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Citation Analysis as a Tool in Journal Evaluation

Journals can be ranked by frequency and impact of citations for science policy studies.

Eugene Garfield

As a communications system, the network of journals that play a paramount role in the exchange of scientific and technical information is little understood. Periodically since 1927, when Gross and Gross published their study (*1*) of references in 1 year's issues of the *Journal of the American Chemical Society*, pieces of the network have been illuminated by the work of Bradford (*2*), Allen (*3*), Gross and Woodford (*4*), Hooker (*5*), Henkle (*6*), Fussler (*7*), Brown (*8*), and others (*9*). Nevertheless, there is still no map of the journal network as a whole. To date, studies of the network and of the interrelation of its components have been limited in the number of journals, the areas of scientific study, and the periods of time their authors were able to consider. Such shortcomings have not been due to any lack of purpose, insight, or energy on the part of investigators, but to the practical difficulty of compiling and manipulating manually the enormous amount of necessary data.

A solution to this problem of data is available in the data base used to produce the *Science Citation Index* (SCI) (*10*). The coverage of the SCI is international and multidisciplinary; it has grown from 600 journals in 1964 to 2400 journals in 1972, and now includes the world's most important sci-

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ITEM NO	CITED JOURNAL	TOTAL	NUMBER OF TIMES CITED 1969	1968	1967	1966	1965	1964	1963	1962	1961	1960	REST
00243	ACTA PATH JAP	36	1	3	3	4	6	7	3	·	·	3	6
00244	ACTA PATH MICROBIOL	736	29	69	87	59	56	59	44	48	20	31	234
00909	AM J ANAT	637	7	27	37	56	32	41	15	26	15	21	360
00910	AM J BOT	1171	13	74	87	68	73	66	57	57	47	49	580
00911	AM J CANCER	103	·	·	·	·	·	·	·	·	·	·	103
00912	AM J CARDIOL	1238	73	201	199	247	134	70	78	66	53	73	44
03591	CAN J SOIL SCI	33	·	2	1	4	1	2	6	6	3	2	6
03592	CAN J SURG	61	2	6	4	3	13	11	3	3	5	1	10
03593	CAN J TECH	3	·	·	·	·	·	·	·	·	·	·	3
03594	CAN J ZOOL	356	46	38	40	28	24	20	19	29	17	22	73
08990	ISRAEL J AGR RES	29	1	1	7	·	1	8	7	2	1	·	1
08991	ISRAEL J BOT	16	·	·	3	5	4	3	1	·	·	·	·
08992	ISRAEL J CHEM	91	14	25	18	10	11	6	7	·	·	·	·
09651	J INVEST DERM	695	24	78	81	69	65	46	30	31	34	22	215
09652	J IOWA MED SOC	13	·	·	·	5	·	·	1	2	·	·	5
09653	J IRISH MED ASS	16	1	3	4	3	3	·	·	·	·	·	2
13390	P CALIF ACAD SCI	18	·	·	1	4	3	·	1	·	·	·	9
13391	P CAMBRIDGE PHIL SOC	389	8	22	23	11	12	9	13	11	17	3	260
19755	Z ANGEW CHEM	47	·	·	1	·	·	1	·	·	1	1	43
19756	Z ANGEW ENT	35	·	·	1	1	4	2	4	1	1	5	16
19757	Z ANGEW GEOL	49	2	7	5	8	5	5	4	4	2	1	6
19758	Z ANGEW MATH	10	1	·	1	·	1	·	1	1	1	·	4

Fig. 1. Journal citation frequencies. The data show the total number of times each journal was cited during the last quarter of 1969 and the distribution by publication date of the particular issues cited. The journals shown were taken from a list of more than 20,000 items (journals, books, reports, theses, and so on) cited during the last quarter of 1969 in journals covered by the SCI.

entific and technical journals in most disciplines. The SCI is published quarterly and is cumulated annually and quinquennially, but the data base from which the volumes are compiled is maintained on magnetic tape and is updated weekly. At the end of 1971, this data base contained more than 27 million references to about 10 million different published items. These references appeared over the past decade in the footnotes and bibliographies of more than 2 million journal articles, communications, letters, and so on. The data base is, thus, not only multidisciplinary, it covers a substantial period of time and, being in machine-readable form, is amenable to extensive manipulation by computer.

In 1971, the Institute for Scientific Information (ISI) decided to undertake a systematic analysis of journal citation patterns across the whole of science and technology. It began by extracting from the data base all references published during the last quarter of 1969 in the 2200 journals then covered by the SCI. The resultant sample was about 1 million citations of journals, books, reports, theses, and so forth. To test whether this 3-month sample was representative of the year as a whole, it was matched against another sample made by selecting every 27th reference from the approximately 4 million references collected over the entire year. The two samples were similar enough in scope (number of different items cited) and detail (relative frequency of their citation by different journals) to convince us that the 3-month data constitute a valid sample.

With this data from the last quarter of 1969, ISI produced three listings that should greatly further efforts to map the network of journal information transfer. The first listing is a cumulation of all citations of the same titles. It gives the number of times each different title was cited during the last quarter of 1969 and distributes that total over the years in which cited issues, editions, and so on were published. This distribution is shown by year from 1969 back to 1960 and in aggregate form for earlier years (*11*). Sample items from this listing are shown in Fig. 1.

The second listing is a detailed citation history of each cited title. It shows how frequently each title was cited and, as above, gives subtotals by year of publication. These citation totals and subtotals are further broken down to show how frequently each journal covered by SCI cited the title in question and the distribution by year of publication of cited items. A portion of this listing is shown in Fig. 2.

The third listing is similar to the second, but it arranges the data by citing journal rather than by cited title. The listing shows, for each journal covered by the SCI, the number of references published in issues processed for the SCI during the last quarter of 1969, and it breaks that total down by publication date of the items to which reference was made. The listing further identifies all titles cited in those references and the frequency with which they are cited. As in Fig. 2, the counts for each cited title are broken down by year of publication. A portion of this listing is shown in Fig. 3.

These listings afford, I believe, a new view of the literature in scientific and technical journals. Before discussing some of its implications, however, I note possible limitations of the data and problems encountered in analyzing the sample.

The SCI data base is, to my knowledge, the largest and most extensive of its kind. It does not, however, cover every scientific and technical journal.

CITED JOURNAL / CITING JRNL	TOTAL	NUMBER OF TIMES CITED 1969	1968	1967	1966	1965	1964	1963	1962	1961	1960	REST
J LINN SOC BOT	17*	0	3	0	3	1	0	0	0	1	1	8
NEW PHYTOL	5	0	1	0	1	0	0	0	0	1	0	2
ALL OTHER (10)	12	0	2	0	2	1	0	0	0	0	1	6
J LIPID RES	902*	33	108	109	98	133	121	75	83	60	58	24
BIOC BIOP A	83	5	8	16	6	13	15	4	6	5	1	4
BIOCHEM J	39	0	4	7	3	6	7	3	3	4	1	1
J BIOL CHEM	39	0	6	7	3	8	3	6	2	2	2	0
J CHROMAT	30	2	3	4	4	2	6	0	4	2	1	2
J CLIN INV	29	1	3	3	3	7	2	2	3	3	1	1
J LIPID RES	28	5	5	4	2	4	1	2	0	3	1	1
P SOC EXP M	25	0	3	1	3	4	3	2	5	1	1	2
MILIT MED	5	0	0	2	0	0	0	1	1	0	1	0
NY ST J MED	5	0	1	1	2	0	0	0	1	0	0	0
ALL OTHER (123)	219	6	19	16	29	43	27	23	15	15	23	3
J LOND MATH SOC	173*	16	19	19	11	8	10	2	8	4	8	68
J LOND MATH	71	8	12	7	5	4	4	0	4	2	4	21
T AM MATH S	11	2	1	2	1	0	0	0	1	0	0	4
P CAMB PHIL	8	1	0	3	0	0	0	0	0	0	0	4

Fig. 2. Statistics on cited journals. The data on cited journals show the total number of times each journal was cited in the last quarter of 1969 and the distribution by publication date of cited issues. For each cited journal, the figure identifies all other journals ("citing journals") that referred to it five times or more during the quarter year (and the distribution of these citations by publication date of cited issues). Journals that referred to the cited journal less than five times are grouped as "all other." The data were taken from a complete list of journals cited during the last quarter of 1969 in journals covered by the SCI.

