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Current Comments®

100 Classics from the *New England Journal of Medicine*

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Recently, we identified the 100 most-cited papers of all time,[1] and indicated which of them were the subjects of *Citation Classics*™ [2] commentaries. We now plan to publish a series of essays listing the most-cited articles from several leading multidisciplinary or multispecialty journals. Publication of these lists constitutes an open invitation to the authors of these *Citation Classics* to submit commentaries if they have not done so already. Simultaneously, we are sending letters of invitation to the authors involved.

This essay examines the classic articles published by the *New England Journal of Medicine* (*NEJM*). Numerous studies have shown this journal to be one of the most influential medical journals in the world. Indeed, it ranks among the highest impact journals regardless of discipline.

Of the thousands of articles published in *NEJM* since its inception in 1812, many hundreds would qualify as *Citation Classics*. Table 1 shows the frequency distribution for the 3,100 papers from *NEJM* cited 50 or more times between 1961 and 1982. Over 250 papers have been cited at least 200 times.

NEJM is famous for the "Ingelfinger rule." The present editor, Arnold Relman, believes that *NEJM* is so well-respected because of his strict enforcement of the rule, among other reasons. Formulated by his predecessor, Franz Ingelfinger,[3] the rule prohibits prior disclosure to the media of papers submitted to *NEJM*. When an author submits a paper, he or she may *not* disclose its substance prior to publication in *NEJM*. The rule undoubtedly protects the "newsworthiness" of *NEJM*. Presumably, it also protects the public. Otherwise, we might be misled by reports that had not been rigorously refereed by medical experts.[4] The Ingelfinger rule has been the subject of considerable debate,[5-10] too extensive to be reviewed here. The public visibility of *NEJM* was recently reinforced when "Bud" Relman was interviewed by Hugh Downs on *20/20*, an American television "magazine."

The 100 most-cited articles from *NEJM* are listed alphabetically by first author in Table 2. Column A shows the number of citations we found for each paper in *Science Citation Index*® (*SCI*®) from 1961 to 1983. These papers were cited at least 270 times during this period. For the papers published before 1961, we added data from the recently published 1955-1964 *SCI* cumulation. Additional *Citation Classics* published in the first half of the twentieth century will be identified when our source data base is extended even further to include pre-1955 material. Many of these could also be identified by limiting the analysis to citation data in the 1955-1964 *SCI* cumulation. In fact, a list of the 250 most-cited publications for that period is included in the introductory *Guide and Lists of Source Publications*[11] to the cumulation. We'll discuss these classics in the near future.

An asterisk in column B of Table 2 indicates that the paper has already been featured as a *Citation Classic* in *Current*

Table 1: Citation frequency distribution, 1961-1982 *SCI®*, for *NEJM* articles with 50 or more citations. A = number of citations. B = number of items receiving that number of citations. C = percent of group.

A	B	C
≥ 500	17	.6
400-499	13	.4
350-399	23	.8
300-349	29	.9
250-299	48	1.6
200-249	130	4.2
150-199	242	7.8
100-149	627	20.3
75-99	734	23.8
50-74	1222	39.6
	3085	100.0

Contents® (*CC®*). The issue number, year, and edition of *CC* in which the commentary appeared are shown in parentheses. Of the 23 *Citation Classics* included, all but one appeared in *CC/Clinical Practice*. In addition, they were mentioned in the list of *Citation Classics* published each week in six *CC* editions.

ISI®'s many detailed studies of *NEJM* confirm in many ways its importance to clinical practice and research. In unpublished article-by-article analyses, we have examined the many components of the impact of such journals as *NEJM*, *Lancet*, *British Medical Journal*, *Journal of the American Medical Association*, *Annals of Internal Medicine*, etc. These analyses confirm that letters to the editors of medical journals play an important role in the progress of medicine. David Spodick, St. Vincent Hospital, Worcester, Massachusetts, and Robert Goldberg, University of Massachusetts Medical School, have recently done an interesting analysis of the four basic types of such correspondence—letters concerning articles, those concerning editorials or essays, letters about letters, and letters presenting cases or original investigations.[12]

In the future, we intend to publish a separate analysis of most-cited "letters." The difficulty of doing so is complicated by the ambiguity of the term "letters." For example, "letters to the editor" of *Nature* report original research. There are also "letters" journals in physics, chemistry, etc. Then there are the correspondence sections of many weekly journals such as *Science*, *NEJM*, *Lancet*, etc. We believe that *SCI* is the only indexing or abstracting service that indexes all of these items comprehensively. And the large number of citations to these letters can affect the impacts we calculate for journals, especially those with large correspondence sections, such as *NEJM* and *Lancet*.

