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Also see: "The number of biochemical articles is growing. But why also the number"

Trends in biochemical literature

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Any working biochemist intuitively knows that the literature is growing. However, quantifying this growth with any degree of precision is not an easy task. But after my interest in this problem was piqued by the late Robert Harte [1], I attempted to produce what is, I hope, an accurate and useful view of the biochemical literature.

Based on information extracted from the *Science Citation Index*® (*SCI*®) data base, I find that, in terms of articles published, the biochemical literature is still growing faster than the scientific literature as a whole. What's more, the number of references in a typical biochemical article is increasing as is the proportion of references to material more than five years older than the citing article.

For the purposes of this paper we have looked at 37 'core' primary journals. Our study encompassed the years 1968–1977 for all core journals (Table I), and also included 1962–1967 for the journals used by Harte*. I refer to the journals studied by Harte as the 'CEBJ journals', since their editors are full members of the Committee of Editors of Biochemical Journals of the IUB.

Of the 37 journals studied, 16 started publication in 1962 or later. Of these, eight started publication in 1970 or later. Thus, just in the number of journals considered important to biochemists, there has been a 76% increase in 16 years.

Table I shows that the number of articles per year produced by the core biochemistry journals increased from 9060 in 1968 to 14,418 in 1977. This amounts to an annual growth rate of 5.3% or a doubling time of 13.4 years. If we look at only the CEBJ journals for the same time period, we find that the number of articles they published annually increased from 6766 to 8491. This is an annual growth rate of 2.6%; however, non-CEBJ journals increased their output at an average annual rate of 11.1%.

The higher growth rate for the non-CEBJ journals is partly due to the birth of new journals. But it also results from the fact that the increase in the average number of items published per year was greater for non-CEBJ core journals. Table II shows that the average number of items published per year by a CEBJ journal increased from 615 in 1968 to 772 in 1977 – an increase of 26%. The average number of items published by a non-CEBJ core journal increased from 143 in 1968 to 228 in 1977 – an increase of 59%.

Over the longer period of 1962–1977 the CEBJ journals had an average annual growth rate of 5.1%. This growth rate conflicts with Harte's findings for the same journals for essentially the same time period (9.8%) but since detailed data were not provided in Harte's report, we have not been able to identify the reason for this difference.

For the earlier period of 1962–1967, the CEBJ journals had an average annual growth rate of 8.1% – about three times greater than the growth of the CEBJ journals during 1968–1977. These data clearly confirm the exponential growth that the literature experienced in the 1960s and the general slowdown which has occurred in the 1970s.

The 5.3% average annual growth rate observed for the core biochemical journals

* To conserve space, some of the supporting data for this article have been omitted. These may be obtained from the author at the above address.

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between 1968–1977 is slightly greater than the growth rate of the *SCI* data base (Table I). Increasing from 311,959 items in 1968 to 465,067 in 1977, the *SCI* had a 4.5% average annual growth rate. To the degree that the *SCI* data base represents the literature of science as a whole, we can say that the growth rate for the biochemistry literature was at least 18% higher.

Preliminary data from our unpublished studies on the literature of mathematics and botany allowed me to compare the growth of the biochemical literature to that of other fields. In striking contrast to biochemistry, the size of the core journals of pure mathematics remained almost constant during 1968–1977 and the number of botany articles increased by an annual growth rate of only 3%.

If we look at individual journals, Table I shows that the highest output of articles in 1977 came from *Biochim. Biophys. Acta* (2080), *J. Biol. Chem.* (1384), and *Biochem. Biophys. Res. Commun.* (1202). The largest average annual growth rates between 1968 and 1977 were shown by *Indian J. Biochem. Biophys.* (24.2%), *FEBS Lett.* (14.4%), and *Eur. J. Biochem.* (9.4%). These three journals all published a substantial number of articles and had a steady increase in articles over the years. The *Ital. J. Biochem.* also had a high annual growth rate (16.9%), but it published relatively few articles and its growth was erratic.

Earlier, I stated that the core biochemistry journals produced about 14,000 articles in 1977. One needs to remember, however, that biochemistry articles can appear in other than core journals – especially in multidisciplinary ones such as *Science*, *Nature*, and the *Proc. Natl. Acad. Sci. U.S.A.* Evidence of this can be seen in Tables III and IV. In these tables we have listed, for 1977, the 50 journals which were cited most by the core biochemistry journals and the 50 journals that cited the core journals the most. Each list contains a substantial number of journals that are not part of the biochemistry core.

To estimate how many biochemistry articles appear in non-core journals, we analysed the citation frequency between core and non-core journals. This indicated that non-core journals would contribute about 5000–10,000 additional biochemistry articles per year. Obviously, this is not very precise. But trying to measure the population of journal articles in a field like biochemistry is as elusive as measuring the ethnic or racial characteristics of a country like the U.S.A. where there is constant intermarriage. Nevertheless, when the estimated number of biochemistry articles published by non-core journals is added to the 14,000 articles published by core journals, it would seem that a minimum of 20,000–25,000 biochemistry articles were produced during 1977.

