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Do Nobel Prize Winners Write Citation Classics?

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In the recently concluded series on the 1,000 articles most cited in the *Science Citation Index*® (*SCI*®), 1961 to 1982, I drew attention to the many Nobel laureates who were authors of one or more of these highly cited papers.¹ It was no surprise that 14 percent of the 1,000 papers were written by Nobel Prize winners, since we knew that as a group they are heavily cited. In 1965 Irv Sher, ISI®'s director of development and quality control, and I examined the 1961 citations to the work of the 1962 and 1963 Nobel laureates in chemistry, physics, and physiology or medicine. We determined that these authors were cited roughly 30 times as often as the average author.² In that study we were counting citations to any and all works by a particular author. We were not then attempting to determine whether an author's citation count represented one or more Citation Classics or a prolific output in which average or slightly above average citations to many works added up to a high count. My purpose here is to pose the question, "Do all or most Nobel Prize winners in the sciences write at least one highly cited work, a Citation Classic?"

To answer this question let us consider the 125 Nobel Prize winners in chemistry, physics, and physiology or medicine from 1965 to 1984. Of these, 104 (or about 83 percent) have written at least

one work cited 300 or more times. We know from past experience that any publication accumulating this many citations is a Citation Classic.³ Only about 10,000 papers, or approximately 0.04 percent of all articles in the *SCI* file, have been cited at this level. Furthermore, in virtually every case, peer judgment has confirmed that such a work is a landmark publication. Of these 104 laureates, 61 published 1 or more papers appearing in our recent report on the 1,000 articles most cited in the *SCI*, 1961 to 1982.¹ These 1,000 articles represent just 0.004 percent of the 23 million different papers cited in the *SCI* during these years.

Table 1 is an alphabetic list of Nobel laureates in the sciences, 1965 to 1984. An asterisk marks those who have written at least one work that has received 300 or more citations. A plus sign stands next to the names of those who have written one or more Citation Classics appearing in our list of the 1,000 most-cited papers.

The answer to the question I posed is evident: not only are Nobel Prize winners highly cited, but most write landmark papers of wide influence as is reflected by the large number of publications (300 or more) citing them.

Let me point out, however, that I do not mean to imply that the remaining 21 laureates from our group of 125 have not

written a Citation Classic. An arbitrary threshold of 300 citations is merely one of the tools we use in identifying Citation Classics. While we have confidence in its accuracy, the use of an absolute citation threshold is not a definitive test. This relatively high level of citation will fail to detect, for example, publications from small, specialty fields. As few as 100 citations (or even fewer) may qualify a work as a Citation Classic in some of these areas, such as radio astronomy, engineering, or mathematics. To identify Citation Classics in smaller fields we use several criteria. One is rank within a specialty journal. If a specialty journal defines a unique field, then the most-cited articles from that journal include many if not all Citation Classics for that field. (The number of articles we consider "most cited" is much greater for a large journal than a small one.)

Nobelists, of course, sometimes publish important papers in multidisciplinary or multispecialty journals, such as *Science* and *Nature*. These journals do not define unique fields very well. A Citation Classic on a specialized subject that is published in one of these large, multidisciplinary journals often does not rank among the most-cited articles for that journal. In this instance, we rely on many factors, including peer judgment and author's comments, when selecting Citation Classics.

Similarly, recently published papers present a special problem. Only the rarest paper is cited more than 300 times within a few years of publication. So we take the recent vintage of articles into consideration in our search for Citation Classics.

Before evaluating the most-cited publications of the remaining 21 laureates in our study, there are two other matters we must note.

First, in some cases, the most cited of a laureate's publications lies outside the body of work for which the Nobel was

awarded. But upon careful consideration of our theme—"Do Nobel Prize winners write Citation Classics?"—this point is not relevant. In another study we could, and perhaps should, consider the related question—"Has the work for which a laureate won the Nobel Prize been highly cited?"

