The Agony and the Ecstasy—
The History and Meaning of the Journal Impact Factor

Presented by

Eugene Garfield
Chairman Emeritus, Thomson ISI
3501 Market Street, Philadelphia PA 19104
Fax: 215-387-1266 - Tel. 215-243-2205
garfield@codex.cis.upenn.edu
www.eugenegarfield.org

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I had considered as an alternative title for my talk "Citation Sanity and Insanity -- the Obsession and Paranoia of Citations and Impact Factors." Others might have preferred "Uses and Abuses of Impact Factors."

Origins of the Impact Factor

I first mentioned the idea of an impact factor in *Science* magazine in 1955.[1] That paper is considered the primordial reference for the concept of the *Science Citation Index*. Five years later, we began the experimental *Genetics Citation Index* project which led to the publication of the 1961 *Science Citation Index.* In 1955, it did not occur to me that "impact" would one day become so controversial. Like nuclear energy, the impact factor is a mixed blessing. I expected it to be used constructively while recognizing that in the wrong hands it might be abused. Since *Current Contents*, no less *SCI*, did not exist, it would have been precocious indeed to contemplate the influence of the nascent impact factor.

In the early 1960s, Irving H. Sher and I created the journal impact factor to help select journals for the new *Science Citation Index (SCI)*. To do this we simply re-sorted the author citation index into the journal citation index. From this simple exercise, we learned that initially a core group of large and highly cited journals needed to be covered in the new *SCI*.

SLIDE 1: TOP JOURNALS SORTED BY ARTICLES PUBLISHED IN 2004

TOP JOURNALS SORTED BY NUMBER OF ARTICLES, 2004

Abbreviated Journal Title	Total Cites	Impact Factor	Articles
J BIOL CHEM	405017	6.355	6585
P NATL ACAD SCI USA	345309	10.452	3084
BIOCHEM BIOPH RES CO	64346	2.904	2312
J IMMUNOL	108602	6.486	1793
BIOCHEMISTRY-US	96809	4.008	1687
J VIROL	74388	5.398	1464
J AGR FOOD CHEM	27992	2.327	1261
CANCER RES	105196	7.690	1253
J NEUROSCI	93263	7.907	1233
BLOOD	97885	9.782	1206
NUCLEIC ACIDS RES	66057	7.260	1160
CIRCULATION	115133	12.563	1129
FEBS LETT	54417	3.843	1112
NEUROSCI LETT	25138	2.019	1101
J CLIN MICROBIOL	35117	3.439	1090
TRANSPLANT P	9048	0.511	1070
CLIN CANCER RES	23585	5.623	1052
BRAIN RES	58204	2.389	1037
J UROLOGY	39589	3.713	1029
ONCOGENE	45546	6.318	1003

Slide 1

In Slide 1, we see the top 20 life science journals sorted by the number of articles published in 2004. *Journal of Biological Chemistry* published 6,500 articles last year.

SLIDE 2: MOST-CITED LIFE SCIENCE JOURNALS 2004

In contrast, slide 2 shows the list of journals most-cited in 2004. The *JBC* was cited over 400,000 times last year – this includes citations to any articles in its entire history.

However, we also recognized that smaller but important review and specialty journals might not be selected if we depended solely on total publication or citation counts.[2]
We needed a simple method for comparing journals regardless of size or citation frequency. So we created the journal "impact factor."

MOST-CITED JOURNALS, 2004

Abbreviated Journal Title	Total Cites	Impact Factor	Articles
J BIOL CHEM	405017	6.355	6585
NATURE	363374	32.182	878
P NATL ACAD SCI USA	345309	10.452	3084
SCIENCE	332803	31.853	845
J AM CHEM SOC	231890	6.903	3167
PHYS REV LETT	229765	7.218	3575
PHYS REV B	185905	3.075	4964
NEW ENGL J MED	159498	38.570	316
ASTROPHYS J	144264	6.237	2478
J CHEM PHYS	138693	3.105	2772
CELL	136472	28.389	288
LANCET	126002	21.713	415
CIRCULATION	115133	12.563	1129
APPL PHYS LETT	112516	4.308	3731
J IMMUNOL	108602	6.486	1793
J GEOPHYS RES	105601	2.839	2085
CANCER RES	105196	7.690	1253
BLOOD	97885	9.782	1206
BIOCHEMISTRY-US	96809	4.008	1687
J NEUROSCI	93263	7.907	1233

Slide 2.

