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Impact of Cumulative Impact Factors

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Most of you have heard about journal impact factors and even used them in one fashion or another? And probably you're also aware that there is considerable controversy about the use of citation analysis to evaluate scientists and institutions. But remarkably, journal impact factors seem to be minimally controversial. Of the many quantitative measures derived from the *Science Citation Index®*, impact factors are probably of the *SCI Journal Citation Reports®* but it may also be due to the lack of any subjective approach that is manageable in evaluating thousands of publications.

The current impact factors is calculated from two basic items of information, a) the number of articles published in two prior consecutive years and b) the number of citations to those articles in the current year. The following illustrates this calculation for the journal C*ell*.

Formula:

$$\frac{\text{Citations in one year (1993) to papers in a journal in the previous two years (1991 and 1992}}{\text{The number of papers in that journal in those two years (1991 and 1992)}}$$

Example: *Cell*

$$\frac{\text{33.696 citations recorded in 1993 to } \textit{Cell} \text{ papers published in 1991 and 1992}}{\text{906 papers published in } \textit{Cell in} \text{ 1991 and 1992 (474 and 432)}}$$

Equals = 37,2

Basing the current citation impact on the output for the two previous years was not accidental – in 1966, 26% of citations (Table 1) of all references cited were to the current year and the two previous year.

Reference Year	% of Unique Ref Items	Cum % of Unique Ref Items	% of Total Citations	Cumulative % of Total Citations
66	3.31	3.31	2.65	2.65
65	10.79	14.10	11.50	14.15
64	11.24	25.34	12.45	26.60
63	9.55	34.89	10.41	37.01
62	8.00	42.89	8.55	45.56
61	6.62	49.51	7.00	52.56
60	5.85	55.36	6.05	58.61
59	4.82	60.18	4.94	63.55
58	4.11	64.29	4.20	67.75
57	3.52	67.81	3.61	71.36
56	3.12	70.93	3.16	74.52
55	2.79	73.72	2.77	77.29
54	2.41	76.13	2.31	79.60
53	2.12	78.25	2.11	81.71
52	1.88	80.13	1.85	83.56
51	1.64	81.77	1.65	85.21
50	1.47	83.24	1.39	86.60
49	1.22	84.46	1.18	87.78
48	1.08	85.54	0.94	88.72
47	0.78	86.32	0.67	89.39
46	0.60	86.92	0.56	89.95
45	0.49	87.41	0.45	90.40

Table 1. Science Citation Index® 1996. Chronological distribution of citations to authored items (non-patents).

Surprisingly, the 26% figure reported in 1966 has declined to 19%. Table 2 shows the relevant pages of the SCI Guide.

Table 3 shows relevant data enlarged. one can only speculate as to why this is happening.

Note that there is a decline from 9,98 in 1993 to 9,61% in 1992, 8,51% in 1991, etc. about 1% per year cited.

The impact factor was invented primarily to facilitate comparisons between journals regardless of size. Absolute citation counts favour the

