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The 250 Most-Cited Primary Authors in the 1984 *SCI*. Part 2. Most-Cited Works, 1955-1985

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In the first part of this two-part essay on primary authors¹ we presented an alphabetic list of the 250 primary authors most cited in the 1984 *Science Citation Index*® (*SCI*®). Seventy of those authors appeared in a previous study of primary authors.² In Part 2 we list the most-cited work for each of the 180 authors new to the list (see Table 1). These items were selected from the 1955-1985 *SCI*; the total number of citations that each item received during this period is also listed.

To save space in Table 1 we provide only abbreviated bibliographic information for any item that appeared in our recent study of the 1,000 most-cited *SCI* papers, 1961-1982.³ But we indicate the *Current Contents*® (*CC*®) issue in which the paper was listed. Forty-seven items from Table 1 appeared in that 10-part series, including many standard methodological life-sciences papers.

Citation Classics

Asterisks before items in Table 1 indicate the 39 items that have had *Citation Classic*® commentaries written about them. Grant R. Bartlett, then at the Laboratory for Comparative Biochemistry, San Diego, California, commented⁴ on his paper that received over 7,320 citations. This paper presented a modification of another classic work, "The colorimetric determination of phosphorus," by C.H. Fiske and Y. SubbaRow (about 14,600 citations).⁵ Fiske appeared in our previous study of primary authors,² and the paper cited above was listed there as his most-cited

item. Fiske was also listed in the first part of this study of primary authors.¹

In 1979 Masatoshi Nei, Center for Demographic and Population Genetics, University of Texas, Houston, wrote a commentary about his *American Naturalist* article on the genetic distance between populations.⁶ His is one of several items in Table 1 that provides life-sciences researchers with mathematical methods for estimating biological measurements. Another is Robert R. Sokal's book *Biometry: The Principles and Practice of Statistics in Biological Research*, first published in 1969 and revised in 1981. It is credited with "familiarizing biological researchers with various statistical methods."⁷ F.J. Rohlf coauthored this book with Sokal when both were at the State University of New York (SUNY), Stony Brook. Rohlf does not appear in the study because he was otherwise cited "only" 114 times in 1984. David J. Finney, Department of Statistics, University of Edinburgh, Scotland, authored *Probit Analysis: A Statistical Treatment of the Sigmoid Response Curve* in 1947; at that time it "clearly met a need. It showed [statistical] methods as applicable not only to insecticides but to estimation of drug potencies, psychometric data, educational tests, and other problems. It also demonstrated that iterative maximum likelihood computations were practicable for a biologist.... [However], the computer revolution has completely changed the situation."⁸

The most-cited work of Corwin Hansch and Toshio Fujita, Department of Chemistry, Pomona College, Claremont, Califor-

nia, is, according to Hansch's commentary, "cited so often [because it] was the first quasi-general mathematical approach to structure-activity relationships. Today our approach has been shown to be valuable in drug and pesticide design, toxicology, reaction of organic compounds with enzymes and other macromolecules, disposition of chemicals in soil, and the bioaccumulation of environmental chemicals in fish, birds, and other forms of life."⁹

Analysis of Table 1

The list of most-cited items includes 35 books, 142 journal articles, and 3 computer programs or manuals for determining crystal structures. The three programs or manuals, by primary authors P. Main, Universities of York, England, and Louvain, Belgium; Carroll K. Johnson, Oak Ridge National Laboratory, Tennessee; and G.M. Sheldrick, University of Cambridge, UK, respectively, have each been cited over 1,000 times; Johnson's work has received over 6,000 citations. Note that we combined citations to each computer program and its manual because in most cases it was impossible to differentiate between them.

The books range in age from 39 years (the previously mentioned *Probit Analysis* by Finney; the second oldest book is Arthur I. Vogel's 1948 *A Text-book of Practical Organic Chemistry*) to 4 years (A.D. Bax's *Two-Dimensional Nuclear Magnetic Resonance in Liquids* and T. Maniatis, E.F. Fritsch, and J. Sambrook's *Molecular Cloning*, both published in 1982). Several books are handbooks or textbooks in statistical and chemical methodology. Reference works in clinical immunology and lysosomes are also listed in Table 1.