It should be noted here that since the *Proc. Natl. Acad. Sci. U.S.A.* is fourth among the journals most cited by the biochemistry core, an argument could have been made to include it as part of the core. But the same argument could be made, albeit somewhat less strongly, for *Nature*, *Science*, *J. Am. Chem. Soc.*, *J. Bact.*, *J. Cell Biol.*, and other important journals that are not devoted exclusively to biochemistry, but are highly cited in the core journals. Therefore, we felt it best to continue in this study our usual practice of defining the core journals as those which solely publish articles related to the field being examined.

Another 'growth' indicator within the biochemical literature is the increase in the average number of references contained in a typical article. To examine this factor I developed an 'R/S' value for each core journal. This is the number of references contained in all of a journal's issues during a specified year (R) divided by the number of source articles (S) it published that year. Average R/S values are shown in Table II for CEBJ journals, for all the core biochemistry journals, and for the average *SCI* journals.

For every year during 1968–1977, the average biochemistry article contained at least 70% more references than the average article in the *SCI* data base. For example, in 1977 the average biochemistry article contained 23.4 references as compared to the 13.5 references in the average *SCI*

TABLE I

Annual total of source items published by each core biochemistry journal, 1968–1977

Journal	Publication Year										
	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	Total
Acta Biochim. Biophys.	93	52	65	116	50	97	46	38	204	51	812
Acta Biochim. Pol.	37	35	37	46	29	37	51	36	41	33	382
Anal. Biochem.	354	388	413	435	437	480	462	557	563	538	4627
Arch. Biochem. Biophys.[a]	608	539	439	516	492	529	528	514	509	544	5218
Biochem. Biophys. Res. Commun.	620	601	834	888	987	1178	1208	1162	1124	1202	9804
Biochem. J.[a]	990	986	1019	1106	1307	680	653	685	777	704	8907
Biochem. Soc. Trans.	–	–	–	–	–	520	246	489	442	645	2342
Biochemistry U.S.A.[a]	604	729	720	772	724	825	854	871	878	923	7900
Biochim. Biophys. Acta[a]	1831	1932	2070	2068	2176	2365	1960	1994	2325	2080	20,801
Biochimie[a]	211	155	132	157	175	200	204	185	185	136	1740
Bioinorg. Chem.	–	–	–	6	25	19	33	39	48	34	204
Biokhimiya[a]	173	190	159	201	202	198	200	197	330	300	2150
Bioorg. Chem.	–	–	–	33	11	25	37	39	36	45	226
Bioorg. Khim.	–	–	–	–	–	–	–	212	183	201	596
Can. J. Biochem.	227	194	212	205	175	224	161	184	154	186	1922
Chem. Phys. Lipids	34	46	59	100	85	63	71	68	78	90	694
Eur. J. Biochem.[a]	317	393	473	507	523	676	665	755	797	710	5816
FEBS Lett.	286[b]	364	640	682	788	806	999	950	960	963	7438
H.-S. Z. Physiol. Chem.[a]	458	418	454	305	599	641	492	447	560	824	5198
Indian J. Biochem. Biophys.	54	76	88	81	101	98	115	115	314	379	1421
Int. J. Biochem.	–	–	136	67	93	75	124	126	105	140	866
Int. J. Pept. Prot. Res.	–	33	32	46	44	55	54	62	71	95	492
Ital. J. Biochem.	28	28	34	16	26	24	54	146	79	114	549
J. Biochem.-Tokyo[a]	252	245	222	298	292	344	352	353	401	468	3227
J. Biol. Chem.[a]	900	912	947	1065	1078	1233	1163	1372	1154	1384	11,208
J. Cyclic Nucl. Res.	–	–	–	–	–	–	–	35	39	40	114
J. Lipid Res.	119	108	85	105	101	95	86	65	96	97	957
J. Mol. Biol.[a]	422	382	394	401	448	467	482	436	435	418	4285
Lipids	118	129	185	188	145	157	181	161	153	197	1614
Mol. Cell. Biochem.	76	59	75	69	69	42	63	72	70	110	705
Nucleic Acids Res.	–	–	–	–	–	–	148	240	301	372	1061
Physiol. Chem. Phys.	–	54	60	57	61	54	60	62	67	59	534
Postepy Biochem.	41	36	36	42	29	30	26	21	26	25	312
Prep. Biochem.	–	–	–	24	28	47	38	33	30	35	235
Rev. Roum. Biochim.	41	42	38	44	41	34	38	42	40	43	403
Seikagaku	39	33	33	31	52	31	29	24	38	91	401
Ukr. Biokhim. Zh.	127	126	124	137	148	146	150	130	140	142	1370
Total	9060	9285	10,215	10,814	11,541	12,495	12,033	12,917	13,753	14,418	116,531
Average	335.6	320.2	340.5	327.7	349.7	367.5	343.8	349.1	371.7	389.7	
SCI data base	312	345	355	365	381	400	401	429	441	465	

[a] Full member of IUB Committee of Editors of Biochemical Journals (CEBJ) as of December 1978.

