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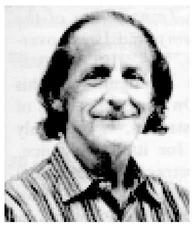

Current Comments®

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The Articles Most Cited in the *SCI*, 1961-1982. 9. More Contemporary Classics of Science

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The 102 articles listed in the Bibliography at the end of this analysis constitute the ninth group of most-cited papers that we have presented from the 1961-1982 *Science Citation Index*® (*SCI*®). The list of papers discussed here includes Frank Wilcoxon's classic 1945 *Biometrics* article on ranking methods. The following year Wilcoxon published his highly cited book, *Some Rapid Approximate Statistical Procedures*,[1] cited 855 times. Thirty-eight other methods papers are also listed in the Bibliography.

Authors

Twenty-one Nobel Prize recipients are among the 233 authors of the 102 papers in this essay. Ten researchers are laureates in medicine (J. Axelrod, A.D. Hershey, A. Kornberg, H.A. Krebs, J. Lederberg, G.E. Palade, E.W. Sutherland, J.R. Vane, J.D. Watson, R.S. Yalow), eight in chemistry (C.B. Anfinsen, V. du Vigneaud, M. Eigen, R. Hoffmann, R.S. Mulliken, M.F. Perutz, F. Sanger, R.B. Woodward), and three in physics (P.W. Anderson, N. Bloembergen, N.F. Mott). Previous lists in the series included an average of "just" 13 Nobelists. Nearly 20 years ago, Irving Sher, ISI®'s director of development and quality control, and I determined that Nobel Prize winners can be expected to publish large numbers of highly cited papers.[2] I will have more to say about this issue in an upcoming essay.

Papers

Table 1 chronologically lists the dates for all 102 papers. About half of them were published in the 1960s, a proportion that has not changed much over the course of this series. Wilcoxon's 1945 *Biometrics* paper, mentioned earlier, is the second oldest of the 102 papers. Harry Goldblatt, James Lynch, Ramon F. Hanzal, and Ward W. Summerville, Institute of Pathology, Case Western Reserve University, Cleveland, Ohio, coauthored the oldest paper (1934). Goldblatt's paper was the first article in a 20-part series on experimental hypertension. In that first paper the researchers described their experiments to elevate blood pressure by various methods involving injury to animal kidneys.[3]

The most recent paper in the Bibliography appeared in 1979 in the *Proceedings of the National Academy of Sciences of the United States of America*. It describes the transfer of DNA fragments from agarose gels to diazobenzyloxymethyl-paper:

> Controlled cleavage of the DNA *in situ* by sequential treatment with dilute acid, which causes partial depurination, and dilute alkali, which causes cleavage and separation of the strands, allows the DNA to leave the gel rapidly and completely, with an efficiency independent of its size. Covalent attachment of DNA to paper prevents losses during subsequent hybridization and washing steps and allows a single paper to be reused many times. Ten percent dextran sulfate, originally found

to accelerate DNA hybridization in solution by about 10-fold, accelerates the rate of hybridization of randomly cleaved double-stranded DNA probes to immobilized nucleic acids by as much as 100-fold, without increasing the background significantly.[4]

Written by Geoffrey M. Wahl, Michael Stern, and George R. Stark, Department of Biochemistry, Stanford University School of Medicine, this contemporary classic has already been cited over 1,700 times. In the first six months of 1985 alone, it was cited over 250 times, reflecting the enormous amount of work done in this area. In 1983 it received 393 citations and in 1984, 363. In Figure 1 we have plotted this paper's citation history. The curves for four additional papers, discussed later in this essay, are also included on the graph.

Several other papers in the Bibliography were also highly cited from 1983 to 1985. The 1974 paper by Enrico Clementi and Carla Roetti, IBM Research Laboratory, San Jose, California, presents tables of "the exponents of the basis functions and the coefficients to be used in analytic wavefunctions expanded in the Roothaan-Hartree-Fock method...."[5] The 1976 article by Harold Weintraub and Mark Groudine, Department of Biochemical Sciences, Frick Laboratory, Princeton University, and published in *Science*, reports that "globin genes are digested by deoxyribonuclease I in red blood cell nuclei but not in fibroblast nuclei."[6] These two papers received 153 and 128 citations in 1983, 140 and 99 in 1984, and 134 and 61 in 1985, respectively.