SOURCE JOURNAL REFERENCE JOURNAL	TOTAL	1969	1968	1967	1966	1965	1964	1963	1962	1961	1960	REST
		NUMBER OF TIMES CITED										
J LIBR AUT	168*	15	50	35	19	8	14	5	6	3	1	12
PROGRAM	15	3	6	5	1	0	0	0	0	0	0	0
J LIBRARY AUTOMATION	7	3	4	0	0	0	0	0	0	0	0	0
ALL OTHER (120)	146	9	40	30	18	8	14	5	6	3	1	12
J LIPID RES	313*	15	36	35	26	25	29	20	10	15	15	87
J BIOL CHEM	43	2	6	3	6	1	3	1	0	1	1	19
J LIPID RES	28	5	5	4	2	4	1	2	0	3	1	1
BIOCHIM BIOPHYS ACTA	19	1	3	1	3	2	3	1	0	2	2	1
BIOCHEM J	13	1	1	3	0	0	0	1	2	1	1	3
J AMER CHEM SOC	12	0	0	0	0	0	0	0	0	1	0	11
BIOCHEMISTRY	9	0	3	0	2	1	2	1	0	0	0	0
J CHEM SOC LONDON	5	0	0	1	0	0	0	0	0	1	0	3
J CHROMATOGR	5	0	1	1	1	0	1	0	1	0	0	0
METHODS ENZYMOL	5	0	0	0	0	0	0	0	1	0	0	4
ALL OTHER (89)	124	5	12	19	10	8	16	10	2	5	6	31
J LOND MATH	743*	21	44	58	52	42	34	31	38	29	33	361
J LOND MATH	52	6	12	5	5	4	3	0	2	1	3	11
P LONDON MATH SOC	37	4	5	7	1	2	2	0	1	1	0	14

Fig. 3. Statistics on citing journals. The data on each citing journal ("source journal") show the total number of references each journal contained in the last quarter of 1969 and the distribution of that total by publication date of journal issues referred to. For each citing journal, the figure identifies all journals ("reference journal") cited five times or more during the quarter year (and gives the distribution by publication data of cited issue). Journals cited less than five times are grouped as "all other." The data are taken from a list of journals processed for the SCI during the last quarter of 1969.

(Nor, as seems likely in view of findings discussed later in this article, need it attempt to.) The list of most frequently cited journals (the first 152 of these journals are given in Fig. 4) shows that the SCI has been remarkably successful in covering all "significant" and "important" journals, insofar as citation counts can be considered a reliable measure of "importance" and "significance." It is, of course, possible that one or more journals not covered by the SCI, and thus not represented in the data here, may cite themselves and other journals so frequently that their inclusion would alter their own and other journals' rankings. Such may be the case, for example, with certain journals in foreign languages, particularly those that do not use the Roman alphabet. As is true of most secondary services, the SCI is less likely to cover a journal that presents problems of transliteration (or transcription) and translation than one that does not. It may be, therefore, that this fact has adversely influenced the ranking of Russian and Japanese journals, for example, which probably cite other Russian and Japanese journals more frequently than do journals in other languages. Whether such an underrepresentation exists, and, if so, to what extent, is difficult to determine. Nevertheless, Soviet information scientists have reported that the SCI does a surprisingly good job of covering Soviet journals. In fact, Soviet scientists seem to have made more use of citation analysis in studies of science policy than have any other scientists (*12–14*).

One must remember that the listings were prepared from a 3-month sample of journal issues. The size of the sample is certainly more than adequate for statistical purposes, and, as noted, the sample has been matched against another sample of more than adequate size. It is nevertheless possible that random events in journal publishing have introduced some degree of distortion. For example, a journal may have, in the time period covered by the sample, departed from its usual policy of accepting only original research communications and published one or two review articles with extensive bibliographies. In the sample, that journal would appear to cite other publications more widely and more frequently than it actually does on the average. Or, a journal may have published an article that has since been cited with extraordinary frequency (*15*). In such a case, a single article will have had an inordinate influence on the ranking of the journal (*16*). Finally, a journal that publishes relatively few articles, but articles of high quality that both cite and are cited frequently, may seem to have considerably less impact than it actually does, particularly if the journal appears infrequently or irregularly and thus escapes representative inclusion in a sample of this type.

In analysis of the sample, an immensely irksome problem was the inconsistency with which different authors and editors abbreviate journal titles in their references. As far as possible, this inconsistency has been minimized by standardizing all variants of the same titles and their abbreviations. Some idea of the work involved in this standardization can be had from the fact that there were more than 100,000 different abbreviations for the 12,000 individual journal titles cited in the 3-month sample (*17*). Inconsistency was made worse by inaccuracy. In some cases, it was possible to disentangle the results of bibliographic carelessness—as, for example, when *Sol. St. Phys.* proved to have been used indiscriminately to identify *Solid State Physics* (Academic Press); *Solid State Physics, Proceedings of the Physical Society, London; Soviet Physics Solid State* (a cover-to-cover translation of *Fizika Tverdogo Tela*); and even *Physica Status Solidi* (Akademie-Verlag). In other cases, however, it was impossible, without going to inordinate expense, to determine exactly which journal was being cited—for example, when *Ann. Phys.* was found to have been used for *Annalen der Physik, Annals of Physics*, and *Annales de Physique*. It is not surprising that the editors of at least one publishing house, having decided that the problem of unique and unambiguous journal title abbreviations is simply insoluble, now use full titles in every reference to a journal.

Finally, it was necessary to make some arbitrary decisions in order to avoid unduly complex bibliographical technicalities. Journals merge; they split into new journals, or into "sections" that may be published separately or together. They change titles, with or without continuing their numbering of volumes and issues. Some journals appear in one or more translations; some such translations are complete, others selective, and some are similarly, others differently, numbered. Supplements outside a regularly enumerated series must be accounted for. In a few cases, journals periodically change their titles on single issues to note special subject matter (*18*). Serials librarianship abounds in difficulties of this type, and there is frequently disagreement on how best to handle them. Briefly: a journal published in sections is considered a single journal; translations of journals are identified with the original versions; changes of title have been ignored and previous volumes attributed to the current title; journals absorbed or incorporated by other journals have been credited to a new or remaining title; supplements have been considered as issues in the regular series. For the purposes of this analysis, such arbitrary decisions seem justified; as required in the future, the raw citation data can, of course, be compiled and manipulated in such a way as to differentiate between changed titles, sections, translations, and so forth.

Some Preliminary Analyses

Figure 4 shows the result of a familiar application of citation analysis. It is a listing of journal titles ranked by the frequency with which they were cited in the references of journals indexed for SCI. This partial listing gives the top 152 of the 565 most frequently cited journals of science and technology. (The top 152 account for 50 percent of all references to journals.)