[b] Began publication July 1968; annual estimate is an extrapolation.

TABLE II

Total items published for CEBJ journals and average number of references per source item (R/S) for CEBJ journals, core biochemistry journals, and all *SCI* journals

	Publication year															
	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
Total source items for CEBJ journals	4183	4261	4773	5413	5759	6184	6766	6881	7029	7396	8016	8158	7553	7809	8351	8491
Average R/S for CEBJ journals	18.2	18.4	19.3	19.4	20.6	20.6	21.6	21.9	21.6	23.0	22.4	24.4	25.8	27.0	26.7	26.1
Average R/S for all 37 core biochem. journals	–	–	–	–	–	–	21.2	21.7	21.0	22.3	21.7	22.8	23.9	24.1	23.6	23.4
Average R/S for all *SCI* journals	–	–	–	–	–	–	12.0	11.6	11.6	12.1	12.4	12.6	13.1	13.3	13.7	13.5

article. Some of the difference can be explained by the fact that the *SCI* data base covers a substantial number of items such as letters and abstracts. These items are not as likely to appear in the core biochemistry journals, which tend to publish full research articles almost exclusively. Because letters and abstracts carry few if any references, the R/S for *SCI* articles as a whole will be lower than the R/S for biochemistry articles. However, this situation could only account for a very small part of the 70% difference.

Table II shows that the average R/S for the core journals has increased 10.4% in ten years, from 21.2 in 1968 to 23.4 in 1977. However, over the 16-year period, 1962–1977, some of the CEBJ journals have had increases in R/S as high as 64% (*Biochim. Biophys. Acta*). On average, the R/S value for CEBJ journals increased by 43% (18.2 to 26.1) from 1962 to 1977 (Table II).

To develop another perspective on the increase in R/S for biochemistry articles, I once again looked at preliminary data from our studies on mathematics and botany journals. As of 1977, biochemistry articles, on average, had 12% more references than botany articles (23.4 v. 21.0) and 85% more references than mathematics articles (23.4 v. 12.6). Mathematics and botany articles increased their R/S values by 8 and 7%, respectively, between 1968 and 1977. These increases are substantially less than the 10.4% growth in the biochemistry R/S over the same period. Nevertheless, all three fields did show an increase in the number of references contained in an average article. Thus, unless the length of an article, or its character, or the amount of information it contains has changed, why should current authors generally cite more references than they did in the past?

There are several possible reasons. The first concerns the increase in team research [2–6]. Since the reward system of science places so much stress on 'first' authorship,

TABLE III

The 50 journals cited most often in the core biochemistry journals in 1977, arranged in descending order according to number of core journal citations received

Journal	Citations received from core biochemistry journals	Journal	Citations received from core biochemistry journals
J. Biol. Chem.[a]	41,665	*Virology*	1508
Biochim. Biophys. Acta[a]	25,193	*J. Virol.*	1465
Biochemistry-U.S.A.[a]	18,151	*J. Neurochem.*	1362
Proc. Natl. Acad. Sci. U.S.A.	16,699	*Cancer Res.*	1331
Biochem. J.[a]	12,370	*Cold Spring Harb. Sym.*	1313
Biochem. Biophys. Res. Commun.[a]	11,518	*Anal. Chem.*	1303
J. Mol. Biol.[a]	10,934	*Exp. Cell Res.*	1277
Nature/Nature-New Biology[b]	10,000	*Enzymes*	1275
Eur. J. Biochem.[a]	9751	*Nucleic Acids Res.*[a]	1210
FEBS Lett.[a]	7309	*Endocrinology*	1175
Arch. Biochem. Biophys.[a]	7229	*Can. J. Biochem.*[a]	1143
Meth. Enzymol.	5210	*Biopolymers*	995
Anal. Biochem.[a]	4949	*Biochem. Pharmacol.*	959
J. Am. Chem. Soc.	4768	*Am. J. Physiol.*	910
Science	4128	*J. Gen. Physiol.*	887
J. Biochem.-Tokyo[a]	3431	*J. Physiol.-London*	884
J. Bact.	2919	*Lipids*[a]	860
J. Cell Biol.	2698	*Mol. General Genet.*	835
Fed. Proc.	2452	*Plant Physiol.*	832
Ann. NY Acad. Sci.	2119	*Proc. Soc. Exp. Biol. Med.*	816
H.-S. Z. Physiol. Chem.[a]	2091	*J. Chromatogr.*	800
Annu. Rev. Biochem.[a]	1800	*Mol. Pharmacol.*	795
J. Lipid Res.[a]	1804	*J. Exp. Med.*	745
J. Clin. Invest.	1728	*Adv. Enzymol. RAMB*[a]	728
Cell	1644	*Biochimie*[a]	703

[a] Core journals.

[b] *Nature-New Biology* published separately from *Nature* in 1971–1973, but included in citation count.

