# Random thoughts on the 100 most cited papers from 1925 to 2008

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*Critics not withstanding, citations seems to have gained a golden currency status in contemporary research. Among the 58 million items collected in the Thomson Reuters' Web of Science database, 100 of the most cited papers up to 7 October 2014 were presented in Nature last year. I present an analysis of the most cited papers such as: (1) how many of the 100 ranked papers were sole-authored or double-authored; (2) distribution pattern of these papers along the decades, between 1925 and 2008, and (3) cited number of references in 83 of the accessible ranked papers. Thirty-one among the 100 most cited papers were sole-authored. Nine science Nobel laureates (Frederick Sanger, Walter Kohn, Roger Tsien, Erwin Neher, Bert Sakmann, Kary Mullis, Oliver Smithies, Georges Kohler and Cesar Milstein) have authored eight of the most cited papers.*

Eugene Garfield (b. 16 September 1925), apart from being a successful publisher of the now defunct *Current Content* weekly and businessman, is also an essayist and founder of bibliometrics and scientometrics[1]. He is also identified as the pioneer in introducing provocative parameters (citation counting and impact factor) for quantitating scientific productivity[2–5].

Critics not withstanding[6,7], citations seems to have gained a golden currency status in contemporary research. Van Noorden *et al.*[8] have presented a ranking of the top 100 research papers among all academic disciplines which had accumulated highest number of citations. This ranking was based on the 58 million items collected in Thomson Reuters' *Web of Science* database (http://apps.webofknowledge.com/). This four-page analysis[8] appeared superficial and had ignored some vital aspects on scientific authorship such as: (1) how many of the 100 ranked papers were sole-authored or double-authored; (2) distribution pattern of these papers along the decades, between 1925 and 2008, and (3) cited number of references in each of the 100 papers ranked. I present an analysis of the most cited papers in this commentary.

## Method

I made an attempt to check the originals of the top 100 most cited papers, to count the cited number of references in each of these papers. Due to lack of suitable access and available funds (to retrieve freely, pre-1995 papers held hostage by a few prominent commercial databases), I was able to collect only 83 among the 100 papers. For each omitted paper, these commercial databases charge in the range of US$ 14.00–38.00.

## Results

Table 1 provides a list of four vital details (first author, published journal, total number of citations received up to 7 October 2014, and cited number of references) for the 100 most cited papers. Science Nobel laureates who had authored most cited papers include Frederick Sanger[9], Walter Kohn[10,11], Roger Tsien[12], Erwin Neher[13], Bert Sakmann[13], Kary Mullis[14], Oliver Smithies[15], Georges Kohler[16] and Cesar Milstein[16].

What is rather interesting is that, 31 among the 100 most cited papers were sole-authored. These are indicated with an asterisk in the second column of Table 1. Among the top 10 most cited papers in the list which had gathered >40,000 citations, three were sole-authored. Furthermore, 28 among the 100 most cited papers had double-authors. Roehr[17] showed that one of the most cited statistics paper authored by Kaplan and Meier[18] (ranked 11 in citation count, Table 1) was in fact two separate sole-author papers when they were originally submitted. According to Roehr[17], the collaboration of Kaplan and Meier was 'essentially a shotgun marriage arranged by an editor who did not want to publish two similar but somewhat conflicting papers. He told the pair to work it out and produce a single paper. It took four years of further refinements before the collaborative document was ready' and this paper was published in 1958.

Table 2 gives the decade-wise distribution of the 100 most cited papers. The oldest paper in the list, published in 1925, was the colorimetric determination of phosphorus by Fiske and Subbarow[19]. The most recent highly cited paper, authored by Sheldrick[20] on the history and development of SHELX system of computer programs appeared in 2008. The decade of 1981–90 has the highest number of most cited papers (25 altogether). However, papers with the largest number of citations (exceeding <65,000 and ranked 1 to 4) describing methods for protein determination[21,22], separating proteins based on electrophoretic mobility[23], and DNA sequencing[9] appeared in 1951, 1976, 1970 and 1977 respectively.