SLIDE 3: LIFE SCIENCE JOURNALS SORTED BY IMPACT FACTOR

TOP JOURNALS SORTED BY IMPACT FACTOR, 2004

Abbreviated Journal Title	Total Cites	Impact Factor	Articles
ANNU REV IMMUNOL	14357	52.431	30
CA-CANCER J CLIN	3725	44.515	
NEW ENGL J MED	159498	38.570	316
NAT REV CANCER	6618	36.557	79
PHYSIOL REV	14671	33.918	35
NAT REV MOL CELL BIO	9446	33.170	84
NAT REV IMMUNOL	5957	32.695	80
NATURE	363374	32.182	878
SCIENCE	332803	31.853	845
ANNU REV BIOCHEM	16487	31.538	33
NAT MED	38657	31.223	168
CELL	136472	28.389	288
NAT IMMUNOL	14063	27.586	130
JAMA-J AM MED ASSOC	88864	24.831	351
NAT GENET	49529	24.695	191
ANNU REV NEUROSCI	8093	23.143	26
PHARMACOL REV	7800	22.837	19
NAT BIOTECHNOL	18169	22.355	138
LANCET	126002	21.713	415

Slide 3

Slide 3 shows the life science journals ranked by impact factor. Note the appearance of small review journals.

The term "impact factor" has gradually evolved, especially in Europe, to describe both journal and author impact. This ambiguity often causes problems. It is one thing to use impact factors to compare journals and quite another to use them to compare authors. Journal impact factors generally involve relatively large populations of articles and citations. Individual authors, on average, produce much smaller numbers of articles although some are phenomenal. The transplant surgeon Tom Starzl has co-authored over 2,000 articles.[3] Over ten years ago, I attended a celebration of Carl Djerassi's 1000th paper.[4]

While my 1955 paper is considered primordial for citation indexing history, it is my 1972 paper in *Science* on "Citation Analysis as a tool in journal evaluation," that has received most attention from journal editors.[5] That paper was published before the *Journal Citation Reports* existed. We used a quarterly issue of the 1969 SCI to identify the most significant journals of science. I bring

this up for an important reason. While our analysis was based on a large sample of literature, the annual *JCR* is not based on a sample. The *JCR* today includes every citation that appears in the 5,000 plus journals that it covers. Therefore, discussions of sampling errors in relation to *JCR* are not particularly meaningful. Furthermore, I myself deplore the quotation of impact factors to three decimal places. ISI uses three decimal places to reduce the number of journals with the identical impact rank. It matters very little whether the impact of *JAMA* is quoted as 21.5 rather than 21.455.

A journal's impact factor is based on two elements: the numerator, which is the number of cites in the current year to any items published in the journal in the previous 2 years; and the denominator, the number of substantive articles (source items) published in the same 2 years. The impact factor could just as easily be based on the previous year's articles alone, which would give even greater weight to rapidly changing fields. A less current impact factor could take into account longer periods of citations and/or sources, but then the measure would be less current. The *JCR* help page provides instruction for computing five-year impact factors.

Scientometrics and Journalology

Citation analysis has blossomed over the past three decades into the field of scientometrics which now has its own International Society of Scientometrics and Informetrics (ISSI).[6] The journal *Scientometrics* was started in 1978. Over 15 years ago, Steve Lock aptly named the application of scientometrics to journals evaluation "journalology."[7]
All citation studies should be normalized to take into account variables such as the discipline, citation density, and half-life.[8]. The citation density is the average number of references cited per source article. Citation density (R/S) is significantly lower for mathematics journals than for molecular biology journals. The half-life (number of retrospective years required to find 50% of the cited references) is longer for a physiology journal than that for a physics journal. For some fields, *JCR*'s two-year based impact factors may or may not give as complete a picture as would a five- or ten-year period.

Nevertheless, when journals are studied within disciplinary categories, the rankings based on 1-, 7- or 15-year impact factors do not differ significantly. I reported on this in *The Scientist*.[9,10] seven years ago. When journals were studied across fields, the ranking for physiology journals improved significantly as the number of years increased, but the rankings within the physiology category did not change significantly. Similarly, Hansen and Henrikson[11] reported "good agreement between the journal impact factor and the overall [cumulative] citation frequency of papers on clinical physiology and nuclear medicine."

There are always exceptions to these generalities. Impact critics will usually find them. They also cite all sorts of anecdotal citation behavior which do not represent average behavior. The same can be said about alleged citation errors, most of which are really variants of one kind or another or do not affect impact since only variants in cited journal
abbreviations matter in calculating impact. These are all unified prior to issuing the *JCR* each

year. And a huge number of author errors or variants are corrected by the ISI system but unseen to the user.

The impact factors reported by *JCR* tacitly imply that all editorial items in *Science, Nature, JAMA, NEJM*, etc. can be neatly categorized. Such journals publish large numbers of items that are not substantive research or review articles. Correspondence, letters, news stories, obituaries, editorials, interviews, and tributes are not included in *JCR*'s calculation of source items (the denominator). But we all know that they may be cited, especially in the current year, but that is also why they don't have a significant effect on the impact calculations. Nevertheless, since the *JCR* numerator includes citations to these more ephemeral items, some distortion will result. But only a small group of journals are affected, if at all. Those that are affected change by 5 or 10%.[8]

The assignment of article publication codes is based on human judgment. A news story might be perceived as a substantive article, and a significant letter might not be. Furthermore, no effort is made to differentiate clinical versus laboratory studies or, for that matter, practice-based versus research-based articles. All these potential variables provide grist for the critical mill of citation aficionados.

