Current Comments®

EUGENE GARFIELD

INSTITUTE FOR SCIENTIFIC INFORMATION®
3501 MARKET ST., PHILADELPHIA, PA 19104

The Languages of Science Revisited: A Focus on Microbiology, 1981-1991

Number 47 November 23, 1992

Introduction

Last November, Charles A. Fewson, Glasgow University, Scotland, invited us to contribute a paper to the 100th volume of *FEMS Microbiology Letters*, which he has edited for about two years now. He had read previous *Current Contents*® (*CC*®) essays on trends in languages of scientific publication and their relative citation impact. So he suggested we use the ISI® database to explore language trends in the microbiology literature.

Al Welljams-Dorof, ISI's director of Corporate Communications, and I took the same approach used in a previous analysis of language use in the scientific literature as a whole.[1] That is, we asked: how many papers are published in which languages; how often are they cited on average (impact); and what languages are the most "multilingual," as indicated by their citation of foreign-language papers.

One of the benefits of writing for a letters journal is the comparatively short editorial response time. Our manuscript was submitted on June 16, 1992, and was accepted for publication just three days later.[2] The journal apparently is very good at honoring a founding goal of FEMS—to foster the rapid and widespread communication of current research.

Federation of European Microbiological Societies—FEMS

FEMS was founded in 1974 by microbiology societies based in 16 nations, all European with the exception of Israel. From the start, the federation represented nations from East and West, North and South. The founding societies were from Bulgaria, Denmark, Finland, France, Germany, Greece, Israel, The Netherlands, Norway, Poland, Portugal, Spain, Sweden, Switzerland, the UK, and Yugoslavia. Societies from seven additional nations have since joined FEMS: Austria, Czechoslovakia, Hungary, Iceland, Italy, Turkey, and the USSR, and societies from Croatia and Slovenia joined this year.[3]

By affiliating these national societies, FEMS aimed to communicate current research faster and to a wider audience. A logical development was journal publishing and FEMS approached Elsevier to launch a quick-turnaround letters journal for microbiologists. After Elsevier's market survey confirmed the viability of the proposed journal, the first issue of *FEMS Microbiology Letters* appeared in January 1977.

The journal is an example of the symbiosis between a nonprofit society and a for-profit publisher. The benefit to FEMS becomes more apparent when you realize that most of its income is derived from royalties on its *Letters*. And Elsevier's business interests can be indicated by the other new journals it has successfully launched with FEMS—*FEMS Microbiology Ecology* (1985), *FEMS Microbiology Reviews* (1985), and *FEMS Microbiology Immunology* (1988), which will be renamed in 1993 as *FEMS Immunology and Medical Microbiology* to reflect its enlarged scope.

Table 1: Five most-cited papers from *FEMS Microbiology Letters*, 1945-1990 *Science Citation Index®*.

Citations 1945-90	1991	Bibliographic Information
260	32	**Rosenberg M, Gutnick D & Rosenberg E.** Adherence of bacteria to hydrocarbons: a simple method for measuring cell surface hydrophobicity. *FEMS Microbiol. Lett.* 9:29-33, 1980.
259	25	**Leffler H & Svanborgeden C.** Chemical identification of a glycosphingolipid receptor for *Escherichia coli* attaching to human urinary tract epithelial cells and agglutinating human erythrocytes. *FEMS Microbiol. Lett.* 8:127-34, 1980.
247	16	**Kallenius G, Cedergren B, Lundblad A, Mollby R, Svenson S B, Svensson S & Winberg J.** The PK antigen as receptor for the hemagglutinin of pyelonephritic *Escherichia coli*. *FEMS Microbiol. Lett.* 7:297-302, 1980.
149	8	**Hed J.** Extinction of fluorescence by crystal violet and its use to differentiate between attached and ingested microorganisms in phagocytosis. *FEMS Microbiol. Lett.* 1:357-61, 1977.
95	3	**Gunsalus R P & Wolfe R S.** Chromophoric factors F342 and F430 of *Methanobacterium thermoautotrophicum*. *FEMS Microbiol. Lett.* 3:191-3, 1978.