It is apparent, even from the makeup of this partial listing, that a good multidisciplinary journal collection need contain no more than a few hundred titles. That is not to say that larger collections cannot be justified, but it does say something indisputable, in terms of cost and benefit, about how large a journal collection need be (or how small it can be) if it is to provide effective coverage of the literature most used by research scientists.

It is also immediately apparent that the majority of all references cite relatively few journals. Figure 5, which plots the distribution of citations among cited journals, shows that only 25 journals (little more than 1 percent of SCI coverage) are cited in 24 percent of all references; that only 152 journals (those listed in Fig. 4) are cited in 50 percent of all references; that only 767 journals are cited in 75 percent of all references; and that only 2000 or so journals are cited in 85 percent of all references. In addition, the data from which Fig. 5 was plotted show that only 540 journals are cited 1000 or more times a year, and that only 968 journals are cited even 400 times a year. When one considers that only 165 or so journals publish 400 or more papers a year, the impact of the average paper must

Item No. (1)	Cited Journal (2)	Times Cited Last Quarter 1969 (3)	1969 Citations to 1967 and 1968 Articles (4)	Articles Published in 1967 and 1968 (5)	Impact Factor (6)
0001	J AM CHEM SOC	26323	22156	3946	5 614
0002	PHYS REV	20674	20740	5767	3 596
0003	J BIOL CHEM	17112	10768	1777	6 059
0004	NATURE LONDON	15325	15956	6811	2 342
0005	J CHEM SOC	14028	17764	5827	3 048
0006	J CHEM PHYS	13690	11696	3738	3 128
0007	SCIENCE	9752	11880	3968	2 993
0008	BIOCHIM BIOPHYS ACTA	9550	10956	3531	3 102
0009	P NAT ACAD SCI USA	8260	11548	1348	8 566
0010	BIOCHEM J	7638	6348	2074	3 060
0011	LANCET	7617	8164	5496	1 485
0012	PHYS REV LETT	6581	11380	2317	4 911
0013	CR ACAD SCI	5789	6576	8345	0 788
0014	AM J PHYSIOL	5420	3156	1013	3 115
0015	J ORG CHEM	5401	5756	2475	2 325
0016	J APPL PHYS	5190	5072	2880	1 761
0017	P SOC EXP BIOL MED	5079	3468	1920	1 806
0018	J MOL BIOL	4982	7340	833	8 811
0019	J PHYSIOL LOND	4966	3036	1248	2 432
0020	P ROY SOC LOND	4864	1916	621	3 085
0021	J CELL BIOL	4813	4596	1357	3 386
0022	J CLIN INVEST	4785	3652	1086	3 362
0023	J PHYS CHEM	4703	4516	1939	2 329
0024	CHEM BER	4541	2128	1037	2 052
0025	NEW ENGL J MED	4512	5252	2226	2 359
0026	J AM MED ASS	4492	3980	3787	1 050
0027	BRIT MED J	4304	4224	6238	0 677
0028	SOV PHYS JETP	4295	3400	754	4 509
0029	ASTROPHYS J	4271	5440	1167	4 661
0030	ANALYT CHEM	4259	2424	1510	1 605
0031	J BACTERIOL	4147	4712	1410	3 341
0032	BIOCHEMISTRY	4076	6344	1114	5 694
0033	NUCL PHYS	4034	6716	2345	2 863
0034	PHYS LETT	3943	7160	3034	2 359
0035	TETRAHEDRON LETT	3937	8252	2902	2 843
0036	J EXP MED	3871	2700	325	8 307
0037	ANN NY ACAD SCI	3787	2344	1216	1 927
0038	ARCH BIOCHEM BIOPHYS	3689	3776	1169	3 230
0039	J GEOPHYS RES	3537	5312	1569	3 385
0040	J POLYM SCI	3458	2888	2069	1 395
0041	BIOCHEM BIOPHYS RES	3417	5108	1190	4 292
0042	FED P	3372	4036	7374	0 547
0043	J PHYS	3308	3256	2379	1 368
0044	T FARADAY SOC	2922	1808	879	2 056
0045	ACTA CRYSTALLOGR	2917	2164	1803	1 200
0046	DOKL AKAD NAUK SSSR	2869	2456	5385	0 456
0047	J PHARMACOL EXP THER	2781	2020	566	3 568
0048	ANGEW CHEM	2728	3660	1251	2 925
0049	J IMMUNOL	2627	2992	726	4 121
0050	INORG CHEM	2620	3976	1247	3 188
0051	SOV PHYS SOLID STATE	2620	2984	1561	1 911
0052	CIRCULATION	2601	2624	2160	1 214
0053	ENDOCRINOLOGY	2548	2276	783	2 906
0054	ACTA CHEM SCAND.	2444	1984	943	2 103
0055	NUOVO CIMENTO	2431	3436	1938	1 772
0056	B SOC CHIM FRANCE	2416	2664	2704	0 985
0057	VIROLOGY	2376	2620	584	4 486
0058	CANCER RES	2349	2344	814	2 879
0059	CAN J CHEM	2280	2392	1182	2 023
0060	HELV CHIM ACTA	2249	1524	539	2 827
0061	Z NATURFORSCHUNG	2200	2172	1650	1 316
0062	AM J MED	2191	1784	395	4 516
0063	J LAB CLIN MED	2120	1284	754	1 702
0064	TETRAHEDRON	2071	3220	1313	2 452
0065	EXP CELL RES	1958	1464	653	2 241
0066	LIEBIGS ANN CHEM	1952	768	492	1 560
0067	ANN INT MED	1946	1844	1098	1 679
0068	PHIL MAG	1943	1180	547	2 157
0069	J CLIN ENDOCR METAB	1903	1888	488	3 868
0070	J APPL PHYSIOL	1836	1460	643	2 270
0071	ACTA PHYSIOL SCAND	1816	1024	413	2 479
0072	J PHYS SOC JAP	1786	1768	2074	0 852
0073	Z PHYS	1764	1228	844	1 454
0074	CIRC RES	1750	1820	432	4 212
0075	PHYTOPATHOLOGY	1713	1632	1597	1 021
0076	J NAT CANCER I	1668	1672	417	4 009
0077	AM J OBSTET GYNECOL	1657	1440	1193	1 207
0078	PLANT PHYSIOL	1646	1808	1149	1 573
0079	IND ENG CHEM	1644	928	856	1 084
0080	ANN SURG	1641	1036	642	1 613
0081	B CHEM SOC JAP	1639	2004	1567	1 278
0082	EUR J BIOCHEM	1635	1992	501	3 976
0083	GENETICS	1618	1340	738	1 815
0084	BLOOD	1614	1256	566	2 219
0085	P IEEE	1610	1856	756	2 455
0086	J OPT SOC AM	1587	1196	1322	0 904
0087	ANALYT BIOCHEM	1519	1672	502	3 330
0088	J GEN PHYSIOL	1507	1208	407	2 968
0089	ARCH INTERN MED	1501	860	486	1 769
0090	AM HEART J	1453	1036	539	1 922
0091	J EXP PSYCHOL	1449	1152	644	1 788
0092	J GEN MICROBIOL	1445	1136	534	2 127
0093	J COMP PHYSIOL PSYCH	1444	888	476	1 865
0094	J PHYS CHEM SOLIDS	1430	1572	801	1 962
0095	CANCER	1416	1224	593	2 064
0096	AM J PATHOL	1401	960	529	1 814
0097	RUSS J PHYS CHEM	1400	1116	1545	0 722
0098	METHODS ENZYMOL	1391	1456	482	3 020
0099	J INORG NUCL CHEM	1391	1356	908	1 493
0100	PEDIATRICS	1382	1060	709	1 495
0101	SURG GYNECOL OBSTET	1374	868	535	1 622
0102	ANAT REC	1365	752	1836	0 409
0103	REV MOD PHYS	1364	816	189	4 317
0104	T MET SOC AIME	1359	1196	901	1 327
0105	CAN J PHYS	1352	2156	1019	2 115
0106	BRIT J PHARMACOL	1348	1348	507	2 658
0107	APPL PHYS LETT	1337	2556	721	3 545
0108	PHYS STAT SOLIDI	1329	2192	1485	1 476
0109	J ELECTROCHEM SOC	1308	1208	1538	0 785
0110	ACTA METALLURG	1304	964	452	2 132
0111	PHYS FLUIDS	1304	1548	1050	1 474
0112	EXPERIENTIA	1297	1592	1565	1 017
0113	GASTROENTEROLOGY	1286	1428	1244	1 147
0114	Z ZELLF MIKR ANAT	1286	1800	653	2 756
0115	SURGERY	1274	996	790	1 260
0116	REV SCI INSTR	1273	968	1148	0 843
0117	AM J ROENTGENOL	1272	1044	860	1 213
0118	AIAA J	1269	1456	1231	1 182
0119	T ASME	1246	800	1332	0 600
0120	AM J CARDIOL	1238	1600	737	2 170
0121	J HISTOCHEM CYTOCHEM	1229	828	362	2 287
0122	J PEDIAT	1229	1076	783	1 374
0123	J ACOUST SOC AM	1219	1016	2196	0 462
0124	NATURWISSENSCHAFTEN	1218	944	1091	0 865
0125	J NUTR	1209	952	489	1 946
0126	SPECTROCHIM ACTA	1201	1248	679	1 837
0127	Z ANORG ALLG CHEM	1188	580	549	1 056
0128	J PERSON SOC PSYCHOL	1186	676	581	1 163
0129	RADIOLOGY	1175	1244	835	1 489
0130	AM J BOT	1171	644	726	0 887
0131	Z PHYS CHEM LEIPZIG	1170	332	252	1 317
0132	J CHROMATOGR	1161	1708	1343	1 271
0133	HOPPE SEYLERS Z	1145	1412	863	1 636
0134	J UROL	1142	656	712	0 921
0135	ARCH PATHOL	1138	556	409	1 359
0136	ARCH SURG	1134	748	867	0 862
0137	AM J DIS CHILD	1127	748	610	1 226
0138	ACTA MED SCAND	1112	680	472	1 440
0139	ANN PHYSICS	1105	692	224	3 089
0140	COLD SPR HARB SYMP	1091	1060	194	5 463
0141	J ORGANOMET CHEM	1089	2784	796	3 497
0142	PFLUGERS ARCH	1083	896	732	1 224
0143	OPT SPECTROSC USSR	1076	1100	814	1 351
0144	KLIN WSCHR	1057	800	1198	0 667
0145	CHEM IND LOND	1049	648	1703	0 380
0146	BER BUNSEN PHYS CHEM	1044	688	771	0 892
0147	BIOCHEM PHARMACOL	1030	1292	684	1 888
0148	PHYSIOL REV	1022	572	33	17 333
0149	J BONE JOINT SURG	1021	500	745	0 671
0150	J NEUROPHYSIOL	1015	692	156	4 435
0151	CR SOC BIOL	1010	596	1316	0 452
0152	REC TRAV CHIM	1010	728	337	2 160