Size vs. Citation Density

There is a widespread but mistaken belief that the size of the scientific community that a journal serves significantly affects the journal's impact factor. This assumption overlooks the fact that while more authors produce more citations, these must be shared by a larger number of cited articles. Most articles in most fields are not well cited, whereas some articles in small fields may have unusual impact, especially where they have cross-disciplinary impact. It is well known that there is a skewed distribution of citations in most fields. The well-known 80/20 rule applies in that 20% of articles may account for 80% of the citations.

To reiterate -- the key determinants in impact are not the number of authors or articles in the field but, rather, the citation density and the age of the literature cited. The average number of citations per article and the immediacy of citations are the significant elements.[12] The size of a field, however, will generally increase the number of "super-cited" papers. And while a few classic methodology papers exceed a high threshold of citation, thousands of other methodology and review papers do not. Nevertheless, review papers on average are cited about twice the average. Publishing mediocre review papers will not necessarily boost your journal's impact.

SLIDE 4: SUPER CITED PAPERS IN THE LIFE SCIENCES

For your amusement, consider this short list of super-cited papers in the life sciences. Incidentally, since they are all a decade or more old, they don't affect the calculation of their journal's impact factor. The Lowry paper was recently discussed in *Journal of Biological*

Chemistry[13] but the authors failed to mention Lowry's own commentary on this most-cited paper in the history of science.[14] Lowry himself noted that it was not his most important paper.

MOST-CITED ARTICLES IN THE *ISI WEB OF SCIENCE* 1945-July, 2005

Authors	Title	Source	Yr	V	Pg	Hits
LOWRY, OH; ROSEBROUGH, NJ; FARR, AL; RANDALL, RJ	PROTEIN MEASUREMENT WITH THE FOLIN PHENOL REAGENT	JOURNAL OF BIOLOGICAL CHEMISTRY	1951	193	265	293,328
LAEMMLI, UK	CLEAVAGE OF STRUCTURAL PROTEINS DURING ASSEMBLY OF HEAD OF BACTERIOPHAGE-T4	NATURE	1970	227	680	192,022
BRADFORD, MM	RAPID AND SENSITIVE METHOD FOR QUANTITATION OF MICROGRAM QUANTITIES OF PROTEIN UTILIZING PRINCIPLE OF PROTEIN-DYE BINDING	ANALYTICAL BIOCHEMISTRY	1976	72	248	120,179
SANGER, F; NICKLEN, S; COULSON, AR	DNA SEQUENCING WITH CHAIN-TERMINATING INHIBITORS	PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES OF THE UNITED STATES OF AMERICA	1977	74	5463	63,909
CHOMCZYNSKI, P; SACCHI, N	SINGLE-STEP METHOD OF RNA ISOLATION BY ACID GUANIDINIUM THIOCYANATE PHENOL CHLOROFORM EXTRACTION	ANALYTICAL BIOCHEMISTRY	1987	162	156	55,987
TOWBIN, H; STAEHELIN, T; GORDON, J	ELECTROPHORETIC TRANSFER OF PROTEINS FROM POLYACRYLAMIDE GELS TO NITROCELLULOSE SHEETS - PROCEDURE AND SOME APPLICATIONS	PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES OF THE UNITED STATES OF AMERICA	1979	76	4350	48,671
FOLCH, J; LEES, M; STANLEY, GHS	A SIMPLE METHOD FOR THE ISOLATION AND PURIFICATION OF TOTAL LIPIDES FROM ANIMAL TISSUES	JOURNAL OF BIOLOGICAL CHEMISTRY	1957	226	497	35,646
SOUTHERN, EM	DETECTION OF SPECIFIC SEQUENCES AMONG DNA FRAGMENTS SEPARATED BY GEL-ELECTROPHORESIS	JOURNAL OF MOLECULAR BIOLOGY	1975	98	503	31,273

Slide 4

I have not included here super cited books such as *Molecular Cloning: a Laboratory Manual* by Maniatis and Sambrook which appeared[15] in numerous editions beginning with 1982. They have been cited in at least 150,000 papers. This is my way of reminding those who are book authors, that *SCI*, *SSCI* and *A&HCI* do include citations to books as well as individual chapters of books.

SLIDE 5: CITATION FREQUENCY DISTRIBUTIONS

Citation Frequency Distribution 1900-August, 2005
(articles cited at least once)

Number of Citations	Approx # of Items Receive Citations	% of WOS
>10,000	61	0.00%
5,000-9,000	120	0.00%
4,000-4,999	116	0.00%
3,000-3,999	215	0.00%
2,000-2,999	664	0.00%
1,000-1,999	3,887	0.02%
900-999	1,232	0.00%
800-899	1,762	0.01%
700-799	2,614	0.01%
600-699	4,077	0.02%
500-599	6,637	0.03%
400-499	12,557	0.06%
300-399	27,059	0.14%
200-299	74,025	0.37%
100-199	343,269	1.73%
50-99	953,064	4.83%
25-49	2,006,529	10.1%
15-24	2,226,603	11.2%
10-14	2,106,995	10.6%
5-9	3,891,542	19.5%
2-4	4,931,952	24.7%
1	3,343,789	16.7%
Items Cited	**19,938,769**	**100.1%**
Total Items in File	**38,163,319**	

Slide 5

For a more realistic view of citation frequencies, slide 5 shows that from 1900-2005, about one half of one percent of cited papers were cited over 200 times. Out of about 38 million source items about half were not cited at all. Keep in mind that "items" includes not only substantive articles but also ephemera mentioned earlier. Therefore, these data provide a distorted picture for high impact journals where the number of uncited publications is much smaller.

