66	Buras A J, Ellis J, Gaillard M K & Nanopoulos D V. **Aspects of the grand unification of strong, weak and electromagnetic interactions.** *Nucl. Phys. B* 135:66-92, 1978. CERN, Geneva, Switzerland.
17	87	104	Callan C G,[1] Dashen R[1] & Gross D J,[2] **Toward a theory of the strong interactions.** *Phys. Rev. D* 17:2717-63, 1978. 1. Inst. Advan. Study, Princeton, NJ. 2. Princeton Univ., Princeton, NJ.
13	27	40	Ferrara S & van Nieuwenhuizen P. **The auxiliary fields of supergravity.** *Phys. Lett. B* 74:333-5, 1978. CERN, Geneva, Switzerland.
9	22	31	Jackiw R,[1] Muzinich I[2] & Rebbi C.[2] **Coulomb gauge description of large Yang-Mills fields.** *Phys. Rev. D* 17:1576-82, 1978. 1. Rockefeller Univ., Dept. Phys., New York, NY. 2. Brookhaven Natl. Lab., Upton, NY.
12	25	37	Stelle K S[1] & West P C,[2] **Minimal auxiliary fields for supergravity.** *Phys. Lett. B* 74:330-2, 1978. 1. King's Coll., Dept. Math., London, UK. 2. Imperial Coll., Blackett Lab., London, UK.
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