If these 100 became the most cited papers in 2014, one may be curious to know how many citations they themselves carried individually. Among the 83 papers which I was able to check for the cited references in them (column 5, Table 1), 11 included only <10 citations. In this citation counting, I excluded vague categories such as 'unpublished data', 'to be published' and 'personal communication'. The dubious honour to carry the least number of citations (only one) was that of Max Hamilton (then affiliated to the University of Leeds, UK), who published a rating scale for depression[24].

Another interesting five-author paper (among whom there were two separate husband–wife couples) published in 1953 in the *Journal of Chemical Physics* with the title 'Equation of state calculations by fast computing machines' had only two citations[25]. The most recognizable name in this paper was Edward Teller (Hungarian-born American theoretical physicist, prominently known as the 'father of the hydrogen bomb), then affiliated to the University of Chicago. Teller also makes another appearance as a

**Table 1.** 100 most cited papers (ISI database 7 October 2014; www.nature.com/top100)

| Citation rank | First author/ *sole author | Journal | Citations received up to 7 October 2014 | Cited no. of references+ |
|---|---|---|---|---|
| 1 | Lowry, O. H. (c) | *J. Biol. Chem.*, 1951, **193**, 265–275 | 305,148 | 25 |
| 2 | *Laemmli, U. K. | *Nature*, 1970, **227**, 680–685 | 213,005 | 22 |
| 3 | *Bradford, M. M. | *Anal. Biochem.*, 1976, **72**, 248–254 | 155,530 | 24 |
| 4 | Sanger, F. (c) | *Proc. Natl. Acad. Sci. USA*, 1977, **74**, 5463–5467 | 65,335 | 14 |
| 5 | Chomczynski, P. (c) | *Anal. Biochem.*, 1987, **162**, 156–159 | 60,397 | 15 |
| 6 | Towbin, H. (c) | *Proc. Natl. Acad. Sci. USA*, 1979, **76**, 4350–4354 | 53,349 | 28 |
| 7 | Lee, C. | *Phys. Rev. B*, 1988, **37**, 785–789 | 46,702 | 16 |
| 8 | *Becke, A. D. | *J. Chem. Phys.*, 1988, **98**, 5648–5652 | 46,145 | 18 |
| 9 | Folch, J. | *J. Biol. Chem.*, 1957, **226**, 497–509 | 45,131 | 9 |
| 10 | Thompson, J. D. | *Nucleic Acids Res.*, 1994, **22**, 4673–4680 | 40,289 | 40 |
| 11 | Kaplan, E. L. (c) | *J. Am. Stat. Assoc.*, 1958, **53**, 457–481 | 38,600 | OU |
| 12 | Altschul, S. F. | *J. Mol. Biol.*, 1990, **215**, 403–410 | 38,380 | 23 |
| 13 | *Sheldrick, G. M. | *Acta Crystallogr. A*, 2008, **64**, 112–122 | 37,978 | 60 |
| 14 | Altschul, S. F. | *Nucleic Acids Res.*, 1997, **25**, 3389–3402 | 36,410 | 90 |
| 15 | Murashige, T. (c) | *Physiol. Plant.*, 1962, **15**, 473–497 | 36,132 | OU |
| 16 | Perdew, J. P. | *Phys. Rev. Lett.*, 1996, **77**, 3865–3868 | 35,405 | 42 |
| 17 | Folstein, M. F. (c) | *J. Psychiatr. Res.*, 1975, **12**, 189–198 | 34,532 | OU |
| 18 | Bligh, E. G. (c) | *Can. J. Biochem. Physiol.*, 1959, **37**, 911–917 | 32,131 | OU |
| 19 | *Southern, E. M. | *J. Mol. Biol.*, 1975, **98**, 503–517 | 31,904 | 13 |
| 20 | Saitou, N. | *Mol. Biol. Evol.*, 1987, **4**, 406–425 | 30,176 | 19 |
| 21 | Livak, K. J. | *Methods*, 2001, **25**, 402–408 | 28,870 | 11 |
| 22 | *Shannon, R. D. | *Acta Crystallogr. A*, 1976, **32**, 751–767 | 28,658 | OU |
