Essays of an Information Scientist, Vol:3, p.45-51, 1977-78 Current Contents, #8, p.5-11, February 21, 1977

CURRENT COMMENTS

Highly Cited Articles. 35. Biochemistry Papers Published in the 1940s.

Number 8, February 21, 1977

We recently published a list of citation classics from the life sciences published in the 1930s that were heavily cited in the period 1961-1975.[1] That list of 59 articles was predominantly composed of biochemical articles, many relating to the analysis of phosphorus and its physiologic compounds.

The number of citation classics published in the forties is too formidable to discuss in one issue. So we have broken them into three groups--biochemical, life sciences, and physical sciences. In Figure 2 we have listed the highly- cited biochemical articles. Papers dealing with phosphorus separation and determination are again prevalent since phosphorus is basic in the study of DNA, sugars, lipids, and other biochemical substances.

Dr. Steward A. Narrod of the Albert Einstein Medical Center in Philadelphia has commented on this parallel. "The work done in the late 1930s and continuing through the 40s laid the basis for biochemical research today.... A good deal of the work today is an offshoot of the work done in the 1940s. Since much of this is a totally new branch, the papers reporting this research would refer back to the 'parent' paper of the field."[2]

For example, paper 52 by Moore and Stein (both Nobel Prize winners) reported the initial separation of proteins into amino acid components. A paper by two other Nobel winners (80), Sutherland and Cori, was the original work leading to the discovery of cyclic AMP as a mediator of hormone reactions.

There are 13 Nobelists on this list. The papers which they either authored or coauthored constitute 13.5% of the 89 articles. Axelrod (paper 12) was the recipient of the 1970 Nobel Prize in Medicine; Martin (15 and 50), 1952 in Chemistry; Kornberg (30), 1959 in Medicine; Lipmann (41 and 42), 1953 in Medicine; Synge (50), 1952 in Chemistry; Moore (52), 1972 in Chemistry; Sanger (65), 1958 in Chemistry; Sumner (79), 1946 in Chemistry; Sutherland (80), 1971 in Medicine; Cori (80), 1947 in Medicine; Huggins (81), 1966 in Medicine; and Otto

Figure 1. Journals that published the highly cited 1940s articles listed in Figure 2. **A** = number of articles. **B** = 1975 impact factor. (Present titles of some journals are given in parentheses.)

A	B	Journal
1	0.346	Acta Biochim. Biophys.
1	1.208	Acta Chem. Scand.
2	1.373	Amer. J. Clin. Pathology
2	2.416	Analytical Chemistry
2	2.887	Arch. Biochemistry (Arch. Biochem. Biophys.)
1	3.188	Biochim. Biophys. Acta
10	3.456	Biochemical Journal
2	3.876	Biochem. Zschr. (Eur. J. Biochemistry)
1	1.475	Chemische Berichte
1	4.700	Endocrinology
6	4.671	J. Amer. Chem. Soc.
45	6.059	J. Biol. Chemistry
1	7.418	J. Clin. Invest.
2	2.855	J. Lab. Clin. Med.
1	1.634	J. Org. Chemistry
1	3.594	J. Pharmacol. Exp. Ther.
3	3.737	Nature
1	2.602	Plant Physiology
1	1.451	Proc. Soc. Exp. Biol. Med.
1		Q.J. Microsc. Sci.
2	5.605	Science
1	0.835	Soil Science
1	0.670	Stain Technology

Warburg, who died in 1970, received the Nobel Prize for Medicine in 1931.

Not by sheer coincidence, in this week's *Citation Classics* we publish the comments of Dr. Walter C. Schneider regarding his classic paper (69) on this list. This paper, as Schneider indicates, was his first as a sole author, and the first paper in a series on "Phosphorus compounds in animal tissue." Number 3 in that series also appears on this list (70). Dr. Schneider comments that it is not entirely surprising to him that so long after publishing the paper it should attain the status of a classic, since methods are the backbone of all scientific research. "What is surprising," he asserts, "is that the method should have survived this comparatively long period of time and still maintained a high citation frequency. For it is the nature of science that methods are constantly being modified and refined with the result that literature references shift from the original to modifications."[3]

In a previous *Citation Classics*[4] we published the comments of Professor Norton Nelson of the New York University Medical Center. His paper (54) was an adaptation of the Somogyi method for the determination of glucose. The presence of his paper on this list illustrates how literature references shift from an original method to modifications of it. Incidentally, Somogyi's original 1945 papers continue to be highly cited and are numbers 74 and 75 on this list. This illustrates the phenomenon of co-citations I've discussed before.