TABLE IV
The 50 journals citing the core biochemistry journals the most often in 1977, arranged in descending order of number of citations given to the core journals

Journal	Citations to core biochemistry journals	Journal	Citations to core biochemistry journals
Biochim. Biophys. Acta[a]	27,357	*J. Am. Chem. Soc.*	2293
J. Biol. Chem.[a]	22,817	*J. Virol.*	2187
Biochemistry-U.S.A.[a]	15,601	*Exp. Cell Res.*	2004
Eur. J. Biochem.[a]	11,359	*Plant Physiol.*	1972
Biochem. J.[a]	10,165	*Virology*	1950
Arch. Biochem. Biophys.[a]	8994	*Int. J. Biochem.*[a]	1921
Biochem. Biophys. Res. Commun.[a]	8945	*J. Cell Biol.*	1884
FEBS Lett.[a]	8216	*Biochimie*[a]	1818
Proc. Natl. Acad. Sci. U.S.A.	8140	*Life Sci.*	1815
J. Biochem.-Tokyo[a]	6655	*Agr. Biol. Chem. Tokyo*	1795
J. Mol. Biol.[a]	5637	*Lipids*[a]	1693
J. Bact.	5362	*Mol. Cell. Biochem.*[a]	1691
Anal. Biochem.[a]	4338	*Endocrinology*	1683
Nucleic Acids Res.[a]	4057	*Science*	1613
Biochem. Soc. Trans.[a]	3085	*J. Nutr.*	1572
Nature	2954	*J. Gen. Microbiol.*	1487
H.-S. Z. Physiol. Chem.[a]	2922	*Bact. Rev.*	1485
Biochem. Pharmacol.	2695	*Bioorg. Khim.*[a]	1467
Can. J. Biochem.[a]	2642	*Phytochemistry*	1464
Annu. Rev. Biochem.[a]	2608	*Am. J. Physiol.*	1455
Mol. Gen. Genet.	2495	*J. Clin. Invest.*	1420
Cell	2473	*Biopolymers*	1414
Biokhimiya[a]	2466	*J. Lipid Res.*[a]	1344
Cancer Res.	2456	*Fed. Proc.*	1339
J. Neurochem.	2438	*Postepy Biochem.*[a]	1340

[a] Core journals.

TABLE V
Percentage of references to items more than five years older than the citing article. (Five selected publication years, for 18 selected core biochemistry journals)

Journal	Publication date of citing article				
	1969	1972	1974	1975	1977
Acta Biochim. Biophys.	54.5	57.8	64.4	65.7	71.7
Anal. Biochem.	54.6	59.2	58.6	58.3	57.2
Annu. Rev. Biochem.	–	26.9	30.0	28.9	40.0
Arch. Biochem. Biophys.	52.4	51.5	53.0	53.1	58.5
Biochem. Biophys. Res. Commun.	32.2	36.2	38.9	41.0	42.9
Biochem. J.	45.3	51.7	52.5	54.9	56.1
Biochemistry-U.S.A.	44.5	49.3	48.8	47.5	51.1
Biochim. Biophys. Acta	43.6	49.2	49.5	50.3	53.3
Biochimie	–	45.5	48.3	52.8	55.9
Biokhimiya	–	58.7	68.0	64.9	55.9
Can. J. Biochem.	54.0	54.1	52.9	56.7	57.0
Eur. J. Biochem.	43.5	49.1	49.3	49.8	51.7
FEBS Lett.	37.3	35.8	40.0	35.3	41.0
H.-S. Z. Physiol. Chem.	47.4	47.4	50.5	49.2	48.0
Int. J. Biochem.	–	50.2	61.3	60.3	59.1
J. Biochem.-Tokyo	55.9	60.2	60.0	61.0	62.7
J. Biol. Chem.	44.6	49.1	48.8	49.1	51.0
J. Mol. Biol.	35.4	40.4	41.4	43.0	45.8

this encourages research teams to publish multi-part papers that could just as easily be published as one paper. When a single piece of team research is broken down into several parts to give each worker a chance as first author, all parts may have to be cited by subsequent workers or reviewers.

A second reason for an increase in the average number of references per paper is the growth of the literature itself. Price argues that part of this increased citation is the inevitable by-product of exponential growth [7]. If the size of the literature that can be cited increases, there is an increase in average citation. This may be true in the early phases of growth, but ultimately there must be a leveling off or all papers will become reviews!

A third reason may also be related to the *SCI* and what I call citation consciousness. It comes from the realization that to cite another person's work is to increase the number of times your own work appears in the *Citation Index*, which increases the possibility other people will have contact with it. Only careful refereeing can prevent the abuse of excess citation. But one can hardly quarrel with the laudable objective of improving retrieval by citing relevant works when we publish. I have always been suspicious of journals which arbitrarily limit an author to 15 references.

A fourth likely reason is the general improvement in the average author's awareness of newly published material because of improved 'current awareness' systems. The availability of *Current Contents*® and other services has no doubt led to better access to the current literature.