Second, and of direct relevance, is the matter of *SCI* coverage. Are our citation data complete for all laureates listed in Table 1? In studies such as this, we try to use all-author data. Thus, even when a laureate is not the first author of a paper, we can link the work with that person. Our all-author data are usually derived from the *SCI Source Index* file, which covers only the articles published since 1955. Any paper published before 1955 in which a Nobelist was not the first author would not be included in the main computer run. We could, of course, check the laureate's bibliography for coauthored articles published before 1955—a large task indeed, and one that was not attempted for this study. More important, however, we lack any record of citations given out in the years before 1955, the earliest year covered by the *SCI*. We are as yet unable to determine whether the citations received by a work in the years before 1955 would give it Citation Classic status.

Therefore, we have excluded from consideration, for reasons of incomplete data, 11 of the remaining 21 Nobel laureates. They are A. Claude, M. Delbrück, J. Dausset, R. G. W. Norrish, P. L. Kapitza, A. Kastler, L. J. Rainwater, H. K. Hartline, K. Lorenz, F. P. Rous, and S. Tomonaga. To reiterate, I am not suggesting that these scientists have not written or cowritten one or more Citation Classics. We are now processing journals for the years 1945 to 1954. When this *SCI* cumulation is completed, we will be able to determine whether the most-cited publications of these laureates are Citation Classics.

Table 1: Nobel Prize winners in physics (P), chemistry (C), and physiology or medicine (M), 1965 to 1984. Those whose names appeared in our series on the 1,000 most-cited articles in the *SCF*, 1961 to 1982, are marked by a plus sign (+). Those who have written a paper cited 300 times or more are designated by an asterisk (*).

Nobel			Nobel		
Author	Year	Prize Country	Author	Year	Prize Country
* Alfven H	1970	P Sweden	+* Kohler G J F	1984	M FRG
Alvarez L W	1968	P US	+* Leloir L F	1970	C Argentina
+* Anderson P W	1977	P US	* Lipscomb W N	1976	C US
+* Anfinsen C B	1972	C US	Lorenz K	1973	M Austria
* Arber W	1978	M Switzerland	* Luria S E	1969	M US
+* Axelrod J	1970	M US	* Lwoff A	1965	M France
+* Baltimore D	1975	M US	* McClintock B	1983	M US
+* Bardeen J	1956	P US	+* Merrifield R B	1984	C US
	1972		+* Milstein C	1984	M UK
* Barton D H R	1969	C UK	+* Mitchell P D	1978	C UK
+* Benacerraf B	1980	M US	+* Monod J	1965	M France
+* Berg P	1980	C US	+* Moore S	1972	C US
+* Bergstrom S K	1982	M Sweden	+* Mott N F	1977	P UK
+* Bethe H A	1967	P US	+* Mottelson B R	1975	P Denmark
+* Bloembergen N	1981	P US	+* Mulliken R S	1966	C US
+* Blumberg B S	1976	M US	* Nathans D	1978	M US
+* Bohr A N	1975	P Denmark	* Neel L	1970	P France
+* Brown H C	1979	C US	+* Nirenberg M W	1968	M US
+* Chandrasekhar S	1983	P US	+* Norrish R G W	1967	C UK
Claude A	1974	M Belgium	+* Onsager L	1968	C US
+* Cooper L N	1972	P US	+* Palade G E	1974	M US
Cormack A M	1979	M US	* Penzias A A	1978	P US
Cornforth J W	1975	C UK	* Porter G	1967	C UK
* Cronin J W	1980	P US	+* Porter R R	1972	M UK
Dausset J	1980	M France	+* Prelog V	1975	C Switzerland
+* de Duve C	1974	M Belgium	* Prigogine I	1977	C Belgium
Delbruck M	1969	M US	Rainwater L J	1975	P US
* Dulbecco R	1975	M US	+* Richter B	1976	P US
+* Edelman G M	1972	M US	Rous F P	1966	M US
+* Eigen M	1967	C FRG	* Rubbia C	1984	P Italy
Esaki L	1973	P Japan	* Ryle M	1974	P UK
+* Feynman R P	1965	P US	* Salam A	1979	P Pakistan
Fischer E O	1973	C FRG	+* Samuelsson B I	1982	M Sweden
* Fitch V L	1980	P US	+* Sanger F	1958	C UK
* Flory P J	1974	C US		1980	
+* Fowler W A	1983	P US	* Schally A	1977	M US
* Fukui K	1981	C Japan	* Schawlow A L	1981	P US
* Gabor D	1971	P UK	+* Schrieffer J R	1972	P US
Gajdusek D C	1976	M US	* Schwinger J S	1965	P US
+* Gell-Mann M	1969	P US	* Siegbahn K M	1981	P Sweden
Giaever I	1973	P US	* Smith H O	1978	M US
+* Gilbert W	1980	C US	* Snell G D	1980	M US
+* Glashow S L	1979	P US	* Sperry R W	1981	M US
+* Granit R A	1967	M Sweden	+* Stein W H	1972	C US
+* Guillemin R	1977	M US	+* Sutherland E W	1971	M US
Hartline H K	1967	M US	* Taube H	1983	C US
* Hassel O	1969	C Norway	+* Temin H M	1975	M US
+* Hershey A D	1969	M US	* Tinbergen N	1973	M UK
* Herzberg G	1971	C Canada	+* Ting S C C	1976	P US
Hewish A	1974	P UK	Tomonaga S	1965	P Japan
+* Hoffmann R	1981	C US	+* Vane J R	1982	M UK
+* Holley R W	1968	M US	van der Meer S	1984	P Netherlands
+* Hounsfield G N	1979	M UK	+* Van Vleck J H	1977	P US
+* Hubel D H	1981	M US	* von Euler U	1970	M Sweden
+* Huggins C B	1966	M US	* von Frisch K	1973	M FRG
* Jacob F	1965	M France	* Wald G	1967	M US
+* Jerne N K	1984	M Denmark	+* Weinberg S	1979	P US
* Josephson B D	1973	P UK	+* Wiesel T N	1981	M Sweden
Kapitza P L	1978	P USSR	* Wilkinson G	1973	C UK
Kastler A	1966	P France	+* Wilson K G	1982	P US
+* Katz B	1970	M UK	* Wilson R W	1978	P US
* Khorana H G	1968	M US	* Wittig G	1979	C FRG
* Klug A	1982	C UK	+* Woodward R B	1965	C US
			+* Yalow R S	1977	M US