Seventy-seven different journals published the 142 articles. Ten articles each appeared in *Nature* and *Science*. *Proceedings of the National Academy of Sciences* had eight; the *Journal of Biological Chemistry*, seven; the *Journal of the American Chemical Society*, five; and the *European Journal of Biochemistry* and *Nuclear Physics B*, four each. The majority of journals represented in Table 1 (51 of 77) each published just one article.

The average number of citations in Table 1 is 2,639; the median frequency is 923. The least-cited work, by M.C.R. Symons, University of Southampton, UK, was published in the *Journal of the Chemical Society* in 1959 and has been referenced nearly 100 times. In contrast, the 1970 paper by U.K. Laemmli, then at the Laboratory of Molecular Biology, MRC, Cambridge, UK, received over 34,400 citations, with nearly 5,580 in 1984 alone. In fact, this figure has increased each year since the paper was published. In Table 2 we list the year-by-year citations to Laemmli's paper. This tells us something about the growth in studies involving protein cleavage. This useful indicator of a specific laboratory procedure has little to do with the intrinsic intellectual value of the original idea. But the method's impact on researchers has clearly been enormous.

Only four other items in Table 1 have been cited over 10,000 times. Three of these are books in chemistry (H.-U. Bergmeyer, now at Boehringer-Mannheim, Biochemical Division, Tutzing/Oberbayern, Federal Republic of Germany [FRG]), psychology (S. Siegel, Department of Psychology, Pennsylvania State University, University Park), or numerical taxonomy (Sokal). The fourth item in Table 1 having over 10,000 citations is a highly cited life-sciences paper by Marion M. Bradford, Department of Biochemistry, University of Georgia, Athens, entitled "A rapid and sensitive method for the quantitation of microgram quantities of protein utilizing the principle of protein-dye binding."

Bergmeyer's book was published in German, as were five other items in Table 1. One of these is Albert Einstein's classic article entitled "A new method for measuring the dimensions of molecules," which provided a diffusion equation that has since been cited in journals from many different fields including chemistry, polymer science, and dairy science.¹⁰ Einstein's work is the oldest in the table; it was published in *Annalen der Physik—Leipzig* in 1906. The only other foreign-language items in the list are by Soviet authors: Vasilii V. Korshak's book

about polymers and V.E. Zakharov's physics article. Originally published in Russian by Akademia Nauk, Moscow, in 1970, Korshak's book was translated into English in 1971 by the Israel Program for Scientific Translations, Jerusalem. In Table 1 we combined the citations to both editions, as we did for the translation and original of the Zakharov article.

The most recent item in Table 1, from a 1984 issue of *Science*, discusses AIDS and was authored by one of the leading researchers in that field, Robert C. Gallo, National Cancer Institute (NCI), National Institutes of Health (NIH), Bethesda, Maryland, and colleagues. That this paper is Gallo's most-cited work, based on just two years of citations, is remarkable. It also indicates the great amount of current research activity in this field. We mentioned the work of French AIDS researchers L. Montagnier and F. Barré-Sinoussi in Part 1 of this essay. In addition Montagnier and Barré-Sinoussi's most-cited work will be discussed in an upcoming *Citation Classic* commentary.

The chronologic breakdown for all the items in Table 1 is as follows: 1900s, 1; 1930s, 1; 1940s, 4; 1950s, 12; 1960s, 42; 1970s, 102; and 18 in the current decade.

Many of the papers published in the 1980s have achieved "classic" status in a relatively short period of time. The paper by Carlo Rubbia (see G. Arnison and colleagues, UA1 Collaboration, European Organization for Nuclear Research [CERN], Geneva, Switzerland) has already received over 290 cites in just three years. It was in an earlier CC study of most-cited 1983 physical-sciences papers,¹¹ and, incidentally, is a typical example of alphabetic name ordering on a multiauthored paper.