Percentage of Total Citations

CITING YEARS

CITED YEARS	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
1994																				1.55
1993																			1.60	7.37
1992																		1.65	7.38	9.99
1991																	1.64	7.47	9.98	9.50
1990																1.65	7.47	10.13	9.61	8.54
1989															1.69	7.42	10.21	9.60	8.51	7.43
1988														1.76	7.55	10.12	9.59	8.43	7.33	6.32
1987													1.86	7.77	10.23	9.58	8.48	7.33	6.36	5.50
1986												1.77	7.52	10.07	9.46	8.33	7.23	6.23	5.39	4.66
1985											1.77	7.54	10.08	9.52	8.32	7.24	6.24	5.38	4.67	4.04
1984										1.80	7.62	10.22	9.68	8.39	7.28	6.34	5.43	4.71	4.08	3.55
1983									1.88	7.65	10.32	9.62	8.45	7.29	6.33	5.46	4.69	4.07	3.56	3.10
1982								1.88	7.76	10.19	9.55	8.39	7.21	6.29	5.48	4.75	4.11	3.56	3.13	2.75
1981							1.49	7.73	10.34	9.62	8.40	7.29	6.24	5.45	4.72	4.12	3.58	3.13	2.75	2.44
1980						1.43	7.13	10.57	9.86	8.62	7.47	6.44	5.58	4.84	4.22	3.71	3.23	2.81	2.49	2.21
1979					1.43	7.16	10.38	9.70	8.47	7.33	6.30	5.46	4.72	4.09	3.59	3.15	2.76	2.42	2.15	1.90
1978				1.50	7.32	10.68	9.90	8.51	7.33	6.33	5.45	4.73	4.09	3.56	3.13	2.75	2.41	2.12	1.88	1.67
1977			1.53	7.58	10.68	10.13	8.58	7.37	6.33	5.50	4.75	4.16	3.63	3.18	2.80	2.48	2.19	1.94	1.73	1.54
1976		1.73	7.59	10.86	9.98	8.71	7.35	6.31	5.43	4.72	4.11	3.59	3.15	2.77	2.46	2.19	1.94	1.74	1.56	1.38
1975	1.81	8.25	11.13	10.06	8.73	7.51	6.41	5.53	4.81	4.18	3.64	3.22	2.81	2.49	2.19	1.95	1.73	1.54	1.39	1.24
1974	8.82	11.02	10.15	8.68	7.44	6.40	5.48	4.70	4.08	3.58	3.13	2.75	2.44	2.15	1.91	1.71	1.52	1.36	1.22	1.11
1973	11.37	10.17	8.84	7.52	6.46	5.53	4.79	4.11	3.55	3.14	2.75	2.44	2.16	1.92	1.72	1.54	1.38	1.23	1.11	1.01
1972	10.21	8.84	7.60	6.46	5.57	4.81	4.19	3.62	3.16	2.79	2.46	2.19	1.95	1.74	1.56	1.40	1.26	1.14	1.03	0.93
1971	8.65	7.43	6.45	5.49	4.76	4.11	3.62	3.13	2.74	2.44	2.16	1.92	1.71	1.52	1.37	1.23	1.10	1.00	0.89	0.82
1970	7.33	6.32	5.49	4.76	4.13	3.61	3.22	2.81	2.50	2.23	2.00	1.80	1.61	1.46	1.32	1.20	1.10	1.00	0.90	0.82
1969	6.29	5.45	4.75	4.11	3.59	3.14	2.80	2.44	2.16	1.92	1.71	1.53	1.37	1.22	1.10	1.00	0.90	0.82	0.73	0.68
1968	5.46	4.75	4.16	3.62	3.19	2.78	2.49	2.18	1.92	1.73	1.54	1.38	1.23	1.10	1.00	0.91	0.82	0.74	0.67	0.61
1967	4.72	4.15	3.63	3.21	2.82	2.48	2.23	1.95	1.73	1.55	1.40	1.25	1.13	1.01	0.92	0.83	0.75	0.68	0.61	0.56
1966	3.95	3.48	3.05	2.69	2.39	2.11	1.90	1.67	1.48	1.34	1.21	1.08	0.97	0.88	0.80	0.73	0.65	0.59	0.54	0.49
1965	3.55	3.13	2.75	2.44	2.17	1.91	1.75	1.54	1.37	1.24	1.13	1.01	0.91	0.82	0.75	0.69	0.63	0.57	0.52	0.47

Cumulative Percentage of Total Citations

CITING YEARS

CITED YEARS	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
1994																				1.55
1993																			1.60	8.92
1992																		1.65	8.98	18.91
1991																	1.64	9.12	18.96	28.41
1990																1.65	9.10	19.25	28.57	36.95
1989															1.69	9.07	19.31	28.85	37.08	44.38
1988														1.76	9.23	19.19	28.90	37.28	44.41	50.70
1987													1.86	9.53	19.47	28.77	37.38	44.61	50.77	56.20
1986												1.77	9.38	19.60	28.92	37.10	44.61	50.84	56.16	60.86
1985											1.77	9.31	19.46	29.11	37.24	44.34	50.58	56.22	60.83	64.90
1984										1.80	9.39	19.61	29.15	37.50	44.52	50.68	56.28	60.93	64.91	68.45
1983									1.88	9.53	19.71	29.33	37.60	44.79	50.85	56.14	60.97	65.00	68.47	71.55
1982								1.88	9.64	19.83	29.26	37.65	44.81	51.08	56.33	60.89	65.08	68.56	71.60	74.30
1981							1.49	9.61	19.98	29.60	37.66	44.95	51.04	56.53	61.05	65.01	68.66	71.69	74.35	76.74
1980						1.43	8.62	20.18	29.84	38.46	45.13	45.01	56.62	61.36	65.28	68.72	71.90	74.50	76.84	78.95
1979					1.43	8.59	19.00	29.88	38.31	45.64	51.43	51.45	61.34	65.45	68.87	71.88	74.65	76.92	78.99	80.85
1978				1.50	8.75	19.27	28.90	38.39	45.64	51.97	56.88	56.92	65.43	69.01	72.00	74.63	77.06	79.04	80.87	82.52
1977			1.53	9.08	19.43	29.40	37.48	45.76	51.97	57.47	61.63	61.64	69.06	72.18	74.80	77.11	79.25	80.98	82.60	84.06
1976		1.73	9.12	19.94	29.41	38.11	44.83	52.07	57.40	62.12	65.74	65.80	72.20	74.95	77.26	79.30	81.19	82.72	84.16	85.44
1975	1.81	9.98	20.25	30.00	38.14	45.62	51.24	57.60	62.21	66.93	69.38	69.40	75.02	77.43	79.45	81.25	82.93	84.26	85.55	86.68
1974	10.63	21.00	30.40	38.68	45.85	52.02	56.72	62.30	66.29	70.47	72.51	72.61	77.46	79.58	81.37	82.96	84.45	85.62	86.77	87.79
1973	22.00	31.17	39.24	46.20	52.04	57.55	61.51	66.41	69.84	73.42	75.26	75.37	79.62	81.50	83.09	84.50	85.82	86.85	87.88	88.80
1972	32.21	40.01	46.84	52.66	57.61	62.36	65.70	70.03	73.00	76.14	77.72	77.81	81.57	83.24	84.65	85.90	87.08	87.99	88.91	89.73
1971	40.86	47.44	53.29	58.15	62.37	66.47	69.32	73.16	75.74	78.53	79.88	80.00	83.27	84.76	86.02	87.13	88.18	88.99	89.80	90.55
1970	48.19	53.76	58.78	62.91	66.50	70.08	72.54	75.97	78.24	80.68	81.88	81.92	84.89	86.22	87.34	88.34	89.28	89.99	90.70	91.37
1969	54.48	59.21	63.53	67.02	70.09	73.22	75.34	78.41	80.40	82.63	83.59	83.73	86.26	87.44	88.44	89.33	90.19	90.81	91.43	92.05
1968	59.95	63.96	67.69	70.64	73.28	76.00	77.83	80.59	82.32	84.24	85.13	85.25	87.49	88.55	89.44	90.24	91.01	91.55	92.10	92.66
1967	64.66	68.11	71.32	73.85	76.10	78.48	80.06	82.54	84.05	85.78	86.53	86.63	88.02	89.56	90.36	91.07	91.76	92.23	92.71	93.22
1966	68.61	71.59	74.37	76.54	78.49	80.59	81.96	84.21	85.53	87.08	87.74	87.88	88.59	90.44	91.16	91.80	92.41	92.82	93.25	93.71
1965	72.16	74.72	77.12	78.98	80.66	82.50	83.71	85.75	86.90	88.14	88.87	88.96	90.50	91.26	91.90	92.48	93.04	93.39	93.77	94.18