A related fifth possible explanation is that researchers have become more aware of the *SCI* and other indexing and abstracting tools and thereby have improved their retrospective search capability.

Whatever the reasons for the increase, our studies show that not only are there more references in biochemistry articles, the references are to a higher proportion of older material than was the case previously. In Table V, for 18 of the core journals, I show for five publication years the percentage of references that are more than five years older than the citing article. The journals were selected from the core list, and include all the CEBJ journals. For all except four of the journals, the percentage of references to material more than five years old has increased between 1969 and 1977. The most extreme example is *Acta Biochim. Biophys.* In 1969, 54.5% of its references were more than five years old. This steadily increased to 71.7% in 1977. However, of greater significance because of the size of the journals are the changes in *Biochem. Biophys. Res. Commun.* and *Biochim. Biophys. Acta.* These journals each had about a 10% increase in references more than five years old. A similar increase has also taken place in mathematics and botany.

The final aspect of our study was to try to determine which of the core biochemistry journals are most utilized by people in the field. The way we did this was to rank the core journals by their 'impact factor'. The impact factor of a journal is defined as the average number of citations received per article published during a specified time period. This measure makes it possible to compare the citation performance of a number of journals which publish different quantities of articles. By comparing the impact we eliminate the advantage a more prolific journal has if absolute citation counts are used. Thus, impact is a qualitative measure.

One reason we are interested in knowing an average R/S value for a group of journals is because of its relationship to impact measurements. As I've reported elsewhere, the number of pages published does not affect impact; the number of references cited does [8]. Thus, the higher R/S value for biochemistry journals as a group is paralleled by higher impact values.

In Table VI the 37 core journals plus three review journals are ranked by impact. In this case the impact represents all the citations received by a journal during 1977 for its 1975 and 1976 articles,

TABLE VI

Thirty-seven core biochemical journals plus three review journals ranked in descending order according to impact factor.

Rank	Journal	1977 Impact factor
1	*Annu. Rev. Biochem.*[a]	26.67
2	*Adv. Enzymol. RAMB*[a]	9.80
3	*CRC Crit. R. Biochem.*[a]	8.60
4	*J. Mol. Biol.*	7.47
5	*J. Biol. Chem.*	5.84
6	*J. Cyclic Nucl. Res.*	5.81
7	*Biochemistry-U.S.A.*	5.14
8	*Eur. J. Biochem.*	3.76
9	*J. Lipid Res.*	3.65
10	*Biochem. Biophys. Res. Commun.*	3.39
11	*Biochem. J.*	3.22
12	*Biochim. Biophys. Acta*	3.18
13	*Nucleic Acids Res.*	3.11
14	*FEBS Lett.*	2.91
15	*Arch. Biochem. Biophys.*	2.88
16	*H.-S. Z. Physiol. Chem.*	2.31
17	*Mol. Cell. Biochem.*	2.20
18	*Biochem. Soc. Trans.*	2.16
19	*Anal. Biochem.*	1.96
20	*Chem. Phys. Lipids*	1.95
21	*Lipids*	1.92
22	*J. Biochem.-Tokyo*	1.86
23	*Can. J. Biochem.*	1.83
24	*Bioorg. Chem.*	1.55
25	*Bioinorg. Chem.*	1.43
26	*Prep. Biochem.*	1.22
27	*Ukr. Biokhim. Zh.*	1.19
28	*Biochimie*	1.13
29	*Ital. J. Biochem.*	1.11
30	*Seikagaku*	1.05
31	*Int. J. Pept. Prot. Res.*	0.85
32	*Acta Biochim. Biophys.*	0.80
33	*Int. J. Biochem.*	0.77
34	*Bioorg. Khim.*	0.70
35	*Acta Biochim. Pol.*	0.57
36	*Biokhimiya*	0.56
37	*Postepy Biochem.*	0.34
38	*Indian J. Biochem. Biophys.*	0.33
39	*Rev. Roum. Biochim.*	0.32
40	*Physiol. Chem. Phys.*	0.28

[a] Review journals.

divided by the total number of 1975 and 1976 articles published. As usual in these kinds of lists, the review journals are at the top [9–10]. The top core journals in terms of impact are *J. Mol. Biol.* (7.47), *J. Biol. Chem.* (5.84), *J. Cyclic Nucl. Res.* (5.81), and *Biochemistry* (5.12). As one would expect, these international journals perform substantially better than journals from Eastern Europe or the Third World.

As I mentioned at the beginning of this article, developing precise measurements of any part of the scientific literature is a difficult task. I have only scratched the surface of the problem. But what I have presented here represents an enormous investment of time and energy. The number of variables involved seems endless. I hope this work will interest others in conducting additional bibliometric studies of this type. ISI stands ready to assist those who take up the challenge.

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Current Comments

The Number of Biochemical Articles Is Growing, But Why Also the Number of References per Article?

