

100 Citation Classics From The Journal of the American Medical Association

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The 100 most-cited *JAMA* articles were identified using the 1955 through 1983 *Science Citation Index*[®] (*SCI*[®]) of the Institute for Scientific Information[®] (*ISI*[®]). The most-cited article received 705 citations, while the least-cited article received 158. The oldest was published in 1910 and the most recent in 1976. These articles describe important medical advances in areas such as asbestos exposure, smoking, and oral contraceptives. Most of the 285 *JAMA* authors are Americans and include Baruch S. Blumberg and Edward A. Doisy, both Nobel laureates. Thirteen of the articles were included in *JAMA*'s original landmark series; the editorial committee used a combination of peer review and citation frequency to select 51 articles.

(*JAMA* 1987;257:52-59)

In 1983, *The Journal of the American Medical Association* celebrated its 100th anniversary. In conjunction with that celebration, the editors selected and reprinted, in successive issues of *THE JOURNAL* from July 1983 through August 1984, 50 "landmark" *JAMA* articles published since 1882.¹ One article, originally rejected by *JAMA* in 1899,² was also reprinted. These articles have now been collected in a book published by the American Medical Association.³ In addition, the series was extended into 1986, although *LANDMARK ARTICLES* are now reprinted quarterly rather than weekly.¹

The landmark series was limited to only those *JAMA* articles published before 1970. The *JAMA* editorial staff thought "that it would be difficult to assess the historic impact of any article less than 15 years old."^{3(p xiii)} To be considered for the series, the original 51 articles had to meet at least one of three criteria: their nomination by *JAMA*'s editorial board or staff; inclusion in the Garrison Morton anthology of medical articles, a medical bibliography of articles from "early times to the present"; and inclusion in a list of the 25 most-cited articles published in *JAMA* since 1950.¹ This latter list was assembled by Kate Walker of the Customized Services Department of ISI, Philadelphia, at *JAMA*'s request. The search covered articles cited in the *SCI* from 1961 to 1982. Of these 25 articles, six were among the first 51 articles reprinted by *JAMA* as *LANDMARK ARTICLES* (see the listings for B.S. Blumberg, E.C. Hammond, C.H. Kempe, W.B. Kouwenhoven, S. Krugman, and I.J. Selikoff in Table 1). The final 51 *LANDMARK ARTICLES* were chosen by a Delphic

process that included the *JAMA* editorial board and staff.

Methods

For this study, the search threshold was expanded to include the 100 *JAMA* articles, published in any year, that were most cited by other journals and serials indexed in the 1955 through 1983 *SCI*. (Textbooks and certain multi-authored monographs are not sources for the *SCI*.) The purpose of this study was simply to identify and examine a more comprehensive group of *JAMA* articles based purely on citation counts. Articles that also appeared in the landmark series are noted; however, the study is not a comparison of the two groups of articles.

The 100 articles selected for this analysis are listed alphabetically by first author with full bibliographic information in Table 1. In cross-discipline studies of most-cited articles from the *SCI* database, methodological and review works often predominate. In studies of just one journal's output, however, such generalizations cannot easily be made; therefore, in this study we did not hypothesize about the types of articles that would appear in Table 1.

But unusual citation or subject-matter patterns sometimes emerge in lists of prestigious articles such as Table 1. For example, some classics may be highly cited articles from areas of research that were at one time "hot" or "popular." Others may be articles that have withstood the test of a true medical classic or landmark. In fact, Table 1 includes 14 articles that to date have also appeared

Table 1.—*JAMA* Articles Most Cited in the *Science Citation Index*[®], 1955 Through 1983

No. of Citations	Bibliographic Data
202	Albright F, Smith PH, Richardson AM: Postmenopausal osteoporosis. <i>JAMA</i> 1941;116:2465-2473. (Massachusetts General Hospital, Harvard University Medical School, Boston)
174	*Allen E, Doisy EA: An ovarian hormone. <i>JAMA</i> 1923;81:819-821. (Washington University Medical School, St. Louis)*
161	Ansfield FJ, Schroeder JM, Curreri AR: Five years clinical experience with 5-fluorouracil. <i>JAMA</i> 1962;181:295-299. (University of Wisconsin Hospital, Madison)
278	Ayd FJ: A survey of drug-induced extrapyramidal reactions. <i>JAMA</i> 1961;175:1054-1060. (Franklin Square Hospital, Baltimore)
202	Barker LF, Shulman NR, Murray R, Hirschman RJ, Ratner F, Diefenbach WCL, Geller HM: Transmission of serum hepatitis. <i>JAMA</i> 1970;211:1509-1512. (National Institute of Arthritis and Metabolic Diseases, Bethesda, Md)
184	Bass M: Sudden sniffing death. <i>JAMA</i> 1970;212:2075-2079. (Johns Hopkins University School of Hygiene and Public Health, Maryland Medical Legal Foundation, Baltimore)
195	Bayless TM, Rosensweig NS: A racial difference in incidence of lactase deficiency. <i>JAMA</i> 1966;197:968-972. (Johns Hopkins University School of Medicine, Baltimore)
259	Beecher HK: The powerful placebo. <i>JAMA</i> 1955;159:1602-1606. (Harvard University Medical School, Boston)
164	Behnke AR, Feen BG, Welham WC: The specific gravity of healthy men. <i>JAMA</i> 1942;118:495-498. (US Navy Medical School, Washington, DC)
165	Bernstein DS, Sadowsky N, Hegsted DM, Guri CD, Stare FJ: Prevalence of osteoporosis in high- and low-fluoride areas in North Dakota. <i>JAMA</i> 1966;198:499-504. (Harvard University School of Public Health and Medical School, Peter Bent Brigham Hospital, Boston)
225	Beutner EH, Lever WF, Witebsky E, Jordan R, Chertock B: Autoantibodies in pemphigus vulgaris. <i>JAMA</i> 1965;192:682-688. (State University of New York Schools of Medicine and Dentistry, Buffalo; Tufts University School of Medicine, Boston)
205	Bistran BR, Blackburn GL, Hallowell E, Heddle R: Protein status of general surgical patients. <i>JAMA</i> 1974;230:858-860. (Massachusetts Institute of Technology, Cambridge; Boston City Hospital, Harvard University Medical School, Boston)
174	Bistran BR, Blackburn GL, Vitale J, Cochran D, Naylor J: Prevalence of malnutrition in general medical patients. <i>JAMA</i> 1976;235:1567-1570. (Massachusetts Institute of Technology, Cambridge; Boston City Hospital, New England Deaconess Hospital, Cancer Research Institute, Boston)
267	*Blalock A, Taussig HB: The surgical treatment of malformations of the heart in which there is pulmonary stenosis or pulmonary atresia. <i>JAMA</i> 1945;128:189-202. (Johns Hopkins University and Hospital, Harriet Lane Home, Cardiac Clinic, Baltimore)*
214	Block M, Jacobson LO, Bethard WF: Preleukemic acute human leukemia. <i>JAMA</i> 1953;152:1018-1028. (University of Chicago, Argonne [Ill] Cancer Research Hospital)
705	*†Blumberg BS, Alter HJ, Visnich S: A "new" antigen in leukemia sera. <i>JAMA</i> 1965;191:541-546. (Fox Chase Cancer Center, Institute for Cancer Research, Philadelphia; National Institutes of Health, Bethesda, Md) (51/79/LS)*†
184	Bunim JJ, Pecher MM, Bollet AJ: Studies on metacortandralone and metacortandracin in rheumatoid arthritis. <i>JAMA</i> 1955;157:311-318. (National Institute of Arthritis and Metabolic Diseases and National Heart Institute, Bethesda, Md)
215	Burkitt DP, Walker ARP, Painter NS: Dietary fiber and disease. <i>JAMA</i> 1974;229:1068-1074. (Medical Research Council, London; South African Institute for Medical Research, Johannesburg, South Africa)
187	Chanock RM, Kim HW, Vargosko AJ, Deleva A, Johnson KM, Cumming C, Parrott RH: Respiratory syncytial virus: I. Virus recovery and other observations during 1960 outbreak of bronchiolitis, pneumonia, and minor respiratory diseases in children. <i>JAMA</i> 1961;176:647-653. (National Institute of Allergy and Infectious Diseases, Bethesda, Md; Children's Hospital, Washington, DC)
192	Clark DE: Association of irradiation with cancer of the thyroid in children and adolescents. <i>JAMA</i> 1955;159:1007-1009. (University of Chicago, Argonne [Ill] Cancer Research Hospital)