From 1961 to 1982 the 102 papers received an average of 721 citations; 4 papers received 739 cites, the highest number of citations in this list (I. Macpherson, P.K. Nakane, M.E. Pullman, E.W. Sutherland), while 4 articles had 697 (S.J. Cooperstein, J. Del Bene, R. Hoffmann, T. Maniatis), the least number. These differences are, of course, insignificant at this level of citation frequency.

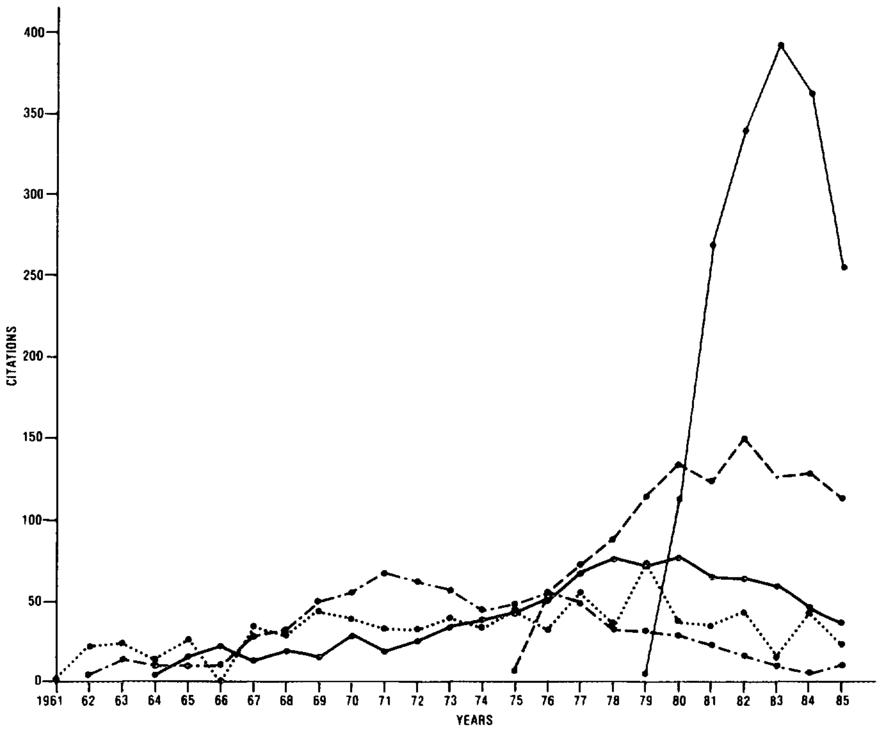
Note that a paper by Ludvig D. Faddeev, Mathematical Institute, Academy of Sciences of the USSR, Leningrad, is included in the Bibliography, although it was cited over 947 times. In terms of rank it should have been listed in Part 5 of this series,[7] but there were two separate sets of citations involved that were not unified. Originally published in Russian in *Zhurnal Eksperimental'noi Teoriticheskoi Fiziki* in November 1960, it was also published in May 1961 in that journal's translated edition, *Soviet Physics JETP*. The English-language version was cited over 700 times.

Paul K. Nakane and Akira Kawaoi's 1974 paper, cited 739 times from 1974 to 1982, continued to be heavily cited in the three years following 1982—it received 127 citations in 1983, 128 in 1984, and 114 in 1985. Macpherson's article was cited 59, 45, and 36 times in that same period. By comparison, the articles by first authors Maynard E. Pullman, Public Health Research Institute of the City of New York, and Earl W. Sutherland, Department of Physiology, Vanderbilt University School of Medicine, Nashville, Tennessee, were cited "only" 19, 41, and 23; and 11, 6, and 11 times, respectively, in 1983, 1984, and 1985. The citation graphs for all four articles are included in Figure 1. It is interesting that citations to Sutherland's 1962 paper peaked in 1971, the year he received the Nobel Prize. Incidentally, the purpose of the comparison in Figure 1 is simply to emphasize the many different

Table 1: Chronologic distribution of publication dates for the ninth group of most-cited papers in the *SCI*®, 1961-1982. A = publication years. B = number of papers.