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Shortly after *Trends in Biochemical Sciences* (*TIBS*) was launched by Elsevier Press in 1976 its first editor, Joan Morgan, asked me to prepare a paper on the growth of the biochemical literature. When I accepted this invitation, I did not realize what it would really take to provide the exhaustive study of the literature it implied. I am sure that Joan Morgan thought it was simply a question of turning on the ISI® faucet and letting the facts pour out. She was no less naive than most people who often make similar requests of me.

When we first started the paper, it was simply going to be another exercise in identifying the core journals in biochemistry. Later it evolved into a census-taking operation. We wanted to know about the growth of the biochemical literature between 1962-77. But more importantly, we saw an opportunity to observe significant quantitative changes in citation patterns.

The paper that I ultimately submitted to *TIBS* was the result of a staggering amount of work.[1] What I thought would be a six-month project took 18 months to complete. We encountered enormous difficulties. While the average biochemist would regard these problems as so much trivia, a genealogist or an epidemiologist might appreciate the difficulties in tracking the history of numerous biochemical journals that either split into different sections,[2] changed their names, or merged with other publications between 1962 and 1977. There were other difficulties, not the least of which was the sheer volume of data we had to work with. It also proved challenging to keep the project together during the time it took to complete.

The paper which was finally published in *TIBS* is reprinted here. But the editors felt they could not justify the space for four tables of data that I have included here, following this editorial. While one can always appreciate the need for any journal to conserve space,[3] the deletion of these tables was somewhat ironic. An earlier paper by the late Robert A. Harte,[4] also published in *TIBS*, appeared without some crucial supporting data. As a consequence we could not compare our data on the doubling time for certain journals.

Our study included 40 core journals of biochemistry, listed in Table A. Three of them were review journals. For those that began publication after 1962, the year of first issue is given. The table also includes information on journal title changes. The biochemical literature probably is still the fastest growing of any field in science. This can't be determined for certain without similar data for other fields. However, the explosive growth rate in the 1960s slowed somewhat during the past decade. Consider for example *Hoppe-Seyler's Zeitschrift für Physiologische*

Chemie. In 1962 this journal published 87 articles per year. By 1969 this increased to 418—an increase of 380% in annual output. Between 1970 and 1977, the annual output increased by only 81%.

But in contrast with the primary literature of biochemistry, the review journals have grown at a much slower rate, if at all, since 1968. Table B lists the three core review journals studied. The number of source items for each journal, along with the average number of references per item, are provided.

Table C illustrates the growth during the 1960s of the so-called CEBJ journals: journals whose editors are full members of the Committee of Editors of Biochemical Journals of the International Union of Biochemistry. The table supports my discussion of the CEBJ journals' growth rates in the text.

Table D lists the average references per source item for each of the 37 primary journals from 1968 to 1977. In the text, I assert that some CEBJ journals have increased their average number of references per source item by as much as 64% in 16 years. This assertion is supported by the data contained in Tables C and D.

The reprinted paper that follows represents my first attempt at a comprehensive study of an entire field of literature. It's not quite the same thing as determining the 100 most-cited authors. Nevertheless studies of this sort are well worth the effort. They can reveal much about trends in science. I hope this paper will encourage others to undertake similar bibliometric studies.

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Tom Di Renzo, Calvin Lee, and Ed Feinberg among others were involved in the research and data gathering for this paper. Tom Di Julia helped prepare these introductory remarks.

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Table A: Core biochemical journals studied, listed alphabetically according to abbreviated titles.

TABLE A

Abbreviated Title	Full Title	Notes
Acta Biochim. Biophys.	Acta Biochimica et Biophysica	1966[1]
Acta Biochim. Pol.	Acta Biochimica Polonica	
Adv. Enzymol. RAMB	Advances in Enzymology and Related Areas of Molecular Biology	[2]
Anal. Biochem.	Analytical Biochemistry	
Annu. Rev. Biochem.	Annual Review of Biochemistry	
Arch. Biochem. Biophys.	Archives of Biochemistry and Biophysics*	
Biochem. Biophys. Res. Commun.	Biochemical and Biophysical Research Communications	
Biochem. J.	Biochemical Journal*	
Biochem. Soc. Trans.	Biochemical Society Transactions	1973[1,3]
Biochemistry-US	Biochemistry*	1962[1]
Biochim. Biophys. Acta	Biochimica et Biophysica Acta*	
Biochimie	Biochimie*	[4]
Bioinorg. Chem.	Bioinorganic Chemistry	1971[1]
Biokhimiya (Biochemistry-USSR)	Biokhimiya (Biochemistry-USSR)*	
Bioorg. Chem.	Bioorganic Chemistry	1971[1]
Bioorg. Khim.	Bioorganicheskaya Khimiya	1975[1]
Can. J. Biochem.	Canadian Journal of Biochemistry	[5]
Chem. Phys. Lipids	Chemistry and Physics of Lipids	1966[1]
CRC Crit. R. Biochem.	CRC Critical Reviews in Biochemistry	1972[1]
Eur. J. Biochem.	European Journal of Biochemistry*	[6]
FEBS Lett.	FEBS Letters	1968[1]
H-S. Z. Physiol. Chem.	Hoppe-Seyler's Zeitschrift fur Physiologische Chemie*	
Indian J. Biochem. Biophys.	Indian Journal of Biochemistry & Biophysics	[7]
Int. J. Biochem.	International Journal of Biochemistry	1970[1]
Int. J. Pept. Prot. Res.	International Journal of Peptide and Protein Research	1969[1,8]
Ital. J. Biochem.	Italian Journal of Biochemistry	
J. Biochem.-Tokyo	Journal of Biochemistry-Tokyo*	
J. Biol. Chem.	Journal of Biological Chemistry*	
J. Cyclic Nucl. Res.	Journal of Cyclic Nucleotide Research	1975[1]
J. Lipid Res.	Journal of Lipid Research	
J. Mol. Biol.	Journal of Molecular Biology*	
Lipids	Lipids	1966[1]
Mol. Cell. Biochem.	Molecular and Cellular Biochemistry	[9]
Nucleic Acids Res.	Nucleic Acids Research	1974[1]
Physiol. Chem. Phys.	Physiological Chemistry and Physics	1969[1]
Postepy Biochem.	Postepy Biochemii	
Prep. Biochem.	Preparative Biochemistry	1971[1]
Rev. Roum. Biochim.	Revue Roumaine de Biochimie	1964[1]
Seikagaku	Seikagaku	
Ukr. Biokhim. Zh.	Ukrainskii Biokhimicheskii Zhurnal	