I have already discussed why an absolute measure (such as a citation threshold) may fail to detect certain Citation Classics, as well as some of the strategies we use to uncover those in smaller fields. Of the remaining 10 Nobel laureates in this study, various relative measures indicate that each has written at least one paper that qualifies as a Citation Classic in its field.

Four have written at least one paper that ranks among the most highly cited papers for the journal in which the paper was published. E.O. Fischer coauthored one article that ranks seventh of all those published in the *Zeitschrift für Anorganische und Allgemeine Chemie*.⁴ L. Esaki's most-cited paper ranks fourth of all papers published in the *IBM Journal of Research and Development*.⁵ M. Ryle's most-cited article ranks 26th of all articles published in the *Monthly Notices of the Royal Astronomical Society*.⁶ Finally, D.C. Gajdusek's most-cited paper ranks 14th for all those published in *Archives of Internal Medicine*.⁷ Each of these articles is a Citation Classic.

As mentioned earlier, some Citation Classics, especially those in small fields, may not rank among the most-cited papers published in a single journal, especially in a large, multidisciplinary journal. A case in point is A. Hewish's most-cited paper, published in *Nature*.⁸ This article, reporting the discovery of pulsars, has received over 200 citations. It is not among the most-cited articles published in *Nature*. Past experience, however, indicates that, for radio astronomy (a relatively small field in terms of number of scientists and number of publications), 200 citations gives this work the status of a Citation Classic. Furthermore, peer judgment confirms this.