Fig. 4. The 152 most frequently cited journals ranked by frequency of citation in journals covered by the SCI. Column 1 gives rank, and column 2 gives abbreviations of the titles of cited journals. Column 3 shows the total number of times each journal was cited during the last quarter of 1969. Column 4 gives an estimate of the total number of citations in 1969 of items published in 1967 and 1968 (the estimate was made by quadrupling the 1969 citations of 1967 and 1968 items in the 3-month sample). Column 5 shows the total number of items processed from each journal by the SCI during 1967 and 1968. Column 6 indicates the impact factor (average citations per published item) derived by dividing the numbers in column 4 by those in column 5.

be recognized as relatively slight. In fact, the average paper is cited only 1.7 times a year (*19*).

This analysis gives good reason for concern about any increase in the number of scientific and technical journals. It is not merely that increased numbers of journals make coverage of the literature more difficult, but that so many journals now being published seem to play only a marginal role, if any, in the effective transfer of scientific information. If one accepts the contention (highly debatable, in my opinion) that there are between 50,000 and 100,000 scientific and technical "journals," the data presented here indicate that only 5 to 6 percent of them are being cited. If such percentages seem unrealistically low, it may be because the estimate of 50,000 to 100,000 scientific and technical journals (requiring indexing and abstracting for "total coverage" of the literature) is itself as unrealistic as information scientists have for some time suspected it must be (*20*). Meaningful discussion of this point—the best of current serials catalogs notwithstanding—is probably impossible in the absence of agreement on what, quantitatively as well as qualitatively, constitutes a "scientific journal." At the very least, it may be advisable to distinguish as journals only those periodicals that publish, for example, 20 or more articles a year.

The predominance of a small group of journals in the citation network has been confirmed by a weekly scanning of SCI input to a system for selective dissemination of information (SDI) (*21*). In this SDI system, a newly published article can be retrieved on the basis of journals cited in the article's bibliography or footnotes. This retrieval criterion is known in an SDI profile as a "cited-journal question." A retrieval profile consisting of only 25 different cited-journal questions will retrieve 50 percent of all articles processed for the SCI every week. In other words, half of all articles published cite at least one of the 25 most frequently cited journals at least once.

It is also interesting that a small group of journals is found to be predominant when the literature is analyzed in other ways. Figure 6, for example, plots numbers of articles published against numbers of journals. It shows that, of the 2200 journals covered by the SCI in 1969, about 500 published about 70 percent of all articles published. As shown in Fig. 7, a small group of 250 journals provided almost half of the 3.85 million references processed for the SCI in 1969. The predominance of cores of journals is ubiquitous. An analysis of what journals first published reports of newly synthesized compounds indexed for *Current Abstracts of Chemistry and Index Chemicus* gives a similar result: of the 183 journals indexed by this publication in 1969, 11 percent of the journals accounted for 60 percent of the new compounds, 22 percent of the journals for 79 percent of the compounds, 32 percent of the journals for 89 percent of the compounds, and so on (*22*). *Chemical Abstracts* presents an even more striking example of this