The skewness of citations is well known and repeated as a mantra by critics of the impact factor. On the one hand, some editors would like to see impacts calculated solely on the basis of their most-cited papers so that their otherwise low impact factors can be ignored. However, since most journals experience this skewness, that should not significantly affect journal rankings. Others would like to see rankings by geographic area because of *SCI*'s alleged English language bias. Europhiles would like to be able to compare their journals by language or geographic groups especially in the social sciences and humanities.

The time required to referee manuscripts may also affect impact. If manuscript processing is delayed, references to articles that are no longer within the *JCR* two-year window will not be counted.[16]

Alternatively, the appearance of articles on the same subject in the same issue of a journal may have an upward effect. Opthof[17] showed how journal impact performance can vary from issue to issue.

For greater precision, it is preferable to conduct item-by-item journal audits so that any differences in impact for different types of editorial items can be taken into account.[18]

Other objections to impact factors are related to the system used in *JCR* to categorize journals. In a perfect system it ought to be possible to compare journals with an identical profile. But in fact there rarely are two journals with identical semantic or bibliographic profiles. ISI's heuristic, somewhat subjective methods for categorizing journals are by no means perfect, even though their specialists do use citation analysis to support their decisions. Some might argue that JCR categories are larger than necessary. Recent work by Alexander Pudovkin and myself[19] is an attempt to group journals more objectively. We rely on the two-way citational relationships between journals to reduce the subjective influence of journal titles. Three decades ago, I demonstrated that journal titles can be deceiving. Citation analysis proved the *Journal of Experimental Medicine* was a leading immunology journal.[20] It still is one of the five top immunology journals based on its impact factor.

SLIDE 6: GENERAL INTERNAL MEDICINE CATEGORY SORTED BY IMPACT 2004.

In Slide 6, you see the list of journals in the JCR category "Medicine, General and Internal." There are no surprises here. Few would quarrel with the assignment of these journals to this category, but this tells us little about their actual subject content.

MEDICINE, GENERAL & INTERNAL
Journals sorted by Impact factor

Abbreviated Journal Title	Total Cites	Impact Factor	Articles
NEW ENGL J MED	159498	38.570	316
JAMA-J AM MED ASSOC	88864	24.831	351
LANCET	126002	21.713	415
ANN INTERN MED	36932	13.114	189
ANNU REV MED	3188	11.200	29
ARCH INTERN MED	26525	7.508	282
BRIT MED J	56807	7.038	623
CAN MED ASSOC J	6736	5.941	100
AM J MED	21000	4.179	285
MAYO CLIN PROC	6816	3.746	161
MEDICINE	4255	3.727	30
ANN MED	2626	3.617	79
J INTERN MED	4793	3.590	135
AM J PREV MED	3972	3.188	143
CURR MED RES OPIN	1148	2.928	212
J GEN INTERN MED	4686	2.821	163
QJM-INT J MED	4073	2.580	73
EUR J CLIN INVEST	4332	2.530	110
PREV MED	5372	2.327	287
J PAIN SYMPTOM MANAG	2941	2.187	117

Slide 6

SLIDE 7: CALCULATING RELATEDNESS COEFFICIENTS

JCR recently added a new feature which provides you the ability to more precisely establish journal categories based on citation relatedness. Slide 7 provides the general formula for calculating citation relatedness between two journals and the relatedness coefficient expressing the average of the maximum and minimum.

CALCULATING RELATEDNESS COEFFICIENT OF JOURNAL$_1$ AND JOURNAL$_2$

$$R_{1>2} = \frac{C_{1>2} \times 10^6}{Ref_1 \times Pap_2}$$

$$R_{1<2} = \frac{C_{1<2} \times 10^6}{Ref_2 \times Pap_1}$$

$$R_{coeff} = \sqrt{R_{1>2} \times R_{1<2}}$$

C = Citations

Ref$_1$ is the number of references cited in Journal 1.

Pap$_2$ is the number of papers published by Journal 2.

Ref$_2$ is the number of references cited in Journal 2.