A	B
1934-1944	1
1945-1949	5
1950-1954	7
1955-1959	16
1960-1964	24
1965-1969	26
1970-1974	16
1975-1979	7

Figure 1: Chronologic distribution of citations to Wahl's 1979 paper (solid line), Nakane's 1974 paper (dash line), Pullman's 1960 paper (dotted line), Sutherland's 1962 paper (dot-dash line), and Macpherson's 1964 paper (bold line).



citation histories for older and more recent papers.

Sutherland, who died in 1974, has two papers in the Bibliography, both of which are from the life sciences. Such papers have predominated in the lists throughout the series. This list is no different—physical-sciences papers account for 26 percent of the articles.

A scan of the titles of the journals that published at least two of the papers (see Table 2) confirms the biochemistry/biomedicine emphasis. These 16 journals published over 50 percent of the articles in this study. However, 62 journals are represented in the Bibliography. Three German journals—*Chemische Berichte*, *Klinische Wochenschrift*, and *Biochemische Zeitschrift*—each published one of the three German-language papers (H. Ehringer, W. König, H. Wagner). One French paper appeared in *Biochimica Biophysica Acta* (P. Grabar). The appearance of any non-English papers in these lists always challenges the widespread assumption that there is a bias against foreign-language papers in citation analyses. Although published in German, Hildebert Wagner's article on "Thin layer chromatography of phosphatides and glycolipids" was cited 737 times in the 1961-1982 *SCI*. But it is difficult to quantify the effect of publication in languages other than English.

The 1971 paper by Louis Gluck and colleagues is a collaborative study by three institutions—the University of California, San Diego; Yale University, New Haven; and the University of Miami, Florida. It describes the use of

Table 2: Journals that published at least two articles in the ninth group of papers most cited in the *SCI*®, 1961-1982. A = journal title. B = number of papers. C = 1983 impact factor.

A	B	C
J. Biol. Chem.	9	5.8
Biochemistry—USA	5	4.1
J. Chem. Phys.	5	3.0
Phys. Rev.	5	---*
Biochim. Biophys. Acta	4	2.4
Nature	4	9.3
Proc. Nat. Acad. Sci. US	4	8.7
Meth. Enzymology	3	1.3
Science	3	7.4
Biochem. J.	2	3.3
J. Amer. Chem. Soc.	2	4.5
J. Cell Biol.	2	9.2
J. Clin. Invest.	2	7.0
J. Exp. Med.	2	11.1
Pharmacol. Rev.	2	8.2
Phil. Trans. Roy. Soc. London A	2	1.6

*The *Physical Review* now appears in several sections. The impact factors for each section are A—2.6, B—3.3, C—2.2, and D—2.7.

amniocentesis to diagnose respiratory distress syndrome (RDS), a frequent consequence of premature birth.

> [RDS] is characterized by breathing difficulty caused by lack of alveolar stability which produces progressive atelectasis and may lead to death with hyaline membranes.[8]

Gluck and colleagues determined that

> changes in phospholipids [such as lecithin] in amniotic fluid (PLAF) reflect those in the lung of the developing fetus. A sudden increase in lecithin concentration after 35 weeks heralds maturity of the pulmonary alveolar lining when respiratory distress syndrome will not occur should the fetus then be born.[8]

In 1979 Gluck discussed his paper in a *Citation Classic*® commentary published in the clinical edition of *Current Contents*®. He noted that

> we since have progressed to a more complex, more informative group of measurements, the Lung Profile, including the L/S ratio [lecithin/sphingomyelin] and percentages of disaturated lecithin, phosphatidyl inositol, and phosphatidyl glycerol. These last two acidic phospholipids appear necessary to stabilize lecithin in the alveolar layer. The accuracy of prediction of fetal lung maturity by Lung Profile appears as close to 100 percent as a biological test is ever likely to be.[9]

An even more recent article is the work of Samuel F. Edwards and Philip W. Anderson, Cavendish Laboratories, Cambridge, UK, on "a new theory of the class of dilute magnetic alloys, called the spin glasses."[10] Published in 1975, it received 127 citations in 1983, 97 in 1984, and 94 in 1985.

Twenty years earlier, Arthur Kornberg, then at Washington University, St. Louis, Missouri, and Bernard L. Horecker and Pauline Z. Smyrniotis of NIH, Bethesda, published a classic methods paper in *Methods in Enzymology*. Kornberg (now at Stanford) and his NIH coworkers examined the properties and methods of purification of glucose-6-phosphate dehydrogenase and 6-phosphogluconic dehydrogenase.