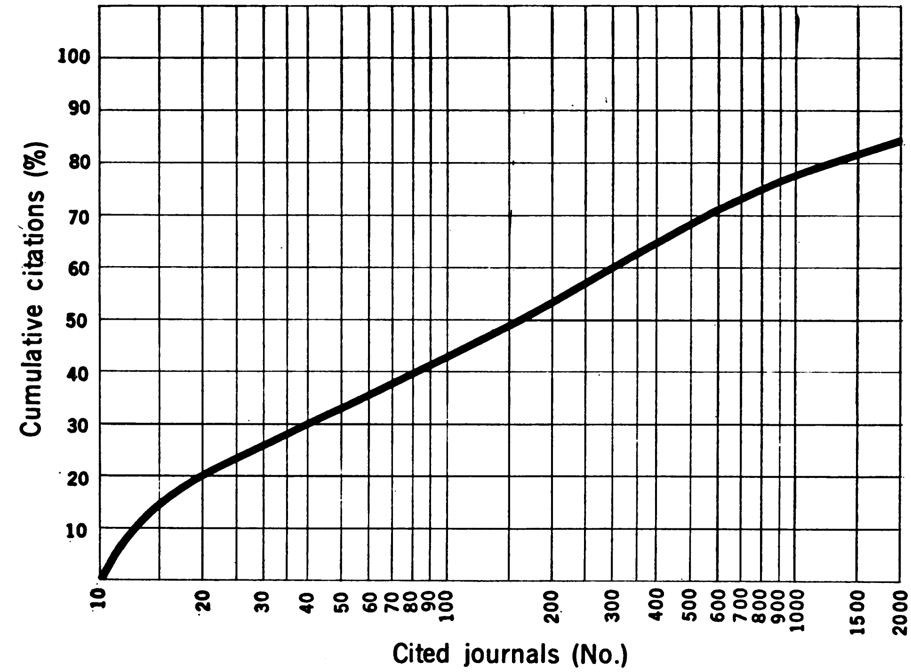

Fig. 5. Distribution of citations among cited journals. The curve shows that a relatively small core of 152 journals accounts for about half of all citations and that only 2000 or so journals account for about 84 percent of all citations.

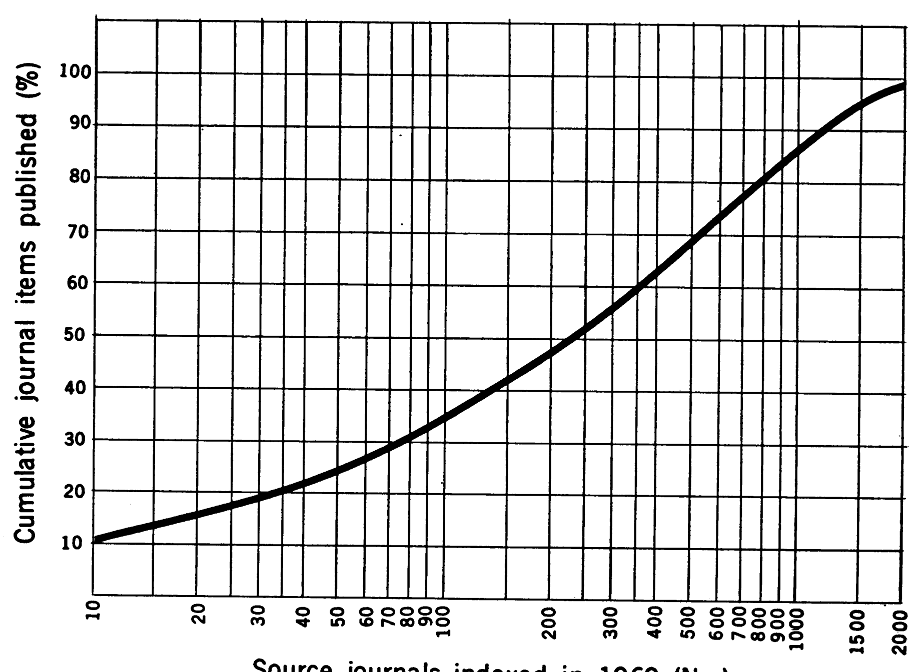

Fig. 6. Distribution of the number of published items among the approximately 2200 journals covered by the SCI in 1969. The curve shows that a relatively small core of journals carried the majority of items published.

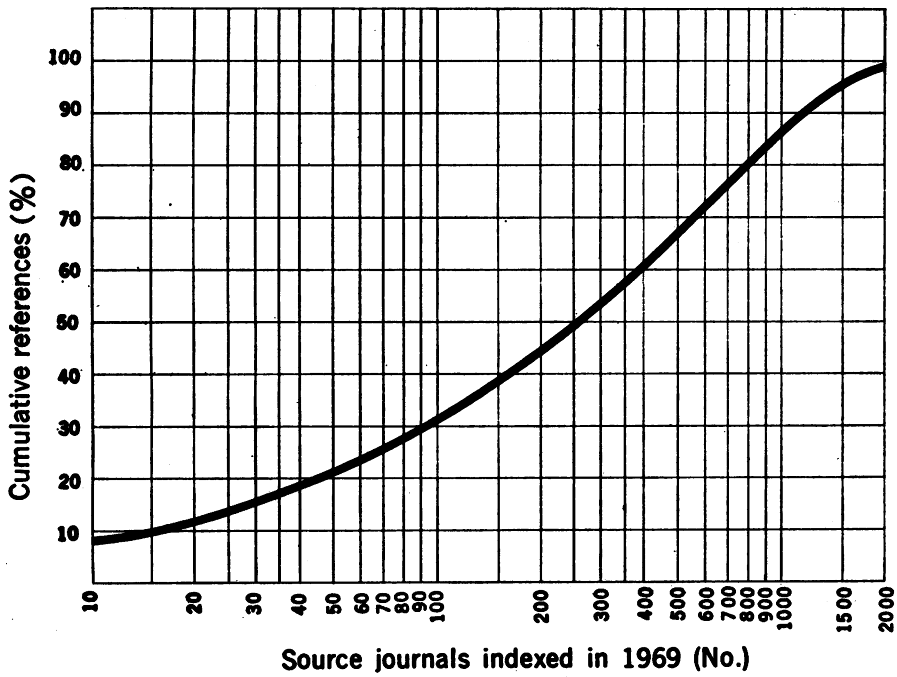

Fig. 7. Distribution of references among journals covered by the SCI in 1969. The curve shows that fewer than 300 journals provided more than half of the references processed.

predominance: about 8 percent of the journals it covers publish more than 75 percent of the items it abstracts (*23*).

The data reported here demonstrate the predominance of a small group of journals in the citation network. Indeed, the evidence seems so conclusive that I can with confidence generalize Bradford's bibliographical law concerning the concentration and dispersion of the literature of individual disciplines and specialties (*2*). Going beyond Bradford's studies, I can say that a combination of the literature of individual disciplines and specialties produces a multidisciplinary core for all of science comprising no more than 1000 journals. The essential multidisciplinary core could, indeed, be made up of as few as 500 journals if, for example, one is attempting to satisfy the needs of libraries in developing countries.

Other Considerations

Citation frequency reflects a journal's value and the use made of it, but there are undoubtedly highly useful journals that are not cited frequently. Scientists read some journals for the same reason people read newspapers—to keep up with what's going on generally—and they may rarely or never cite such journals in their published work (*24*). A popular review journal such as *Scientific American* or a news-oriented journal such as *New Scientist* may rank relatively low on a times-cited list (in fact, *Scientific American* is 449th, while *New Scientist* ranks well below 1000), but that does not mean that they are therefore less important or less widely used than journals that are cited more frequently. It merely means that they are written and read primarily for some purpose other than the communication of original research findings.

Citation frequency is, of course, a function of many variables besides scientific merit. Some of them are known or can reasonably be assumed: an author's reputation, controversiality of subject matter, circulation, availability and extent of library holdings, reprint dissemination, coverage by secondary services, priority in allocation of research funds, and others. It is extremely difficult, even when possible, to clarify the relations among such variables and their relative impact on citation frequency. One such variable is, however, fairly obvious. If every article has an equal likelihood of being cited, it should follow that the more articles a journal publishes, the more frequently the journal will be cited. For the most part, the data show that such is indeed the case. Although many articles are never cited (*25, 26*), I have very rarely found among the 1000 most frequently cited journals one that is not also among the 1000 journals that are most productive in terms of articles published. Citation frequency of a journal is thus a function not only of the scientific significance of the material it publishes (as reflected by citation), but also of the amount of material it publishes.

