

Current Comments®

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Update on the Most-Cited Papers in the SCI, 1955-1986. Part 2. Sixty Years of Research, from Insecticides to AIDS

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With a second group of 100 highly cited papers from the *Science Citation Index*® (*SCI*®), 1955-1986, we conclude this two-part extension of previous *SCI* studies. As in those earlier studies, this group displays predominantly life-sciences and methods papers. Also represented, however, are papers from physics, chemistry, mathematics, engineering and technology, and the social sciences.

In the first part of this essay, we presented a group of 100 highly cited papers from the *Science Citation Index*® (*SCI*®), 1955-1986.¹ That essay, as we mentioned, expands and updates our previous series on the 1,000 most-cited papers in the *SCI*, 1961-1982,² and an essay on 250 highly cited papers from 1955 to 1964.³ All of these papers are by definition *Citation Classics*®.

In this essay, we'll discuss another group of papers from the *SCI*—papers that, although not included in the previous studies, are among the most highly cited in the *SCI*. These papers are listed in the Bibliography at the end of this essay, in alphabetic order by first author. The most-cited paper received approximately 960 citations; the least-cited, around 850. The average number of citations is 892. As we've noted previously, papers from the life sciences tend to dominate these *SCI* studies. The present group of papers is no exception. However, the domination by life sciences is not as pronounced as in some of the earlier studies. There is a larger representation of papers from physics and chemistry, and also papers from mathematics, the social sciences, and engineering and technology.

Journals

The papers in the Bibliography were published in 62 journals. Nine journals account for slightly more than 40 percent of the pa-

pers in this group. These journals are listed in Table 1, along with the other journals that published at least two papers appearing in this study. Many of the journals that were prominent in the last essay¹ (as well as in previous *SCI* studies) are featured in Table 1. These include *Science*, *Analytical Biochemistry*, *Physical Review*, and the *New England Journal of Medicine*. However, there are journals that did not appear in the first part of this update, including *Bell System Technical Journal* (which has been superseded by *AT&T Technical Journal*) and the *Journal of the American Oil Chemists' Society*. Table 2 shows the chronologic distribution of publication dates for the papers in the Bibliography. As was the case in the first part of this study, the largest number of papers appeared between 1975 and 1979.

Authors

There are 252 unique authors in this study. Ten have won the Nobel Prize. Frederick Sanger, Medical Research Council Laboratory of Molecular Biology, Cambridge, UK, who won the Nobel Prize in chemistry in 1958 and again in 1980, is co-author of the most-cited paper in this study. "The use of thin acrylamide gels for DNA sequencing," written with colleague A.R. Coulson and published in *FEBS Letters* in 1978, was cited over 960 times. Sanger also appeared in the Bibliography in the first part of this essay.

Table 1: Journals that published at least two papers in the second group of articles most cited in the 1955-1986 *SCI*[®]. Articles that appear in our most-cited *SCI* article studies for 1961-1982 or 1955-1964 have been excluded. A = journal title. B = number of papers. C = 1986 impact factor.

A	B	C
Science	6	12.43
Anal. Biochem.	5	2.46
J. Biol. Chem.	5	6.31
Nature*	5	15.25
Phys. Rev.	5	**
Annu. Rev. Biochem.	4	31.62
J. Chem. Phys.	3	3.30
Phys. Rev. D—Part. Fields	3	2.61
Proc. Roy. Soc. London Ser. A	3	1.64
Bell Syst. Tech. J.***	2	0.35
Biochem. J.	2	4.23
Exp. Cell Res.	2	2.48
J. Amer. Oil Chem. Soc.	2	0.87
J. Clin. Invest.	2	6.74
J. Exp. Med.	2	10.92
J. Mol. Biol.	2	6.59
Meth. Enzymology	2	1.65
N. Engl. J. Med.	2	17.75

*Nature includes Nature New Biol.

**Superseded by Phys. Rev. A—Gen. Phys., Phys. Rev. B—Condensed Matter, Phys. Rev. C—Nucl. Phys., and Phys. Rev. D—Part. Fields.

***Superseded by AT&T Tech. J.

Another of the Nobel laureates in this group is Rita Levi-Montalcini, now at the Institute of Cell Biology, Rome, Italy, who shared the 1986 prize in physiology or medicine for the discovery of nerve growth factor (NGF). Included in the Bibliography is "Nerve growth factor," a 1968 paper from *Physiological Reviews* coauthored with colleague Pietro U. Angeletti. This paper, reviewing various aspects of NGF, has been cited over 860 times. In our study of the 1986 Nobel Prize in medicine, we identified this paper as Levi-Montalcini's most-cited work.⁴

Another Nobel laureate in the Bibliography is Rosalyn S. Yalow, Veterans Administration Hospital, Bronx, New York, who shared the 1977 prize in physiology or medicine for the development of radioimmunoassay. Yalow was a coauthor of a 1963 paper from *Science*, "Hypoglycemia: a potent stimulus to secretion of growth hormone" (the first author is J. Roth). This paper has been cited in over 920 publications.