| 23 | Otwinowski, Z. | *Methods Enzymol. A*, 1997, **276**, 307–326 | 28,647 | OU |
| 24 | *Cox, D. R. (c) | *J. R. Stat. Soc. B*, 1972, **34**, 187–220 | 28,439 | 26 |
| 25 | *Becke, A. D. | *Phys. Rev. A*, 1988, **38**, 3098–3100 | 26,475 | 22 |
| 26 | DuBois, M. | *Anal. Chem.*, 1956, **28**, 350–356 | 25,735 | 54 |
| 27 | *Reynolds, E. S. (c) | *J. Cell Biol.*, 1963, **17**, 208–212 | 24,449 | 14 |
| 28 | Thompson, J. D. | *Nucleic Acids Res.*, 1997, **25**, 4876–4882 | 24,098 | 27 |
| 29 | Bland, J. M. (c) | *Lancet*, 1986, **327**, 307–310 | 23,826 | 8 |
| 30 | Weber, K. | *J. Biol. Chem.*, 1969, **244**, 4406 | 23,642 | 49 |
| 31 | Chirgwin, J. M. | *Biochemistry*, 1979, **18**, 5294–5299 | 23,435 | 34 |
| 32 | *Scatchard, G. | *Ann. N.Y. Acad. Sci.*, 1949, **51**, 660–672 | 23,421 | OU |
| 33 | Baron, R. M. | *J. Pers. Soc. Psychol.*, 1986, **51**, 1173–1182 | 23,356 | 46 |
| 34 | Kohn, W. | *Phys. Rev.*, 1965, **140**, A1133–A1138 | 23,059 | 13 |
| 35 | *Mosmann, T. | *J. Immunol. Methods*, 1983, **65**, 55–63 | 23,011 | OU |
| 36 | *Iijima, S. | *Nature*, 1991, **354**, 56–58 | 22,899 | 11 |
| 37 | Fiske, C. H. | *J. Biol. Chem.*, 1925, **66**, 375–400 | 22,690 | 17 |
| 38 | *Davis, B. J. | *Ann. N.Y. Acad. Sci.*, 1964, **121**, 404–427 | 22,074 | OU |
| 39 | Hohenberg, P. | *Phys. Rev.*, 1964, **136**, B864–B871 | 21,931 | 15 |
| 40 | Feinberg, A. P. (c) | *Anal. Biochem.*, 1983, **132**, 6–13 | 21,446 | 33 |
| 41 | *Felsenstein, J. | *Evolution*, 1985, **39**, 783–791 | 21,373 | 12 |
| 42 | Grynkiewicz, G. | *J. Biol. Chem.*, 1985, **260**, 3440–3450 | 19,561 | 36 |
| 43 | Kresse, G. | *Phys. Rev. B*, 1996, **54**, 11169–11186 | 18,856 | 72 |
| 44 | *O'Farrell, P. H. (c) | *J. Biol. Chem.*, 1975, **250**, 4007–4021 | 18,489 | 36 |
| 45 | Tamura, K. | *Mol. Biol. Evol.*, 2007, **24**, 1596–1599 | 18,286 | 9 |
| 46 | *Zadeh, L. A. (c) | *Inf. Control*, 1965, **8**, 338–353 | 18,203 | 3 |
| 47 | *Sheldrick, G. M. | *Acta Crystallogr. A*, 1990, **46**, 467–473 | 17,728 | OU |
| 48 | McKhann, G. | *Neurology*, 1984, **34**, 939–944 | 17,220 | 31 |
| 49 | Monkhorst, H. J. | *Phys. Rev. B*, 1976, **13**, 5188–5192 | 17,087 | 6 |
| 50 | *Burton, K. (c) | *Biochem. J.*, 1956, **62**, 315–323 | 17,067 | 32 |
| 51 | *Radloff, L. S. | *Appl. Psychol. Meas.*, 1977, **1**, 385–401 | 17,055 | OU |
| 52 | Hamill, O. P. | *Pflug. Arch. Eur. J. Physiol.*, 1981, **391**, 85–100 | 17,025 | 23 |
| 53 | *Hamilton, M. (c) | *J. Neurol. Neurosurg. Psychiatry*, 1960, **23**, 56–62 | 16,734 | 1 |
| 54 | Beck, A. T. | *Arch. Gen. Psychiatry*, 1961, **4**, 561–571 | 16,264 | 15 |
| 55 | Kyte, J. | *J. Mol. Biol.*, 1982, **157**, 105–132 | 16,059 | 70 |
| 56 | Gornall, A. G. (c) | *J. Biol. Chem.*, 1949, **177**, 751–766 | 16,009 | 18 |
| 57 | Dempster, A. P. | *J. Roy. Stat. Soc. B*, 1977, **39**, 1–38 | 15,993 | 39 |
| 58 | Metropolis, N. | *J. Chem. Phys.*, 1953, **21**, 1087–1092 | 15,902 | 2 |
| 59 | Benjamini, Y. | *J. Roy. Stat. Soc. B*, 1995, **57**, 289–300 | 15,898 | 14 |
| 60 | Smith, P. K. | *Anal Biochem.*, 1985, **150**, 76–85 | 15,802 | 11 |
| 61 | *Oldfield, R. C. | *Neuropsychologia*, 1971, **9**, 97–113 | 15,517 | 8 |