Another example is I. Giaever's most-cited paper, published in the enormous journal *Physical Review*.⁹ This paper has

been cited by "only" 190 publications. However, this level of citation for a paper in the field of superconductivity indicates that the paper is a Citation Classic. (Giaever's modest and witty *Citation Classic*[®] commentary on this article was published in *Current Contents*[®] in 1984.¹⁰)

A.M. Cormack's most-cited work, published in two parts in 1963 and 1964 in the *Journal of Applied Physics*,^{11,12} laid down the mathematical foundations for computerized axial tomography (CAT). Both papers together were cited in more than 240 publications. However, this subspecialty of applied physics is another relatively small field, in which a citation threshold lower than 300 would qualify works as Citation Classics. I will have more to say about the citation history of Cormack's Citation Classic in a moment.

J.W. Cornforth's most-cited paper, dealing with the biosynthesis of cholesterol, was published in the *Journal of Biological Chemistry*.¹³ This paper has received over 160 citations; while not among the most cited for this journal, it is highly cited for studies on cholesterol, and, in fact, is a core document in our research front #85-2737, "Gene expression and other characterization studies of the synthesis and secretion of cell-membrane proteins and glycoproteins."

The most-cited papers by Nobelists S. van der Meer and L.W. Alvarez are of recent vintage. Van der Meer's most-cited paper, published in 1983 in *Physics Letters B*,¹⁴ was mentioned in my essay on the 1984 Nobel laureates.¹⁵ Van der Meer's paper has already been cited in over 170 papers. The most-cited paper by Alvarez, "Extraterrestrial cause for the Cretaceous-Tertiary extinction," was published in *Science* in 1980.¹⁶ It has received over 200 citations. Consider that the typical paper receives about two citations per year.¹⁷ These two papers

are indeed Citation Classics. (It is relevant to observe that Alvarez wrote his most-cited paper some 12 years after he was awarded the Nobel Prize.)

Citation phenomena such as delayed recognition^{18,19} or obliteration by incorporation^{20,21} may have affected the citation counts of any of these publications. A year-by-year accounting of citations to Cormack's study showed that this publication was virtually ignored until the early 1970s.²² Cormack's work began to be cited only after G.N. Hounsfield's article on the CAT scanner was published in the *British Journal of Radiology* in 1973.²³ (Hounsfield's paper has been cited over 800 times. It is among the 1,000 most-cited papers we examined recently.¹) Since most citations to a paper are received in the first decade after publication, delayed recognition "handicapped" citations to Cormack's most-cited work. Obliteration by incorporation, in which the substance of a publication is quickly absorbed into the common knowledge of a field and no longer requires overt citation, would be expected of the pioneering research of Nobel laureates.

Despite the possibility of either delayed recognition or obliteration by incorporation having affected the citation counts of the most-cited publications of the laureates examined here, the 114 Nobel Prize winners in this study have each produced at least one work that we would identify as a Citation Classic.

A few years ago I introduced into my annual discussion of the Nobel Prize winners the concept of "scientists of Nobel class."²² Obviously, there are far more scientists whose work is worthy of the Nobel Prize than the number of prizes given each year. Scientists of Nobel class are those who citations indicate

are influential among their peers and possible candidates for this special recognition. This group includes many highly cited scientists who have not written Citation Classics. Prolific authors may never produce an unusually high-impact article or book, but by 20 to 40 years of persistent, dogged research, can produce an important cumulative impact on their field. Only peer judgment can determine which of these authors is uniquely qualified for the Nobel or some other illustrious award. Indeed, citation frequency by itself is not adequately indicative of outstanding and influential publications.

The relationship between publication productivity, citations, influence, and recognition in the form of prizes such as the Nobel is complex. Citations, while usually a strong indicator of influence, are only one indicator. While we did not find any recent Nobel laureates who had not written at least one Citation Classic, it is impossible to say that there will not be any in the future. After all, objective measures of influence, such as citations, may not always be found to match the Nobel committee's subjective evaluations of "beauty in science." Indeed, I'd be suspicious if they did. In many respects evaluating Nobel science is like comparing a masterpiece by Rembrandt to one by Matisse.

In general, however, this and previous studies confirming the high cumulative counts of Nobel laureates lend support to the observation of sociologist Harriet Zuckerman, Columbia University, that "Nobel Prizes do not go to unknowns."²⁴

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