swer the question, What is the best solution? The other difficulty is in the composition of the proposed commission. As a bipartisan commission, half of the members would represent a political party that has already recorded its opposition to a Department of Science and Technology. This fact almost guarantees a balancing membership of persons committed to support the idea. At this stage the idea needs nonpartisan analysis rather than bipartisan compromise.

Whether the commission is appointed or not, means of improving the administrative arrangements with which the federal government carries out its scientific and technical responsibilities will continue to be discussed. The decisions that will ultimately be made will be sounder ones if scientists and government representatives have considered the alternatives objectively and have analyzed the probable consequences of various organizational patterns.

References and Notes

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3. The bills in question are: S. 676, 86th Congress, first session, by Senator Hubert Humphrey and others; S. 586, 86th Congress, first session, by Senator Estes Kefauver; several similar earlier bills that died in committee; and S. 1851, 86th Congress, first session, by Senator Hubert Humphrey and others. The latter bill differs from the others in recommending a commission to study a Department of Science and Technology, rather than recommending specific plans for such a department.
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Mathematical Evaluation of the Scientific Serial

Improved bibliographic method offers new objectivity in selecting and abstracting the research journal.

L. Miles Raisig

In the 33 years since the report in *Science* of the Gross and Gross (*1*) method of weighing the value of the serial publication in the field of chemistry, scientists, librarians, and literature specialists have sought to provide similar "objective" evaluations for serials in several other fields.

Those later studies, which lay claim to objectivity through the counting of the number of citations quoted, rest quite solidly upon the assumptions made by Gross and Gross in 1927. (i) The value of any journal in any scientific field may be measured directly and objectively by determination of the number of times the journal is cited in the literature of that field; that is, the greater the number of citations, the greater the value of the journal. (ii) Any well-used, subjectively valuable journal in the scientific field may be chosen as the source for counting citations to other journals.

In those studies it is further variously assumed that the journal selected as a source of citations is representative of the field, and that if two or more source journals are used, both or all may be weighted equally.

In a recent thorough review of the basic citation method, I found it to be neither scientifically objective nor mathematically sound, based as it is upon raw counts of citations wholly unrelated to the numbers of original articles published.

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Qualitative Measurement Possible

In this article is offered an improved citation-count method, designed to measure qualitatively the value of any scientific serial by means of a related quantitative citation count.

Unlike the method of Gross and Gross, this improved method does not (i) underrate the serial which must for a temporary period suspend publication or reduce sharply the number of original articles it customarily publishes (for example, many German journals during 1917 and 1918); (ii) overrate the serial which, by reason of a few heavily cited articles, appears to be of considerable value; or (iii) overrate the serial which publishes a large number of very short articles (for example, *Comptes rendus de l'académie des sciences*), which therefore may appear to be relatively heavily cited.

In theory the new method rests upon the following assumptions. (i) Any original (hitherto unpublished) article which appears in a serial publication has immediate and retrospective "reader impact"; that is, it may immediately or in the future be used and quoted in the preparation of another original article

and therefore has research potential. (ii) The research potential of any one original article may be expressed as unity (1.0). (iii) The research potential of all of the original articles in any one unit or volume of a serial publication may be expressed as the total number of articles times 1.0. (iv) The research potential indicated by the total number of original articles in one unit of one serial publication may be contrasted mathematically with the totals for original articles in comparable units of other serials.

Steps in Evaluation

In practice the method requires the following steps. (i) One unit or volume of one or more journals is chosen as the source(s), and all citations appearing there are tabulated separately by journal and period of time. (ii) These tabulations are corrected to include counts of single references to original articles only. (iii) The number of original articles appearing in each cited journal within each period (to the year of count) is tabulated. (iv) The relationship of the number of articles quoted to the number of articles published [the "index of research potential realized" (RPR index)] is found for each journal for each period by dividing the citation count by the published-article count for that period. The decimal part of 1.0 resulting is the "RPR index," and that journal which has the highest index is considered the most valuable.

