

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.

* * * * *

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
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.

¹First year of publication.

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

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

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

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

⁶Superseded *Biochemische Zeitschrift*, March 1967.

⁷Partially superseded *Annals of Biochemistry and Experimental Medicine* in 1964 as *Indian Journal of Biochemistry*; title changed 1971.

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

⁹Superseded *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.

Journal	Publication Year									
	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
<u>Adv. Enzymol. RAMB</u>										
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
<u>Annu. Rev. Biochem.</u>										
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
<u>CRC Crit. R. Biochem.</u>										
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.

Journal	Publication Year					
	1962	1963	1964	1965	1966	1967
<u>Arch. Biochem. Biophys.</u>						
Source Items	408	296	416	425	440	517
References/Item	19.1	18.8	21.1	18.1	21.4	21.3
<u>Biochem. J.</u>						
Source Items	814	804	717	909	929	1043
References/Item	14.2	14.0	17.8	17.0	16.1	17.9
<u>Biochemistry-US</u>						
Source Items	172	250	354	397	606	510
References/Item	25.6	24.0	24.6	24.9	26.4	26.6
<u>Biochim. Biophys. Acta</u>						
Source Items	1372	1258	1427	1492	1587	1648
References/Item	16.3	16.7	16.9	18.6	18.3	19.0
<u>Biochimie</u>						
Source Items	94	193	346	442	223	283
References/Item	22.8	13.2	9.4	9.2	12.1	13.0
<u>Biokhimiya</u>						
Source Items	157	153	160	173	169	168*
References/Item	18.5	18.0	17.4	18.2	18.7	18.2
<u>Eur. J. Biochem.</u>						
Source Items	109	159	99	137	114	174
References/Item	22.3	25.8	23.7	25.0	27.1	27.3
<u>H-S. Z. Physiol. Chem.</u>						
Source Items	87	156	132	153	143	366
References/Item	17.6	19.7	18.2	20.5	20.9	15.7
<u>J. Biochem.-Tokyo</u>						
Source Items	157	184	216	204	221	243
References/Item	15.0	15.0	16.5	16.7	17.8	17.4
<u>J. Biol. Chem.</u>						
Source Items	680	675	678	751	910	845
References/Item	23.4	24.9	27.3	26.8	26.8	27.5
<u>J. Mol. Biol.</u>						
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. INL.	21.2	21.7	21.0	22.3	21.7	22.8	23.9	24.1	23.6	23.4
AVG. SC/ INL.	12.0	11.6	11.6	12.1	12.4	12.6	13.1	13.3	13.7	13.5