*Full member IUB Committee of Editors of Biochemical Journals as of December 1978.

[1]First year of publication.

[2]Title was *Advances in Enzymology and Related Subjects of Biochemistry* through 1966.

[3]Replaced proceedings section formerly included in *Biochemical Journal*, 1973.

[4]Title *Bulletin de la Societe de Chimie Biologique* through 1970.

[5]Partial continuation of *Canadian Journal of Biochemistry and Physiology*, 1964.

[6]Superseded *Biochemische Zeitschrift*, March 1967.

[7]Partially superseded *Annals of Biochemistry and Experimental Medicine* in 1964 as *Indian Journal of Biochemistry*; title changed 1971.

[8]Title was *International Journal of Protein Research* through Vol. 4, No. 1, 1972.

[9]Superseded *Enzymologia* May 1973.

Table B: Total number of source items and average number of references per item for the core biochemistry review journals for the years 1968-1977.

TABLE B

Journal	Publication Year									
	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
Adv. Enzymol. RAMB										
Source Items	11	10	10	16	8	22	13	13	7	6
References/Item	147.9	209.4	148.3	245.8	165.9	216.5	145.2	169.3	108.1	141.0
Annu. Rev. Biochem.										
Source Items	26	29	30	38	32	24	32	34	30	30
References/Item	199.3	234.5	235.2	228.6	232.2	200.6	241.8	209.0	227.0	215.0
CRC Crit. R. Biochem.										
Source Items	—	—	—	—	4	8	10	6	6	5
References/Item	—	—	—	—	192.8	287.9	173.5	239.8	124.2	191.8

Table C: Total number of source items and average number of references per item for the CEBJ primary journals for the years 1962-1967.

TABLE C

Journal	Publication Year					
	1962	1963	1964	1965	1966	1967
Arch. Biochem. Biophys.						
Source Items	408	296	416	425	440	517
References/Item	19.1	18.8	21.1	18.1	21.4	21.3
Biochem. J.						
Source Items	814	804	717	909	929	1043
References/Item	14.2	14.0	17.8	17.0	16.1	17.9
Biochemistry-US						
Source Items	172	250	354	397	606	510
References/Item	25.6	24.0	24.6	24.9	26.4	26.6
Biochim. Biophys. Acta						
Source Items	1372	1258	1427	1492	1587	1648
References/Item	16.3	16.7	16.9	18.6	18.3	19.0
Biochimie						
Source Items	94	193	346	442	223	283
References/Item	22.8	13.2	9.4	9.2	12.1	13.0
Biokhimiya						
Source Items	157	153	160	173	169	168*
References/Item	18.5	18.0	17.4	18.2	18.7	18.2
Eur. J. Biochem.						
Source Items	109	159	99	137	114	174
References/Item	22.3	25.8	23.7	25.0	27.1	27.3
H-S. Z. Physiol. Chem.						
Source Items	87	156	132	153	143	366
References/Item	17.6	19.7	18.2	20.5	20.9	15.7
J. Biochem.-Tokyo						
Source Items	157	184	216	204	221	243
References/Item	15.0	15.0	16.5	16.7	17.8	17.4
J. Biol. Chem.						
Source Items	680	675	678	751	910	845
References/Item	23.4	24.9	27.3	26.8	26.8	27.5
J. Mol. Biol.						
Source Items	133	133	228	330	417	387
References/Item	20.4	20.9	21.0	21.2	21.8	21.3

*Estimated, based on data for second half of 1967.

Table D: Average number of references per source item for the core primary journals for the years 1968-1977.