The 89 articles on this list were published in 23 different journals. These journals are listed alphabetically in Figure 1. Thirteen journals published one article apiece: six journals published two apiece. Four journals published the other 72% of the articles.

Nature published three, *Journal of the American Chemical Society* 6, *Biochemical Journal* 10, and the *Journal of Biological Chemistry* 45. The vast majority of the articles are in English (85). Three articles were published in a German-language journal, and one in French.

More than two-thirds of the articles were published in the latter half of the 1940s--65, as compared to 24 for the period from 1940 to 1944. All of the articles were cited more than 150 times during the period 1961-1975. On the average, they were each cited 650 times during those 15 years, and continue to be cited about 45 times a year.

The most frequently cited paper (26 by Gornall, Bardawill, and David) was cited 5,400 times from 1961 to 1975, and averaged 360 citations per year. Nelson's paper (54) ranked second--3,265 citations--an average of 218 over the 15 year period. Significantly, both of those articles continue to be heavily cited. The citation rate for the paper by Gornall et al. has even increased, reflecting the high interest in the measurement of serum protein.

Some of the procedures on this list are now so basic it is remarkable that they continue to be cited at all. Roe and Kuether's blood ascorbic acid determination (61); Dische's color reaction of hexuronic acids (17); Somogyi's sugar determination (74 and 75); and the Bonsnes/Taussky colorimetric determination of creatine (10)--all are still heavily cited. However, the Martin/Synge (50) chromatographic method for determining amino acids in proteins is now less cited. This is probably due to the "obliteration phenomenon."[5]

There can be no doubt about the significance of the articles on this list. Published nearly 30 years ago, most of these classics are still highly-cited. To de-emphasize the significance anyone may attribute to absolute citation counts we have listed the papers in alphabetic order.

REFERENCES

1. **Garfield E.** Citation classics. 2. Articles from the life sciences 1930-1939. *Current Contents®* No. 43, 25 October 1976, p. 5-10.
2. **Narrod S A.** Personal communication, 16 November 1976.
3. **Schneider W C.** Personal communication, 9 November 1976.
4. **Nelson N.** *Citation classics:* A photometric adaptation of the Somogyi method for the determination of glucose. *Current Contents* No. 3, 17 January 1976, p. 13.
5. **Garfield E.** The 'obliteration phenomenon' in science, and the advantage of being obliterated. *Current Contents* No. 51/52, 22 December 1975, p. 5-7.

Figure 2. Highly cited articles in biochemistry published in the 1940s. A = item number. **B** = total citations 1961-1975. **C** = average yearly citations 1961-1975. **D** = citations in 1974. **E** = citations in 1975. Articles are listed alphabetically by first author.