SLIDE 8: JOURNALS: *JAMA* - RELATED JOURNALS SORTED BY CITATION RELATEDNESS COEFFICIENT

Slide 8

JOURNALS MOST RELATED BY CITATION RELATEDNESS TO JAMA
√ = Not in Medicine, General & Internal Category

	Journal	Rcoefficient
	JAMA-J AM MED ASSOC	274.97
	ANN INTERN MED	127.26
	NEW ENGL J MED	123.09
	ARCH INTERN MED	89.85
	J GEN INTERN MED	70.26
√	CONTROL CLIN TRIALS	69.23
√	ADV RENAL REPLACE TH	66.41
√	MED CARE	66.02
	J FAM PRACTICE	64.81
√	HEALTH AFFAIR	64.64
√	J AM GERIATR SOC	53.06
√	CURR CONTR TRIALS C	52.84
√	ACAD MED	52.75
√	INQUIRY-J HEALTH CAR	52.00
	CAN MED ASSOC J	46.98
	AM J MED	46.70
	AM J PREV MED	45.37
√	ARCH PEDIAT ADOL MED	40.25
√	CLIMACTERIC	39.73
√	J AM MED INFORM ASSN	38.28
√	MENOPAUSE	34.55
√	PHARMACOEPIDEM DR S	34.20
√	AM J MED QUAL	33.89
√	ENDOCRIN METAB CLIN	33.89
√	MATURITAS	31.90
√	BLOOD PRESS MONIT	30.20
	FAM MED	30.16

Slide 8 is a list of the 20 journals most related to *JAMA* by the citation relatedness coefficient, which reflects how often *JAMA* cites and is cited by each of the journals listed. The relatedness coefficient takes into account the sizes of the journals involved (papers published) as well as the number of times each journal cites the other.

The top four journals related to JAMA remain the same as in the sort by impact, but many journals have moved up in rank such as *Journal of Family Planning* and *Journal of the American Geriatrics Society*. The checks on the left indicate the journal was not assigned to the General Medicine category.

SLIDE 9: *NEJM* RELATED JOURNALS SORTED BY CITATION RELATEDNESS

Slide 9

JOURNALS MOST RELATED BY CITATION RELATEDNESS TO NEW ENGLAND JOURNAL OF MEDICINE
√ = Not in Medicine, General & Internal Category

	Journal	Rcoefficient
	NEW ENGL J MED	345.24
	JAMA-J AM MED ASSOC	123.09
	ANN INTERN MED	124.85
	ARCH INTERN MED	64.49
	AM J MED	61.13
√	CIRCULATION	57.36
√	J AM COLL CARDIOL	58.15
	MAYO CLIN PROC	47.96
√	CHEST	37.64
√	PROG CARDIOVASC DIS	45.66
	CAN MED ASSOC J	40.31
√	CRIT CARE MED	35.11
√	CURR PROB CARDIOLOGY	36.19
√	J CARD FAIL	34.62
√	EUR HEART J	36.77
√	AM HEART J	37.99
√	AM J CARDIOL	33.90
	AM J MED SCI	27.40
√	MED LETT DRUGS THER	32.97
√	RESUSCITATION	24.79
√	BONE MARROW TRANSPL	22.66
√	GASTROENTEROL CLIN N	24.72
√	CURR OPIN CARDIOL	21.46
	MED CLIN N AM	22.25
√	HEART	22.54

Performing the identical exercise for the *NEJM*, we see differences that are quite striking. The top four journals are there: *NEJM, Annals of Internal Medicine, JAMA, and Archives of Internal Medicine*, but the next two are cardiology journals, as are 9 of the next 12 journals shown.

While this observation does not affect the categorization of *NEJM* as a general medicine journal, the next slide will demonstrate further that it is relevant to list it in the cardiology category, as well.

SLIDE 10: JCR CARDIAC & CARDIOVASCULAR SYSTEMS BY IMPACT FACTOR

Here is the listing of the cardiac journals category in the 2004 *JCR*. The ranking by impact factor probably conforms to the general idea of the most prestigious journals in the field.

Slide 10

***JCR* Category: Cardiac & Cardiovascular Systems**
Source: 2004 *Journal Citation Reports*

Rmax Rank	*JCR* Rank	Abbreviated Journal Title	Total Cites	Impact Factor	Articles
3	1	Circulation	115133	12.563	1129
12	2	Circulation Research	35038	9.972	340
2	3	Journal of the American College of Cardiology	40841	9.133	591
4	4	European Heart Journal	10890	6.247	250
16	5	Trends In Cardiovascular Medicine	1497	4.716	53
13	6	Cardiovascular Research	12390	4.575	269
14	7	Journal of Molecular and Cellular Cardiology	7618	4.198	163
7	8	American Heart Journal	14243	3.681	356
17	9	American J of Physiology-Heart and Circulatory Physiology	23887	3.539	652
6	10	Heart	6023	3.271	314
15	11	Journal of Thoracic and Cardiovascular Surgery	15028	3.263	327
5	12	American Journal of Cardiology	29703	3.140	824
19	13	Chest	27826	3.118	654
11	14	Basic Research in Cardiology	1702	3.009	45
	15	European J of Cardiovascular Prevention & Rehabilitation	46	3.000	73
1	16	Journal of Cardiovascular Electrophysiology	4258	2.967	205
8	17	Journal of Cardiac Failure	1213	2.879	79
18	18	Journal of Heart and Lung Transplantation	4023	2.813	220
10	19	European Journal of Heart Failure	1164	2.796	118
9	20	Progress in Cardiovascular Diseases	1327	2.676	31