(*Contd*)

**Table 1.** (*Contd*)

| Citation rank | First author/ *sole author | Journal | Citations received up to 7 October 2014 | Cited no. of references[+] |
|---|---|---|---|---|
| 62 | Friedewald, W. T. | *Clin. Chem.*, 1972, **18**, 499–502 | 15,469 | 12 |
| 63 | Saiki, R. K. | *Science*, 1988, **239**, 487–491 | 15,160 | 19 |
| 64 | *Duncan, D. B. (c) | *Biometrics*, 1955, **11**, 1–42 | 15,047 | 25 |
| 65 | Novoselov, K. S. | *Science*, 2004, **306**, 666–669 | 15,022 | 16 |
| 66 | *Ellman, G. L. | *Arch. Biochem. Biophys.*, 1959, **82**, 70–77 | 15,019 | 4 |
| 67 | *Boyum, A. (c) | *Scand. J. Clin. Lab. Invest.*, 1968, **21**, S77–S89 | 14,934 | OU |
| 68 | Landis, J. R. | *Biometrics*, 1977, **33**, 159–174 | 14,903 | OU |
| 69 | Brunger, A. T. | *Acta Crystallogr. D*, 1998, **54**, 905–921 | 14,898 | 61 |
| 70 | *Dunning Jr, T. H. | *J. Chem. Phys.*, 1989, **90**, 1007–1023 | 14,617 | 52 |
| 71 | Laskowski, R. A. | *J. Appl. Crystallogr.*, 1993, **26**, 283–291 | 14,462 | OU |
| 72 | Ware, J. E. | *Med. Care*, 1992, **30**, 473–483 | 14,332 | 45 |
| 73 | *Akaike, H. (c) | *IEEE Trans. Autom. Control*, 1974, **19**, 716–723 | 14,275 | 45 |
| 74 | Yanisch-Perron, C. | *Gene*, 1985, **33**, 103–119 | 14,232 | 36 |
| 75 | Devereux, J. | *Nucleic Acids Res.*, 1984, **12**, 387–395 | 14,226 | 14 |
| 76 | Posada, D. | *Bioinformatics*, 1998, **14**, 817–818 | 14,099 | 12 |
| 77 | Kresse, G. | *Phys. Rev. B*, 1999, **59**, 1758–1775 | 14,049 | 51 |
| 78 | Hsu, S. M. (c) | *J. Histochem. Cytochem.*, 1981, **29**, 577–580 | 13,881 | 12 |
| 79 | Jorgensen, W. L. | *J. Chem. Phys.*, 1983, **79**, 926–935 | 13,774 | 29 |
| 80 | Dewar, M. J. S. | *J. Am. Chem. Soc.*, 1985, **107**, 3902–3909 | 13,718 | 21 |
| 81 | *Bartlett, G. R. (c) | *J. Biol. Chem.*, 1959, **234**, 466–468 | 13,523 | 7 |
| 82 | *Kraulis, P. J. | *J. Appl. Crystallogr.*, 1991, **24**, 946–950 | 13,496 | OU |
| 83 | *Bondi, A. | *J. Phys. Chem.*, 1964, **68**, 441–451 | 13,417 | 42 |
| 84 | Ellman, G. L. (c) | *Biochem. Pharmacol.*, 1961, **7**, 88–95 | 13,332 | 13 |