A	B	C	D	E	Bibliographic Data
1.	1105	73	56	61	**Allen R J L.** The estimation of phosphorus. **Biochem. J. 34**:858-65, 1940.
2.	263	17	16	10	**Archibald R M.** Determination of citrulline and allantoin and demonstration of citrulline in blood plasma. **J. Biol. Chem. 156**:121-42, 1944.
3.	213	14	15	10	**Archibald R M.** Colorimetric determination of urea. **J. Biol. Chem. 157**:507-18, 1945.
4.	1806	120	213	222	**Arnon D I.** Copper enzymes in isolated chloroplasts; polyphenoloxidase in *Beta Vulgaris*. **Plant Physiology 24**:1-15, 1949.
5.	412	27	19	12	**Baker J R.** The histochemical recognition of lipine. **Q. J. Microscop. Sci. 87**:441-70, 1946.
6.	2019	134	56	68	**Barker S B & Summerson W H.** The colorimetric determination of lactic acid in biological material. **J. Biol. Chem. 138**:535-54, 1941.
7.	694	46	51	59	**Benesi H A & Hildebrand J H.** A spectrophotometric investigation of the interaction of iodine with aromatic hydrocarbons. **J. Amer. Chem. Soc. 71**:2703-07, 1949.
8.	958	63	82	83	**Bessey O A, Lowry O H & Brock M J.** A method for the rapid determination of alkaline phosphatase with five cubic millimeters of serum. **J. Biol. Chem. 164**:321-29, 1946.
9.	300	20	10	20	**Blix G.** The determination of hexosamines according to Elson and Morgan. **Acta. Chem. Scand. 2**:467-73, 1948.
10.	832	55	38	50	**Bonsnes R W & Taussky H H.** On the colorimetric determination of creatine by the Jaffe reaction. **J. Biol. Chem. 158**:581-91, 1945.
11.	206	13	6	4	**Brockmann H & Schodder H.** Aluminiumoxyd mit abgestuftem Adsorptionsvermögen zur chromatographischen Adsorption (Aluminum oxide with stepped adsorption capacity for chromatographic adsorption). **Chem. Berichte 74**:73-8, 1941.
12.	191	12	21	15	**Brodie B B & Axelrod J.** The estimation of acetanilide and its metabolic products, aniline, n-acetyl p-aminophenol and p-aminophenol (free and total conjugated) in biological fluids and tissues. **J. Pharmacol. Exp. Ther. 94**:22-8, 1948.
13.	426	28	28	25	**Brown A H.** Determination of pentose in the presence of large quantities of glucose. **Arch. Biochem. Biophys. 11**:269-78, 1946.
14.	489	32	35	24	**Cohn E F, Strong L E, Hughes W L Jr, Mulford D J, Ashworth J N, Melin M & Taylor H L.** Preparation and properties of serum and plasma proteins. 4. A system for the separation into fractions of the protein and lipoprotein components of biological tissues and fluids. **J. Amer. Chem. Soc. 68**:459-75, 1946.
15.	294	19	12	6	**Consden R, Gordon A H & Martin A J P.** Qualitative analysis of proteins; a partition chromatographic method using paper. **Biochem. J. 38**:224-32, 1944
16.	183	12	10	3	**Derrien Y, Michel D & Roche J.** Recherches sur la preparation et les proprietes de la thyroglobuline pure (On preparation and properties of pure thyroglobulin). **Biochim. Biophys. Acta. 2**:454-70, 1948.
17.	1326	88	69	70	**Dische Z.** A new specific color reaction of hexuronic acids. **J. Biol. Chem. 167**:189-98, 1947.
18.	946	63	66	50	**Dische Z & Shettles L B.** A specific color reaction of methylpentoses and a spectrophotometric micromethod for their determination. **J. Biol. Chem. 175**:595-604, 1948.
19.	191	12	10	11	**Dische Z, Shettles L B & Osnos M.** New specific color reactions of hexoses and spectrophotometric micromethods for their determination. **Arch. Biochem. 22**:169-84, 1949.
20.	314	20	27	30	**Drabkin D L.** Spectrophotometric studies. 14. The crystallographic and optical properties of the hemoglobin of man in comparison with those of other species. **J. Biol. Chem. 164**:703-23, 1946.

Figure 2 (Cont.)