Table 2. Science Citation Index® 1975-94. Chronological distribution of citations to authored items (non-patents). Citation data for citing years earlier than 1975 and for cited years earlier than 1965 are available in editions of the *SCI*® published prior to 1989.

Reference Year	% Total	Cumulative %
1994	1.55	1.55
1993	7.37	8.92
1992	9.99	18.91
1991	9.50	28.41
1990	8.54	36.95
1989	7.43	44.38
1988	6.32	50.70

Table 3. Science Citation Index® 1994. Chronological distribution of citations to authored items (non-patents).

largest journals whether in current output or in cumulative output over the past century. Thus even a defunct journal might receive more citations than an existing one. For many years the *Journal of Agricultural Research* which ceased publication about 1950, was cited more than other living journals.

Table 4 shows a ranked list of journals in the 1993 *Journal Citation Reports* arranged by total citations to all years. Deceased journals are omitted. This ranking does not discriminate between journals on the basis of age or size. Current productivity or output is also an important indicator of a journal's influence. Table 5 shows the top 50 journals in terms of items processed for the 1993 *SCI* – all published over 950 articles per year.

This is a good place to show another version of these data. Figure 1

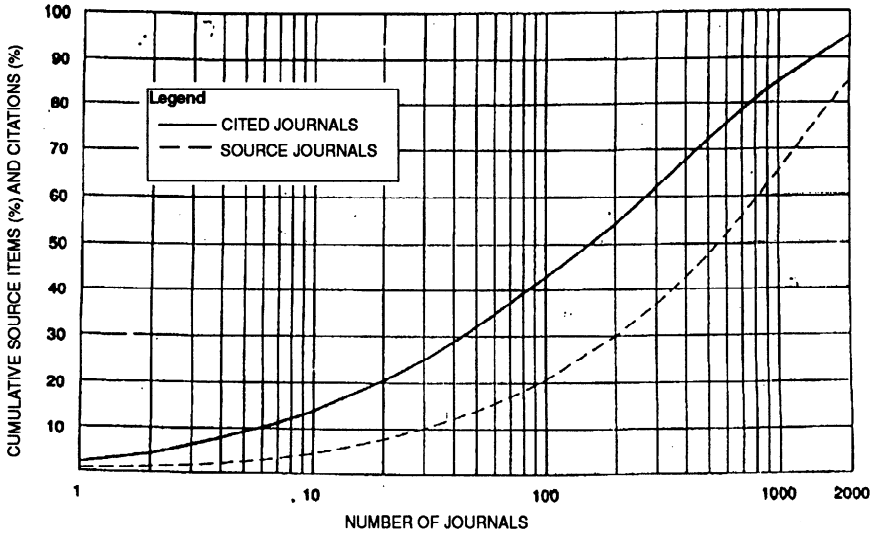

Figure 1. Distribution of published items and citations among science journals, 1989 SCI.