| 85 | *Blochl, P. E. | *Phys. Rev. B*, 1994, **50**, 17953–17979 | 13,330 | 67 |
| 86 | Kirkpatrick, S. | *Science*, 1983, **220**, 671–680 | 13,293 | 30 |
| 87 | Moncada, S. | *Pharmacol. Rev.*, 1991, **43**, 109–142 | 13,267 | 404 |
| 88 | *Marquardt, D. W. (c) | *J. Soc. Ind. Appl. Math.*, 1963, **11**, 431–441 | 13,258 | OU |
| 89 | Kresse, G. | *Comput. Mater. Sci.*, 1996, **6**, 15–50 | 13,084 | 64 |
| 90 | O'Regan, B. | *Nature*, 1991, **353**, 737–740 | 12,873 | 19 |
| 91 | *Spurr, A. R. (c) | *J. Ultrastruct. Res.*, 1969, **26**, 31–43 | 12,807 | 18 |
| 92 | Berman, H. M. | *Nucleic Acids Res.*, 2000, **28**, 235–242 | 12,754 | 36 |
| 93 | Perdew, J. P. | *Phys. Rev. B*, 1992, **45**, 13244–13249 | 12,748 | 26 |
| 94 | Bimboim, H. C. | *Nucleic Acids Res.*, 1979, **7**, 1513–1523 | 12,721 | 23 |
| 95 | Jones, T. A. | *Acta Crystallogr. A*, 1991, **47**, 110–119 | 12,649 | OU |
| 96 | Vosko, S. H. | *Can. J. Phys.*, 1980, **58**, 1200–1211 | 12,583 | 42 |
| 97 | Kohler, G. | *Nature*, 1975, **256**, 495–497 | 12,391 | 14 |
| 98 | Matthews, D. R. | *Diabetologia*, 1985, **28**, 412–419 | 12,257 | 22 |
| 99 | Brunauer, S. | *J. Am. Chem. Soc.*, 1938, **60**, 309–319 | 12,252 | 13 |
| 100 | Ronquist, F. | *Bioinformatics*, 2003, **19**, 1572–1574 | 12,209 | 5 |

*Sole author status by asterisk. (c) Refers to the availability of 'citation classic' commentary by the author in Eugene Garfield's website (http://garfield.library.upenn.edu/classics.html; accessed on 14 August 2015).
[+]Column prepared by S.S.K. after checking the original paper; OU, Original unchecked.

senior author in a 1938 paper entitled 'Adsorption of gases in multimolecular layers'[26]. It carried 13 citations. While 28 among the 83 papers checked had 11–20 citations, 16 papers counted 21–30 citations, and 10 papers were enriched with 31–40 citations. The largest number of citations (404) appeared in a 1991 review paper on physiology, pathophysiology and pharmacology of nitric oxide[27].