SLIDE 11: JOURNALS MOST RELATED TO *CIRCULATION* BY CITATION RELATEDNESS

JOURNALS MOST RELATED BY CITATION RELATEDNESS TO CIRCULATION

Journal	Rmax	Rcirc>j	Rj>circ	Rcoeffidient	Rank by Rcoefficient
CIRCULATION	160.16	160.16	160.16	160.16	1
J AM COLL CARDIOL	165.01	85.54	165.01	118.81	2
J CARDIOVASC ELECTR	220.69	27.68	220.69	78.16	3
AM J CARDIOL	156.28	32.9	156.28	71.71	4
EUR HEART J	159.56	31.57	159.56	70.97	5
AM HEART J	139.48	30.65	139.48	65.38	6
NEW ENGL J MED	170.03	170.03	19.35	57.36	7
PROG CARDIOVASC DIS	124.73	24.96	124.73	55.80	8
J CARD FAIL	128.67	20.57	128.67	51.45	9
CORONARY ARTERY DIS	170.9	14.68	170.9	50.09	10
CURR PROB CARDIOLOGY	180.95	12.9	180.95	48.31	11
BASIC RES CARDIOL	105.09	21.21	105.09	47.21	12
HEART	145.6	14.54	145.6	46.01	13
PACE	159.27	10.76	159.27	41.40	14
J AM SOC ECHOCARDIOG	144.16	11.7	144.16	41.07	15
CARDIOLOGY	113.14	14.54	113.14	40.56	16
CURR OPIN CARDIOL	142.56	11.14	142.56	39.85	17
CARDIOVASC DRUG THER	112.77	10.89	112.77	35.04	18
CATHETER CARDIO INTE	164.94	6.94	164.94	33.83	19
J CARDIOV MAGN RESON	153.61	7.44	153.61	33.81	20
J INTERV CARD ELECTR	173.06	6.45	173.06	33.41	21
J NUCL CARDIOL	169.8	6.45	169.8	33.09	22
EUR J HEART FAIL	123.25	8.31	123.25	32.00	23
CLIN CARDIOL	115.94	7.09	115.94	28.67	24
INT J CARDIOL	125.83	5.56	125.83	26.45	25
J ELECTROCARDIOL	119.84	5.45	119.84	25.56	26
INT J CARDIOVAS IMAG	129.29	4.74	129.29	24.76	27

Slide 11

However, using the *JCR* relatedness ranking method, some journals would be assigned to different *JCR* categories. Using *Circulation*, the highest impact journal in this area, to represent cardiology, we find that *NEJM* ranked 7th among the most related journals in this field. Heretofore one could only guess at the proximity of *NEJM* to this or other topics. However, this analysis also tells us something about the *JCR* placement of the journal *Coronary Artery Disease*. *JCR* assigns it to the category "Peripheral Vascular Disease" but it is in fact the 10th journal in this list.

Journal Performance Indicators

SLIDE 12: JPI DATA ON JAMA – CITATION IMPACT (ALL ITEMS) IN ONE YEAR PERIODS, 1981 TO 2004

JAMA
CITATION IMPACT (ALL ITEMS)
IN ONE YEAR PERIODS 1981 TO 2004
Source: *ISI Journal Performance Indicators file*, 2004

Rank	Year	Impact	Citations	Papers		
1	1981	29.57	16,291	551		
2	1982	35.53	20,358	573		
3	1983	40.11	22,219	554		
4	1984	35.26	21,791	618		
5	1985	35.05	18,436	526		
6	1986	48.76	24,576	504		
7	1987	44.70	26,688	597		
8	1988	48.40	30,009	620		
9	1989	55.79	34,979	627		
10	1990	54.83	35,968	656	31,257	Citations received 1999-2004 = 84.5
11	1991	47.19	30,389	644	370	Articles published in JAMA in 1999
12	1992	58.48	34,389	588		
13	1993	65.55	38,349	585		
14	1994	70.54	39,148	555		
15	1995	81.99	45,094	550		
16	1996	60.16	32,908	547		
17	1997	58.19	32,821	564		
18	1998	75.20	37,372	497		
→ 19	1999	84.48	31,257	370	←	
20	2000	56.71	21,040	371		
21	2001	49.98	18,842	377		
22	2002	42.84	16,921	395		
23	2003	19.09	7,311	383		
24	2004	3.34	1,174	351		

Slide 12

Many of the discrepancies with journal impact factors are eliminated altogether in another ISI database called the *Journal Performance Indicators (JPI)*.[21] This annual compilation now covers the period 1981 to 2004. Unlike *JCR*, the database links each source item to its own unique citations. Therefore, the impact calculations are more precise. Only citations to the substantive items are counted in the denominator. And it is possible to obtain cumulative impact measures covering longer time spans.