RANK	JOURNAL TITLE	<-------CITATIONS IN 1993 TO-------> ALL YEARS	1992	1991	92+91
1	P NATL ACAD SCI USA	234319	21310	29115	50425
2	J BIOL CHEM	231324	23914	27621	51535
3	NATURE	226827	21628	23806	45434
4	SCIENCE	170514	17544	21528	39072
5	J AM CHEM SOC	148900	10455	12230	22685
6	CELL	113325	14277	19319	33596
7	PHYS REV B	106320	12214	13350	25564
8	J CHEM PHYS	102263	6958	7846	14804
9	PHYS REV LETT	103790	12619	14011	26630
10	NEW ENGL J MED	92729	7309	10085	17394
11	LANCET	80055	6593	8691	15284
12	J IMMUNOL	78615	6761	10061	16822
13	BIOCHEMISTRY-US	76131	7529	9146	16675
14	AM J PHYSIOL	71574	5858	8184	14042
15	BIOCHIM BIOPHYS ACTA	66827	3951	5945	9896
16	BRAIN RES	61842	3533	5615	9148
17	CANCER RES	60626	5755	7607	13362
18	J CLIN INVEST	58670	3912	6183	10095
19	ASTROPHYS J	57088	5178	6018	11196
20	J CELL BIOL	56430	5233	6771	12004
21	J PHYS CHEM-US	54721	5338	6607	11945
22	BIOCHEM BIOPH RES CO	52503	4596	6750	11346
23	NUCLEIC ACIDS RES	52218	4187	6601	10788
24	EMBO J	49572	6684	7158	13842
25	J APPL PHYS	48376	3076	5782	8858
26	J GEOPHYS RES	48212	3182	4461	7643
27	APPL PHYS LETT	47338	6814	7749	14563
28	J ORG CHEM	47277	4128	4781	8909
29	CIRCULATION	47233	4224	6452	10676
30	BIOCHEM J	47145	3746	4135	7881
31	J EXP MED	45771	4692	5984	10676
32	BLOOD	44029	5525	7770	13295
33	TETRAHEDRON LETT	43808	4105	4894	8999
34	MOL CELL BIOL	42653	5223	6788	12211
35	J BACTERIOL	40320	4183	4632	8815
36	ANAL BIOCHEM	39801	915	1286	2201
37	J MOL BIOL	39780	3335	3266	6601
38	ENDOCRINOLOGY	38953	3164	4518	7682
39	PHYS REV A	38123	4613	4603	9216
40	CANCER	37762	1478	2711	4189
41	JAMA-J AM MED ASSOC	37230	3231	3665	6896
42	FEBS LETT	36934	3992	4694	8686
43	PHYS LETT B	35907	4931	5728	10659
44	BRIT MED J	35904	2878	2699	5577
45	J VIROL	35652	4968	5762	10730
46	INORG CHEM	34414	2439	3122	5561
47	J PHYSIOL-LONDON	32493	2095	2475	4570
48	CHEM PHYS LETT	31731	3883	3927	7810
49	ANAL CHEM	30888	2098	2792	4890
50	EUR J BIOCHEM	30575	2781	3256	6037
51	ANN INTERN MED	29871	2310	2729	5039
52	J COMP NEUROL	29124	1214	2374	3588
53	GASTROENTEROLOGY	28929	2770	2764	5534
54	J PHARMACOL EXP THER	28878	2075	2948	5023

Table 4. 1993 Citations to all years. Journals ranked by Times Cited in 1993.

demonstrates how a relatively small group of journals dominates scientific publication. I called this the Law of Concentration in contrast to Bradford's Law of Scattering. The dashed line shows that 100 journals produce 20% of the articles published. The solid line shows that 100 journals receive 42% of the citations.

RANK	JOURNAL TITLE	IMPACT FACTOR	CITATIONS IN 1993 TO 1993 ITEMS	SOURCE ITEMS IN 1993	IMMEDIACY INDEX
1	PHYS REV B	3.159	2672	4770	0.560
2	J BIOL CHEM	6.793	4174	3916	1.066
3	J APPL PHYS	1.784	859	2833	0.303
4	P NATL ACAD SCI USA	10.325	3608	2441	1.478
5	AM J PHYSIOL	3.139	872	2351	0.371
6	APPL PHYS LETT	3.503	1106	2293	0.482
7	J AM CHEM SOC	5.365	2061	2276	0.906
8	PHYS REV LETT	7.111	2546	2186	1.165
9	J CHEM PHYS	3.615	1658	2165	0.766
10	TETRAHEDRON LETT	2.258	1043	2134	0.489
11	JPN J APPL PHYS	1.348	424	2060	0.206
12	J PHYS CHEM-US	3.395	1252	1999	0.626
13	BIOCHIM BIOPHYS ACTA	2.467	551	1890	0.292
14	ASTROPHYS J	3.387	378	1870	0.202
15	J GEOPHYS RES	2.396	1091	1773	0.615
16	BIOCHEMISTRY-US	5.109	1520	1770	0.859
17	BRAIN RES	2.854	461	1658	0.278
18	BIOCHEM BIOPH RES CO	3.312	510	1636	0.312
19	PHYS LETT B	3.079	1051	1617	0.650
20	CHEM PHYS LETT	3.018	934	1599	0.584
21	FEBS LETT	3.339	681	1509	0.451
22	TRANSPLANT P	1.089	321	1421	0.226
23	J ORG CHEM	3.235	805	1334	0.603
24	PHYS REV D	3.007	1145	1330	0.859
25	J IMMUNOL	7.065	1137	1321	0.861
26	NUCL INSTRUM METH B	1.157	345	1296	0.266
27	PHYS REV A	2.271	714	1277	0.559
28	ELECTRON LETT	1.095	361	1216	0.297
29	PHYS REV E		473	1193	0.396
30	CANCER	2.249	348	1190	0.292
31	MACROMOLECULES	2.807	481	1131	0.425
32	NUCLEIC ACIDS RES	3.783	657	1104	0.595
33	EUR J PHARMACOL	2.849	367	1093	0.336
34	SYNTHETIC MET	1.652	495	1092	0.453
35	NUCL INSTRUM METH A	0.948	414	1084	0.382
36	INORG CHEM	2.684	504	1082	0.466
37	J BACTERIOL	3.965	819	1063	0.770
38	BIOCHEM J	3.659	638	1050	0.608
39	ANN NY ACAD SCI	0.850	229	1047	0.219
40	J CHEM SOC CHEM COMM	2.540	554	1043	0.531
41	SCIENCE	21.074	4291	1030	4.166
42	J PHYS-CONDENS MAT	1.654	308	1025	0.300
43	CANCER RES	6.011	803	1015	0.796
44	PHYS LETT A	1.149	297	1009	0.294
45	ASTRON ASTROPHYS	2.122	121	998	0.121
46	NATURE	22.326	5256	990	5.309
47	NUCL PHYS B	4.535	825	970	0.851
48	PHYTOCHEMISTRY	1.102	143	968	0.148
49	J MATER SCI	0.765	155	967	0.160
50	J VIROL	5.647	914	954	0.958