By contrast the 1981 paper by Bernard J. Carroll, University of Michigan, Ann Arbor, and colleagues describes a laboratory test for the diagnosis of melancholia and has been quoted 680 times since it was published in *Archives of General Psychiatry*.

Three articles in Table 1 were published in 1982. They are by first authors Wolfgang A. Herrmann, Institute for Inorganic Chemistry, University of Regensburg, FRG;

Table 2: Year-by-year citations to the 1970 *Nature* paper by U.K. Laemmli that describes "Cleavage of structural proteins during the assembly of the head of bacteriophage T4."

Year	Number of SCP® citations
1970	4
1971	39
1972	106
1973	206
1974	289
1975	485
1976	722
1977	1,162
1978	1,562
1979	2,053
1980	2,621
1981	3,549
1982	4,338
1983	4,971
1984	5,577
1985	6,734

Masato Kasuga, National Institute of Arthritis, Diabetes, and Digestive and Kidney Diseases, NIH; and Joachim Messing, Department of Biochemistry, University of Minnesota, St. Paul. Each received approximately 135, 270, and 960 citations from 1982 to 1985, respectively. Messing and colleague Jeffrey Vieira, also at the University of Minnesota, identified a new pair of M13 bacteriophage vectors for selecting either DNA strand from double-digest DNA restriction fragments. This useful technique allows selection of the required single stranded DNA fragment for subsequent cloning and sequencing.

The article by Marek-Marsel Mesulam, Harvard Neurological Unit, Beth Israel Hospital, Boston, Massachusetts, previously appeared in a study of 1978 papers most cited in 1978 and 1979,¹² as did the papers by Bernard M. Babior, Tufts University and New England Medical Center, Boston; Ronald B. Herberman and Howard T. Holden, NCI; and Kenneth M. Yamada and Kenneth Olden, NCI. This seems to confirm that the list of 1978 papers (and its annual counterparts) did forecast a significant future trend to watch.

Another paper from 1978 has also been a citation superstar for its authors: Anthony S. Fauci and colleagues' article on the spec-

trum of vasculitis, a "clinicopathological process characterized by inflammation and necrosis of blood vessels."¹³ This paper has received over 420 citations from 1978 to 1985.

The 1977 paper by Roger Guillemin and colleagues, Salk Institute for Biological Studies, La Jolla, California, appeared in our study of the 1977 life-sciences articles most cited in 1977 and 1978.¹⁴ Since its publication, researchers have explicitly quoted the article, which discusses secretion of endorphin and adrenocorticotropin by the pituitary gland, over 860 times.

Older classics in Table 1 include the book by Robert H. MacArthur, Princeton University, and Edward O. Wilson, Harvard University, entitled *The Theory of Island Biogeography*. Biogeography is the study of "the distribution of species of organisms over the face of the earth. [It] is concerned with the limits and geometric structure of individual species populations and with the differences in biotas [a biota consists of the plants, animals, and microorganisms indigenous to one area] at various points on the earth's surfaces. The local, ecological distribution of species, together with such synecological features as the structure of the food web, are treated under biogeography only insofar as they relate to the broader aspects of distribution."¹⁵ (p. 185) In their book the authors limited their discussion of biogeography to islands. Chapter 1 states that "the island is the first unit that the mind can pick out and begin to comprehend. By studying clusters of islands, biologists view a simplex microcosm of the seemingly infinite complexity of continental and oceanic biogeography."¹⁵ (p. 3) Since 1967 this book has appeared as a reference over 1,700 times.

William G. Cochran, Department of Biostatistics, Johns Hopkins University, Baltimore, Maryland, and Gertrude M. Cox, Institute of Statistics, University of North Carolina, Chapel Hill, authored *Experimental Designs* in 1950; along with the classic works by Finney, Hansch, Nei, and Sokal discussed earlier, it provides research

workers from widely diverse fields with a statistical background in designing experiments. Researchers have cited it often since 1955—3,210 times.

Charlotte E. Moore's three-volume National Bureau of Standards circular on atomic-energy levels also continues to be quoted—since 1955 it has received almost 9,000 citations. Since the paper was published in 1949, this figure excludes five years of citations not yet covered by the *SCI*. We continue to work on these years and hope to complete the 1945-1954 cumulation by 1988.