In Table 3 we have provided the chronological distribution of the papers in this study. It is surprising how many of them were published in the 1970s. However, the dynamics of the literature explosion are such that the old is rapidly displaced by the new literature. A different method of analysis is needed to properly identify the *Citation Classics* for each year of the older literature. Most of the classics in Table 2 are core papers in ISI research fronts. For example, the most-cited paper, by D.S. Fredrickson and colleagues, was part of the core literature of a research front entitled "Metabolic derangements and clinical aspects of apolipoprotein disorders" included in our 1983 *Index to Research Fronts in ISI/BIOMED®*.[13] A more detailed discussion of Fredrickson's paper follows here.

Table 4 lists the countries where the authors of the most-cited papers in this study are based. For US papers, we also show the number of authors from individual states. As the official publication of the Massachusetts Medical Society, it is not altogether surprising that so many *NEJM* papers are by authors from that state. In fact, all are from the city of Boston. With the exception of one author from Connecticut, however, no other New England state is represented. A much more detailed study would be needed to determine if there is a "bias" in publications selected by this journal of international impact.

The oldest article in Table 2 was published in 1948 by a team of researchers from the Children's Medical Center, Boston: S. Farber, L.K. Diamond, R.D. Mercer, R.F. Sylvester, and J.A. Wolff. The article describes the effects of

Table 2: Most-cited articles from *NEJM*, 1961-1982 *SCI*®, in alphabetic order by first author. Asterisks indicate articles with *Citation Classics*™ commentaries. The issue number, year, and edition of *Current Contents*® in which these commentaries appeared are in parentheses. A = total citations, 1961-1983 *SCI*. B = bibliographic data.