In view of the relation between size and citation frequency, it would seem desirable to discount the effect of size when using citation data to assess a journal's importance. We have attempted to do this by calculating a relative impact factor—that is, by dividing the number of times a journal has been cited by the number of articles it has published during some specific period of time. The journal impact factor will thus reflect an average citation rate per published article (*27*). However, the development of impact factors that fairly relate the size of a journal during the cited years to its current citation rate is a formidable challenge to statistical analysis. With the SCI data base, it is easy to determine how frequently a journal has been cited within a given period of time, but it is much more difficult to agree on a total-items-published base to which such citation counts can properly be related because the items may have been published at any point in the journal's history. In selecting an items-published base (*28*) for each journal, I have been guided by the chronological distribution of cited items in each annual edition of the SCI (*19*, p. 15; *29*). An analysis of this distribution has shown that the typical cited article is most heavily cited during the 2 years after its year of publication. (In any given year, 21 to 25 percent of all references cite articles that are 3 or fewer years old.) Therefore, since my sample consists of references made in 1969, I have taken as the items-published base for each journal the number of items it published during 1967 and 1968. To calculate an impact factor for each journal, I divided the number of times 1967 and 1968 articles were cited in 1969 by the number of articles published in 1967 and 1968. Martyn and Gilchrist used a similar method in ranking British journals in an analysis of 1965 SCI data (*30*).

Figure 8 shows the top 152 of the 565 most frequently cited journals ranked by impact factor. Many of the 152 journals do not appear on this high-impact list; in fact, only 75 journals are common to both lists. It will be interesting to observe further changes in the ranking of the most frequently cited journals as calculations of impact factor are extended to 1000 journals and eventually to the approximately 2400 journals now covered by the SCI.

Some Applications

The results of this type of citation analysis would appear to be of great potential value in the management of library journal collections. Measures of citation frequency and impact factor should be helpful in determining the optimum makeup of both special and general collections. Analysis of the chronological distribution of items cited can serve as a guide in determining the optimum size of back files, and, since the data give a detailed view of each journal's citation history, binding and retention schedules can be rationally established journal by journal, rather than for groups of journals (*31*). Another application, which harried librarians may welcome, is the correlation of data on citation frequency and impact with subscription costs. Such a correlation can provide a solid basis for cost-benefit analysis in the management of subscription budgets.

Individual scientists also face the problem of selecting journals to read and keep, as well as compiling reference and reading lists for themselves and their students. Although each of the relatively few journals that are very useful in a given discipline or specialty may be well known, it can be difficult to gauge the merits of the other journals in that discipline or specialty and to decide what journals to get and how long to keep them. It should be noted, in this connection, that analyses of citation frequency and impact factor can be tailored to the specific interests and requirements of individuals by restricting the number of citing journals to a small group of familiar titles. Thus, with a list of the ten or so most frequently cited chemical journals (or merely ten journals favored by a particular chemist), one can, by constructing lists of citation frequency and impact factor, gradually augment the small group and the citation data base with journals of demonstrable relevance. I am using this technique to establish a list of journals for the projected *Social Sciences Citation Index.*

Editors and editorial boards of scientific and technical journals may also find citation analysis helpful. As it is, those who formulate editorial policies have few objective and timely measures of their success. A wrong policy, or a policy wrongly implemented, may have serious effects on revenue and prestige, and the work of regaining readers and reputation can be difficult and expen-