21.	297	19	16	19	**Fishman W H, Springer B & Brunetti R.** Application of an improved glucuronidase assay method to the study of human blood β -glucuronidase. **J. Biol. Chem. 173**:449-56, 1948.
22.	1288	85	46	37	**Friedemann T E & Haugen G E.** Pyruvic acid. 2. The determination of keto acids in blood and urine. **J. Biol. Chem. 147**:415-42, 1943.
23.	182	12	15	10	**Gilman H & Haubein A H.** The quantitative analysis of alkyllithium compounds. **J. Amer. Chem. Soc. 66**:1515-6, 1944.
24.	514	34	28	39	**Gomori G.** A modification of the colorimetric phosphorus determination for use with the photoelectric colorimeter. **J. Lab. Clin. Med. 27**:955-60, 1942.
25.	884	58	71	81	**Goodwin T W & Morton R A.** The spectrophotometric determination of tyrosine and tryptophan in proteins. **Biochem. J. 40**:628-32, 1946.
26.	5396	359	497	425	**Gornall A G, Bardawill C J & David M M.** Determination of serum proteins by means of the biuret reaction. **J. Biol. Chem. 78**:751-66, 1949.
27.	1339	89	57	59	**Hanes C S & Isherwood F A.** Separation of the phosphoric esters on the filter paper chromatogram. **Nature 164**:1107-12, 1949.
28.	163	10	8	4	**Henderson L M & Snell E E.** A uniform medium for determination of amino acids with various microorganisms. **J. Biol. Chem. 172**:15-29, 1948.
29.	963	64	52	55	**Hestrin S.** The reaction of acetylcholine and other carboxylic acid derivatives with hydroxylamine and its analytic application. **J. Biol. Chem. 180**:249-61, 1949.
30.	574	38	26	34	**Horecker B L & Kornberg A.** The extinction coefficients of the reduced band of pyridine nucleotides. **J. Biol. Chem. 175**:385-90, 1948.
31.	398	26	15	19	**Hotchkiss R D.** A microchemical reaction resulting in the staining of polysaccharide structures in fixed tissue preparations. **Arch. Biochem. 16**:131-41, 1948.
32.	559	37	31	34	**Hughes E W.** The crystal structure of melamine. **J. Amer. Chem. Soc. 63**:1737, 1941.
33.	301	20	2	3	**Jermyn M A & Isherwood F A.** Improved separation of sugars on the paper partition chromatogram. **Biochem. J. 44**:402-07, 1949.
34.	305	20	12	7	**Johnson M J.** Isolation and properties of a pure yeast polypeptidase. **J. Biol. Chem. 137**:575-86, 1941.
35.	378	25	17	25	**Kalckar H M.** Differential spectrophotometry of purine compounds by means of specific enzymes. 1. Determination of hydroxypurine compounds. **J. Biol. Chem. 167**:429-43, 1947.
36.	640	42	40	50	**Kalckar H M.** Differential spectrophotometry of purine compounds by means of specific enzymes. 3. Studies of the enzymes of purine metabolism. **J. Biol. Chem. 167**:461-75, 1947.
37.	170	11	10	27	**Kilmer V J & Alexander L T.** Methods of making mechanical analyses of soils. **Soil Science 68**:15-24, 1949.
38.	216	14	17	20	**Klotz I M, Walker M & Pivan R B.** The binding of organic ions by proteins. **J. Amer. Chem. Soc. 68**:1486-90, 1946.
39.	467	31	43	24	**Koelle G B & Friedenwald J S.** A histochemical method for localizing cholinesterase activity. **Proc. Soc. Exp. Biol. Med. 70**:617-22, 1949.
40.	172	11	11	8	**Kubowitz F & Ott P.** Isolierung und Kristallisation eines Gärungsfermentes aus Tumoren (Isolation and crystallization of a respiratory enzyme from tumors). **Biochem. Zschr. 314**:94-117, 1943.
41.	753	50	35	34	**Lipmann F & Tuttle L C.** A specific micromethod for the determination of acyl phosphates. **J. Biol. Chem. 159**:21-8, 1945.
42.	209	13	14	10	**Loomis W F & Lipmann F.** Reversible inhibition and the coupling between phosphorylation and oxidation. **J. Biol. Chem. 173**:807-09, 1948.
43.	745	49	41	47	**Lowry O H & Lopez J A.** The determination of inorganic phosphate in the presence of labile phosphate esters. **J. Biol. Chem. 162**:421-8, 1946.
44.	361	24	24	21	**McManus J F A.** Histological demonstration of mucin after periodic acid. **Nature 158**:202, 1946.
45.	242	16	10	13	**McManus J F A.** Histological and histochemical uses of periodic acid. **Stain Technol. 23**:99-108, 1948.

Figure 2 (cont.)