A	B
358	**Adams R D, Fisher C M, Hakim S, Ojemann R G & Sweet W H.** Symptomatic occult hydrocephalus with "normal" cerebrospinal-fluid pressure. *NEJM* 273:117-26, 1965. Mass. Gen. Hosp.; Harvard Med. Sch., Boston, MA; Military Hosp.; Nat. Univ., Bogota, Colombia.
380	***Aisenberg A C & Bloch K J.** Immunoglobulins on the surface of neoplastic lymphocytes. *NEJM* 287:272-6, 1972. Harvard Univ.; Mass. Gen. Hosp., Boston, MA. (24/82/CP)
380	***Alfrey A C, LeGendre G R & Kaehny W D.** The dialysis encephalopathy syndrome. *NEJM* 294:184-8, 1976. Univ. Colorado Med. Ctr., Denver, CO. (7/83/CP)
584	**Babior B M.** Oxygen-dependent microbial killing by phagocytes. *NEJM* 298:659-68, 1978. New Engl. Med. Ctr. Hosp. and Tufts Univ. Sch. Med., Boston, MA.
628	***Baehner R L & Nathan D G.** Quantitative nitroblue tetrazolium test in chronic granulomatous disease. *NEJM* 278:974-6, 1968. Children's Hosp. Med. Ctr.; Harvard Med. Sch., Boston, MA. (44/82/CP)
663	**Bast R C, Zbar B, Borsos T & Rapp H J.** BCG and cancer. *NEJM* 290:1413-20; 1458-69, 1974. NIH, NCI, Bethesda, MD.
399	**Beller G A, Smith T W, Abelmann W H, Haber E & Hood W B.** Digitalis intoxication. *NEJM* 284:989-97, 1971. Boston City Hosp; Mass. Gen. Hosp.; Harvard Med. Sch., Boston, MA.
330	**Bendixen H H, Hedley-Whyte J, Chir B & Laver M B.** Impaired oxygenation in surgical patients during general anesthesia with controlled ventilation. *NEJM* 269:991-6, 1963. Harvard Med. Sch., Boston, MA.
432	**Bonadonna G, Brusamolino E, Valagussa P, Rossi A, Brugnatelli L, Brambilla C, De Lena M, Tancini G, Bajetta E, Musumeci R & Veronesi U.** Combination chemotherapy as an adjuvant treatment in operable breast cancer. *NEJM* 294:405-10, 1976. Ist. Naz. Tumori, Milan, Italy.
430	**Borer J S, Bacharach S L, Green M V, Kent K M, Epstein S E & Johnston G S.** Real-time radionuclide cineangiography in the noninvasive evaluation of global and regional left ventricular function at rest and during exercise in patients with coronary-artery disease. *NEJM* 296:839-44, 1977. NIH, NHLBI, Bethesda, MD.
376	***Boyd A E, Lebovitz H E & Pfeiffer J B.** Stimulation of human-growth-hormone secretion by L-dopa. *NEJM* 283:1425-9, 1970. Duke Univ. Med. Ctr., Durham, NC. (33/82/CP)
287	**Brady R O, Gal A E, Bradley R M, Martensson E, Warshaw A L & Laster L.** Enzymatic defect in Fabry's disease. *NEJM* 276:1163-7, 1967. NIH, NINDB, NIAMD, Bethesda, MD.
497	**Brescia M J, Cimino J E, Appel K & Hurwich B J.** Chronic hemodialysis using venipuncture and a surgically created arteriovenous fistula. *NEJM* 275:1089-92, 1966. Vet. Admin. Hosp., Bronx, NY.
325	**Broder S, Humphrey R, Durm M, Blackman M, Meade B, Goldman C, Strober W & Waldmann T.** Impaired synthesis of polyclonal (non-paraprotein) immunoglobulins by circulating lymphocytes from patients with multiple myeloma. *NEJM* 293:887-92, 1975. NIH, NCI, Bethesda; Johns Hopkins Univ., Baltimore, MD.
288	**Brouet J-C, Flandrin G & Seligmann M.** Indications of the thymus-derived nature of the proliferating cells in six patients with Sezary's syndrome. *NEJM* 289:341-4, 1973. Hop. St.-Louis, Paris, France.
504	***Brunner H R, Laragh J H, Baer L, Newton M A, Goodwin F T, Krakoff L R, Bard R H & Buhler F R.** Essential hypertension: renin and aldosterone, heart attack and stroke. *NEJM* 286:441-9, 1972. Columbia Univ., Coll. Physic. Surg.; Presbyterian Hosp., New York, NY. (40/82/CP)
685	**Buhler F R, Laragh J H, Baer L, Vaughan E D & Brunner H R.** Propranolol inhibition of renin secretion. *NEJM* 287:1209-14, 1972. Columbia Univ., Coll. Physic. Surg.; Presbyterian Hosp., New York, NY.
352	**Cahill G F.** Starvation in man. *NEJM* 282:668-75, 1970. Harvard Med. Sch.; Diabetes Fdn., Inc.; Peter Bent Brigham Hosp., Boston, MA.
598	**Claman H N.** Corticosteroids and lymphoid cells. *NEJM* 287:388-97, 1972. Univ. Colorado Sch. Med., Denver, CO.
329	**Clements J A, Platzker A C G, Tierney D F, Hobel C J, Creasy R K, Margolis A J, Thibeault D W, Tooley W H & Oh W.** Assessment of the risk of the respiratory-distress syndrome by a rapid test for surfactant in amniotic fluid. *NEJM* 286:1077-81, 1972. Univ. California, San Francisco & Los Angeles, CA.
339	***Cohen A S.** Amyloidosis. *NEJM* 277:522-30, 1967. Boston Univ. Sch. Med., Boston, MA. (21/83/CP)
286	**Cohen S & Harris L D.** Does hiatus hernia affect competence of the gastroesophageal sphincter? *NEJM* 284:1053-6, 1971. Univ. Hosp.; Boston Univ. Sch. Med., Boston, MA.
587	**Cotzias G C, Papavasiliou P S & Gellene R.** Modification of Parkinsonism—chronic treatment with L-dopa. *NEJM* 280:337-45, 1969. Brookhaven Nat. Lab., Upton, NY.
524	**Cotzias G C, Van Woert M H & Schiffer L M.** Aromatic amino acids and modification of Parkinsonism. *NEJM* 276:374-9, 1967. Brookhaven Nat. Lab., Upton, NY.
402	***Danzinger R G, Hofmann A F, Schoenfield L J & Thistle J L.** Dissolution of cholesterol gallstones by chenodeoxycholic acid. *NEJM* 286:1-8, 1972. Mayo Clin.; Mayo Fdn., Rochester, MN. (29/82/CP)
296	**Dietschy J M & Wilson J D.** Regulation of cholesterol metabolism. *NEJM* 282:1128-38, 1970. Univ. Texas Southwestern Med. Sch., Dallas, TX.
336	**DuPont H L, Formal S B, Hornick R B, Snyder M J, Libonati J P, Sheahan D G, LaBrec E H & Kalas J P.** Pathogenesis of *Escherichia coli* diarrhea. *NEJM* 285:1-9, 1971. Univ. Maryland Sch. Med.; Walter Reed Army Inst. Res., Baltimore, MD.
389	**Farber S, Diamond L K, Mercer R D, Sylvester R F & Wolff J A.** Temporary remissions in acute leukemia in children produced by folic acid antagonist, 4-aminopteroyl-glutamic acid (aminopterin). *NEJM* 238:787-93, 1948. Children's Med. Ctr., Boston, MA.
500	**Fisher B, Carbone P, Economou S G, Frelick R, Glass A, Lerner H, Redmond C, Zelen M, Band P, Katrych D L, Wolmark N & Fisher E R.** l-phenylalanine mustard (L-PAM) in the management of primary breast cancer. *NEJM* 292:117-22, 1975. Univ. Pittsburgh Sch. Med., Pittsburgh, PA.
333	**Frantz A G & Rabkin M T.** Human growth hormone. *NEJM* 271:1375-81, 1964. Mass. Gen. Hosp.; Harvard Med. Sch., Boston, MA.