FEMS' Role in Improving Scientific Communication

The revenue from its publishing royalties has allowed FEMS to fund other worthwhile initiatives. One is its organization of international symposia and conferences. The professional value of scientific meetings—which can serve as personal "information encounter groups"—has been stressed here before.[4,5] The benefits to graduate and postdoctoral students just entering the profession are obvious. To its credit, FEMS began offering grants for students to attend conferences in 1986, and continues to fund a variety of fellowships and laboratory workshops.

New President's Priorities: Advocacy and Lobbying

The new president of FEMS, who began a three-year term this year, is P. Helena Mäkelä, National Public Health Institute, Helsinki, Finland. She encourages microbiologists to take an active role as advocates for their research—in Mäkelä's words, to "demonstrate to the public, politicians and administrators how useful microbiological research is and what it promises for the future."[6]

She also asks why "FEMS has not been very visible as a lobbyist for microbiology."[6] In this US presidential election year, "lobbyist" may have a distinctly negative connotation among the public. Of course, this should not divert attention from a good and necessary idea. That is, scientists from all fields of research ought to organize responsible "political action committees" to present—and promote—their interests to policymakers. In that way, the research community can work toward the ideal where its self-interests and those of the community coincide. It's an idea I've advocated before,[7] and am glad Mäkelä is challenging FEMS to consider it seriously.

FEMS Microbiology Letters

FEMS' *Letters* has had three editors in its 16 years: David W. Tempest, University of Sheffield, England (1976-1981); Edwin A. Dawes, University of Hull, England (1982-1990); and Fewson. Mäkelä stated that the *Letters* "has been remarkably successful in establishing itself as a journal that has to be read...."[6] This is borne out by a variety of ISI data.

For example, the 1990 *Journal Citation Reports®* indicates that the journal's impact factor was 1.34, and ranks 27th out of 68 microbiology journals indexed by ISI that year.[8] In addition, *FEMS Microbiology Reviews* ranked 6th with an impact of 3.28, and *FEMS Microbiology Ecology* was 21st with an impact of 1.48.

Also, *FEMS Microbiology Letters* has published 24 papers cited at least 50 times in the 1945-1988 *Science Citation Index®* database. Of the 32.7 million cited publications in this database, less than 1.5 percent were cited 50 or more times. Table 1

shows the five most-cited papers from the journal through 1990. Full bibliographic information is provided, and 1991 citations are shown separately to indicate continued interest in the papers. The celebratory 100th volume of *FEMS Microbiology Letters* will include a table of the 20 most-cited papers.

Conclusion: English Is the Lingua Franca of Microbiology Research

The results reported in the reprinted paper that follows should come as no surprise to *CC* readers. We found that in microbiology, as in virtually all scientific fields, English is the dominant language of research communication.

The study was based on 78 ISI-indexed microbiology journals, including 88,816 papers published and cited from 1981 through 1991. In summary, English accounted for 90-95 percent of the papers in each year. The impact or average citations per paper for English-language articles was greater than that of other languages by factors ranging from 2.4 to 14.4.

The study also gave an opportunity to deflate a popular misconception—that English-language papers ignore research published in other languages. In fact, the majority of citations *to* papers published in English, German, French, or Italian were *from* English-language papers. Russian-language papers were the exception. More than 90 percent of citations they received were from Russian-language papers. We have commented on the apparent "language barrier" of Russian and Japanese publications previously.[1]

In conclusion, we congratulate *FEMS Microbiology Letters* on reaching its milestone 100th volume, and wish it continued success in the years ahead. We also wish Mäkelä success in achieving the important goals of FEMS, particularly the rapid and international communication of microbiology research. This is especially critical at a time when the research communities in the former East Bloc nations are in transition and even disarray. It is essential to the future economic and cultural vitality of these nations that their scientific resources remain strong—and free of the entrenched bureaucracy and undue political influence on scholarship that had become typical in the past.