Table 1.—*JAMA* Articles Most Cited in the *Science Citation Index*, 1955 Through 1983 (cont)

328	*†Conn JW, Cohen EL, Rovner DR: Suppression of plasma renin activity in primary aldosteronism. <i>JAMA</i> 1964;190:213-221. (University of Michigan Medical Center, Ann Arbor) (5/79/CP)*†
181	Conn JW, Cohen EL, Rovner DR, Nesbit RM: Normokalemic primary aldosteronism. <i>JAMA</i> 1965;193:200-206. (University of Michigan Medical Center, Ann Arbor)
159	Coursin DB: Convulsive seizures in infants with pyridoxine-deficient diet. <i>JAMA</i> 1954;154:406-408. (St. Joseph's Hospital, Lancaster, Pa)
162	Craighead JE, Hanshaw JB, Carpenter CB: Cytomegalovirus infection after renal allotransplantation. <i>JAMA</i> 1967;201:725-728. (Peter Bent Brigham Hospital, Harvard University Medical School; Boston; University of Rochester [NY] School of Medicine and Dentistry)
521	*Crohn BB, Ginzburg L, Oppenheimer GD: Regional ileitis. <i>JAMA</i> 1932;99:1323-1329. (Mount Sinai Hospital, New York)*
217	Dole VP, Nyswander M: A medical treatment for diacetylmorphine (heroin) addiction. <i>JAMA</i> 1965;193:646-650. (Rockefeller Institute; Beth Israel Hospital, New York)
175	Doyle JT, Dawber TR, Kannel WB, Kinch SH, Kahn HA: The relationship of cigarette smoking to coronary heart disease. <i>JAMA</i> 1964;190:886-890. (Albany [NY] Medical College; National Heart Institute, Bethesda, Md; Heart Disease Epidemiological Study, Framingham, Mass)
177	Drenick EJ, Swendseid ME, Bland WH, Tuttle SG: Prolonged starvation as treatment for severe obesity. <i>JAMA</i> 1964;187:100-105. (Veterans Administration Center, University of California, Department of Medicine and School of Public Health, Los Angeles)
266	Dubois EL, Tuffanelli DL: Clinical manifestations of systemic lupus erythematosus. <i>JAMA</i> 1964;190:104-111. (University of Southern California School of Medicine, Los Angeles County General Hospital, Los Angeles)
226	*Duke WW: The relation of blood platelets to hemorrhagic disease. <i>JAMA</i> 1910;55:1185-1192. (Johns Hopkins University, Baltimore)*
188	Dustan HP, Taylor RD, Corcoran AC, Page IH: Rheumatic and febrile syndrome during prolonged hydralazine treatment. <i>JAMA</i> 1954;154:23-29. (Cleveland Clinic Foundation, Frank E. Bunts Educational Institute, Cleveland)
169	Eaton LM, Lambert EH: Electromyography and electric stimulation of nerves in diseases of motor unit. <i>JAMA</i> 1957;163:1117-1124. (Mayo Clinic, University of Minnesota, Rochester)
233	Edwards CL, Hayes RL: Scanning malignant neoplasms with gallium 67. <i>JAMA</i> 1970;212:1182-1190. (Oak Ridge [Tenn] Associated Universities)
296	Enos WF, Holmes RH, Beyer J: Coronary disease among United States soldiers killed in action in Korea. <i>JAMA</i> 1953;152:1090-1093. (Armed Forces Institute of Pathology, Washington, DC)
204	Farber S: Chemotherapy in the treatment of leukemia and Wilms' tumor. <i>JAMA</i> 1966;198:826-836. (Children's Cancer Research Foundation, Children's Hospital Medical Center, Harvard University Medical School, Boston)
190	Ferrer MI: The sick sinus syndrome in atrial disease. <i>JAMA</i> 1968;206:645-646. (Columbia University College of Physicians and Surgeons, Bellevue Hospital, Columbia-Presbyterian Medical Center, Presbyterian Hospital, New York)
220	Fields WS, Maslenikov V, Meyer JS, Hass WK, Remington RD, Macdonald M: Joint study of extracranial arterial occlusion: V. Progress report of prognosis following surgery or nonsurgical treatment for transient cerebral ischemic attacks and cervical carotid artery lesions. <i>JAMA</i> 1970;211:1993-2003. (University of Texas Graduate School of Biomedical Science and School of Public Health, Baylor College of Medicine, Houston; Institute of Neurology Hospital and Clinic, Montevideo, Uruguay; New York University School of Medicine, New York)
331	Finland M, Jones WF, Barnes MW: Occurrence of serious bacterial infections since introduction of antibacterial agents. <i>JAMA</i> 1959;170:2188-2197. (Boston City Hospital, Harvard University Medical School, Boston)
218	Foldes FF, Molloy R, McNall PG, Koukal LR: Comparison of toxicity of intravenously given local anesthetic agents in man. <i>JAMA</i> 1960;172:1493-1498. (Mercy Hospital, University of Pittsburgh School of Medicine)
333	Friedman M, Rosenman RH: Association of specific overt behavior pattern with blood and cardiovascular findings. <i>JAMA</i> 1959;169:1286-1296. (Mount Zion Hospital, Harold Brunn Institute, San Francisco)