In order to demonstrate the operation and possible value of this method, the five journals that ranked highest for the period 1871-1925 in the Gross and Gross study were re-counted and re-evaluated: *Berichte der deutschen chemischen Gesellschaft; Journal of the Chemical Society* (London); *Liebig's Annalen der Chemie; Zeitschrift für physikalische Chemie* (Leipzig); and *Comptes rendus de l'académie des sciences*. The citations to these journals in the *Journal of the American Chemical Society* (*2*) were carefully screened and tabulated. All references which did not specifically relate to these journals were deleted; as in the Gross and Gross study, all references to the *Journal of the American Chemical Society* were excluded. Each remaining reference was traced to the article cited and was counted only if the article was original. A citation to any article was counted once only, regardless of the number of times the article itself may have been quoted. Excluded from the counts of original articles were letters, review articles, reports of patents, book reviews, abstracts, and purely biographical material. Since *Comptes rendus de l'académie des sciences* included articles on a number of subjects, only those relating to chemistry were counted. In Table 1 appear the Gross and Gross raw counts of citations and the corrected citation counts and total original article counts made in the study under discussion. In Table 2 appear the RPR indexes and the ranks in both studies, for the periods 1871-1925 and 1916–1925, respectively, for the five journals that were re-evaluated.

Changes in Journal Ranks

It may be noted that while there are minor differences in the RPR indexes for the period 1871–1925 for the *Journal of the Chemical Society, Annalen der Chemie,* and *Zeitschrift für physikalische Chemie* (and these differences are not critical), the *Berichte der deutschen chemischen Gesellschaft* drops in rank from first in the Gross and Gross study to fourth in this study. The *Journal of the Chemical Society, Annalen der Chemie,* and *Zeitschrift für physikalische Chemie* each advance one step in rank. Coincidentally, *Comptes rendus de l'académie des sciences* keeps the same rank in both studies, but it is likely that in any re-evaluation of a large number of journals by the present method it would drop to a much lower rank.

With the widespread use of the basic Gross and Gross method, there has arisen a marked difference of opinion concerning its value in the objective evaluation and selection of scientific periodicals. Brodman (*3*) in 1944 and Postell (*4*) in 1946 both found con-

Table 1. Results of citation and article counts for the period 1871–1925, made in this study and in the Gross and Gross study. (*a*) Gross and Gross raw count of citations; (*b*) single-citation corrected count made in this study; (*c*) original article count made in this study.

Study	1871–1875	1876–1880	1881–1885	1886–1890	1891–1895	1896–1900	1901–1905	1906–1910	1911–1915	1916–1920	1921–1925	Totals
					Berichte der deutschen chemischen Gesellschaft							
a	33	44	53	56	60	64	79	115	67	30	78	679
b	32	43	47	58	55	64	76	116	62	32	84	669
c	1895	2628	2886	3447	3106	2886	3597	3413	2239	1243	2182	29,502
					Journal of the Chemical Society							
a		1	2	5	20	21	47	45	60	37	122	360
b	4	5	6	9	19	16	40	40	52	30	103	324
c	204	340	347	392	488	590	790	1126	1226	624	1855	7,982
					Liebig's Annalen der Chemie							
a		13	18	19	21	22	23	33	37	8	26	220
b	9	13	17	17	21	19	18	32	34	9	23	212
c	717	578	492	594	599	470	439	548	506	159	372	5,474
					*Zeitschrift für physikalische Chemie**							
a				6	16	28	19	29	21	6	53	178
b				6	15	27	22	24	20	3	46	163
c				289	524	623	645	779	672	188	648	4,368
					Comptes rendus de l'académie des sciences							
a		8	9	7	21	15	23	15	23	3	26	150
b	3	2	2	8	9	9	22	16	24	1	26	122
c†	980	1159	1224	1320	1467	1605	1858	1687	1469	642	1516	14,927

* Began publication in 1887. † Articles on chemistry only.

siderable reason to question the value of the citation-count method. Brodman sought but failed to find a close correlation between the ranks of physiology journals established by raw counts of citations and the ranks revealed through an opinion poll of medical-college personnel. Postell, in relating Brodman's ranks to ranks based on the circulation statistics of the library of a college of medicine, found some correlation between the ranks from the opinion poll and those from the library statistics, but little correlation between the latter and ranks from raw counts of citations. Stevens (*5*) in 1953 found the raw count method useful in the main. Morgan (*6*) in 1957 applied the raw count method to a study of periodical literature in the field of physiology and found evidence of the method's usefulness. It is obvious that when such a difference of opinion exists there is ample reason for endeavoring to develop a method that is more mathematically sound.