Table 5. *SCI* Journal citation reports. Journals ranked by source items in 1993.

ity. It is a preliminary indicator of influence. However, there are some journals which achieve a remarkably high impact in spite of, or maybe even because of, their size. Thus, one might reasonably argue for a combined measure reflecting size, citation and currency.

That is illustrated in Table 6 which shows the journals most-cited in 1993 for their 1991 and 1992 articles. Undoubtedly this tells us something

RANK	JOURNAL TITLE	CITATIONS IN 1993 TO 92+91	<—SOURCE ITEMS IN—> 1992	1991	92+91	IMPACT FACTOR
1	J BIOL CHEM	51535	3891	3695	7586	6.793
2	P NATL ACAD SCI USA	50425	2502	2382	4884	10.325
3	NATURE	45434	1033	1002	2035	22.326
4	SCIENCE	39072	977	877	1854	21.074
5	CELL	33696	432	474	906	37.192
6	PHYS REV LETT	26630	1965	1780	3745	7.111
7	PHYS REV B	25564	4198	3895	8093	3.159
8	J AM CHEM SOC	22685	2167	2061	4228	5.365
9	NEW ENGL J MED	17394	378	354	732	23.762
10	J IMMUNOL	16822	1126	1255	2381	7.065
11	BIOCHEMISTRY-US	16675	1676	1588	3264	5.109
12	LANCET	15284	469	493	962	15.888
13	J CHEM PHYS	14804	2054	2041	4095	3.615
14	APPL PHYS LETT	14563	2056	2101	4157	3.503
15	AM J PHYSIOL	14042	2323	2150	4473	3.139
16	EMBO J	13825	555	493	1048	13.208
17	BLOOD	13292	843	794	1637	8.120
18	CANCER RES	13062	1130	1043	2173	6.011
19	MOL CELL BIOL	12211	610	713	1323	9.230
20	J CELL BIOL	12004	521	505	1026	11.700
21	J PHYS CHEM-US	11935	1784	1731	3515	3.395
22	BIOCHEM BIOPH RES CO	11346	1705	1721	3426	3.312
23	ASTROPHYS J	11196	1680	1626	3306	3.387
24	NUCLEIC ACIDS RES	10788	1216	1636	2852	3.783
25	J VIROL	10730	967	933	1900	5.647
26	CIRCULATION	10676	550	637	1187	8.994
26	J EXP MED	10676	411	369	780	13.687
28	PHYS LETT B	10659	1721	1741	3462	3.079
29	J CLIN INVEST	10095	604	581	1185	8.519
30	BIOCHIM BIOPHYS ACTA	9896	1993	2019	4012	2.467
31	PHYS REV A	9216	2159	1899	4058	3.271
32	BRAIN RES	9148	1574	1631	3205	2.854
33	TETRAHEDRON LETT	8999	2039	1947	3986	2.258
34	J ORG CHEM	8909	1344	1410	2754	3.235
35	J APPL PHYS	8858	1963	3003	4966	1.784
36	J BACTERIOL	8815	1122	1101	2223	3.965
37	FEBS LETT	8686	1360	1241	2601	3.339
38	BIOCHEM J	7881	1127	1027	2154	3.659
39	CHEM PHYS LETT	7810	1359	1229	2588	3.018
40	ENDOCRINOLOGY	7682	913	892	1805	4.256
41	J GEOPHYS RES	7643	1510	1680	3190	2.396
42	NEURON	6954	216	187	403	17.256
43	JAMA-J AM MED ASSOC	6896	588	644	1232	5.597
44	GENE DEV	6782	218	221	439	15.449
45	J MOL BIOL	6601	642	512	1154	5.720
46	PHYSICA C	6587	814	2048	2862	2.302
47	PHYS REV D	6332	1165	941	2106	3.007
48	J NEUROSCI	6283	419	363	782	8.035
49	MACROMOLECULES	6200	1138	1071	2209	2.807
50	EUR J BIOCHEM	6037	981	845	1826	3.306
51	NUCL PHYS B	6014	711	615	1326	4.535
52	SURF SCI	5748	1210	968	2178	2.639
53	EUR J PHARMACOL	5730	1046	965	2011	2.849
54	FASEB J	5722	171	173	344	16.634