TABLE D

Journal	Publication Year									
	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
Acta Biochim. Biophys.	9.6	17.0	14.4	5.6	15.9	5.4	18.2	16.4	2.6	19.1
Acta Biochim. Pol.	22.2	20.8	20.4	20.5	19.6	21.5	21.9	21.2	24.4	21.1
Anal. Biochem.	11.9	12.9	12.0	13.2	13.9	13.5	13.5	15.8	14.7	16.4
Arch. Biochem. Biophys.	24.3	23.5	24.1	25.1	26.2	25.7	26.1	29.0	29.5	30.1
Biochem. Biophys. Res. Commun.	12.1	13.2	13.2	13.7	14.4	14.9	15.2	15.5	16.0	16.5
Biochem. J.	17.9	17.5	17.6	16.5	15.4	26.0	25.9	26.9	26.4	26.9
Biochem. Soc. Trans.	—	—	—	—	—	10.3	11.6	10.0	10.3	11.2
Biochemistry-US	26.7	26.3	27.6	27.3	28.7	28.4	29.8	30.6	31.8	31.9
Biochim. Biophys. Acta	18.8	19.9	19.7	21.7	22.8	24.4	25.1	26.8	27.1	26.7
Biochimie	26.2	19.4	21.0	21.6	23.8	23.3	24.8	24.3	25.9	26.9
Bioinorg. Chem.	—	—	—	20.3	21.5	21.9	20.8	25.6	23.1	20.8
Biokhimiya	18.8	17.3	16.8	17.4	16.8	17.1	18.2	17.8	18.8	21.9
Bioorg. Chem.	—	—	—	25.2	18.9	33.4	32.0	23.9	28.1	29.0
Bioorg. Khim.	—	—	—	—	—	—	—	15.4	20.7	18.5
Can. J. Biochem.	24.3	20.9	22.5	22.2	22.3	23.0	24.7	24.8	24.4	27.3
Chem. Phys. Lipids	23.8	22.2	32.8	17.9	18.3	24.9	23.1	19.2	23.4	23.0
Eur. J. Biochem.	26.7	27.3	25.3	26.4	27.1	26.5	27.8	28.5	28.5	28.7
FEBS Lett.	11.8	12.7	12.6	14.1	14.4	15.7	17.0	17.0	16.5	16.7
H-S. Z. Physiol. Chem.	12.9	13.0	10.8	18.6	9.5	8.8	10.9	12.2	9.2	6.9
Indian J. Biochem. Biophys.	17.5	17.4	15.3	20.0	17.1	16.2	19.3	19.0	6.9	5.5
Int. J. Biochem.	—	—	20.6	20.1	24.2	24.4	21.0	27.2	24.9	26.0
Int. J. Pept. Prot. Res.	—	24.8	20.2	26.3	31.4	25.6	25.4	20.1	25.2	24.6
Ital. J. Biochem.	43.0	49.3	20.2	20.8	20.8	19.8	12.8	3.3	17.0	8.3
J. Biochem.-Tokyo	18.0	19.3	20.5	18.1	20.5	19.3	21.1	21.1	19.5	22.6
J. Biol. Chem.	28.4	29.0	27.5	29.4	29.0	29.3	30.7	30.9	31.7	30.4
J. Cyclic Nucl. Res.	—	—	—	—	—	—	—	25.3	25.5	25.9
J. Lipid Res.	24.9	22.3	25.2	26.8	25.9	25.8	24.6	29.3	24.8	28.3
J. Mol. Biol.	23.2	24.2	24.0	26.0	26.0	27.0	28.7	28.9	30.3	30.3
Lipids	17.3	16.7	20.6	21.6	20.5	18.2	24.3	19.2	22.3	21.1
Mol. Cell. Biochem.	18.5	21.2	17.5	17.5	19.0	45.7	33.5	38.6	41.5	33.1
Nucleic Acids Res.	—	—	—	—	—	—	20.1	19.6	21.5	23.6
Physiol. Chem. Phys.	—	23.3	18.9	18.5	20.0	18.3	18.7	17.8	18.4	22.0
Postepy Biochem.	84.1	76.3	80.3	74.2	98.3	98.0	89.2	99.1	89.8	118.8
Prep. Biochem.	—	—	—	17.8	16.1	15.5	17.7	14.7	20.8	15.9
Rev. Roum. Biochim.	15.0	10.1	16.1	17.2	16.8	17.1	17.8	15.4	16.9	16.9
Seikagaku	49.3	41.7	37.3	51.4	20.6	40.4	59.2	84.7	48.9	29.8
Ukr. Biokhim. Zh.	13.2	16.5	23.4	20.1	19.6	19.4	17.3	22.2	18.6	18.5
AVG. BIOCHEM. JNL.	21.2	21.7	21.0	22.3	21.7	22.8	23.9	24.1	23.6	23.4
AVG. *SCI* JNL.	12.0	11.6	11.6	12.1	12.4	12.6	13.1	13.3	13.7	13.5