330 **Fraser D W, Tsai T R, Orenstein W, Parkin W E, Beecham H J, Sharrar R G, Harris J, Mallison G F, Martin S M, McDade J E, Shepard C C, Brachman P S & Field Invest. Team.** Legionnaires' disease. *NEJM* 297:1189-97, 1977. Ctr. Dis. Control, Atlanta, GA.

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308 **Graw R G, Herzig G, Perry S & Henderson E S.** Normal granulocyte transfusion therapy. *NEJM* 287:367-71, 1972. NIH, NCI, Bethesda, MD.

339 **Greenblatt D J & Koch-Weser J.** Drug therapy. *NEJM* 293:702-5, 1975. Mass. Gen. Hosp., Boston, MA; Ctr. Rech. Merrell Intl., Strasbourg, France.

502 **Gregory G A, Kitterman J A, Phibbs R H, Tooley W H & Hamilton W K.** Treatment of the idiopathic respiratory-distress syndrome with continuous positive airway pressure. *NEJM* 284:1333-40, 1971. Univ. California, San Francisco, CA.

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456 **Harker L A & Slichter S J.** Platelet and fibrinogen consumption in man. *NEJM* 287:999-1005, 1972. Univ. Washington Sch. Med; King County Central Blood Bank, Seattle, WA.

346 **Haussler M R & McCain T A.** Basic and clinical concepts related to vitamin D metabolism and action. *NEJM* 297:974-83, 1977. Univ. Arizona, Tucson, AZ.

721 **Herbst A L, Ulfelder H & Poskanzer D C.** Adenocarcinoma of the vagina. *NEJM* 284:878-81, 1971. Vincent Mem. Hosp., Boston, MA.

525 **Herman M V, Heinle R A, Klein M D & Gorlin R.** Localized disorders in myocardial contraction. *NEJM* 277:222-32, 1967. Peter Bent Brigham Hosp.; Harvard Med. Sch., Boston, MA.

404 ***Hersh E M & Oppenheim J J.** Impaired in vitro lymphocyte transformation in Hodgkin's disease. *NEJM* 273:1006-12, 1965. NIH, NCI, Bethesda, MD. (13/83/CP)

370 ***Hogg J C, Macklem P T, Thurlbeck W M & Path M C.** Site and nature of airway obstruction in chronic obstructive lung disease. *NEJM* 278:1355-60, 1968. McGill Univ.; Royal Victoria Hosp., Montreal, Canada. (52/82/CP)

310 **Jaffe E S, Shevach E M, Frank M M, Berard C W & Green I.** Nodular lymphoma—evidence for origin from follicular B lymphocytes. *NEJM* 290:813-9, 1974. NIH, NCI, NIAID, Bethesda, MD.