165	Gordon T, Kannel WB: Premature mortality from coronary heart disease. <i>JAMA</i> 1971;215:1617-1625. (National Heart and Lung Institute, Bethesda, Md; Heart Disease Epidemiological Study, Framingham, Mass)
179	Grayston JT, Alexander ER, Kenny GE, Clarke ER, Fremont JC, MacColl WA: <i>Mycoplasma pneumoniae</i> infections. <i>JAMA</i> 1965;191:369-374. (University of Washington School of Medicine, Group Health Cooperative of Puget Sound, Seattle)
245	Hammond EC, Horn D: Smoking and death rates—report on 44 months of follow-up of 187,783 men: I. Total mortality. <i>JAMA</i> 1958;166:1159-1172. (American Cancer Society, New York)
292	*Hammond EC, Horn D: Smoking and death rates—report on 44 months of follow-up of 187,783 men: II. Death rates by cause. <i>JAMA</i> 1958;166:1294-1308. (American Cancer Society, New York)*
173	Hammond EC, Horn D: The relationship between human smoking habits and death rates. <i>JAMA</i> 1954;155:1316-1328. (American Cancer Society, New York)
173	Hass WK, Fields WS, North RR, Kricheff II, Chase NE, Bauer RB: Joint study of extracranial arterial occlusion: II. Arteriography, techniques, sites, and complications. <i>JAMA</i> 1968;203:961-968. (New York University School of Medicine, New York; University of Texas Southwestern Medical School, Dallas; Wayne State University College of Medicine, Detroit)
195	*Herrick JB: Clinical features of sudden obstruction of the coronary arteries. <i>JAMA</i> 1912;59:2015-2020. (Presbyterian Hospital, Chicago)*
276	†Hersh EM, Bodey GP, Nies BA, Freireich EJ: Causes of death in acute leukemia. <i>JAMA</i> 1965;193:105-109. (National Cancer Institute, Bethesda, Md) (1/80/CP)†
173	Hill JM, Roberts J, Loeb E, Khan A, MacLellan A, Hill RW: L-Asparaginase therapy for leukemia and other malignant neoplasms. <i>JAMA</i> 1967;202:882-888. (Wadley Institute of Molecular Medicine, Dallas)
185	Hirschman RJ, Shulman NR, Barker LF, Smith KO: Virus-like particles in sera of patients with infectious and serum hepatitis. <i>JAMA</i> 1969;208:1667-1670. (National Institute of Arthritis and Metabolic Diseases, Bethesda, Md)
203	Jick H, Miettinen OS, Shapiro S, Lewis GP, Siskind V, Slone D: Comprehensive drug surveillance. <i>JAMA</i> 1970;213:1455-1460. (Lemuel Shattuck Hospital, Tufts University School of Medicine, Harvard University School of Public Health, Boston)
195	Jordon RE, Beutner EH, Witebsky E, Blumental G, Hale WL, Lever WF: Basement zone antibodies in bullous pemphigoid. <i>JAMA</i> 1967;200:751-756. (State University of New York Schools of Medicine and Dentistry, Buffalo; Tufts University School of Medicine, Boston)
221	Kannel WB, Wolf PA, Verter J, McNamara PM: Epidemiologic assessment of the role of blood pressure in stroke. <i>JAMA</i> 1970;214:301-310. (Heart Disease Epidemiological Study, Framingham, Mass; Boston University School of Medicine; National Heart Institute, Bethesda, Md)
173	Kaplowitz N, Kok E, Javitt NB: Postprandial serum bile acid for the detection of hepatobiliary disease. <i>JAMA</i> 1973;225:292-293. (Cornell University Medical College, New York)
260	*Kempe CH, Silverman FN, Steele BF, Drogemueller W, Silver HK: The battered-child syndrome. <i>JAMA</i> 1962;181:17-24. (University of Colorado School of Medicine, Children's Hospital, Denver)*
167	*Klemperer P, Pollack AD, Baehr G: Diffuse collagen disease. <i>JAMA</i> 1942;119:331-332. (Mount Sinai Hospital, New York)*
216	Kligman AM: Topical pharmacology and toxicology of dimethyl sulfoxide—Part 1. <i>JAMA</i> 1965;193:796-804. (University of Pennsylvania School of Medicine, Philadelphia)
298	Koch-Weser J, Klein SW: Procainamide dosage schedules, plasma concentrations, and clinical effects. <i>JAMA</i> 1971;215:1454-1460. (Massachusetts General Hospital, Harvard University Medical School, Boston)
476	*Kouwenhoven WB, Jude JR, Knickerbocker GG: Closed-chest cardiac massage. <i>JAMA</i> 1960;173:1064-1067. (Johns Hopkins University School of Medicine, Baltimore)*
427	Krugman S, Giles JP: Viral hepatitis. <i>JAMA</i> 1970;212:1019-1029. (New York University School of Medicine, Willowbrook State School, Staten Island, NY)
464	*Krugman S, Giles JP, Hammond J: Infectious hepatitis. <i>JAMA</i> 1967;200:365-373. (New York University School of Medicine, Willowbrook State School, Staten Island, NY)*
161	Krugman S, Giles JP, Hammond J: Viral hepatitis, type B (MS-2 strain). <i>JAMA</i> 1971;217:41-45. (New York University School of Medicine, Willowbrook State School, Staten Island, NY)

Table 1.—*JAMA* Articles Most Cited in the *Science Citation Index*, 1955 Through 1983 (cont)