Unfortunately, Kornberg's paper has not yet been discussed in a *Citation Classic* commentary, but 27 other papers in the list have been. They are indicated in the Bibliography by asterisks (*). We encourage the authors of the other 75 papers to share their insights with us by writing about their landmark papers.

I think it is important to repeat here that *Classic* commentaries often provide readers with the "personal" side of science while revealing to them the important events or quirks of fate that triggered particular scientific breakthroughs. For example, in 1982 Wolfgang König commented on his 1970 work with Rolf Geiger in the Department of Pharmaceutical Research at Hoechst AG, Frankfurt, Federal Republic of Germany. One of their tasks there was to develop new methods in peptide chemistry. Prior to the publication of the paper included in this study, they tested many compounds as potential additives to dicyclohexylcarbodiimide but had discouraging results until

> one day I glanced by chance at an advertisement of my principal, Hoechst AG, showing the formula of benzotriazole. I was immediately fascinated by the idea that the 1-hydroxyderivative should com-

prise structural elements most favourable for our purposes. In a matter of days we showed in preliminary tests that 1-hydroxybenzotriazole was indeed the additive we had looked for the whole time.[11]

Daniel Branton, Department of Botany, University of California, Berkeley, authored a paper in the Bibliography entitled "Fracture faces of frozen membranes." Like König, he also experienced a "flash of recognition" that solved a research problem.

Late in 1963, while reexamining some old electron micrographs on onion root-tip cells, I discovered what had been staring me in the face all along. I saw that the fracture process used in freeze-etching was splitting biological membranes, which are only about 85Å thick, into two even thinner halves! In other words, what all of us had been interpreting as the surfaces of membranes were in fact fracture faces within the membrane itself. I was so astonished that I could not at first believe what was plain to see.[12]

On a more personal note are Nicholas Bruchovsky's recollections on his work with testosterone.

Recalling this past experience is doubly pleasurable since the effort not only brings to mind a stimulating and productive time in the United States, but also affords an occasion to read 56 letters written to my then future wife. My surprise upon her welcome revelation that the letters were still in existence was possibly exceeded by the satisfaction of being able to sharpen my memory concerning the... events [of my research].[13]

The unsettled times of the 1960s, in which so many of the papers in this series were written, are recalled by Dale G. Deutsch, Department of Biochemistry, Purdue University, Lafayette, Indiana, in his 1983 commentary about "Plasminogen: purification from human plasma by affinity chromatography."

This work on plasminogen was performed at Purdue University where I became a graduate student after two years in the Peace Corps. I worked in Edwin Mertz's laboratory where my project was to purify and characterize plasminogen.... The multiple-step procedures were very laborious and after about a year of drying out and repacking monstrous columns, I became discouraged and drifted out of the laboratory. My lack of good results made me embarrassed to approach Mertz (who concluded I was goofing off), and he suggested I get a master's degree. To make matters worse, my course work wasn't going well, and the chance to help take over the administration building, as part of an antiwar demonstration, came as a welcome relief during this period.[14]

Conclusion

In our next installment of this series we will list the 10th group of most-cited papers from the 1961-1982 *SCI*. At that time we will summarize the following kinds of information about the 1,000 discoveries and methodological breakthroughs we have listed in this series: average citation frequency, institutional and geographic affiliations, journals, languages of publication, disciplines, and so on. These analyses will provide us with some interesting perspectives on the 1,000 papers that have significantly influenced modern research. Nevertheless, it is important to stress that these discoveries, important as they are, represent the tip of an enormous iceberg or, more accurately, a series of pyramids. In one interpretation, the literature consists of large numbers of infrequently cited papers all "standing on the shoulders"[15] of smaller groups of well-cited, or "giant," papers. These are like pyramids standing on their apexes. In the 1961-1982 *SCI*, the 1,000 most-cited papers received about 1,500,000, or 1.5 percent, of the 100,000,000 citations we processed for those years. The same data, however, may support the perspective on science known as the Ortega hypothesis,[16] which states that these giant papers are built on the contributions of the masses of less cited works. This can be visualized as a pyramid standing on its base. As citation networks can demonstrate, the two theories are not necessarily contradictory. A simple model for this would be a series of pyramids connected at their apexes.

