Current Comments

The 1977 Articles Most Cited from 1977 to 1979. Part 1. Life Sciences

Number 29 July 21, 1980

Last year, we published lists of the 1976 articles that were most-cited during the years 1976-1977.[1,2] At various times, we have performed similar studies for papers published in each year since 1970. This essay, and the one to follow, will identify those papers published in 1977 that were most-cited in 1977 and 1978. This week, we consider articles in the life sciences. Next week's study will focus on papers in the physical sciences.

Studies of this sort are useful for determining "where the action is" in science. If a paper on a given topic receives an immediate burst of citations, then it follows that a number of researchers are working on the same topic or in related areas. These studies may also have value for determining the important papers of a given year. I'm not saying that the authors of the articles on this list will all win Nobel or Lasker prizes. But it is a certainty that most of these papers will continue to be highly cited as time passes.

By the way, those of you who are interested in the "epidemiology" of citation should consult the work of Bill Goffman, Case Western Reserve University, on the subject.[3] I'll have more to say on this topic in an upcoming essay.

The average paper on this list received 66 citations during the two year period of 1977 and 1978. Of these, ten were received in 1977 and 56 in 1978. The most-cited paper on the list received 350 citations. The least-cited received 44. Incidentally, 12 papers received 44 citations. For that reason, our list contains 103 papers instead of the usual 100.

The papers on this list appeared in 36 journals. The *Proceedings of the National Academy of Sciences USA* accounted for 14 papers, more than any other journal. The *Proceedings* also topped all other journals in our study of the 1976 life science papers that were most-cited in 1976-77. In fact, the top five journals in that study are also the top five in this one, although their order has changed somewhat. These journals contributed more than half, that is, 52, of the articles in this study. In addition to the *Proceedings,* the other top journals are: *Cell* (13 papers); *New England Journal of Medicine* (10); *Nature* (8); and *Science* (7). A complete list of the journals in this study appears in Table 1.

The authors on this list came from 84 institutions (shown in Table 2). American laboratories again predominate. The US is represented by 52 institutions. The United Kingdom accounts for nine institutions. Denmark has five, Sweden has four, and Canada has three. France and the Federal Republic of Germany each have two. Israel, Italy, Japan, Kenya, the Netherlands, Norway, and Switzerland all have one institution listed here. Without exception, the papers in this study were written in English.

Only eight papers were single-author works. There are 19 papers with two authors. Twenty papers had three

Table 1: The 36 journals represented on the list of 1977 life science papers most-cited in 1977-78. The numbers in parentheses are the impact factors for the journals. (Impact equals average number of citations received by articles within each journal according to the 1978 *Journal Citation Reports®*.) The figures at the right indicate the number of papers from each journal which appear on the list.

Journals	Number of Papers
Proc. Nat. Acad. Sci. US (9.339)	14
Cell (12.933)	13
N. Engl. J. Med. (12.274)	10
Nature (5.409)	8
Science (5.927)	7
J. Exp. Med. (9.834)	4
Lancet (8.644)	4
Prostaglandins (5.077)	4
Annu. Rev. Biochem. (29.525)	3
Brain Res. (4.067)	3
J. Mol. Biol. (7.438)	3
Circulation (6.721)	2
Endocrinology (5.44)	2
J. Amer. Chem. Soc. (5.327)	2
J. Biol. Chem. (6.062)	2
Physiol. Rev. (17.314)	2
Am. J. Med. (4.396)	1
Annu. Rev. Physiol. (10.318)	1
Biochemistry (4.914)	1
Blood (5.473)	1
Brit. J. Cancer (2.928)	1
Brit. J. Pharmacology (4.576)	1
Cancer (3.048)	1
Chem. Biol. Interactions (1.000)	1
Gastroenterology (5.382)	1
Gene (5.902)	1
Int. J. Cancer (4.776)	1
J. Cell Biol. (8.102)	1
J. Immunol. (5.217)	1
J. Neuro. Trans. (2.808)	1
J. Neurochem. (3.260)	1
J. Virol. (4.547)	1
Life Sci. (3.410)	1
Neuropharmacology (2.928)	1
Neurosci. Letter (2.503)	1
Rev. Physiol. Biochem. (9.533)	1

authors, 14 had four, and 17 had five. Seven papers had six authors, eight had seven, three had eight, and three had nine. One paper had ten authors, one had 11, one had 12, and one had 16.