46.	203	13	12	12	**MacFadyen D A.** Estimation of formaldehyde in biological mixtures. **J. Biol. Chem. 158**:107-33, 1945.
47.	441	29	43	38	**MacKinney G.** Absorption of light by chlorophyll solutions. **J. Biol. Chem. 140**:315-22, 1941.
48.	396	26	16	12	**Markham R.** A stream distillation apparatus suitable for micro-Kjeldahl analysis. **Biochem. J. 36**:790-91, 1942.
49.	296	19	6	3	**Markham R & Smith J D.** Chromatographic studies of nucleic acids. 1. A technique for the identification and estimation of purine and pyrimidine bases, nucleosides and related substances. **Biochem. J. 45**:294-8, 1949.
50.	245	15	11	11	**Martin A J P & Synge R L M.** A new form of chromatogram employing two liquid phases. 1. A theory of chromatography. 2. Application to the micro-determination of the higher monoamino-acids in proteins. **Biochem. J. 35**:1358-68, 1941.
51.	382	25	22	23	**Michel H O.** An electrochemical method for the determination of red blood cell and plasma cholinesterase activity. **J. Lab. Clin. Med. 34**:1564-8, 1949.
52.	895	59	47	47	**Moore S & Stein W H.** Photometric ninhydrin method for use in the chromatography of amino acids. **J. Biol. Chem. 176**:367-88, 1948.
53.	534	35	22	37	**Morris D L.** Quantitative determinations of carbohydrates with Dreywood's anthrone reagent. **Science 107**:254-55, 1948.
54.	3265	217	165	153	**Nelson N.** A photometric adaptation of the Somogyi method for the determination of glucose. **J. Biol. Chem. 153**:375-80, 1944.
55.	767	51	54	45	**Park J T & Johnson M J.** A submicrodetermination of glucose. **J. Biol. Chem. 181**:149-51, 1949.
56.	901	60	39	24	**Partridge S M.** Aniline hydrogen phthalate as a spraying reagent for chromatography of sugars. **Nature 164**:443, 1949.
57.	934	62	39	26	**Partridge S M & Westall R G.** Filter-paper partition chromatography of sugars. 1. General description and application of the qualitative analysis of sugars in apple juice, egg white and foetal blood of the sheep. **Biochem. J. 42**:238-50, 1948.
58.	225	15	11	21	**Racker E.** Spectrophotometric measurement of hexokinase and phosphohexokinase activity. **J. Biol. Chem. 167**:843-54, 1947.
59.	293	19	11	9	**Remmert L F & Cohen P P.** Partial purification and properties of a proteolytic enzyme of human serum. **J. Biol. Chem. 181**:431-48, 1949.
60.	564	37	27	18	**Roe J H, Epstein J H & Goldstein N P.** A photometric method for the determination of insulin in plasma and urine. **J. Biol. Chem. 178**:839-45, 1949.
61.	537	35	31	23	**Roe J H & Kuether C A.** The determination of ascorbic acid in whole blood and urine through the 2,4-dinitrophenylhydrazine derivative of dehydroascorbic acid. **J. Biol. Chem. 147**:399-407, 1943.
62.	423	28	21	22	**Roe J H & Rice E W.** A photometric method for the determination of free pentoses in animal tissues. **J. Biol. Chem. 173**:507-12, 1948.
63.	346	23	11	21	**Rosenthal T B.** The effect of temperature on the pH of blood and plasma *in vitro*. **J. Biol. Chem. 173**:25-30, 1948.
64.	214	14	12	3	**Russell J A.** The colorimetric estimation of small amounts of ammonia by the phenol-hypochlorite reaction. **J. Biol. Chem. 156**:457-61, 1944.
65.	938	62	25	31	**Sanger F.** The free amino groups of insulin. **Biochem. J. 39**:507-15, 1945.
66.	214	14	9	7	**Sayers M A, Sayers G & Woodbury L A.** The assay of adrenocorticotrophic hormone by the adrenal ascorbic acid-depletion method. **Endocrinology 42**:379-93, 1948.
67.	676	45	25	39	**Schales O & Schales S S.** A simple and accurate method for the determination of chloride in biological fluids. **J. Biol. Chem. 140**:879-84, 1941.
68.	1761	117	135	86	**Schmidt G & Thannhauser S J.** A method for the determination of desoxyribonucleic acid, ribonucleic acid, and phosphoproteins in animal tissues. **Biochem. J. 161**:83-9, 1945.

Figure 2 (cont.)