Conclusion

The authors listed in this study have been primary authors of highly cited books, articles, and computer programs. Although the bias of first authorship may have caused other prominent authors to be excluded from the study, we are sure that those listed are a good sampling of scientists performing valuable research.

There is a sizeable literature on the merits and deficiencies of first-author citation analyses. Much of this is based on the erroneous assumption that one cannot obtain all-author data from the *SCI*, starting with the *Source Index* section. As long as an individual's *curriculum vitae* is available or a bibliography of that author's papers, total citations can be obtained from the *Citation Index* section of the *SCI* by looking up each item identified. This is made easier by using the 5- and 10-year *SCI* cumulations.

For a complete author analysis, especially when many names are involved, some analysts use first-author data as a preliminary indicator. Rustom Roy, Pennsylvania State University, University Park, has published on this subject, as have many others. In the Roy method one adjusts first-author citation data by using, as a multiplier, the ratio of authors' total papers to their first-authored papers.^{16,17} If this ratio is used for primary-author cohorts whose com-

plete *curricula vitae* are available, approximations to all-author data may be achieved. But if one is to discuss these methods intelligently, then all the usual caveats on citation analysis must be reviewed. The amount of bibliographic research required to include the Roy factor in even a portion of our 1984 files is clearly beyond the scope of an already significant editorial budget. The purpose of the International Science Indicators Project (to be discussed at greater length in

the future) is to pool resources so that such work can be done at reasonable cost to all concerned.

* * * * *

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Table 1: Most-cited items for those primary authors who did not appear in the previous *SCI*[®] primary-authors study. Bibliographic data for the papers that were among the 1,000 most cited in the 1961-1982 *SCI* are not repeated here. But the issue number and date of the *CC*[®] in which the paper was listed appear in parentheses. Asterisks (*) indicate papers that have been subjects of *Citation Classic*[®] commentaries. The *CC* editions in which these commentaries appeared are listed at the end of each reference.