William E. Snizek, Department of Sociology, Virginia Polytechnic Institute and State University, Blacksburg, recently reexamined the Ortega hypothesis in a paper published in *Scientometrics*.[17] For those less familiar with the literature of the sociology of science, it is important to note that there is some ambiguity in this eponym. It became popular as a result of the primordial paper by Jonathan and Stephen Cole.[18] Their paper was, in fact, a refutation of the ideas expressed originally by Ortega y Gasset in 1932.[16] It is, of course, my own literary license to assume that we can substitute papers for authors when talking about a pyramidal model of the literature. The literature on this subject concentrates primarily on the question of whether or not the elite, or highly cited, scientists tend to cite other elite scientists. Our *Citation Classics* series demonstrates that there are thousands of scientists who have made significant contributions. But we have not yet been able to examine these in a systematic way to determine to what extent those who are also *of Nobel class*[19] have been influenced by the work of less eminent persons. A database consisting of the *Contemporary Classics in Science*,[20] including their citation links both forward and backward, may help illuminate this interesting controversy.

* * * * *

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Bibliography of Most-Cited Papers, 1961-1982. Part 9

The ninth group of articles most cited in the *SCI*®, 1961-1982, in alphabetic order by first author. A = 1961-1982 citations. The 1983 citations appear in parentheses. B = bibliographic data. An asterisk (*) indicates that the paper was the subject of a *Citation Classic*® commentary. The issue and year of the commentary follow the bibliographic reference.

A		B
729	(22)	**Armstrong J A, Bloembergen N, Ducuing J & Pershan P S.** Interactions between light waves in a nonlinear dielectric. *Phys. Rev.* 127:1918-39, 1962.
724	(51)	**Axelrod J & Tomchick R.** Enzymatic O-methylation of epinephrine and other catechols. *J. Biol. Chem.* 233:702-5, 1958.
704	(62)	***Bambynek W, Crasemann B, Fink R W, Freund H-U, Mark H, Swift C D, Price R E & Rao P V.** X-ray fluorescence yields, Auger, and Coster-Kronig transition probabilities. *Rev. Mod. Phys.* 44:716-813, 1972. (41/81/PC&ES)
721	(27)	***Bates D R & Damgaard A.** The calculation of the absolute strengths of spectral lines. *Phil. Trans. Roy. Soc. London A* 242:101-22, 1949. (9/79/PC&ES)
729	(51)	**Belavin A A, Polyakov A M, Schwartz A S & Tyupkin Y S.** Pseudoparticle solutions of the Yang-Mills equations. *Phys. Lett. B* 59:85-7, 1975.
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729	(56)	**Boyle W.** An extension of the ^{51}Cr-release assay for the estimation of mouse cytotoxins. *Transplantation* 6:761-4, 1968.
699	(15)	***Branton D.** Fracture faces of frozen membranes. *Proc. Nat. Acad. Sci. US* 55:1048-56, 1966. (1/79/AB&ES)
730	(18)	***Bruchovsky N & Wilson J D.** The conversion of testosterone to 5α-androstan-17β-ol-3-one by rat prostate *in vivo* and *in vitro*. *J. Biol. Chem.* 243:2012-21, 1968. (30/80/LS)
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734	(5)	**Burgi E & Hershey A D.** Sedimentation rate as a measure of molecular weight of DNA. *Biophys. J.* 3:309-21, 1963.
699	(61)	**Burton W K, Cabrera N & Frank F C.** The growth of crystals and the equilibrium structure of their surfaces. *Phil. Trans. Roy. Soc. London A* 243:299-358, 1951.
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722	(56)	**Chaney A L & Marbach E P.** Modified reagents for determination of urea and ammonia. *Clin. Chem.* 8:130-2, 1962.
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709	(26)	**Cleland W W.** The kinetics of enzyme-catalyzed reactions with two or more substrates or products. II. Inhibition: nomenclature and theory. *Biochim. Biophys. Acta* 67:173-87, 1963.
732	(153)	**Clementi E & Roetti C.** Roothaan-Hartree-Fock atomic wavefunctions. *At. Data Nucl. Data Tables* 14:177-478, 1974.
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