Thirty authors have more than one paper on the list. N. Ling, S. Moncada, and J.R. Vane each have four papers. R. Guillemin, C. Rivier, L. Terenius, and W. Vale each authored three papers. The authors with two papers on the list are F. Bloom, M. Brown, S. Bunting, W.P. Castelli, A.H. Conney, R. Elde, D.W. Fraser, W. Gilbert, T. Gordon, D.S. Hogness, T. Hökfelt, M.C. Hjortland, D.M. Jerina, R.D. Kornberg, M.J. Kuhar, W. Levin, A.M. Maxam, J.E. McDade, P. Needleman, A. Raz, J. Rossier, C.C. Shepard, and T.R. Tsai.

The papers on our list fall into 17 subject areas: DNA and RNA research, endorphins and enkephalins, cardiovascular research, neuropharmacology and neuroendocrinology, virology, prostaglandins, immunology and T-cells, pathology, benzo(a)pyrene, cell surface membranes, protein synthesis and structure, cell physiology, cyclic nucleotides, gastroenterology, hematology, oncology, and physiology. One paper on a statistical method of randomized clinical trials is listed alone in clinical research methods. In order to discourage invidious comparisons of citations to individual papers, we alphabetized the listings under each subject area.

Twenty-eight papers, more than one-quarter of those on this list, are from the area of DNA and RNA research. The two most highly cited papers fall into this category. The most-cited article is a methodology paper by A.M. Maxam and W. Gilbert which describes a technique for determining the nucleotide sequence of a DNA molecule. Nucleotides are the constituent parts of DNA and RNA. The second most-cited paper is by F. Sanger and colleagues. It reports the nucleotide sequence for a certain variety of bacteriophage, a virus that infects bacteria. Bacteriophages are popular for use in research into heredity.

Eleven papers deal with endorphins and enkephalins, endogenously produced opiates found in the brain and pituitary gland. The 1978 Lasker award was presented for the discovery of these substances. The three co-winners, Solomon Snyder, John Hughes, and Hans Kosterlitz, each have a paper in this group. Last year, on the basis of co-citation cluster analysis, I presented a strong case for naming additional winners,[4] including Candice Pert. I also stated that L. Terenius of Uppsala University, Sweden, should have been

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

National Institutes of Health	14 (46)
NIMH	3 (7)
NIAMDD	2 (5)
NHLBI	3 (15)
NCI	3 (13)
NIAID	3 (6)
Johns Hopkins University	9 (27)
Harvard University	7 (13)*
Wellcome Research Laboratories, UK	6 (17)
MIT	5 (11)
Salk Institute	5 (24)
Stanford University	5 (15)
University of California	4 (15)
Irvine	1 (2)
San Francisco	3 (13)
University of Pennsylvania[1]	4 (9)
University of Uppsala, Sweden	4 (6)
Cold Spring Harbor Laboratory	3 (6)*
Hoffmann-La Roche	3 (9)
MRC, Cambridge, UK	3 (18)
Weizmann Institute of Science, Rehovot, Israel	3 (8)
Basel Institute of Immunology, Switzerland	2 (3)
Center for Disease Control, Atlanta, GA	2 (18)
Columbia University	2 (6)*
Karolinska University Stockholm, Sweden	2 (5)
State University of New York Stony Brook, NY	2 (6)
University of Alabama	2 (8)
University of Cambridge, UK	2 (7)
University of London, UK	2 (6)
University of Southern California Medical Center	2 (4)
University of Washington, Seattle, WA	2 (11)
Upjohn Co., Kalamazoo, MI	2 (9)
Washington University Medical School, MO	2 (5)
A/S Ferrosan Research Laboratories, Soeborg, Denmark	1 (1)
Ayerst Research Laboratory Montreal, Canada	1 (1)
Bispebjerg Hospital Copenhagen, Denmark	1 (2)
Brookhaven National Laboratory Upton, NY	1 (3)
CNRS, Paris, France	1 (2)
California Institute of Technology	1 (1)
Carnegie Institute of Washington	1 (2)
Case Western Reserve University	1 (2)
Children's Hospital of Philadelphia	1 (3)
City of Hope Medical Center Duarte, CA	1 (2)
Deutsche Forschungsgemeinschaft Bonn-Bad Godesberg, FRG	1 (1)
Fred Hutchinson Cancer Research Center, Seattle, WA	1 (8)
George Washington University	1 (1)
Georgetown University	1 (2)
Honolulu Heart Study	1 (1)
Imperial College, London, UK	1 (1)
Institut de Chimie Biologique Strasbourg, France	1 (1)
Institute of Medical Sciences San Francisco, CA	1 (1)
Institute Recherches Cliniques Montreal, Canada	1 (3)
Instituto Nazionale Tumori, Milan, Italy	1 (5)
Memorial Sloan-Kettering Cancer Center, New York, NY	1 (2)
Mercy Catholic Medical Center Philadelphia, PA	1 (3)
New York State Department of Health	1 (1)
New York University School of Medicine	1 (1)
Oregon State University, Corvallis, OR	1 (5)
Oxford University, Oxford, UK	1 (5)
Presbyterian Hospital, New York, NY	1 (1)*
Princeton University	1 (4)
Psychiatric Research Center Uppsala, Sweden	1 (2)
Rigshospitalet, Copenhagen, Denmark	1 (2)
Rockefeller University, New York, NY	1 (1)
Rutgers University Medical School Piscataway, NJ	1 (1)
Royal Postgraduate Medical School London, UK	1 (3)
Scripps Clinic and Research Foundation La Jolla, CA	1 (4)
Seattle University	1 (1)
Southern General Hospital Glasgow, UK	1 (5)
Squibb Institute for Medical Research Princeton, NJ	1 (3)
St. Hans Mental Hospital Roskilde, Denmark	1 (1)
Temple University School of Medicine Philadelphia, PA	1 (2)
Tohoku University, Sendai, Japan	1 (1)
University of Aarhus, Aarhus, Denmark	1 (2)
University of Aberdeen, Aberdeen, UK	1 (4)
University of Amsterdam Amsterdam, The Netherlands	1 (2)
University of Chicago	1 (2)
University of Colorado Medical Center Denver, CO	1 (2)
University of Laval, Quebec, Canada	1 (3)
University of Lund, Lund, Sweden	1 (1)
University of Mainz, Mainz, FRG	1 (4)
University of Michigan	1 (4)
University of Minnesota Medical School	1 (2)
University of Texas Health Sciences Center, Dallas, TX	1 (2)
University of Tromsø, Tromsø, Norway	1 (4)
Veterans' Administration Hospital Little Rock, AR	1 (5)
Veterans' Administration Hospital New York, NY	1 (1)
WHO Immunology Research and Training Center, Nairobi, Kenya	1 (1)
Worcester Foundation, Shrewsbury, MA	1 (2)
Wyeth Laboratories, Philadelphia, PA	1 (1)
Yale University	1 (1)