Sheldon L. Glashow, Harvard University, Cambridge, Massachusetts, and Abdus

Salam, International Center for Theoretical Physics, Trieste, Italy, and Imperial College, London, UK, two of the three theoretical physicists who shared the 1979 Nobel Prize in physics, also have papers in the Bibliography. Glashow's "Partial-symmetries of weak interactions," a 1961 paper from *Nuclear Physics*, has been cited more than 880 times. Glashow also coauthored, with colleagues A. De Rújula and H. Georgi, "Hadron masses in a gauge theory," a 1975 paper from *Physical Review D—Particles and Fields*. This paper has been cited over 875 times. Salam coauthored "Lepton number as the fourth 'color,'" another paper from *Physical Review D—Particles and Fields*, with colleague J.C. Pati. This 1974 paper has been cited in approximately 880 publications. The other Nobel laureates in the Bibliography are Philip W. Anderson (physics, 1977), Roger Guillemin (physiology or medicine, 1977), Lev D. Landau (physics, 1962), Julian Schwinger (physics, 1965), and Ulf S. von Euler (physiology or medicine, 1970).

Citation Classics

Twelve papers in this study have been the subjects of *Citation Classic* commentaries, as denoted by the asterisks in the Bibliography. Henry B. Mann, for example, Department of Mathematics, University of Arizona, Tucson, commented in 1979 on his paper "On a test of whether one of two random variables is stochastically larger than the other." This paper, coauthored with D.R. Whitney, appeared in the *Annals of Mathematical Statistics* in 1947 (this journal was superseded in 1973 by the *Annals of Probability* and the *Annals of Statistics*). The "U-statistic" test set forth in this paper, developed while the authors were at Ohio State University, Columbus, was devised to improve statistical analysis of bacteriological studies on two populations of rats. As Mann explains, "It was the thorough study of the distribution of the U-statistic that made the test easily applicable and very popular."⁵ This paper has been cited in over 910 publications.

In a commentary published in 1979, A.E. Bence, Department of Earth and Space

Sciences, State University of New York, Stony Brook, discusses "Empirical correction factors for the electron microanalysis of silicates and oxides," which has been cited over 920 times. This paper, coauthored with A.L. Albee while the authors were at the California Institute of Technology, Pasadena, and published in the *Journal of Geology* in 1968, describes methods to solve certain problems in electron microprobe analysis in mineralogy. The authors' objectives, as Bence explains, were twofold: "to develop simplified data reduction procedures that could be carried out on the hand calculators then available, and to lay the groundwork for computer control of the X-ray spectrometers, thus permitting online control and real-time data reduction."⁶ The success of their matrix correction procedure, as Bence notes, "is attested to by the number of laboratories that use it to reduce their data."⁶ In the nine years since Bence's commentary, the paper has remained highly cited, receiving at least 85 citations per year between 1984 and 1986.

The Bibliography includes two landmark papers in HIV (known in the US as AIDS) research, one of which has been the subject of a *Citation Classic* commentary. That paper is "Isolation of a T-lymphotropic retrovirus from a patient at risk for acquired immune deficiency syndrome (AIDS)."⁷ This 1983 paper from *Science*, by François Barré-Sinoussi, Pasteur Institute, Paris, and colleagues, was also included in our study of highly cited 1983 articles from the *Social Sciences Citation Index*[®], 1983-1985.⁸ It has been cited in over 940 publications.

The other key paper in AIDS research is by Robert C. Gallo, National Cancer Institute, Bethesda, Maryland, and colleagues, from *Science*: "Frequent detection and isolation of cytopathic retroviruses (HTLV-III) from patients with AIDS and at risk for AIDS." This 1984 article, cited approximately 890 times, will be the subject of a forthcoming *Citation Classic* commentary in the *Life Sciences* edition of *Current Contents*[®]. Like the paper by Barré-Sinoussi and colleagues, it describes efforts to isolate the AIDS virus. Another paper in the Bibliography, a 1981 article from the *New*

Table 2: Chronologic distribution of publication dates for the second group of articles most cited in the 1955-1986 *SCI*[®]. Articles that appear in our most-cited *SCI* article studies for 1961-1982 or 1955-1964 have been excluded.

Publication Year	Number of Papers
1925-1929	1
1930-1934	2
1935-1939	3
1940-1944	3
1945-1949	4
1950-1954	9
1955-1959	4
1960-1964	11
1965-1969	14
1970-1974	10
1975-1979	27
1980-1984	12

England Journal of Medicine by Michael S. Gottlieb, University of California at Los Angeles School of Medicine, and colleagues, is one of the first clinical descriptions of the condition now known as AIDS.

Other Selected Papers

The oldest paper in this study is from 1925: "A method of computing the effectiveness of an insecticide," by W.S. Abbott, US Department of Agriculture. This paper, published in the *Journal of Economic Entomology*, has been cited over 910 times. Our data indicate that the paper was still being cited in 1986.