For example, the cumulated impact for *JAMA* articles published in 1999 was 84.5. This was derived by dividing the 31,257 citations received (from 1999 to 2004) by the 370 articles published in 1999.

$$\frac{31{,}257}{370} \quad \frac{\text{Citations received 1999-2004}}{\text{Articles published in JAMA}} = 84.5$$

In 1999, *JAMA* published 1905 items of which 680 were letters, and 253 editorials. Citations to these items were not included in the *JPI* calculation of impact.

SLIDE 13: MYCOLOGY JOURNALS EFFECT OF TIME ON IMPACT RANKINGS FOR ONE, FIVE, AND 24 YEAR PERIOD.

EFFECT OF TIME ON IMPACT RANKINGS OF MYCOLOGY JOURNALS
Ranks for one, five, and 24 year period

Rank	2004 Impact Factor	Impact 2000-2004	Impact 1981-2004
1	Fungal Genetics/Biol. (3.05)	Fungal Genetics/Biol. (5.81)	Yeast (17.53)
2	Yeast (1.94)	Yeast (5.13)	Experimental Mycology (14.36)
3	Mycorrhiza (1.74)	**Medical Mycology** (4.53)	J. Med. Veter. Mycol. (12.76)
4	**Medical Mycology** (1.45)	Mycorrhiza (3.37)	Fungal Genetics/Biol. (9.70)
5	Mycologia (1.43)	Mycologia (3.20)	Mycologia (8.46)
6	Fungal Diversity (1.89)	Mycological Research (3.17)	Mycological Research (7.72)
7	Mycological Research (1.13)	Lichenologist (1.95)	Mycorrhiza (7.16)
8	Lichenologist (0.73)	Fungal Diversity (1.87)	Mycopathologia (6.19)
9	Mycopathologia (0.87)	Mycoses (1.63)	**Medical Mycology** (6.16)
10	Mycoses (0.69)	Mycopathologia (1.53)	Lichenologist (5.90)

From: http://in-cites.com/research/2005/april_25_2005-1.html
Slide 13

To illustrate the chronological changes in rankings for a group of related journals, consider the topic of mycology which was reported recently in *inCites* for April 25, 2005.[22] (http://in-cites.com/research/2005/april_25_2005-1.html)

inCites is a free ISI news bulletin.

While the journal *Medical Mycology* ranked 4th in 2004, it moved to 3rd place when five years of data were used but 9th when 23 years of data were used. This example seems to contradict the generalization I made when discussing physiology journals.

In addition to helping libraries decide which journals to purchase, journal impact factors are also used by authors to decide where to submit their articles. As a general rule, the journals with high impact factors include the most prestigious. The perception of prestige is a murky subject. Some

would equate prestige with high impact. However, some librarians argue that the numerator in the impact-factor calculation is itself even more relevant. Bensman[23] argued that this 2-year total citation count is a better guide to journal significance and cost-effectiveness than is the impact factor. This brings us full circle to the first slide I showed you on the most-cited journals.

Journal impact can also be useful in comparing expected and actual citation frequency. Thus, when *ISI* prepares a personal citation report it provides data on the expected citation impact not only for a particular journal but also for a particular year, because impact factors can change from year to year.

The use of journal impact factors instead of actual article citation counts to evaluate individuals is a highly controversial issue. Granting and other policy agencies often wish to bypass the work involved in obtaining actual citation counts for individual articles and authors. And allegedly recently published articles may not have had enough time to be cited, so it is tempting to use the journal impact factor as a surrogate evaluation tool. Presumably the mere acceptance of the paper for publication by a high impact journal is an implied indicator of prestige. Typically, when the author's recent bibliography is examined, the impact factors of the journals involved are substituted in lieu of the actual citation count. Thus, the impact factor is used to estimate the expected influence of individual papers which is rather dubious considering the known skewness observed for most journals.

Today so-called "webometrics" are increasingly brought into play, though there is little evidence that this is any better than traditional citation analysis. Web "sitations" may occur a little earlier, but they are not the same as Citations. Thus, one must distinguish between readership or downloading and actual citation in new research papers. But some studies would indicate that web sitation is a harbinger of future citation

The assumption that the impact of recent articles cannot be evaluated in *SCI* is not universally correct. While there may be several years delay on some topics, papers that achieve high impact are usually cited within months of publication and certainly within a year or so. This pattern of immediacy has enabled *ISI* to identify "hot papers" in its bimonthly publication *Science Watch*. However, full confirmation of high impact is generally obtained 2 years later. *The Scientist magazine* waits up to 2 years to select "hot papers" for commentary by authors. Most of these papers will eventually go on to become "citation classics."[24] .

SLIDE 14: EXAMPLES OF HOT PAPERS

Slide 14.