185	Kutt H, McDowell F: Management of epilepsy with diphenylhydantoin sodium. <i>JAMA</i> 1968;203:969-972. (Bellevue Hospital, Cornell University Medical College, New York)
506	†Laragh JH, Angers M, Kelly WG, Lieberman S: Hypotensive agents and pressor substances. <i>JAMA</i> 1960;174:234-240. (Columbia University College of Physicians and Surgeons, Presbyterian Hospital, New York) (35/79/CP)†
195	Laragh JH, Heinemann HO, Demartini FE: Effect of chlorothiazide on electrolyte transport in man. <i>JAMA</i> 1958;166:145-152. (Presbyterian Hospital, Francis Delafield Hospital, Columbia University College of Physicians and Surgeons, New York)
231	Laragh JH, Sealey JE, Ledingham JGG, Newton MA: Oral contraceptives. <i>JAMA</i> 1967;201:918-922. (Columbia University College of Physicians and Surgeons, Presbyterian Hospital, New York)
246	Li MC, Whitmore WF, Golbey R, Grabstald H: Effects of combined drug therapy on metastatic cancer of the testis. <i>JAMA</i> 1960;174:1291-1299. (Sloan-Kettering Institute for Cancer Research, Memorial Center for Cancer and Allied Diseases, New York)
323	†Lown B, Amarasingham R, Neuman J: New method for terminating cardiac arrhythmias. <i>JAMA</i> 1962;182:548-555. (Harvard University School of Public Health, Peter Bent Brigham Hospital and Medical Clinics, Boston) (17/79/CP)†
428	Lown B, Fakhro AM, Hood WB, Thorn GW: The coronary care unit. <i>JAMA</i> 1967;199:188-198. (Peter Bent Brigham Hospital and Medical Clinics, Harvard University School of Public Health and Medical School, Boston)
199	Magnius LO, Lindholm A, Lundin P, Iwarson S: A new antigen-antibody system. <i>JAMA</i> 1975;231:356-359. (National Bacteriology Laboratory, Stockholm; Sahlgren's Hospital; University of Gothenburg, [Sweden])
167	Master AM, Dublin LI, Marks HH: The normal blood pressure range and its clinical implications. <i>JAMA</i> 1950;143:1464-1470. (Mount Sinai Hospital, Metropolitan Life Insurance Co, New York)
208	Maxwell MH, Rockney RE, Kleeman CR, Twiss MR: Peritoneal dialysis: 1. Technique and applications. <i>JAMA</i> 1959;170:917-924. (University of California, Veterans Administration Center, Wadsworth Hospital, Los Angeles)
193	*Merritt HH, Putnam TJ: Sodium diphenyl hydantoinate in the treatment of convulsive disorders. <i>JAMA</i> 1938;111:1068-1073. (Boston City Hospital, Harvard University Medical School, Boston)*
449	†Moore GE, Gerner RE, Franklin HA: Culture of normal human leukocytes. <i>JAMA</i> 1967;199:519-524. (New York State Department of Health, Roswell Park Memorial Institute, Buffalo) (26/80/CP)†
170	Nesbit RM, Baum WC: Endocrine control of prostatic carcinoma. <i>JAMA</i> 1950;143:1317-1320. (University of Michigan, Ann Arbor)
326	Niederman JC, McCollum RW, Henle G, Henle W: Infectious mononucleosis. <i>JAMA</i> 1968;203:205-209. (Yale University School of Medicine, New Haven, Conn; University of Pennsylvania School of Medicine and Children's Hospital, Philadelphia)
172	Page IH: The production of persistent arterial hypertension by cellophane perinephritis. <i>JAMA</i> 1939;113:2046-2048. (Indianapolis City Hospital, Lilly Laboratories, Indianapolis)
192	Palmer ED: The vigorous diagnostic approach to upper-gastrointestinal tract hemorrhage. <i>JAMA</i> 1969;207:1477-1480. (Veterans Administration Hospital, East Orange, NJ)
169	Perry HM, Schroeder HA: Syndrome simulating collagen disease caused by hydralazine (Apresoline). <i>JAMA</i> 1954;154:670-673. (Washington University School of Medicine, Barnes Hospital, St. Louis)
165	Potts WJ, Smith S, Gibson S: Anastomosis of the aorta to a pulmonary artery. <i>JAMA</i> 1946;132:627-631. (Children's Memorial Hospital, Northwestern University Medical School, Chicago)
168	Prinzmetal M, Ekmekci A, Kenamer R, Kwoczynski JK, Shubin H, Toyoshima H: Variant form of angina pectoris. <i>JAMA</i> 1960;174:1794-1800. (Cedars of Lebanon Hospital, Institute for Medical Research, University of California School of Medicine, Los Angeles; City of Hope Medical Center, Duarte, Calif)
255	Rashkind WJ, Miller WW: Creation of an atrial septal defect without thoracotomy. <i>JAMA</i> 1966;196:991-992. (Children's Hospital, Philadelphia)