Item No. (1)	Cited Journal (2)	Times Cited Last Quarter 1969 (3)	1969 Citations to 1967 and 1968 Articles (4)	Articles Published in 1967 and 1968 (5)	Impact Factor (6)
0001	ACCOUNTS CHEM RES	247	820	28	29.285
0002	ADV PROTEIN CHEM	373	184	8	23 000
0003	PHARMACOL REV	725	448	20	22.400
0004	BACTERIOL REV	646	804	39	20.615
0005	ANNU REV BIOCHEM	468	932	53	17 584
0006	PHYSIOL REV	1022	572	33	17 333
0007	SOLID STATE PHYS	384	228	14	16.285
0008	ADV ENZYMOL	291	192	20	9.600
0009	INT REV CYTOL	230	144	16	9 000
0010	J MOL BIOL	4982	7340	833	8.811
0011	REC PROG HORMONE RES	417	232	27	8.592
0012	P NAT ACAD SCI USA	8260	11548	1348	8.566
0013	J EXP MED	3871	2700	325	8.307
0014	Q REV	488	452	55	8.218
0015	CHEM REV	1003	408	50	8.160
0016	ANNU REV PL PHYSIOL	314	296	42	7.047
0017	J CRYST GROWTH	232	820	125	6.560
0018	ANNU REV MICROBIOL	254	288	44	6.545
0019	J BIOL CHEM	17112	10768	1777	6.059
0020	METHODS BIOCHEM ANAL	285	80	14	5.714
0021	BIOCHEMISTRY	4076	6344	1114	5.694
0022	J AM CHEM SOC	26323	22156	3946	5 614
0023	SOV PHYS USP	586	612	109	5.614
0024	COLD SPR HARB SYMP	1091	1060	194	5.463
0025	BIOL REV	358	176	34	5.176
0026	J VIROL	560	1860	360	5.166
0027	MEDICINE	410	240	48	5.000
0028	J CELL SCI	552	600	122	4.918
0029	PHYS REV LETT	6581	11380	2317	4.911
0030	ASTROPHYS J	4271	5440	1167	4.661
0031	AM J MED	2191	1784	395	4.516
0032	SOV PHYS JETP	4295	3400	754	4.509
0033	VIROLOGY	2376	2620	584	4.486
0034	J NEUROPHYSIOL	1015	692	156	4.435
0035	PSYCHOL REV	593	368	83	4.433
0036	REV MOD PHYS	1364	816	189	4.317
0037	BIOCHEM BIOPHYS RES	3417	5108	1190	4.292
0038	MON NOT ROY ASTR SOC	868	1008	238	4.235
0039	CIRC RES	1750	1820	432	4.212
0040	J IMMUNOL	2627	2992	726	4 121
0041	Q J MED	437	284	70	4.057
0042	J NAT CANCER I	1668	1672	417	4.009
0043	EUR J BIOCHEM	1635	1992	501	3.976
0044	MOL PHARMACOL	300	564	144	3.916
0045	DEVELOP BIOL	435	552	142	3.887
0046	J CLIN ENDOCR METAB	1903	1888	488	3.868
0047	CHEM ENG LONDON	268	392	104	3.769
0048	J LIPID RES	929	876	235	3.727
0049	ADV PHYS	318	284	77	3.688
0050	PSYCHOL B	610	564	154	3.662
0051	IMMUNOLOGY	801	1208	335	3.605
0052	PHYS REV	20674	20740	5767	3.596
0053	J PHARMACOL EXP THER	2781	2020	566	3.568
0054	APPL PHYS LETT	1337	2556	721	3.545
0055	J ORGANOMET CHEM	1089	2784	796	3.497
0056	J CELL PHYSIOL	860	628	180	3.488
0057	BRAIN RES	420	1140	327	3.486
0058	BRIT MED B	426	432	127	3.401
0059	J CELL BIOL	4813	4596	1357	3.386
0060	J GEOPHYS RES	3537	5312	1569	3.385
0061	J CLIN INVEST	4785	3652	1086	3.362
0062	J BACTERIOL	4147	4712	1410	3.341
0063	ANALYT BIOCHEM	1519	1672	502	3.330
0064	IMMUNOCHEMISTRY	271	404	125	3.232
0065	ARCH BIOCHEM BIOPHYS	3689	3776	1169	3.230
0066	INORG CHEM	2620	3976	1247	3.188
0067	J CHEM PHYS	13690	11696	3738	3.128
0068	J ULTRASTRUCT RES	979	1392	445	3.128
0069	AM J PHYSIOL	5420	3156	1013	3.115
0070	TRANSPLANTATION	513	1000	321	3.115
0071	BIOCHIM BIOPHYS ACTA	9550	10956	3531	3.102
0072	ANN PHYSICS	1105	692	224	3.089
0073	P ROY SOC LOND	4864	1916	621	3.085
0074	BIOCHEM J	7638	6348	2074	3 060
0075	J CHEM SOC	14028	17764	5827	3 048
0076	METHODS ENZYMOL	1391	1456	482	3 020
0077	SCIENCE	9752	11880	3968	2.993
0078	GENET RES	371	464	155	2.993
0079	J GEN PHYSIOL	1507	1208	407	2.968
0080	ANGEW CHEM	2728	3660	1251	2.925
0081	ENDOCRINOLOGY	2548	2276	783	2.906
0082	CANCER RES	2349	2344	814	2.879
0083	EXP PARASITOL	437	492	171	2.877
0084	NUCL PHYS	4034	6716	2345	2.863
0085	TETRAHEDRON LETT	3937	8252	2902	2.843
0086	PLANTA	707	1172	414	2.830
0087	HELV CHIM ACTA	2249	1524	539	2.827
0088	J COMP NEUROL	969	376	133	2.827
0089	BIOPOLYMERS	452	656	235	2.791
0090	CHROMOSOMA	458	440	159	2.767
0091	Z ZELLF MIKR ANAT	1286	1800	653	2.756
0092	CLIN SCI	680	552	205	2.692
0093	BRIT J PHARMACOL	1348	1348	507	2.658
0094	SURFACE SCI	399	844	321	2.629
0095	AM J HUM GENET	405	332	128	2.593
0096	PLANET SPACE SCI	508	892	348	2.563
0097	DISCUSS FARADAY SOC	702	292	114	2.561
0098	J NEUROCHEM	801	900	357	2 521
0099	SOV J NUCL PHYS	742	1588	630	2.520
0100	MUTAT RES	274	532	213	2.497
0101	J CATAL	431	764	308	2.480
0102	ACTA PHYSIOL SCAND	1816	1024	413	2.479
0103	CHEM PHYS LETT	294	996	402	2.477
0104	GEOCHIM COSMOCH ACTA	814	744	301	2 471
0105	P IEEE	1610	1856	756	2.455
0106	STEROIDS	473	680	277	2.454
0107	TETRAHEDRON	2071	3220	1313	2.452
0108	J PHYSIOL LOND	4966	3036	1248	2.432
0109	INT J CANCER	275	452	189	2.391
0110	PSYCHOPHARMACOLOGIA	277	388	163	2.380
0111	NEW ENGL J MED	4512	5252	2226	2.359
0112	PHYS LETT	3943	7160	3034	2.359
0113	EARTH PLANET SC LETT	269	672	286	2.349
0114	NATURE LONDON	15325	15956	6811	2.342
0115	J PHYS CHEM	4703	4516	1939	2.329
0116	J ORG CHEM	5401	5756	2475	2.325
0117	J EXP ANALYSIS BEHAV	509	424	184	2.304
0118	J HISTOCHEM CYTOCHEM	1229	828	362	2.287
0119	J APPL PHYSIOL	1836	1460	643	2.270
0120	AM J ANAT	637	256	113	2.265
0121	EXP CELL RES	1958	1464	653	2.241
0122	BLOOD	1614	1256	566	2.219
0123	J FLUID MECH	998	1036	472	2.194
0124	HISTOCHEMIE	323	668	305	2.190
0125	AM J CARDIOL	1238	1600	737	2.170
0126	REC TRAV CHIM	1010	728	337	2.160
0127	PHIL MAG	1943	1180	547	2.157
0128	J BIOCHEM	966	1064	498	2.136
0129	ACTA METALLURG	1304	964	452	2.132
0130	J GEN MICROBIOL	1445	1136	534	2.127
0131	CAN J PHYS	1352	2156	1019	2.115
0132	ANN MATH	702	184	87	2.114
0133	ACTA CHEM SCAND	2444	1984	943	2.103
0134	BRIT J HAEMATOL	581	608	290	2.096
0135	METABOLISM	550	564	270	2.088
0136	RADIO SCI	385	760	365	2.082
0137	CANCER	1416	1224	593	2.064
0138	PHOTOCHEM PHOTOBIOL	343	472	229	2.061
0139	AM J SCI	602	284	138	2.057
0140	T FARADAY SOC	2922	1808	879	2.056
0141	CHEM BER	4541	2128	1037	2.052
0142	MOL PHYS	698	652	319	2.043
0143	CAN J CHEM	2280	2392	1182	2.023
0144	J EXP BOT	352	336	167	2.011
0145	B SEISMOL SOC AM	344	416	208	2.000
0146	J SEDIMENT PETROLOGY	423	480	240	2.000
0147	ARCH MIKROBIOL	438	600	305	1.967
0148	DIABETES	785	936	477	1.962
0149	J PHYS CHEM SOLIDS	1430	1572	801	1.962
0150	INORG NUCL CHEM LETT	247	620	316	1 962
0151	J ENDOCRINOL	983	1104	566	1 950
0152	PROTOPLASMA	301	380	195	1 948

Fig. 8. The 152 most frequently cited journals ranked by impact factor (average number of citations per item published). The column headings are explained in the legend of Fig. 4.

sive. Editors can find useful indicators of a journal's performance in the extent of self-citation, the number of times cited per year, and the distribution of citations among citing journals within and outside the specialty literature.

Perhaps the most important application of citation analysis is in studies of science policy and research evaluation. Price has shown how citation data can be used to identify research fronts (*25*). Soviet information scientists are using citation data to evaluate the implementation of science policy in the U.S.S.R. (*12, 14, 32*), and the sociological studies of Hagstrom and others (*33*) give convincing evidence of the utility of this approach.

Unanswered Questions

The data reported here suggest many avenues for further study. What, for example, is the significance of an abnormally high self-citation rate? Is it characteristic of parochialism, eccentricity, mediocrity? Does it indicate that a particular field of study has as yet no basis for interaction with other fields? Which is true in a particular case and how does one go about finding out?

What is the significance of a wide, multidisciplinary spread of titles cited in the references of a given journal or group of journals? Is it a measure of multidisciplinary activity? If so, is it a valid enough measure to warrant applying the Weinberg criterion (*34*) of multidisciplinary impact in order to determine the amount of government support merited by particular areas of research? Does the fact that *Ecology*, for example, cites more than 500 different journals in a total of 1000 references make it more multidisciplinary than the *Journal of the American Chemical Society*, which cites only twice as many journals in ten times the number of references, or than *Physical Review*, which cites only 600 or so journals in 15,000 references? Does the nonlinearity of publication and citation distributions among citing and cited journals confirm beyond doubt only that relatively few journals are primary nodes in the communications network, or does it have some other significance?

And what is the significance of a wide disparity between the number of journals cited by a given journal and the number that cite it? *Ecology* cites 500 or so journals but, in turn, is cited by only 115. What does this say, other than the obvious, about ecology and *Ecology*? Is the applicability of work done in ecology and being reported in *Ecology* much narrower than the interests of ecologists?