HOT PAPER: Citations: 515
Title: A NOVEL CORONAVIRUS ASSOCIATED WITH SEVERE ACUTE RESPIRATORY SYNDROME
Authors: Ksiazek TG; Erdman D; Goldsmith CS; Zaki SR; Peret T; Emery S; Tong SX; Urbani C; Comer JA; Lim W; Rollin PE; Dowell SF; Ling AE; Humphrey CD; Shieh WJ; Guarner J; Paddock CD; Rota P; Fields B; Derisi J; Yang JY; Cox N; Hughes JM; Leduc JW; Bellini WJ; Anderson LJ
Source: N ENGL J MED 348: (20) 1953-1966 MAY 15 2003
Addresses:
Ctr Dis Control & Prevent, Special Pathogens Branch, Natl Ctr Infect Dis, Atlanta, GA 30333 USA.
Ctr Dis Control & Prevent, Resp & Enter Virus Brach, Natl Ctr Infect Dis, Atlanta, GA USA.
Ctr Dis Control & Prevent, Infect Dis Pathol Act, Natl Ctr Infect Dis, Atlanta, GA USA.
Ctr Dis Control & Prevent, Influenza Branch, Natl Ctr Infect Dis, Atlanta, GA USA.
Ctr Dis Control & Prevent, Div Bacterial & Mycot Dis, Natl Ctr Infect Dis, Atlanta, GA USA.
Ctr Dis Control & Prevent, Off Director, Div Viral & Rickettsial Dis, Natl Ctr Infect Dis, Atlanta, GA USA.
WHO, Hanoi, Vietnam.
Queen Mary Hosp, Govt Virus Unit, Hong Kong, Hong Kong, Peoples R China.
Int Emerging Infect Dis Program, Bangkok, Thailand.
Univ Calif San Francisco, San Francisco, CA 94143 USA.
Singapore Gen Hosp, Dept Pathol, Singapore, Singapore.
Ctr Dis Control, Dept Hlth, Taipei, Taiwan.

HOT PAPER: Citations: 475
Title: IDENTIFICATION OF A NOVEL CORONAVIRUS IN PATIENTS WITH SEVERE ACUTE RESPIRATORY SYNDROME
Authors: Drosten C; Gunther S; Preiser W; Van Der Werf S; Brodt HR; Becker S; Rabenau H; Panning M; Kolesnikova L; Fouchier Ram; Berger A; Burguiere Am; Cinatl J; Eickmann M; Escriou N; Grywna K; Kramme S; Manuguerra Jc; Muller S; Rickerts V; Sturmer M; Vieth S; Klenk HD; Osterhaus ADME; Schmitz H; Doerr HW
Source: N ENGL J MED 348: (20) 1967-1976 MAY 15 2003
Addresses:
Bernhard Nocht Inst Trop Med, Dept Virol, Natl Reference Ctr Trop Infect Dis, Bernhard Nocht Str 74, D-20359 Hamburg, Germany.
Bernhard Nocht Inst Trop Med, Dept Virol, Natl Reference Ctr Trop Infect Dis, D-20359 Hamburg, Germany.
Univ Frankfurt, Inst Med Virol, D-6000 Frankfurt, Germany.
Univ Frankfurt, Med Clin 3, D-6000 Frankfurt, Germany.
Univ Marburg, Inst Virol, D-3550 Marburg, Germany.
Inst Pasteur, Natl Influenza Ctr No France, Paris, France.
Erasmus Univ, Inst Virol, Rotterdam, Netherlands.

From: http://in-cites.com/hotpapers/2005/may05-cli.html

Two recent examples of Hot Papers published in *JAMA* and *NEJM* include papers on coronavirus at http://in-cites.com/hotpapers/2005/may05-cli.html

"A NOVEL CORONAVIRUS ASSOCIATED WITH SEVERE ACUTE RESPIRATORY SYNDROME"

"IDENTIFICATION OF A NOVEL CORONAVIRUS IN PATIENTS WITH SEVERE ACUTE RESPIRATORY SYNDROME"

Conclusion

Of the many conflicting opinions about impact factors, Hoeffel[25] expressed the situation succinctly.

"Impact Factor is not a perfect tool to measure the quality of articles but there is nothing better and it has the advantage of already being in existence and is, therefore, a good technique for scientific evaluation. Experience has shown that in each specialty the best journals are those in which it is most difficult to have an article accepted, and these are the journals that have a high impact factor. Most of these journals existed long before the impact factor was devised. The use of impact factor as a measure of quality is widespread because it fits well with the opinion we have in each field of the best journals in our specialty."

Yes, a better evaluation system would involve actually reading each article for quality but then this entire congress is dedicated to the difficulties of reconciling peer review judgments. When it comes time to evaluating faculty, most people do not have or care to take the time to read the articles any more! Even if they did, their judgment surely would be tempered by observing the comments of those who have cited the work. We call this citation context analysis. Fortunately, new full-text capabilities in the web make this more practical to perform.

I have had to rush through a lot material to save time but hope that I have given you a balanced view of a complex and controversial topic.

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