158	Reed CE, Sosman A, Barbee RA: Pigeon-breeders' lung. <i>JAMA</i> 1965;193:261-265. (University of Wisconsin, Madison; Wood Veterans Administration Hospital, Milwaukee)
301	†Reynoso G, Chu TM, Holyoke D, Cohen E, Nemoto T, Wang J-J, Chuang J, Guinan P, Murphy GP: Carcinoembryonic antigen in patients with different cancers. <i>JAMA</i> 1972;220:361-365. (New York State Department of Health, Roswell Park Memorial Institute, Buffalo) (3/83/CP)†
220	Rosenman RH, Brand RJ, Jenkins CD, Friedman M, Straus R, Wurm M: Coronary heart disease in the Western Collaborative Group Study. <i>JAMA</i> 1975;233:872-877. (Mount Zion Hospital Medical Center, Harold Brunn Institute, San Francisco; University of California School of Public Health, Berkeley; St Joseph Hospital, Burbank, Calif; Boston University School of Medicine)
188	Rosenthal SM, White EC: Clinical application of the bromsulphthalein test for hepatic function. <i>JAMA</i> 1925;84:1112-1114. (McGill University Faculty of Medicine, Royal Victoria Hospital, Montreal)
186	Salassa RM, Bennett WA, Keating FR, Sprague RG: Postoperative adrenal cortical insufficiency. <i>JAMA</i> 1953;152:1509-1515. (Mayo Clinic, Rochester, Minn)
190	Schroeder HA: Relation between mortality from cardiovascular disease and treated water supplies. <i>JAMA</i> 1960;172:1902-1908. (Dartmouth College Medical School, Hanover, NH; Brattleboro Retreat, West Brattleboro, Vt)
264	Schwab RS, England AC, Poskanzer DC, Young RR: Amantadine in the treatment of Parkinson's disease. <i>JAMA</i> 1969;208:1168-1170. (Massachusetts General Hospital, Harvard University Medical School, Boston)
170	Seegmiller JE, Howell RR, Malawista SE: The inflammatory reaction to sodium urate. <i>JAMA</i> 1962;180:469-475. (National Institute of Arthritis and Metabolic Diseases, Bethesda, Md)
258	*Selikoff IJ, Churg J, Hammond EC: Asbestos exposure and neoplasia. <i>JAMA</i> 1964;188:142-146. (Mount Sinai Hospital, New York)*
351	Selikoff IJ, Hammond EC, Churg J: Asbestos exposure, smoking, and neoplasia. <i>JAMA</i> 1968;204:106-110. (Mount Sinai School of Medicine, American Cancer Society, New York)
629	Steinbrocker O, Traeger CH, Batterman RC: Therapeutic criteria in rheumatoid arthritis. <i>JAMA</i> 1949;140:659-662. (American Rheumatism Association, New York Rheumatism Association, Committee for Therapeutic Criteria, New York)
183	Sutnick AI, London WT, Gerstley BJS, Cronlund MM, Blumberg BS: Anicteric hepatitis associated with Australia antigen. <i>JAMA</i> 1968;205:670-674. (Fox Chase Cancer Center, Institute for Cancer Research, Philadelphia)
160	Taves DR, Fry BW, Freeman RB, Gillies AJ: Toxicity following methoxyflurane anesthesia: II. Fluoride concentrations in nephrotoxicity. <i>JAMA</i> 1970;214:91-95. (University of Rochester [NY] School of Medicine and Dentistry)
209	Wagner HN, Sabiston DC, Iio M, McAfee JG, Meyer JK, Langan JK: Regional pulmonary blood flow in man by radioisotope scanning. <i>JAMA</i> 1964;187:601-603. (Johns Hopkins University School of Medicine, Baltimore)
169	Wilkerson HLC, Krall LP: Diabetes in a New England town. <i>JAMA</i> 1947;135:209-216. (Public Health Service, Boston)
197	Wilkins L: Masculinization of female fetus due to use of orally given progestins. <i>JAMA</i> 1960;172:1028-1032. (Johns Hopkins University School of Medicine, Baltimore)
171	Wilmore DW, Dudrick SJ: Growth and development of an infant receiving all nutrients exclusively by vein. <i>JAMA</i> 1968;203:860-864. (University of Pennsylvania School of Medicine, Philadelphia)
265	Witebsky E, Rose NR, Terplan K, Paine JR, Egan RW: Chronic thyroiditis and autoimmunization. <i>JAMA</i> 1957;164:1439-1447. (University of Buffalo [NY] School of Medicine, Buffalo General Hospital)

*Articles reprinted in *JAMA* as LANDMARK ARTICLES.

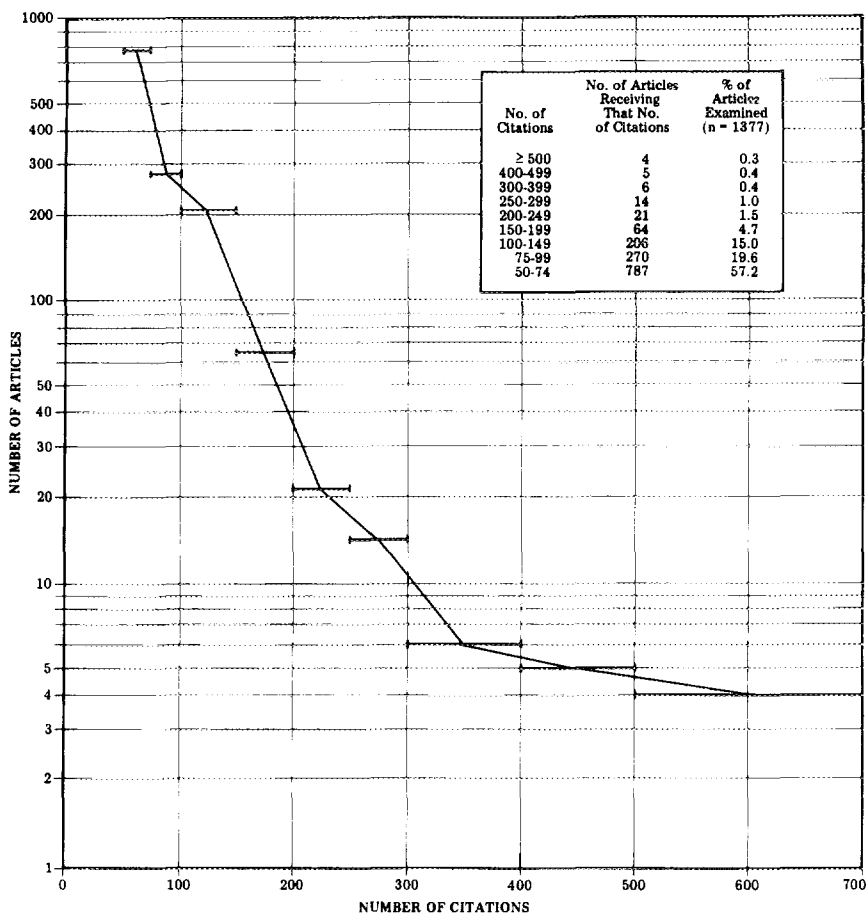
†Articles for which *Citation Classics* commentaries have been published. Issue number, year, and edition of *Current Contents* are given in parentheses.

in *JAMA*'s landmark series. They are indicated in Table 1 by asterisks.

There were 1377 *JAMA* articles cited at least 50 times from 1955 through 1983 in the *SCI*; the

group of 100 in Table 1 constitutes about 7% of this group. Figure 1 shows the frequency distribution for the 1377 papers and their typical hyperbolic distribution. The majority (57%) of the ar-

Fig 1.—Frequency distribution of *JAMA* articles cited in 1955 through 1983 *Science Citation Index*[®].



ticles received 50 to 74 citations since their publication. In contrast, the 100 articles in Table 1 averaged 238 citations from 1955 through 1983.