380 **Jaffe N, Frei E, Traggis D & Bishop Y.** Adjuvant methotrexate and citrovorum-factor treatment of osteogenic sarcoma. *NEJM* 291:994-7, 1974. Sidney Farber Cancer Ctr.; Children's Hosp. Med. Ctr.; Harvard Med. Sch.; Harvard Sch. Publ. Hlth., Boston, MA.

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304 **Kumar A, Falke K J, Geffin B, Aldredge C F, Laver M B, Lowenstein E & Pontoppidan H.** Continuous positive-pressure ventilation in acute respiratory failure. *NEJM* 283:1430-6, 1970. Harvard Med. Sch., Mass. Gen. Hosp., Boston, MA.

381 ***Lerner P I & Weinstein L.** Infective endocarditis in the antibiotic era. *NEJM* 274:199-206, 1966. New Engl. Med. Ctr. Hosp.; Tufts Univ. Sch. Med., Boston, MA. (19/82/CP)

377 **Lindner A, Charra B, Sherrard D J & Scribner B H.** Accelerated atherosclerosis in prolonged maintenance hemodialysis. *NEJM* 290:697-701, 1974. Univ. Washington Sch. Med.; Vet. Admin. Hosp., Seattle, WA.

312 **Lipschitz D A, Cook J D & Finch C A.** A clinical evaluation of serum ferritin as an index of iron stores. *NEJM* 290:1213-6, 1974. Univ. Washington Sch. Med., Seattle, WA.

477 **Lo Gerfo P, Krupey J & Hansen H J.** Demonstration of an antigen common to several varieties of neoplasia. *NEJM* 285:138-41, 1971. Columbia Univ. Coll. Physic. Surg.; Inst. Cancer Res., New York, NY; McGill Univ. Med. Clin.; Montreal Gen. Hosp., Montreal, Canada; Hoffmann-La Roche, Inc., Nutley, NJ.

291 **Lotz M, Zisman E & Bartter F C.** Evidence for a phosphorus-depeletion syndrome in man. *NEJM* 278:409-15, 1968. Georgetown Univ. Sch. Med. and Distr. Columbia Gen. Hosp., Washington, DC.; NIH, NHI, Bethesda, MD.

425 **Lukes R J & Tindle B H.** Immunoblastic lymphadenopathy. *NEJM* 292:1-8, 1975. Univ. Southern California Sch. Med. & Los Angeles County Med. Ctr., Los Angeles, CA.

378 **McCaffrey R, Harrison T A, Parkman R & Baltimore D.** Terminal deoxynucleotidyl transferase activity in human leukemic cells and in normal human thymocytes. *NEJM* 292:775-80, 1975. Mass. Inst. Technol.; Children's Hosp. Med. Ctr.; Sidney Farber Cancer Ctr.; Harvard Med. Sch., Boston, MA.

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383 **Mitenko P A & Ogilvie R I.** Rational intravenous doses of theophylline. *NEJM* 289:600-3, 1973. Montreal Gen. Hosp.; McGill Univ., Montreal, Canada.

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380 **Nash G, Blennerhassett J B & Pontoppidan H.** Pulmonary lesions associated with oxygen therapy and artificial ventilation. *NEJM* 276:368-74, 1967. Harvard Med. Sch.; Mass. Gen. Hosp., Boston, MA.

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300 **O'Brien J S, Okada S, Chen A & Fillerup D L.** Tay-Sachs disease. *NEJM* 283:15-20, 1970. Univ. California San Diego, Sch. Med., La Jolla, CA.

319 **Okada K, Kamiyama I, Inomata M, Imai M, Miyakawa Y & Mayumi M.** e-Antigen and anti-e in the serum of asymptomatic carrier mothers as indicators of positive and negative transmission of hepatitis B virus to their infants. *NEJM* 294:746-9, 1976. Okubo Municip. Hosp.; Jichi Med. Sch.; Univ. Tokyo, Japan.