Table 6. *SCI* Journal citation reports. Journals rankings 1993. Ranked by time 1991 and 1992 items were cited in 1993.

about their overall current influence. However, it is important to mention that there are differences between fields as to the rate at which knowledge is accumulated. But surprisingly even a field like astrophysics has a cited half-life less than 10 years, as is also the case for plant science journals. While a journal like *Cell* has a cited half-life of four years, it would require more study to say anything authoritative. The new CD-ROM version of

JCR will allow this to be done more easily.

If you compare Table 6 to Table 4 you can see how the rankings change. *JBC* moves to 1st place and *PNAS* moves to 2nd. *Nature* moves from 46th place to 3rd and *Science* moves from 41st to 4th.

I much regret that ISI did not originally publish long-term cumulative factors in the *Journal Citation Reports*. However, the urgencies of meeting annual schedules and the lower priority it received as a give-away product discouraged this from happening. As I often demonstrated in *Current Contents* essays, you can easily combine data for consecutive issue of *JCR* to obtain such information.

Keep in mind, however, that a five -or ten - year impact number can be calculated in two ways. The first is to use one base year as a baseline and create a moving five-year window. The other is to use several base years and include all citations for the same base years. The latter would generally produce a lower value, but not always. For example, *JAMA* published 627 articles in 1989 (see Equation 2). In the five years 1989-93, it received 11,320 citations. This gives a five-year impact of 18.05. It published 3,101 articles from 1989 to 1993 and received 29,047 citations in those five years

One-years window

1989-93 Citations to 1989 Articles	11,320	+
1989 Articles	627	
Five-Year Impact	18.05	

Five-years window

1989-93 Citations to 1989-93 Articles	29,407	+
1989-93 Articles published	3,101	
Five-Year Impact	9.37	

Equation 2. Five-year impact for *Jama*.

or a five-year impact of 9.37. This gives you a preliminary idea of the possible differences in current and cumulative impact.

The following Equation 3, I've done the same exercise for *Nature* and

Science. The current year impact and the most recent five-year impact, however, do not give us an absolute picture of the long-term performance of journals. And as we will see, there turns out to be considerable variance from year-to-year depending upon whether the journal published one or more super-cited articles.

As editors you know that it is not always easy to categorize or character-

One-years window (1989)

NATURE		*SCIENCE*	
73,834 Citations / 1,042 Articles	= 70.86	66,445 Citations / 829 Articles	= 80.16

Five-years window (1989-93)

209,721 Citations / 5,194 Articles	= 40.38	174,532 Citations / 4,568 Articles	= 38.21

Equation 3. Five-year impact for *Nature* and *Science*.

ize different types of editorial matter. Not all review articles are labelled as such and many reviews contain original research data as well. Such hybrids are also to be observed in characterizing letters to the editor, which vary considerably in quality and scope. That is why I have always urged editors to conduct an item-by-item citation audit. These audits may or may not confirm your own subjective estimate of the best quality articles - or the most innovative or the most premature. But they will give you some objective indicators of the way they have influenced your readers and the scientific community. Let me turn now to the presentation of my main slides. With the advent of the ISI Journal Performance Indicators databases, I realized that it would be relatively easy to obtain long- term measures of impact. These had never before been published. In the next tables I've compiled such cumulative data for the single year 1981 as well as for the five-year period 1981-5.

Table 7 shows the top 34 research journals ranked by current impact

Table 7 shows the top 34 research journals ranked by current impact factor for 1993. Later, I'll show you data for review journals. The rank by current impact is shown on the left followed by the cumulative impact for 1981 articles followed in turn by a number showing the rank by cumulative impact. Lest the folks at *Cell* jump to any conclusions, let me point out that about 20% of their articles are classified as reviews. So it would be reasonable to separate these two classes of articles in a deeper analysis.