Results

The least-cited article in the study, by Charles E. Reed, Abe Sosman, and Robert A. Barbee of the University of Wisconsin, Madison, and Wood Veterans Administration Hospital, Milwaukee, was cited 158 times, while the most-cited article, "A 'New' Antigen in Leukemia Sera," was cited 705 times. This report by Baruch S. Blumberg, Harvey J. Alter, and Sam Visnich of the Fox Chase Cancer Center, Institute for Cancer Research, Philadelphia, and the National Institutes of Health, Bethesda, Md, has appeared often in ISI's studies of most-cited articles. In addition,

it was selected as a *JAMA* LANDMARK ARTICLE. It has also been the subject of a commentary^{4,5} in ISI's *Citation Classic*[®] series. The authors of seven articles in Table 1 (indicated by daggers) have commented on their classic articles. Six of these are included along with 311 other commentaries in *Contemporary Classics in Clinical Medicine*.⁶ A *Citation Classic* is an article or book that ranks in the upper percentile of cited works published in a journal or field. Once identified, the article's author(s) is invited to publish a commentary in *Current Contents*[®].

In a 1979 commentary, Blumberg⁴ remarked that his 1965 *JAMA* article was the first to use the term *Australia antigen*; the work it described set the pattern for the research in that area for the next ten years. Its most important clinical applications, however, were for hepatitis research, and,

in fact, Blumberg and colleagues subsequently identified the Australia antigen as the surface antigen of the hepatitis B virus. This discovery was reported in a 1967 report published in the *Annals of Internal Medicine*.⁷ It is one of the most-cited articles for that journal.⁸ Both the *JAMA* and *Annals* articles represent a fraction of Blumberg's diversified work with diseases of the liver. An additional article in this study that Blumberg coauthored with first author Alton I. Sutnick and colleagues, Fox Chase Cancer Center, Institute for Cancer Research, discusses anicteric hepatitis (Table 1).

In Table 2, the 100 papers are summarized by general subject categories. Fourteen specialties are each represented by two or more articles. For example, "infectious disease" is represented by nine articles, six of which discuss anicteric, infectious, serum, or viral hepatitis. One of these, "Infectious Hepatitis: Evidence for Two Distinctive Clinical, Epidemiological, and Immunological Types of Infection," by Saul Krugman of New York University School of Medicine and colleagues, was a *JAMA* LANDMARK ARTICLE.

The effect of smoking on health is described in five articles listed in Table 2 under epidemiology. E. Cuyler Hammond and Daniel Horn together authored three of these; two are the first and second parts of a study performed when both researchers were at the American Cancer Society in New York. From 1958 through 1983, the two articles were cited about 540 times. Part 2 was included in the landmark series and was discussed in retrospect by Sir Richard Doll, Imperial Cancer Research Fund, University of Oxford (England). He commented that Hammond and Horn's study broke new ground not only because it was one of the first to demonstrate a relationship between cigarette smoking and a host of different illnesses, but also because it was one of the first large-scale epidemiological studies of a noninfectious disease. The size of the study and its success, especially, gave researchers the validity they needed to undertake other major epidemiological studies.^{3(pp396-399)}

A fourth article in Table 1 concerned with smoking, "Asbestos Exposure, Smoking, and Neoplasia," received about 350 citations from 1968 through 1983 and was also coauthored by E. C. Hammond along with first author Irving J. Selikoff and Jacob Churg, both of Mount Sinai School of Medicine, New York. The fifth article was written by Joseph T. Doyle of Albany (NY) Medical College and colleagues, and discusses the relationship of cigarette smoking to coronary heart diseases. It has been cited over 175 times since 1964.

The citations to all five articles on smoking are plotted in Figure 2. Four of the articles peaked

Table 2.—Field Distribution of the 100 *JAMA* Articles Most Cited in the *Science Citation Index*[®], 1955 Through 1983

Field	No. of Articles Listed in Table 1
Cardiovascular research	16
Cancer research	12
Epidemiology	11
Infectious disease	9
Pharmacology	8
Pathology	7
Nutrition	6
Endocrinology	5
Neurology	5
Gastroenterology	4
Immunology	4
General medicine	3
Rheumatology	3
Anesthesiology	2
Other	5

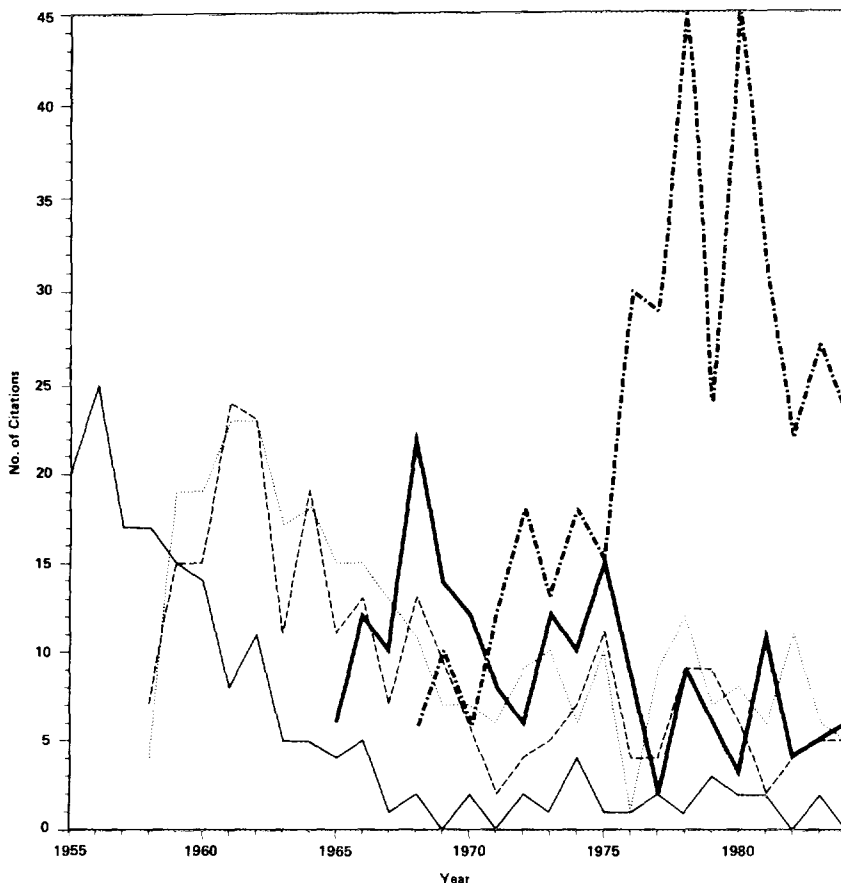
in citations within a few years after publication, although each also subsequently experienced citation "surges." The most recent of the five articles received the greatest number of citations each year since 1972. And it continued to be cited over twice as often in the 1980s as each of the four other works. Interestingly, the two-part Hammond-Horn article and Doyle's 1964 report were cited at similar rates each year although not the same number of times.