*One or more of these authors represents a second affiliation for a single authored paper.

1. Including the Wistar Institute of Anatomy and Biology, Philadelphia, PA.

considered. Terenius continues to produce important work in this field, as evidenced by his three papers in this group. The group also includes three papers by Roger Guillemin, who shared the 1977 Nobel prize in physiology or medicine for his work on hormones.

Cardiovascular research contributed eight papers. Three of them deal with high-density lipoproteins (HDLs). The three papers that deal with HDLs suggest that these substances may retard the progression of atherosclerosis by transporting cholesterol away from the arterial walls.

Eight papers are on various topics in the field of neuropharmacology/neuroendocrinology. The most-cited among them is a review by K. Starke on the release of noradrenaline, a hormone which raises blood pressure as one of its primary effects.

Virology accounts for eight papers. Two of them deal with murine C-type viruses, which cause leukemia in mice. Two other papers in this group deal with simian virus 40, which causes tumors in monkeys.

Prostaglandin research accounts for seven papers. Prostaglandins are fatty acids which are responsible for lowering blood pressure and for stimulating the contraction of smooth-type muscles. Five of these papers deal with prostaglandin X, also called prostacyclin or PGX. This variety inhibits blood clotting. The third most-cited paper on the list, that by S. Moncada, E.A. Higgs, and J.R. Vane, shows that human blood vessel tissue can produce prostaglandin X.

There are six papers on the list from immunology and T-cell research. T-cells (thymic-derived lymphocytes) play an important role in the body's defenses against diseases. They have the ability to "recognize" antigens and to regulate the production of appropriate antibodies. T-cells can also kill tumor cells. Thus, they may have a role to play in cancer prevention.

Six papers on the list are from the field of pathology. Two of them deal with "Legionnaires' disease." The first outbreak of this form of pneumonia occurred in Philadelphia in the summer of 1976. Its cause was at that time a mystery. The two papers on which D.W. Fraser and J.E. McDade appear as first authors represent the initial steps toward isolating the bacterium responsible for the outbreak. Both papers are the result of work done at the federal Center for Disease Control in Atlanta.

Three papers deal with benzo(a)pyrene, a common carcinogen. Benzo(a)pyrene is generated through incomplete combustion processes. This would include automobile exhausts, cigarette smoke, and even forest fires.