1993 Rank	Journal	1993 Impact	1981 Av/Cites 1981-93	1981 Cum Rank
1.	Cell	37.2	125.5	1
2.	NEJM	23.8	115.8	2
3.	Nature	22.3	70.5	8
4.	Science	21.1	61.1	10
5.	Lancet	15.9	51.6	17
6.	J Exp Med	13.7	89.3	3
7.	J Cell Biol	11.7	80.7	5
8.	PNAS (Biol)	10.3	85.9	4
9.	Arch Gen Psych	9.5	78.8	6
10.	Ann Int Med	9.3	53.7	15
11.	Am J Hum Genet	9.2	24.3	31
12.	Mol Cell Biol	9.2	46.8	20
13.	Circulation	9.0	54.3	13
14.	CA Cancer J	8.9	10.3	34
15.	J Clin Invest	8.5	77.1	7
16.	Blood	8.1	52.7	16
17.	J Neurosci	8.0	70.1	9
18.	J Natl Canc I	7.5	30.6	29
19.	Phys Rev L	7.1	43.0	21
20.	J Immunol	7.1	55.0	12
21.	Ann Neurol	7.0	36.6	26
22.	Syst Zool	6.8	42.8	22
23.	JBC	6.8	48.7	18
24.	Angew Chem	6.2	21.0	32
25.	Cancer Res	6.0	36.7	25
26.	Gastroenterology	5.9	47.4	19
27.	Circulation Res	5.8	54.1	14
28.	J Mol Biol	5.7	60.7	11
29.	J Virology	5.7	32.2	28
30.	Am J Pathol	5.7	42.2	23
31.	JAMA	5.6	20.7	33
32.	Eur J Immunol	5.6	41.9	24
33.	Arthritis Rheum	5.5	27.3	30
34.	Lab Invest	5.5	35.6	27

Table 7. Current vs cumulative impact

In Table 8, I've shown these 34 journals ranked by the cumulative impact number for their 1981 articles. In the second column, the current 1993 impact is shown. As you can see, the order is quite different. While *Cell*

and *NEJM* are the first two listed in both columns, *Journal of Experimental Medicine* moves from 7th to 3rd, *PNAS* moves from 9th to 4th, and *Journal of Cell Biology* moves from 6th to 5th. *Archives of General Psychiatry* moves from 9th to 6th. Considering that this is a behavioral science journal, it is all the more remarkable and may say something about its shift to neuroscience. The change in rank for *Nature* and *Science* is significant as are the rankings for many of the other titles.

Journal	1981 Articles Av Cum Cites 1981-93	1993 Impact Factor	1981-6 Articles Av Cum Impact 1981-93
1. Cell	125.5	37.2	140.0
2. NEJM	115.8	23.8	107.8
3. J Exp Med	89.3	13.7	82.2
4. PNAS (Biol)	85.9	10.3	74.0
5. J Cell Biol	80.7	11.7	66.5
6. Arch Gen Psych	78.8	9.5	69.3
7. J Clin Invest	77.1	8.5	64.0
8. Nature	70.5	22.3	87.5
9. J Neurosci	70.1	8.0	52.6
10. Science	61.1	21.1	79.2
11. J Mol Biol	60.7	5.7	55.7
12. J Immunol	55.0	7.1	47.1
13. Circulation	54.3	9.0	46.9
14. Circulation Res	54.1	5.8	58.5
15. Ann Int Med	53.7	9.3	54.1
16. Blood	52.7	8.1	45.7
17. Lancet	51.6	15.9	47.6
18. JBC	48.7	6.8	47.7
19. Gastroenterology	47.4	5.9	39.3
20. Mol Cell Biol	46.8	9.2	50.6
21. Phys Rev L	43.0	7.1	40.5
22. Syst Zool	42.8	6.8	26.7
23. Am J Pathol	42.2	5.7	34.9
24. Eur J Immunol	41.9	5.6	32.1
25. Cancer Res	36.7	6.0	33.4
26. Ann Neurol	36.6	7.0	36.6
27. Lab Invest	35.6	5.5	41.9
28. J Virology	32.2	5.7	32.4
29. J Natl Canc I	30.6	7.5	22.4
30. Arthritis Rheum	27.3	5.5	27.0
31. Am J Hum Genet	24.3	9.2	24.3
32. Angew Chem	21.0	6.2	21.9
33. JAMA	20.7	5.6	22.2
34. CA Cancer J	10.3	8.9	15.6

Table 8. Current vs current impact factor

It is important to note, however, that a single year does not tell the whole story. In the last column is shown the cumulative impact for 1981-6 articles. Remarkably, for some journals this goes up rather than down, see e.g.

Nature, Science, Circulation Research, and *Annals of Internal Medicine.* The Table 9 covers another aspect of journalology that has distressed me since the publication of David Hamilton's ill conceived diatribe in Science in which he mischievously misquoted data he did not understand concerning citedness in science and the humanities. As you can see from these data, the journals that produce the highest impact articles have an extremely low degree of uncitedness. Even this, by itself, does not say enough be-