The second most-cited article in Table 1, by Otto Steinbrocker, Cornelius H. Traeger, and Robert C. Batterman of the American Rheumatism Association and New York Rheumatism Association, Committee for Therapeutic Criteria, New York, summarizes recommendations for uniform therapeutic criteria in rheumatoid arthritis. The need for such criteria arose from the recognition of the confusing language and standards found in the many therapeutic reports on the disease.

Burrill B. Crohn, Leon Ginzburg, and Gordon D. Oppenheimer of Mount Sinai Hospital, New York, published the third most-cited article. A *JAMA* LANDMARK ARTICLE, it discusses regional ileitis, which is now known eponymically as Crohn's disease. When the article was written in 1932, the descriptive definition of the disease was based on 14 cases, a fairly large sample for that era, especially since it was probably "a new disease in its early stages of evolution."^{3(p209)}

Since the diseases discussed above affect so many people, it may not be surprising that the Steinbrocker et al and Crohn et al articles have been cited over 750 and 570 times, respectively, since 1955. However, the number of articles pub-

Fig 2.—Chronologic distribution of citations to Hammond and Horn's 1954 article (thin solid line) and 1958 two-part article (first part, broken line; second part, dotted line), Doyle and colleagues' 1964 article (thick solid line), and Selikoff and colleagues' 1968 article (dot-dash line).



lished on any subject is affected by many factors, not the least of which is funds for research. In 1985, researchers continued to use these articles—that year, 26 articles cited Crohn and colleagues' work, while 69 cited the Steinbrocker et al article. In 1955, Crohn and colleagues' article was cited "only" ten times and Steinbrocker and coworkers' article received 20 citations. These figures may, however, be affected by the smaller number of clinical journals indexed in the *SCI* in that year.

Crohn and colleagues' article was published 53 years ago, while the Steinbrocker et al article has been in print for 36 years. Nearly one fourth of the other articles from Table 1 were published before 1955—two from 1910 through 1919, three from 1930 through 1939, seven from 1940

through 1949, and nine from 1950 through 1954. William Waddell Duke of Johns Hopkins University, Baltimore, wrote the oldest article (1910), in which he discussed the relationship of blood platelets to hemorrhagic disease. From 1955 to 1983, Duke's article was cited 226 times. But it undoubtedly received many earlier citations from 1910 to 1954. Citation frequency is often affected by the number of articles published at a given time. At least seven times as many articles were published in 1985 as in 1955.

The most recent article in Table 1, by Bruce R. Bistran of the Massachusetts Institute of Technology, Cambridge, and colleagues, was published in 1976 and was cited 174 times from 1976 to 1983. It reported that "significant protein-calorie malnutrition occurs commonly in

municipal hospitals in both medical and surgical services.⁹ To detect protein deficiencies, the researchers used anthropometric measurements rather than the analyses of patient hair and vitamin assays used in previous studies. Bistran and G.L. Blackburn published an earlier *JAMA* article, also included in Table 1, on this same topic.

In addition to Bistran, 28 other authors contributed to two or more articles in Table 1; seven of these (J.P. Giles, E.C. Hammond, D. Horn, W.B. Kannel, S. Krugman, J.H. Laragh, and E. Witebsky) authored three or more articles.

Baruch S. Blumberg, author of two articles and mentioned earlier, is one of two Nobel laureates in the study. He was awarded the 1976 Prize in medicine or physiology with D. Carleton Gajdusek (United States) for their discoveries pertaining to the origin and dissemination of infectious diseases. The other Nobel laureate in Table 1 is Edward A. Doisy of Washington University Medical School, St. Louis. Doisy and Henrik Dam of Denmark shared the 1943 Prize in medicine or physiology for their analysis of vitamin K. Doisy and Edgar Allen, also of Washington University Medical School, are coauthors of a 1923 *JAMA* LANDMARK ARTICLE that presented their preliminary work on estrogen, an ovarian hormone (Table 1).

As can be surmised from the institutional affiliations listed for the articles discussed so far, the majority of the 285 authors conducted their research in the United States. For example, 30 articles are from New York institutions, including New York University, Mount Sinai Hospital, Columbia University, and the American Cancer Society. The New York State Department of Health's Roswell Park Memorial Institute in Buffalo has two articles in Table 1 (see the listings for G.E. Moore and G. Reynoso).

Twenty-one articles are from Massachusetts, including 13 from Harvard University and many from six hospitals in the Boston area. Four of these hospitals (Massachusetts General Hospital, New England Deaconess Hospital, Peter Bent Brigham Hospital, and Children's Hospital) are affiliated with Harvard. An additional 18 articles are from institutions in Maryland, including ten from the National Institutes of Health and seven from Johns Hopkins University. Pennsylvania has three from the University of Pennsylvania and two from Fox Chase Cancer Center; both institutions are in Philadelphia. Table 3 summarizes all the affiliations by state or national address.

JAMA, the official organ of the American Medical Association, is an international vehicle for communicating advances in clinical medicine to physicians in other countries.¹⁰ Of the 100 articles in Table 1, one is from Uruguay (W.S. Fields) and is coauthored with Americans, while

Table 3.—Geographic Areas* Represented by the 100 Most-Cited Articles Published in *JAMA* (Listed in Descending Order of Number of Articles Produced)

Country	No. of Articles	No. of Multinational Institutional Collaborations	National Institutional Affiliation of Collaborators
United States	98	1	Uruguay
New York	30	...	...
Massachusetts	21	...	...
Maryland	18	...	...
Pennsylvania	8	...	...
California	6	...	...
Illinois	4	...	...
Michigan	4	...	...
District of Columbia	3	...	...
Texas	3	...	...
Minnesota	2	...	...
Missouri	2	...	...
Wisconsin	2	...	...
Colorado	1	...	...
Connecticut	1	...	...
Indiana	1	...	...
New Hampshire	1	...	...
New Jersey	1	...	...
Ohio	1	...	...
Tennessee	1	...	...
Vermont	1	...	...
Washington	1	...	...
Canada	1	0	...
South Africa	1	1	United Kingdom
Sweden	1	0	...
United Kingdom	1	1	South Africa
Uruguay	1	1	United States

*According to institutional affiliations.

one article each is from Canada (S.M. Rosenthal), Sweden (L.O. Magnus), and the United Kingdom and South Africa together (D.P. Burkitt).