There were three papers on cell surface membranes. This group includes the fourth most-cited paper on the list, by J.E. Rothman and J. Lenard. Their paper discusses the mechanisms by which cells assemble their membranes.

Three papers deal with various topics in protein synthesis and structure. The paper by D.W. Cleveland and colleagues at Princeton University received 103 citations. That article described a method for mapping peptides, the constituent parts of proteins. Only nine other papers on the list received 100 or more citations.

A number of other areas of research are represented in this study. Cell physiology, cyclic nucleotides, gastroenterology, hematology, and oncology each have two papers. There was one paper in physiology and the one in clinical research methods mentioned above.

As I have stated before, the early citation history of a paper is a useful predictor of future citation activity.[1] This point has also been made by others.[5,6] So this year, I decided to find out how these most-cited articles did perform in the following year—that is, 1979. As it happens 75% of them would remain on the list. Since a quarter of them would be displaced, we've listed in Figure 2 the

25 other 1977 papers that would have been on our list if this study was based on three years instead of two. Thus, you might say these papers had a slower start but have now picked up more momentum.

It is also probably true that many of the papers in Figure 2 barely missed the list in Figure 1 simply because they were actually published in the early part of 1978. Since we cannot determine the actual day of publication for the thousands of papers we study, it is quite possible that a few papers with equivalent citation rates have been omitted. While it may be obvious, it is worth repeating that only a small fraction of the millions of papers published ever achieve a lifetime impact of 100 or more citations. What we do not yet know is how milestone papers, for whatever reason, do not achieve such citation distinction and why. This is a subject of considerable interest to historians who want to use quantitative methods to identify the major breakthroughs in each field.

In part II of this study, we will report on the 1977 physical science papers that were most-cited in 1977-78.

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

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Figure 1: The 1977 life sciences articles most-cited in 1977-78. The authors' addresses 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.

DNA & RNA RESEARCH

77	78	Total Citations	Bibliographic Data
1	61	62	**Aloni Y, Dhar R, Laub O, Horowitz M & Khoury G.** Novel mechanism for RNA maturation: the leader sequences of simian virus 40 mRNA are not transcribed adjacent to the coding sequences. *Proc. Nat. Acad. Sci. US* 74:3686-90, 1977. NCI, NIH, Lab. DNA Tumor Viruses, Bethesda, MD; Weizmann Inst. Sci., Dept. Genet., Rehovot, Israel
1	48	49	**Bastos R N & Aviv H.** Globin RNA precursor molecules: biosynthesis and processing in erythroid cells. *Cell* 11:641-50, 1977. Weizmann Inst. Sci., Dept. Virol., Rehovot, Israel
7	106	113	**Berget S M, Moore C & Sharp P A.** Spliced segments at the 5' terminus of adenovirus 2 late mRNA. *Proc. Nat. Acad. Sci. US* 74:3171-5, 1977. MIT, Ctr. Cancer Res. & Dept. Biol., Cambridge, MA
1	48	49	**Bolivar F, Rodriguez R L, Greene P J, Betlach M C, Heyneker H L & Boyer H W.** Construction and characterization of new cloning vehicles. 2. A multi-purpose cloning system. *Gene* 2:95-113, 1977. Univ. Calif., Dept. Biochem. & Biophys., San Francisco, CA; Univ. Washington, Dept. Microbiol., Seattle, WA

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6 83 89 **Klessig D F.** Two adenovirus mRNAs have a common 5' terminal leader sequence encoded at least 10 kb upstream from their main coding regions. *Cell* 12:9-21, 1977. Cold Spring Harbor Lab., Cold Spring Harbor, NY

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ENDORPHINS & ENKEPHALINS

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PHYSIOLOGY

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Figure 2: The 1977 life sciences articles which are among the 100 most-cited in 1977-79, and which do not appear in Figure 1.

77 78 79 T **LIFE SCIENCES**

ENZYMOLOGY

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PROSTAGLANDINS

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CELL PHYSIOLOGY

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4 35 59 98 **Small J V & Sobieszek A.** Studies on the function and composition of the 10-NM(100-A) filaments of vertebrate smooth muscle. *J. Cell Sci.* 23:243-68, 1977. Aarhus Univ., Inst. Molec. Biol., Aarhus, Denmark

1 26 99 126 **Silverstein S C, Steinman R M & Cohn Z A.** Endocytosis. *Ann. Rev. Biochem.* 46:669-722, 1977. Rockefeller Univ., Dept. Cell. Physiol. & Immunol., New York, NY