Van Noorden *et al.*[8] have emphasized the research areas or themes in which majority of the most cited papers had appeared. These are biological techniques (method papers), bioinformatics, phylogenetics, statistics, density functional theory and crystallography. But a convincing answer to the question, 'Why these 100 papers came to be most cited?' was not offered. Van Noorden *et al.*[8] ended their survey with a left-handed compliment offered by Yale University chemist Peter Moore, 'If citations are what you want, devising a method that makes it possible for people to do the experiments they want at all, or more easily, will get you a lot further than, say, discovering the secret of the Universe.' I, for one, feel that this is rather demeaning to the sincere efforts of scientists. Apart from the method papers, even conceptual papers like that of Lofti Zadeh[28] on fuzzy sets had received recognition in this top 100 list.

An answer to the posed question above, has been offered by naturalist Edward O. Wilson[29], who had listed five diagnostic features of science that distinguish it from pseudoscience. These diagnostic features are as follows:

Repeatability – the same phenomenon sought again, by independent investigation.
Economy – gather largest amount information with least amount of effort by simplest and esthetically most pleasing steps.

**Table 2.** Decade-wise distribution of 100 most cited papers

| Decade | No. of papers | Distribution according to citation rank number from ISI database |
|---|---|---|
| 1921–30 | 1 | 37 |
| 1931–40 | 1 | 99 |
| 1941–50 | 2 | 32, 56 |
| 1951–60 | 12 | 1, 9, 11, 18, 26, 50, 53, 58, 64, 66, 81 |
| 1961–70 | 14 | 2, 15, 27, 30, 34, 38, 39, 46, 54, 67, 83, 84, 88, 91 |
| 1971–80 | 19 | 3, 4, 6, 17, 19, 22, 24, 31, 44, 49, 51, 57, 61, 62, 68, 73, 94, 96, 97 |
| 1981–90 | 25 | 5, 7, 12, 20, 25, 29, 33, 35, 40, 41, 42, 47, 48, 52, 55, 60, 63, 70, 74, 75, 78, 79, 80, 86, 98 |
| 1991–2000 | 21 | 8, 10, 14, 16, 23, 28, 36, 43, 59, 71, 72, 76, 77, 82, 85, 87, 89, 90, 92, 93, 95 |
| 2001–08 | 5 | 13, 21, 45, 65, 100 |

Mensuration – quantitation of by accepted scales that leads to unambiguous generalization.
Heuristics – offer opportunities to make new findings in unpredictable directions.
Consilience – explanations that can be linked with already known phenomena and offer consistence with each other.

Recently, there have been a couple of cases of published data that bordered on sloppiness and overt hype (arsenic-loving bacterium, published in *Science*[30–32]) as well as research fraud (Stimulus triggered acquisition of pluripotency cells, aka STAP cells, published in *Nature*, only to be retracted later[33–37]). Incomplete description of the methods and zero reproducibility of reported results by other interested groups are the common denominators for these erroneous reports. According to the numerous method papers among the 100 most cited papers, the simple fact that the described methods were flawless and had withstood the test of time to offer good reproducibility can be considered as the secret for their extraordinary citedness.

The foresight of Garfield in soliciting short commentaries on the highly cited papers (which he called 'citation classics') to provide the human angle on the conducted research and writing the work for eventual publication emphasizing acceptance and rejection deserves commendation. He had made these 'citation classics' commentaries accessible in his website[38]. I could locate at least 25 of these commentaries (column 2, Table 1) for the most cited top 100 papers analysed in this commentary.