Journal	# Items	1981 Articles Av Cum Cites 1981-93 (All)	1981 Cited Items (Cited)	1981 % Uncited	1981 Total Cites
1. Cell	393	125.5	125.5	0.00	49,307
2. NEJM	378	115.8	117.1	1.06	43,784
3. J Exp Med	343	89.3	89.6	0.29	30,630
4. PNAS (Biol)	1550	85.9	86.0	0.13	133,135
5. J Cell Biol	367	80.7	80.7	0.00	29,629
6. Arch Gen Psych	152	78.8	79.8	1.31	11,970
7. J Clin Invest	418	77.1	77.5	0.48	32,226
8. Nature	1375	70.5	72.5	2.76	96,881
9. J Neurosci	106	70.1	70.1	0.00	7,432
10. Science	1077	61.1	63.9	4.36	65,831
11. J Mol Biol	307	60.7	61.3	0.99	18,629
12. J Immunol	989	55.0	55.1	0.20	54,380
13. Circulation	416	54.3	55.4	1.92	22,601
14. Circulation Res	267	54.1	54.1	0.00	14,439
15. Ann Int Med	290	53.7	54.9	2.10	15,528
16. Blood	360	52.7	52.7	0.00	18,983
17. Lancet	641	51.6	69.3	25.60	33056
18. JBC	2220	48.7	49.0	0.59	108,107
19. Gastroenterology	325	47.4	48.0	1.23	15,408
20. Mol Cell Biol	122	46.8	47.2	0.81	5,713
21. Phys Rev L	992	43.0	43.2	0.40	42,463
22. Syst Zool	34	42.8	44.1	2.86	1,455
23. Am J Pathol	167	42.2	42.8	1.19	7,053
24. Eur J Immunol	171	41.9	42.9	2.33	7,156
25. Cancer Res	851	36.7	36.9	0.59	31,245
26. Ann Neurol	222	36.6	37.6	2.69	8,131
27. Lab Invest	139	35.6	35.9	0.71	4,952
28. J Virology	483	32.2	32.5	0.83	15,558
29. J Natl Canc I	306	30.6	30.8	0.65	9375
30. Arthritis Rheum	204	27.3	28.0	2.44	5,577
31. Am J Hum Genet	78	24.3	24.6	1.27	1,896
32. Angew Chem	413	21.0	21.6	2.66	8,664
33. JAMA	551	20.7	22.8	9.20	11,382
34. CA Cancer J	36	10.3	13.8	24.32	372

Table 9. Cumulative impact and uncitedness. 1981 articles cited 1981-93

cause we need to study the meaning of uncitedness. Many articles may be cited only one or two times because their content is superseded by subsequent papers reporting on studies conducted over a long period of time. That also should be the subject of a separate investigation. This is a good way to segue into Table 10 covering review journals. As you can see, *Annual Review of Biochemistry* achieves an impact of over 320 for the 188 articles it published from 1981-86.

COUNTRY	6yr avg	SumOfCITATIONS	SumOfSOURCES
ANN R BIOCH	320.31	60219	188
ANN R CELL	231.35	7866	34
ADV PROTEIN	205.29	4311	21
ANN R IMMUN	194.59	16929	87
PHYSIOL REV	176.53	22066	125
REV M PHYS	167.85	21821	130
ADV IMMUNOL	159.19	6686	42
MICROBIOL R	145.28	18015	124
ANN R NEUR	141.60	13877	98
PHARM REV	138.26	10646	77
ANN R PLANT	138.22	17139	124
ANN R GENET	131.99	13199	100
ENDOCR REV	128.49	17731	138
ADV PHYSICS	108.93	6318	58
ANN R PHARM	107.59	15493	144
ADV CARB C	96.80	3388	35
ANN R ASTRO	94.43	8782	93
ADV ORGMET	90.62	3534	39
CHEM REV	90.54	13853	153
BRAIN RES R	89.74	9602	107
ANN R PH CH	85.64	10277	120
IMMUNOL REV	80.12	22753	284
Q REV BIOPH	77.37	3946	51
REV PHYS B	76.94	3847	50
ANN R PHYSL	75.35	20722	275
PROG NUCL	74.16	2373	32
PSYCHOL REV	73.71	11646	158
CRC C R BI	72.47	7754	107
ANN R ECOL	70.42	8239	117
REC PROG H	70.05	4273	61
ANN R MICRO	68.73	9829	143
ACC CHEM RE	68.44	23887	349
ANN R BIOPH	65.31	7184	110
ADV ENZYM	56.98	2963	52
EPIDEMIOL R	53.32	3039	57
PHYS REPORT	52.06	24259	466
PROG NEUROB	50.34	5789	115

Table 10. Cumulative impact 1981-94. review journal articles published 1981-6

The variation from year to year is substantial as shown in Table 11:

Year	Cumulative Impact
1981	328.65
1982	251.03
1983	391.28
1984	369.95
1985	311.64
1986	299.68
1987	519.93

Table 11. *Annual Review of Biochemistry* year-by-year cumulative impact. Note the huge increase for 1987

Let me remind you that there are many other details which must be taken into consideration. E.g. journals which appear in translation may receive credit for more citations than they deserve since both the original and the translation may be cited simultaneously. We cannot easily unscrambled these data although Braun et al. did so recently for the *Angewandte Chemie* in the new journal *Chemical Intelligencer.*

Journal	6-Year Impact Ranking	Current Impact Ranking
Lancet	70	18
Circulation Research	51	100
Brain Research	210	338

Table 12. Current rankings vs cumulative rankings

In final Table 12, I've assembled some data on three journals to illustrate how rankings change up or down based on current versus cumulative rankings. I hope that all of these data have justified my title - the impact of cumulative impact.