0 41 53 94 **Weissbach A.** Eukaryotic DNA polymerases. *Ann. Rev. Biochem.* 46:25-47, 1977. Roche Inst. Molec. Biol., Dept. Cell Biol., Nutley, NJ

IMMUNOLOGY & T-CELLS

1 29 67 97 **Bresnihan B & Jasin H E.** Suppressor function of peripheral blood mononuclear cells in normal individuals and in patients with systemic lupus erythematosus. *J. Clin. Invest.* 59:106-16, 1977. Univ. Texas Southwestern Med. Sch., Dept. Int. Med., Dallas, TX

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2 41 58 101 **Kay H D, Bonnard G D, West W H & Herberman R B.** A functional comparison of human Fc-receptor-bearing lymphocytes active in natural cytotoxicity and antibody-dependent cellular cytotoxicity. *J. Immunol.* 118:2058-66, 1977. NCI, NIH, Lab. Immunodiag., Bethesda, MD

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8 27 61 96 **Blattner F R, Williams B G, Blechl A E, Denniston-Thompson K, Faber H E, Furlong L A, Grunwald D J, Kiefer D O, Moore D D, Schumm J W, Sheldon E L & Smithies O.** Charon phages: safer derivatives of bacteriophage lambda for DNA cloning. *Science* 196:161-9, 1977. Univ. Wisconsin, Lab. Genet., Madison, WI

1 27 79 107 **Bolivar F, Rodriguez R L, Betlach M C & Boyer H W.** Construction and characterization of new cloning vehicles. 1. Ampicillin-resistant derivatives of the plasmid pMB9. *Gene* 2:75-93, 1977. Univ. Calif., Depts. Biochem. & Biophys., San Francisco, CA

4 39 96 139 **Donis-Keller H, Maxam A M & Gilbert W.** Mapping adenines, guanines, and pyrimidines in RNA. *Nucleic Acid. Res.* 4:2527-38, 1977. Harvard Univ., Dept. Biochem. & Molec. Biol., Cambridge, MA

0 37 70 107 **Goodman H M, Olson M V & Hall B D.** Nucleotide sequence of a mutant eukaryotic gene: the yeast tyrosine-inserting ochre suppressor SUP4-o. *Proc. Nat. Acad. Sci. US* 74:5453-7, 1977. Univ. Washington, Dept. Genet., Seattle, WA

1 25 68 94 **Jeffreys A J & Flavell R A.** A physical map of the DNA regions flanking the rabbit β-globin gene. *Cell* 12:429-39, 1977. Univ. Amsterdam, Sect. Med. Enzymol. & Molec. Biol., Lab. Biochem., Amsterdam, The Netherlands

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0 30 71 101 **Tilghman S M, Tiemeier D C, Polsky F, Edgell M H, Seidman J G, Leder A, Enquist L W, Norman B & Leder P.** Cloning specific segments of the mammalian genome: bacteriophage λ containing mouse globin and surrounding gene sequences. *Proc. Nat. Acad. Sci. US* 74:4406-10, 1977. NICHHD, NIH, Lab. Molec. Genet., Bethesda, MD

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1 36 61 98 **Goplaath R M & Vincenzi F F.** Phosphodiesterase protein activator mimics red blood cell cytoplasmic activator of (Ca^{2+}-Mg^{2+})ATPase. *Biochem. Biophys. Res.* 77:1203-9, 1977. Univ. Washington, Sch. Med., Dept. Pharmacol., Seattle, WA

0 40 93 133 **Rasmussen H & Goodman D B P.** Relationships between calcium and cyclic nucleotides in cell activation. *Physiol. Rev.* 57:421-509, 1977. Yale Univ. Sch. Med., Dept. Cell Biol. & Int. Med., New Haven, CT

0 25 72 97 **Roberts J L & Herbert E.** Characterization of a common precursor to corticotropin and β-lipotropin: identification of β-lipotropin peptides and their arrangement relative to corticotropin in the precursor synthesized in a cell-free system. *Proc. Nat. Acad. Sci. US* 74:5300-4, 1977. Univ. Oregon, Dept. Chem., Eugene, OR

NEUROPHARMACOLOGY

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0 26 89 115 **Rossier J, Vargo T M, Minick S, Ling N, Bloom F E & Guillemin R.** Regional dissociation of β-endorphin and enkephalin contents in rat brain and pituitary. *Proc. Nat. Acad. Sci. US* 74:5162-5, 1977. Salk Inst. Biol. Stud., Arthur Vining Davis Ctr. Behav. Neurobiol. & Labs. Neuroendocrinol., La Jolla, CA