Number of 1955-85 <i>SCI</i> Citations	Bibliographic Data
3,635	*Ames B N. See <i>CC</i> (23):3-9, 4 June 1984. (12/84/LS)
3,486	Armitage P. <i>Statistical methods in medical research</i> . New York: Wiley, 1971. 504 p.
293	Arnison G, et al. Experimental observations of lepton pairs of invariant mass around 95 GeV/c ² at the CERN SPS collider. <i>Phys. Lett. B</i> 126:398-410, 1983.
862	*Babior B M. Oxygen-dependent microbial killing by phagocytes. Part 1. <i>N. Engl. J. Med.</i> 298:659-68, 1978. (16/85/LS)
623	Baker P F, Hodgkin A L & Ridgway E B. Depolarization and calcium entry in squid giant axons. <i>J. Physiol.—London</i> 218:709-55, 1971.
712	Bard A J & Faulkner L R. <i>Electrochemical methods: fundamentals and applications</i> . New York: Wiley, 1980. 718 p.
818	Barrett A J. Lysosomal enzymes. (Dingle J T, ed.) <i>Lysosomes: a laboratory handbook</i> . Amsterdam, The Netherlands: North-Holland, 1972. p. 46-135.
7,321	*Bartlett G R. See <i>CC</i> (23):3-9, 4 June 1984. (4/85/LS)
221	Bax A D. <i>Two-dimensional nuclear magnetic resonance in liquids</i> . Delft, The Netherlands: Delft University Press, 1982. 200 p.
12,818	Bergmeyer H-U, ed. <i>Methoden der enzymatischen Analyse</i> (Methods of enzymatic analysis). Weinheim, FRG: Verlag Chemie, 1962. 4 vols.
612	Berridge M J. The interaction of cyclic nucleotides and calcium in the control of cellular activity. <i>Advan. Cyclic Nucl. Res.</i> 6:1-98, 1975.
402	Binder K. Monte Carlo methods in statistical physics. <i>Top. Curr. Phys.</i> 7:1-376, 1979.
531	Binkley J S, Pople J A & Hehre W J. Self-consistent molecular orbital methods. 21. Small split-valence basis sets for first-row elements. <i>J. Amer. Chem. Soc.</i> 102:939-50, 1980.
2,440	Birnboim H C & Doly J. A rapid alkaline extraction procedure for screening recombinant plasmid DNA. <i>Nucl. Acid. Res.</i> 7:1513-23, 1979.
515	Blaustein M P. Sodium ions, calcium ions, blood pressure regulation, and hypertension: a reassessment and a hypothesis. <i>Amer. J. Physiol.</i> 232:C165-73, 1977.
7,219	*Bligh E G. See <i>CC</i> (23):3-9, 4 June 1984. (52/78)
546	*Bohlmann F. Zur Konfigurationsbestimmung von Chinolizidin-Derivaten (On the determination of configurations of quinolizidine derivatives). <i>Chem. Ber.</i> 91:2157-67, 1958. (33/83/PC&ES)
3,310	Bohr A & Mottelson B R. <i>Nuclear structure</i> . New York: Benjamin, 1969. 3 vols.
2,226	Bolivar F. See <i>CC</i> (40):3-9, 1 October 1984.
6,017	*Bonner W M. See <i>CC</i> (23):3-9, 4 June 1984. (1/83/LS)
1,726	Box G E P & Jenkins G M. <i>Time series analysis: forecasting and control</i> . San Francisco, CA: Holden-Day, 1970. 575 p.
6,900	*Boyum A. See <i>CC</i> (23):3-9, 4 June 1984. (45/82/LS)
12,270	Bradford M M. See <i>CC</i> (23):3-9, 4 June 1984.
479	Braestrup C & Squires R F. Specific benzodiazepine receptors in rat brain characterized by high-affinity [³ H]diazepam binding. <i>Proc. Nat. Acad. Sci. USA</i> 74:3805-9, 1977.
567	Brown M S & Goldstein J L. Receptor-mediated control of cholesterol metabolism. <i>Science</i> 191:150-4, 1976.
942	*Burnstock G. See <i>CC</i> (33):3-11, 19 August 1985. (3/85/LS)
733	Carpenter G & Cohen S. ¹²⁵ I-labeled human epidermal growth factor. <i>J. Cell Biol.</i> 71:159-71, 1976.
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1,578	*Cleland W W. See <i>CC</i> (35):3-9, 27 August 1984. (28/77)
2,502	*Cleveland D W. See <i>CC</i> (35):3-9, 27 August 1984. (41/84/LS)
3,210	Cochran W G & Cox G M. <i>Experimental designs</i> . New York: Wiley, 1950. 454 p.
453	Cohen P. The subunit structure of rabbit-skeletal-muscle phosphorylase kinase, and the molecular basis of its activation reactions. <i>Eur. J. Biochem.</i> 34:1-14, 1973.
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APPENDIX TO TABLE I

The *Current Contents*® (CC®) essays listed below are reprinted in:

- Garfield E. *Essays of an information scientist: the awards of science and other essays*. Philadelphia: ISI Press, 1985. Vol. 7.
- , *Essays of an information scientist: ghostwriting and other essays*. Philadelphia: ISI Press, 1986. Vol. 8.

The corresponding volume and page numbers for each essay are indicated in parentheses after the CC reference.

- CC (23):3-9, 4 June 1984. (Vol. 7, p. 175-81)
- CC (29):3-12, 16 July 1984. (Vol. 7, p. 218-27)
- CC (35):3-9, 27 August 1984. (Vol. 7, p. 270-6)
- CC (40):3-9, 1 October 1984. (Vol. 7, p. 306-12)
- CC (42):3-12, 15 October 1984. (Vol. 7, p. 326-35)
- CC (14):3-10, 8 April 1985. (Vol. 8, p. 132-9)
- CC (20):3-12, 20 May 1985. (Vol. 8, p. 187-96)
- CC (33):3-11, 19 August 1985. (Vol. 8, p. 311-9)