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421 ***Page D L, Caulfield J B, Kastor J A, DeSanctis R W & Sanders C A.** Myocardial changes associated with cardiogenic shock. *NEJM* 285:133-7, 1971. Mass. Gen. Hosp.; Harvard Med. Sch., Boston, MA. (3/84/CP)

483 **Parrish J A, Fitzpatrick T B, Tanenbaum L & Pathak M A.** Photochemotherapy of psoriasis with oral methoxsalen and longwave ultraviolet light. *NEJM* 291:1207-11, 1974. Harvard Med. Sch.; Mass. Gen. Hosp., Boston, MA.

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417 **Perry T L, Hansen S & Kloster M.** Huntington's chorea. *NEJM* 288:337-42, 1973. Univ. British Columbia, Vancouver, Canada.

378 ***Pincus T, Schur P H, Rose J A, Decker J L & Talal N.** Measurement of serum DNA-binding activity in systemic lupus erythematosus. *NEJM* 281:701-5, 1969. NIH, NIAID, NIAMDD, Bethesda, MD; Robert Breck Brigham Hosp., Boston, MA. (2/83/CP)

551 ***Rhoads G G, Gulbrandsen C L & Kagan A.** Serum lipoproteins and coronary heart disease in a population study of Hawaii Japanese men. *NEJM* 294:293-8, 1976. NHLI, Honolulu, HI. (43/82/CP)

1172 ***Ross R & Glomset J A.** The pathogenesis of atherosclerosis. *NEJM* 295:369-77, 420-5, 1976. Univ. Washington Sch. Med. & Region. Primate Res. Ctr., Seattle, WA. (1/83/LS; 34/82/CP)

306 **Ruddy S, Gigli I & Austen K F.** The complement system of man. *NEJM* 287:489-95, 1972. Harvard Med. Sch.; Robert Breck Brigham Hosp., Boston, MA.

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395 **Smith D C, Prentice R, Thompson D J & Herrmann W L.** Association of exogenous estrogen and endometrial carcinoma. *NEJM* 293:1164-7, 1975. Univ. Washington, Seattle, WA.

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282 **Tripodi D, Parks L C & Brugmans J.** Drug-induced restoration of cutaneous delayed hypersensitivity in anergic patients with cancer. *NEJM* 289:354-7, 1973. Johns Hopkins Hosp., Baltimore, MD.

A	B
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aminopterin on children with acute leukemia. It was cited more than 300 times from 1955 to 1983. For 30 consecutive years, this article was cited between four and 27 times. We hope one of the authors can approximate how often it was cited in the pre-1955 period. By the way, the first author of this paper, who died in 1973, is the same Sidney Farber for whom the famous cancer center in Boston is named. Two papers from this institution are included on the list (see N. Jaffe and R. McCaffrey).

W.E.C. Wacker, D.D. Ulmer, and B.L. Vallee, Peter Bent Brigham Hospital, Boston, collaborated on the next oldest paper. Published in 1956, the article demonstrates how blood levels of metalloenzymes can be used to diagnose myocardial infarction. It was cited between five and 26 times for 28 consecutive years.

The most-cited article was published in five parts in four 1967 issues of *NEJM*. Fredrickson, R.I. Levy, and R.S. Lees were then affiliated with the National Heart Institute, Bethesda, Maryland. Fredrickson is now at the National Academy of Sciences, Washington, DC, and Lees is affiliated with the Massachusetts Institute of Technology, Cambridge. Levy, still with the National Institutes of Health, explained in his commentary[14] that "up to the time the articles were published, specialists in the field who attempted to treat patients

Table 3: Frequency distribution of publication dates for the 100 most-cited articles from *NEJM*, *SCI*® 1961-1982. A = publication date. B = number of articles.

A	B
1940-1949	1
1950-1959	1
1960-1964	3
1965-1969	24
1970-1974	44
1975-1979	27
	100

Table 4: Geographic areas represented by the 100 most-cited papers published in *NEJM*, listed in descending order of the number of papers produced.