Table 2. RPR indexes and ranks for this study and the study of Gross and Gross for the periods 1871–1925 and 1916–1925.

Journal	RPR index	Rank	
		This study	Gross and Gross study
Period 1871–1925			
Berichte der deutschen chemischen Gesellschaft	.022	4	1
Journal of the Chemical Society	.040	1	2
Liebig's Annalen der Chemie	.038	2	3
Zeitschrift für physikalische Chemie	.037	3	4
Comptes rendus de l'académie des sciences	.008	5	5
Period 1916–1925			
Berichte der deutschen chemischen Gesellschaft	.033	4	2
Journal of the Chemical Society	.053	3	1
Liebig's Annalen der Chemie	.060	1	*
Zeitschrift für physikalische Chemie	.058	2	3
Comptes rendus de l'académie des sciences	.012	5	†

* Ranked 9th of 22 journals studied. † Ranked 14th of 22 journals studied.

Practical Applications

The improved citation-count method here described has two very practical applications. Primarily, it provides new criteria for selecting periodicals by pointing the way to the re-evaluation and re-establishment of such widely used lists as those which appear in Brown's *Scientific Serials* (*7*), as well as to a thorough review and reconsideration of all scientific serials. There is a need in this country for an official or semi-official body to lead and correlate the activities of several libraries or scientific groups in making citation and article counts, in screening citations, and in assembling, publishing, and distributing corrected lists, all in the interest of better evaluation, and consequent better use, of the scientific serial. Better evaluation is important in itself, but it acquires additional importance when the choice of journal articles for abstracting is concerned. It is apparent that not every scientific article will find its way into an abstracting journal. It is assumed that the most important articles in what are now considered to be the most important journals will, within a reasonable length of time, be included in some type of index and in some type of abstracting periodical. It is just here that the second application of this objective method of evaluation becomes apparent. Use of the method would minimize chance in the selection of periodical literature to be abstracted and would speed up the abstracting of material from the journal found to be most valuable.

Let us suppose that a journal devoted solely to publishing abstracts of the current periodical literature in chemistry were to limit its choice of articles to be abstracted to the five journals studied here. On the basis of RPR indexes established for the period 1871–1925, it is possible to predict with confidence the expected future ranks of these journals. The number of original articles to be abstracted from each of these journals would then be directly proportional to the ranks of the journals in the RPR indexes. Of every 100 articles to be chosen, the abstracting periodical would select 28 from the *Journal of the Chemical Society*, 26 from *Annalen der Chemie*, 25 from *Zeitschrift für physikalische Chemie*, 15 from *Berichte der deutschen chemischen Gesellschaft*, and 6 from *Comptes rendus de l'académie des sciences*. The actual choice of articles within these limits would of course remain a matter of editorial decision.

Absolute Objectivity Unattainable

Mathematical determination of the ranks of journals to be evaluated will not of itself provide absolute objectivity in the selection of periodicals to be purchased, bound, kept, or discarded. It must be related, rather, to data on such characteristics of periodicals as language(s) and country of publication, editorial policy, circulation, group or other affiliation, length and type of article, frequency of publication, generality or specialty of subject matter, and cost. It is expected that evaluations obtained in continuing large-scale studies will reduce the importance of these characteristics as criteria of selection, but will not eliminate or cancel them entirely. The final decision in the selection of periodicals is tempered almost always by local needs and desires, and by budget limitations within the local situation. In practical applications, sound judgment as well as mathematical tabulation is needed to assure objectivity.

The results obtained in this study should be considered not as final but as indicative of the possible value of the method in the long-term evaluation of many journals. The method itself constitutes a mathematical measure of the success of any scientific journal as a vehicle for the communication of ideas. In the larger view, it may in time serve as the key to such presently abstruse problems as the value of the general scientific serial to the specialist (particularly in the field of medicine), the measurement of the effect of published abstracts upon the journals from which the original articles were abstracted, the importance of country of origin as a factor in serial selection, and the exploration and establishment of new relationships in subject fields and serial publications.

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