Comment

JAMA's classic articles are frequently independently identified by peer judgment as milestone articles. But if about 1% of the articles published in a high-impact journal such as *JAMA* were arbitrarily selected, at least 250 articles could probably be listed. Future lists should take into account more precisely the dynamics of literature

Table 4.—Year-by-Year Distribution of the Number of Items Cited in the *Science Citation Index*[®], 1955 Through 1984

Year	No. of Cited Items	% of All Items Cited 1955-1984	No. of Articles Listed in Table 1	Year	No. of Cited Items	% of All Items Cited 1955-1984	No. of Articles Listed in Table 1
Prior years	446 185	1.73	0	1936	86 145	0.33	0
1901	16 379	0.06	0	1937	90 265	0.35	0
1902	17 984	0.07	0	1938	92 611	0.36	1
1903	18 579	0.07	0	1939	93 250	0.36	1
1904	20 165	0.08	0	1940	87 520	0.34	0
1905	20 360	0.08	0	1941	83 466	0.32	1
1906	21 136	0.08	0	1942	75 020	0.29	2
1907	21 939	0.09	0	1943	71 613	0.28	0
1908	22 832	0.09	0	1944	68 398	0.27	0
1909	24 531	0.10	0	1945	71 347	0.28	1
1910	25 512	0.10	1	1946	91 176	0.35	1
1911	25 444	0.10	0	1947	114 417	0.44	1
1912	27 271	0.11	1	1948	145 030	0.56	0
1913	27 612	0.11	0	1949	172 225	0.67	1
1914	24 636	0.10	0	1950	207 037	0.80	2
1915	19 546	0.08	0	1951	227 522	0.88	0
1916	19 120	0.07	0	1952	259 969	1.01	0
1917	17 965	0.07	0	1953	300 861	1.16	3
1918	17 383	0.07	0	1954	334 170	1.29	4
1919	19 098	0.07	0	1955	373 953	1.45	3
1920	23 885	0.09	0	1956	401 657	1.55	0
1921	28 571	0.11	0	1957	428 442	1.66	2
1922	32 529	0.13	0	1958	466 910	1.81	3
1923	36 029	0.14	1	1959	504 731	1.95	3
1924	39 652	0.15	0	1960	569 245	2.20	7
1925	43 207	0.17	1	1961	586 545	2.27	2
1926	48 369	0.19	0	1962	646 312	2.50	4
1927	51 377	0.20	0	1963	723 808	2.80	0
1928	55 367	0.21	0	1964	783 758	3.03	6
1929	58 162	0.23	0	1965	823 465	3.19	8
1930	62 411	0.24	0	1966	818 772	3.17	4
1931	64 376	0.25	0	1967	863 424	3.34	7
1932	69 733	0.27	1	1968	887 630	3.44	7
1933	70 555	0.27	0	1969	915 466	3.54	3
1934	74 173	0.29	0	1970	916 356	3.55	8
1935	80 429	0.31	0	1971-1984	10 766 502	41.66	10

growth so that articles from earlier decades are not drowned out by the big fish in the current ocean of literature.

To illustrate this point, Table 4 lists, by year, the number of articles that were cited in the 1955 through 1984 *SCI*, as well as the percentage that these papers are of the total 1955 through 1984 file. The articles from Table 1 are also broken

down by number of articles per year. It is interesting to compare the percentages given in the third column of Table 4 with the corresponding figures in the fourth column. Surprisingly, 14 articles from Table 1 were published in the first half of the 20th century; the literature from this period constitutes a relatively small portion of the *SCI* file. In general, from 1950 through 1970, there

is a great deal of similarity between the year-by-year distribution of articles in the *SCI* file and Table 1, but there is a greater percentage of articles from the later 1960s in Table 1. In fact, the majority of the articles in Table 1 are clustered most heavily in the years after 1955, which is when *SCI* coverage begins. Only 10% of these articles, however, were published from 1971 through 1983, while over 40% of the *SCI* file, 1955 through 1984, is from that 22-year period.

Citation behavior is a very complex matter, but "obliteration by incorporation," when articles are no longer cited because their substance has been absorbed by current knowledge,¹¹ is the common fate of many great discoveries. Indeed, there is an upper limit to explicit citation, with rare exceptions. Perhaps the most discussed article in the history of science is the Watson-Crick description of DNA's double helix.¹² Yet this article and many other classics have been explicitly cited less than 1300 times. Even the Avery-MacLeod-McCarty article,¹³ which heralded the age of molecular biology, has been cited "only" 620 times.

Some articles in this study may have been delayed in their recognition; others, not even listed, may be equally deserving of classic status. For example, Jonas E. Salk's report on the preparation and use of poliomyelitis virus vaccine¹⁴ received only 39 citations since it was published in 1955. It was not included in Table 1 because the minimum citation count in that list is 158. However, this article is considered a classic in

its field, as evidenced by its inclusion in *JAMA*'s LANDMARK ARTICLE series. And Albert B. Sabin's LANDMARK ARTICLE, "Live, Orally Given Poliovirus Vaccine,"¹⁵ has also been "infrequently" cited—just over 90 times since it was published in 1960.

Conclusion

In conclusion, of the 100 articles in Table 1 designated as *JAMA* citation classics, 82 were published before 1970. Thirteen of these 82 appeared in *JAMA*'s original LANDMARK ARTICLE series of 51 articles, which had a publication cutoff date of 1970. Therefore, about 16% of the 82 eligible articles in Table 1, which were chosen purely by citation counts, also appeared in the landmark series. This would seem to demonstrate that citation frequency is one of several valid indicators that editors, historians, and others can use to identify classic works. Combined with subjective peer judgment, quantitative criteria can be used judiciously. Lists of most-cited articles serve to jog our memories of the many important discoveries in medicine, many of which are unheralded. We tend to remember those works that received the widest public acclaim.

* * * * *

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