Several investigators of problems in science policy and science management are already using the SCI data base to explore such questions and many others. Each is trying, for different reasons, to build a model of the journal communication network that will provide more functional definitions of disciplines and specialties, that will make it possible to define in detail how different fields of knowledge interact, that will provide methods of predicting interdisciplinary impact, and that will perhaps provide more effective ways of monitoring research performance. Using the SCI data base to map the journal communications network may contribute to more efficient science.

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17. The largest number of variants of the same journal title and its abbreviations was 42, the total reached in the case of *Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences*.
18. For example, the *South African Journal of Obstetrics and Gynaecology*, the *South African Journal of Nutrition*, the *South African Journal of Radiology*, and others are composed of specially titled (and color-coded) issues from the regularly numbered series of the *South African Medical Journal*.
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27. The impact factor discussed in this article (average citation rate per published item) gives some idea of the frequency with which the "average" paper in a particular journal is cited. The factor is, of course, adversely affected by papers in the journal which are not cited at all, and, as noted above, favorably affected by papers cited with unusual frequency. The influence of uncited and very frequently cited papers can be discounted by considering the total number of citations in relation to cited items only (rather than in relation to all published items), or by considering only number of cited items (rather than total citations) in relation to all published items. For example, if the items-published base is 100 articles and one article has been cited 50 times while 99 articles have not been cited at all, the impact factor would be 0.50. The same impact factor of 0.50 could be derived for the journal that had half of its 100 articles cited only once and the other half not cited at all. If one considers only cited items, a per-cited-item impact factor can be derived to distinguish between the two journals. In the first case, the per-cited-item impact factor would be 50.0; in the second, 1.0. If one considers only the number of citable items cited, a citable-items-cited impact factor can be derived to further distinguish between the two journals. In the first case, the citable-items-cited impact factor would be 0.01; in the second, 0.5. Enormous amounts of computer time would be required to derive these different impact factors, although one must acknowledge their potential usefulness. It should be noted also that either of these impact factors can be derived from the other by dividing one of them into the impact factor used in this article.
28. The problem of selecting an items-published base is further complicated by the variety in the kinds of items published in scientific

journals. Many journals publish only full-length reports of original research. Many others publish, in addition, editorials, technical communications, letters, notes, general correspondence, scientific news surveys and notes, book reviews, and so on; all of these are potentially citable items. I have not attempted in this article to limit the definition of items-published to lead articles, original communications, or the like. Even assuming it were possible to construct an acceptable classification that would accommodate all of the different kinds of published material, it would have been impossible for me, within the resources available for this article, to have examined individually each of the approximately 600,000 items that I use for the items-published base. If such a differentiation among kinds of material were included in an analysis such as this one, it is reasonable to assume that lead articles in such journals as *Science*, *Nature*, *Lancet*, and *Journal of the American Medical Association* would, as a group, have higher impact factors than those that are shown for these journals in Fig. 8.

29. The percentage (in terms of total citations) of citations of items that are 3 or fewer years old has been, for the years 1964 to 1970, 31.09, 30.24, 26.60, 25.91, 25.32, 25.18, and 23.95, respectively. It is interesting to note that the yearly percentage of such items has gradually decreased as SCI coverage has increased, while the citation rate per cited item has gradually increased (*19*). The significance of these trends is an interesting matter for future investigation.
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NEWS AND COMMENT

Cancer Advisory Board: Nobody's Rubber Stamp

The National Cancer Advisory Board is 9 months old and has met formally three times. It is beginning to get a sense of itself now, and it seems to be an advisory body with a difference. To be sure, there are still many facets of its official personality that have yet to be smoothed out, and its modus operandi remains somewhat ill-defined. Nevertheless, by the time the third meeting of the board, held recently at the National Cancer Institute (NCI), was over, one thing was apparent: the board, charged with overseeing the national cancer program, is taking its responsibility in deadly earnest. This advisory board intends to take a firm hand in *making* policy and setting priorities as the National Cancer Institute puts the new national drive to conquer cancer into high gear.

Unlike a host of other governmental advisory bodies, which tend merely to approvingly review the faits accomplis of the agencies they serve, this group intends to have a say about things before they happen. It also intends to look with a cold eye at programs of long standing, although that will cause a lot of people no small measure of discomfort.

The board is a successor to the old cancer advisory council, which had long been part of the organizational structure of the cancer institute. Eighteen members of the board are new. A half-dozen others are former NCI council members who will serve until their previous appointments expire. "The most striking difference between the old council and the board," said one holdover member during a coffee break, "is that the board is determined to have a mind of its own. At council meetings, we usually just said OK to whatever was put before us. But it is clear that this board is not going to be a rubber stamp for anyone."

The board was created by the National Cancer Act of 1971, the law that gave the NCI special status at the National Institutes of Health (NIH), and its members were appointed directly by the White House last March. It is responsible, in the Washington hierarchy, to the three-man cancer advisory panel, which, in turn, reports to Richard Nixon.

The October meeting of the board was billed as a "program review" session, at which the main order of business was a look at what the NCI was doing. During its two-and-a-half days of work, the board listened to about a dozen briefings by NCI officials and scientists, who described what is happening in their departments. When board members felt they were not getting the kind of information they wanted, they plainly said so.

The board agreed to name a "blue-

The members of the Cancer Advisory Panel are:
Benno C. Schmidt (chairman), J. H. Whitney and Company, New York; Robert A. Good, University of Minnesota Medical School; and R. Lee Clark, University of Texas, M. D. Anderson Hospital and Tumor Institute.
The current members of the National Cancer Advisory Panel are:
For 6-year terms: Jonathan E. Rhoads (chairman), University of Pennsylvania School of Medicine; Frank J. Dixon, Scripps Clinic and Research Foundation, La Jolla, California; John R. Hogness, Institute of Medicine, National Academy of Sciences; Howard E. Skipper, Southern Research Institute, Birmingham, Alabama; Laurance S. Rockefeller, Rockefeller Brothers, New York; and W. Clarke Wescoe, Winthrop Laboratories, New York.
For 4-year terms: Harold Amos, Harvard Medical School; Elmer Bobst, Warner-Lambert Pharmaceutical Company, Morris Plains, New Jersey; Sidney Farber, Children's Cancer Research Foundation, Boston, Massachusetts; Donald E. Johnson, Advertisers Press, Flint, Michigan; Irving M. London, Harvard–Massachusetts Institute of Technology Program in Health Sciences and Technology; and Gerald P. Murphy, Roswell Park Memorial Institute, Buffalo, New York.
For 2-year terms: Mary Lasker, Albert and Mary Lasker Foundation, New York; Harold P. Rusch, University of Wisconsin Medical Center, Madison; Joseph H. Ogura, Washington University School of Medicine, St. Louis, Missouri; Frederick Seitz, Rockefeller University, New York; Sol Spiegelman, Columbia University; James D. Watson, Harvard University.
The members from the former advisory council are:
Arnold L. Brown, Mayo Clinic; James S. Gilmore, Jr., Gilmore Broadcasting Corporation, Kalamazoo, Michigan; Kenneth L. Krabbenhoft, Wayne State University School of Medicine; William W. Shingleton, Duke University Medical Center; and Philippe Shubik, University of Nebraska.
The ex-officio members are:
Edward David, Science Advisor to the President; Elliot Richardson, Secretary, Department of Health, Education, and Welfare; Robert Marston, Director, National Institutes of Health; Marc Musser, Veterans Administration; Richard Wilbur, Department of Defense. Alternates are Lyndon Lee, Veterans Administration; and D. Murray Angevine, Armed Forces Institute of Pathology.