Another of the older papers in this study is "A theory of water and ionic solution, with particular reference to hydrogen and hydroxyl ions," by J.D. Bernal and R.H. Fowler, University of Cambridge, UK. This 1933 paper from the *Journal of Chemical Physics* has received over 900 citations. I have written previously about Bernal, the physicist, philosopher, and historian of science who had considerable influence on my own career.⁹ In their 1933 paper, Bernal and Fowler explore various properties of water, including the crystal structure of ice, the X-ray diffraction curve for water, and the degree of hydration of positive and negative ions in water. As the graph of year-by-year citations demonstrates in Figure 1, this paper has maintained a steady citation record over the years.

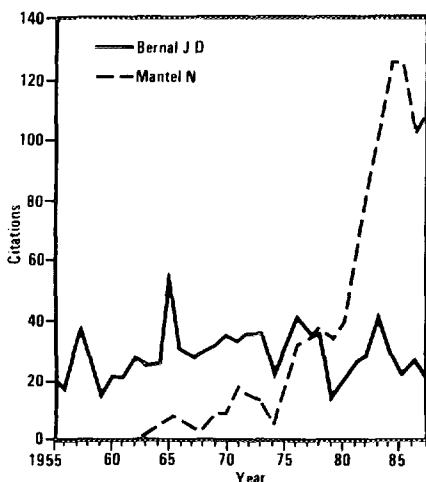


Figure 1: Year-by-year citations to two papers listed in the Bibliography. Solid line=Bernal J D. *J. Chem. Phys.* 1:515-48, 1933 (902 cites 1955-1986 *SCI*[®], 21 cites 1987 *SCI*). Broken line=Mantel N. *J. Amer. Statist. Assn.* 58:690-700, 1963 (887 cites 1955-1986 *SCI*, 109 cites 1987 *SCI*).

Also shown in the graph in Figure 1 are year-by-year citations to another paper, "Chi-square tests with one degree of freedom; extensions of the Mantel-Haenszel procedure," by Nathan Mantel, now of American University, Washington, DC. This 1963 paper from the *Journal of the American Statistical Association* has been cited approximately 885 times. It discusses a method for analyzing statistical data from retrospective disease studies. As the title implies, this paper expands on a previous article by Mantel and colleague William Haenszel, appearing in the *Journal of the National Cancer Institute* in 1959.¹⁰ Mantel discussed this *Citation Classic* in 1981.¹¹

As Figure 1 demonstrates, following a small decline in the early 1970s, citations to Mantel's 1963 paper rose steadily through the late 1970s and surged sharply through the mid-1980s. Mantel notes that there are several factors that might explain this increase in citations. For one, the methods described in this paper have more general applications than the 1959 work. Mantel also suggests that the rise in citations may reflect an increased interest on the part of statisticians in epidemiological studies. He notes

further that his work is being increasingly cited in recent textbooks on epidemiology. Lastly, he believes that the methods may have simply taken time to catch on.¹² This paper, which represents an overlap of mathematics and the life sciences, illustrates that it is sometimes difficult to classify these papers into different fields. Mantel, incidentally, also appeared in the Bibliography in the first part of this essay.¹

The most recent papers in this study are from 1984. Two are by Michael J. Berridge, Department of Zoology, University of Cambridge (one of these papers was coauthored by Robin F. Irvine, AFRC Institute of Animal Physiology, Cambridge). Both papers discuss inositol trisphosphate and its role in cellular signal transduction, and both have received approximately 860 citations. The other 1984 paper is by Gallo and colleagues, discussed above.

Although authors in the US and the UK account for the great majority of articles in this study (72 papers from the US, 16 from the UK), other countries are represented. Sweden, for example, accounts for three papers. One of these, "Peptidergic neurones," by Tomas Hökfelt and colleagues, Department of Histology, Karolinska Institute, Stockholm, is among the most-cited articles in this study. This 1980 paper from *Nature* received around 960 citations.

Also cited about 960 times is a paper from Canada, "Nutrient requirements of suspension cultures of soybean root cells," by O.L. Gamborg and colleagues, Prairie Regional Laboratory, National Research Council of Canada, Saskatoon. This paper, published in *Experimental Cell Research* in 1968, is one of two in this study from Canada.

Another paper in the Bibliography is by Oliver H. Lowry and colleagues, Department of Pharmacology, Washington University School of Medicine, St. Louis, Missouri. "The quantitative histochemistry of brain," a 1954 paper from the *Journal of Biological Chemistry*, was cited nearly 890 times. Lowry, of course, whom we've dubbed the world's "Citation Laureate," is author of the most-cited paper ever published.¹³ His 1951 paper on protein analysis¹⁴ was included in the first part of

our study of the top 1,000 papers in the *SCI*, 1961-1982, and has received over 100,000 citations.

This concludes our update of highly cited papers in the *SCI*. Authors who haven't done so are invited to submit *Citation Classic* commentaries on the papers in this study. For the older papers, we invite surviving colleagues and associates to comment on these classics. Interested authors can con-

tact Richard Greenlee, manager of professional communications, ISI®, at 215-386-0100, extension 1429.

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A

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