1. Cronin, B. and Atkins, H. A. (eds), *The Web of Knowledge: A Festschrift in Honor of Eugene Garfield*, Information Today Inc, Medford, NJ, 2000.
2. Garfield, E., *Science*, 1955, **122**, 108–111.
3. Garfield, E., *J. Am. Med. Assoc.*, 1996, **295**, 90–93.
4. Garfield, E., *Libr. Q.*, 1996, **66**, 449–458.
5. Balaram, P., *Curr. Sci.*, 2010, **99**, 857–858.
6. Siekevitz, P., *FASEB J.*, 1991, **5**, 139.
7. Lawrence, P. A., *Curr. Biol.*, 2007, **17**(15), R583–R585.
8. Van Noorden, R., Maher, B. and Nuzzo, R., *Nature*, 2014, **514**, 550–553.
9. Sanger, F., Nicklen, S. and Coulson, A. R., *Proc. Natl. Acad. Sci. USA*, 1977, **74**, 5463–5467.
10. Kohn, W. and Sham, L. J., *Phys. Rev.*, 1965, **140**, A1133–A1138.
11. Hohenberg, P. and Kohn, W., *Phys. Rev.*, 1964, **136**, B864–B871.
12. Grynkiewicz, G., Poenie, M. and Tsien, R. Y., *J. Biol. Chem.*, 1985, **260**, 3440–3450.
13. Hamill, P. O., Marty, A., Neher, E., Sakmann, B. and Sigworth, F. J., *Pflug. Arch. Eur. J. Physiol.*, 1981, **391**, 85–100.
14. Saiki, R. K. *et al.*, *Science*, 1988, **239**, 487–491.
15. Devereux, J., Haeberli, P. and Smithies, O., *Nucleic Acids Res.*, 1984, **12**, 387–395.
16. Kohler, G. and Milstein, C., *Nature*, 1975, **256**, 495–497.
17. Roehr, B., *Br. Med. J.*, 2011, **343**, d5507.
18. Kaplan, E. L. and Meier, P., *J. Am. Stat. Assoc.*, 1958, **53**, 457–481.
19. Fiske, C. H. and Subbarow, Y., *J. Biol. Chem.*, 1925, **66**, 375–400.
20. Sheldrick, G. M., *Acta. Crystallogr.*, 2008, **A64**, 112–122.
21. Lowry, O. H., Rosebrough, N. J., Farr, A. L. and Randall, R. J., *J. Biol. Chem.*, 1951, **193**, 265–275.
22. Bradford, M. M., *Anal. Biochem.*, 1976, **72**, 248–254.
23. Laemmli, U. K., *Nature*, 1970, **227**, 680–685.
24. Hamilton, M., *J. Neurol. Neurosurg. Psychiatr.*, 1960, **23**, 56–62.
25. Metropolis, N., Rosenbluth, A.W., Rosenbluth, M. N., Teller, A. H. and Teller, E., *J. Chem. Phys.*, 1953, **21**, 1087–1092.
26. Brunauer, S., Emmett, P. H. and Teller, E., *J. Am. Chem. Soc.*, 1938, **60**, 309–319.
27. Moncada, S., Palmer, R. M. and Higgs, E. A., *Pharmacol. Rev.*, 1991, **43**, 109–142.
28. Zadeh, L. A., *Inf. Control*, 1965, **8**, 338–353.
29. Wilson, E. O., *Am. Sci.*, 1998, **86**, 6–7.
30. Pennisi, E., *Science*, 2010, **330**, 1734–1735.
31. Wolfe-Simon, F. *et al.*, *Science*, 2011, **332**, 1163–1166.
32. Wolfe-Simon, F. *et al.*, *Science*, 2011, **332**, 1149-j–1149-j.
33. Obokata, H. *et al.*, *Nature*, 2014, **505**, 641–647.
34. Obokata, H. *et al.*, *Nature*, 2014, **505**, 676–680.
35. Cyranoski, D., *Nature*, 2014, **507**, 283.
36. Cyranoski, D., *Nature*, 2014, **508**, 299.
37. Cyranoski, D., *Nature*, 2014, **511**, 140–143.
38. http://garfield.library.upenn.edu/classics.html (accessed 14 August 2015).

ACKNOWLEDGEMENTS. I dedicate this commentary to Dr Eugene Garfield on his 90th birthday. For over 30 years, he has been one of my mentors in research on the history of science. A brief editorial commentary entitled, 'Most cited medical papers: a tangential view' authored by me, is currently in press for the *International Medical Journal* (Tokyo).

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