United States	
Massachusetts	30
Maryland	16
New York	14
California	13
Washington	7
Colorado	3
Georgia	3
Arizona	2
Michigan	2
New Jersey	2
Texas	2
Washington, DC	2
Alabama	1
Connecticut	1
Hawaii	1
Minnesota	1
New Mexico	1
North Carolina	1
Pennsylvania	1
Tennessee	1
Canada	5
France	2
Colombia	1
Italy	1
Japan	1
Switzerland	1

with hyperlipidemia had to grapple with complicated classifications that often proved contradictory and misleading in clinical practice. The system of classifying blood lipid disorders that we introduced was...a simpler, more convenient code than the existing classifications."

As to why the article was cited so often, Levy suggests, "Perhaps one of the intrinsic reasons for the volume of citation received by our articles is that they drew attention to an important group of diseases that are common and often potentially fatal.... Our objective was to break down some of the conventional clichés and approaches to the management of these patients by providing a more rational and workable alternative. Perhaps the frequency with which our work is cited is proof that in some measure we succeeded."[14] It should be noted that, while this five-part paper received 6,400 citations, the number of unique citing publications involved is "only" about 1,900 since most authors cited several or all parts of the study.

The second most-cited paper, by R. Ross and J.A. Glomset, University of Washington School of Medicine, Seattle, is also a multipart review paper. It was cited about 1,200 times in 800 papers from 1976 to 1983. The authors reviewed three major hypotheses on the fatty degeneration of the inner lining of arteries, or "atherogenesis." In a recent commentary,[15] Ross observed, "One unique feature of the school of medicine at the University of Washington was the fact that at particular points in time at least three hypotheses of atherogenesis had been developed, surprisingly, all emanating from the same department! Since all three...had generated a fair amount of interest, we decided that... those notions should be related...."

The third most-cited article is another multipart review paper. Published in 1975, the article reviews the literature on bone marrow transplantation. About 740 papers cited it more than 1,000 times. The paper was coauthored by nine researchers based at the University of Washington School of Medicine. E.D. Thomas describes the article as a "potpourri of topics including a brief history of the field, a review of the more significant advances based on work in animals...and a review of the developments that set the stage for marrow transplantation in man."[16] In his commentary, Thomas offers a partial explanation for the frequent citation of this paper. "Unlike most reviews, the article contained a great deal of clinical data and interpretation that had not been published previously.... Of even greater importance, perhaps, is the fact that [it] appeared at that junction in time marking the emergence of marrow transplantation from an experimental laboratory procedure and/or a desperate clinical undertaking to an accepted form of therapy for selected patients...."[16] I can't agree completely with his assumption that most reviews do not contain clinical data and interpretation. It is quite possible that this may in fact be characteristic of highly cited reviews. But data compilations do tend to be highly cited.

Citation Classics commentaries provide interesting background information on how significant scientific advances were developed and carried out. More than 1,800 scientists have already accepted our invitation to write a personalized account of their papers. We believe this collection constitutes an important sociological statement about scientific activity. We are most grateful to those authors who have already responded. So that papers from *NEJM* may be appropriately represented in this collection, we now extend our invitation to the new group of authors identified here. And we will follow up this study with lists of most-cited articles from other superstar journals in medicine as well as the life, physical, and social sciences.

As I have explained on numerous occasions, many of these papers are not considered to be the most important or significant work produced by the individuals involved. The impact or utility to science of a particular well-cited paper may have little to do with the level of

creativity required. We often publish more than one commentary by a prolific author. Any author is free to point out the utilitarian nature of a particular work. But throughout science there is often an inseparable bond between theory and practice. Behind some of the most important "simple" discoveries may lie years of significant theoretical or experimental research or contemplation. On the other hand, clinical problems or technological breakthroughs often open the way to basic discoveries.

But scientific journals are not designed to communicate either history, sociology, or biography. For the objective purposes they serve, especially with the need for precision and condensation, journals cannot allow adequate space for personal history or interpretation. Even if they did, they could not provide the hindsights of these *Citation Classics*. These commentaries are written long after the original work is published. It is difficult to imagine that this kind of hindsight would be possible even if journals were willing to include accounts of the author's prepublication trials and tribulations.

Authors of the articles in Table 2 who have not yet received letters of invitation, and anyone who wants more information on *Citation Classics*, should call (215) 386-0100, extension 1381.

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