69.	1518	101	71	72	**Schneider W C.** Phosphorus compounds in animal tissues. 1. Extraction and estimation of desoxypentose nucleic acid and of pentose nucleic acid. **J. Biol. Chem. 161**:293-303, 1945.
70.	282	18	16	14	**Schneider W C.** Phosphorus compounds in animal tissues. 3. A comparison of methods for the estimation of nucleic acids. **J. Biol. Chem. 164**:747-51, 1946.
71.	738	49	32	29	**Schneider W C.** Intracellular distribution of enzymes. 3. The oxidation of octonic acid by rat liver fractions. **J. Biol. Chem. 176**:259-66, 1948.
72.	706	47	25	31	**Scholander P F.** Analyzer for accurate estimation of respiratory gases in one-half cubic centimeter scales. **J. Biol. Chem. 167**:235-50, 1947.
73.	393	26	21	14	**Sibley J A & Lehninger A L.** Determination of aldolase in animal tissues. **J. Biol. Chem. 177**:859-72, 1949.
74.	603	53	35	35	**Somogyi M.** A new reagent for the determination of sugars. **J. Biol. Chem. 160**:61-8, 1945.
75.	970	64	49	37	**Somogyi M.** Determination of blood sugar. **J. Biol. Chem. 160**:69-73, 1945.
76.	289	19	20	19	**Spies J R & Chambers D C.** Chemical determination of tryptophan; study of color-forming reactions of tryptophan p-dimethylaminobenzaldehyde, and sodium nitrite in sulfuric acid solution. **Analytical Chem. 20**:30-9, 1948.
77.	739	49	43	42	**Spies J R & Chambers D C.** Chemical determination of tryptophan in proteins. **Analytical Chem. 21**:1249-66, 1949.
78.	173	11	10	11	**Stadie W C & Riggs B C.** Microtome for the preparation of tissue slices for metabolic studies of surviving tissues *in vitro*. **J. Biol. Chem. 154**:687-90, 1944.
79.	311	20	24	17	**Sumner J B.** A method for the colorimetric determination of phosphorus. **Science 100**:413-4, 1944.
80.	330	22	17	25	**Sutherland E W, Cori C F, Haynes R & Olsen N.** Purification of the hyperglycemic-glycogenolytic factor from insulin and from gastric mucosa. **J. Biol. Chem. 180**:825-37, 1949.
81.	314	20	19	21	**Talalay P, Fishman W H & Huggins C.** Chromogenic substrates. 2. Phenolphthalein glucuronic acid as substrate for the assay of glucuronidase activity. **J. Biol. Chem. 166**:757-72, 1946.
82.	158	10	11	10	**Tipson R S.** On esters of p-toluenesolfonic acid. **J. Org. Chem. 9**:235-41, 1944.
83.	678	45	42	40	**Vandekamer J H, Ten Bokkel Huinink H & Weyers H A.** Rapid method for the determination of fat in feces. **J. Biol. Chem. 177**:347-55, 1949.
84.	294	19	7	8	**Van Slyke D D & Folch J.** Manometric carbon determination. **J. Biol. Chem. 136**:509-41, 1940.
85.	454	30	17	25	**Vosburgh W C & Cooper G R.** Complex ions. 1. The identification of complex ions in solution by spectrophotometric measurements. **J. Amer. Chem. Soc. 63**:437-42, 1941.
86.	2594	172	193	161	**Warburg O & Christian W.** Isolierung und Kristallisation des Garungsferments Enolase (Isolation and crystallisation of the enzyme enolase) **Biochem. Zschr. 310**:384-421, 1942.
87.	285	19	17	15	**Ware A G & Seegers W H.** Two-stage procedure for the quantitative determination of prothrombin concentration. **Amer. J. Clin. Pathol. 19**:471-82, 1949.
88.	181	12	4	4	**Winzler R J, Devor A W, Mehl J W & Smyth L M.** Studies on the mucoproteins of human plasma. 1. Determination and isolation. **J. Clin. Invest. 27**:609-16, 1948.
89.	187	12	9	12	**Wolfson W Q, Cohn C, Calvary E & Ichiba F.** Studies on serum proteins. 4. A rapid procedure for the estimation of total protein, true albumin, total globulin, alpha globulin, beta globulin and gamma globulin in 1.0 ml. of serum. **Amer. J. Clin. Pathol. 18**:723-30, 1948.