REFERENCES

1. **Garfield E & Welljams-Dorof A.** Language use in international research: a citation analysis. *Ann. Amer. Acad. Polit. Soc. Sci.* 511:10-24, 1990. (Reprinted in: *Essays of an information scientist: journalology, KeyWords Plus, and other essays.* Philadelphia: ISI Press, 1991. Vol. 13. p. 282-94.)
2. ----------. The microbiology literature: languages of publication and their relative citation impact. *FEMS Microbiol. Lett.* 100:33-7, 1992.
3. **Dawes E A.** The Federation of European Microbiological Societies—an historical review. *FEMS Microbiol. Lett.* 100:15-23, 1992.
4. **Garfield E.** Information encounter groups. *Essays of an information scientist.* Philadelphia: ISI Press, 1977. Vol. 2. p. 498-9.
5. ----------. Making contacts at conferences—a problem for the young scientist. *Ibid.*, 1980. Vol. 3. p. 668-72.
6. **Mäkelä P H.** What is ahead, FEMS? *FEMS Microbiol. Lett.* 100:11-2, 1992.
7. **Garfield E.** We need a lobby for basic research: here's how it might be done. *Op. cit.*, 1977. Vol. 1. p. 418-20.
8. ----------, ed. *Science Citation Index 1990: Journal Citation Reports.* Philadelphia: Institute for Scientific Information, 1990. Microfiche edition.

Reprinted with permission from *FEMS Microbiology Letters* 100:33-7, 1992.

The microbiology literature: Languages of publication and their relative citation impact

Eugene Garfield and Alfred Welljams-Dorof
Institute for Scientific Information (ISI)
Philadelphia, Pennsylvania, USA

Received 16 June 1992
Accepted 19 June 1992

Key words: Citation analysis; Science Citation Index; Language trends; Impact trends; Scientometrics

1. SUMMARY

This study examined trends in the number of papers published annually in various languages in 78 microbiology journals indexed in the *Science Citation Index*® (*SCI*®), 1981-1991. Trends in the average number of citations per paper (impact) for each language were also tracked. In addition, interlingual citation patterns were examined. The results showed that English is the lingua franca of microbiology research, accounting for 90-95 percent of all *SCI*-indexed papers in this time period. Also, the impact of English-language papers was greater than that of other languages by factors ranging from 2.4 to 14.4. Lastly, the majority of citations *to* papers published in English, German, French, or Italian were *from* English-language papers. The exception was papers in Russian—more than 90 percent of citations they received were from Russian-language papers.

2. INTRODUCTION

It is perhaps a truism to say that English is the dominant language of current international scientific communication. Previous studies have shown that most of the world's research literature indexed in the databases of the Institute for Scientific Information® (ISI®) is written and published in English, and that English-language papers are by far the most frequently cited [1-4]. Of course, the relative proportion of English- and non-English-language papers in other secondary information services, for example *Index Medicus*, *Chemical Abstracts*, or *Biological Abstracts*, will vary. Nevertheless, English will still dominate.

The previous studies referenced above examined language publication and citation data for science as a whole. They also were limited to papers indexed in a single annual *SCI* file. The objective of the present study was to determine language patterns in *microbiology* by focusing specifically on *SCI*-indexed journals in this specialty. Another objective was to analyze *longitudinal trends*, both in the numbers of papers published in various languages and their average citation frequency (impact), by using data over an 11-year time period, 1981-1991.

3. METHODS

3.1 Journal data set

This study was based on a total of 78 microbiology journals indexed in the *SCI* during the years 1981-1991. The annual number of journals varied, increasing from 49 in 1981 to 59 in 1991. This expanded *SCI* coverage reflects a number of factors—growth of the microbiology literature, journal 'twigging', publication mergers and splits, and so on.

The *SCI* microbiology journal set has consistently been international in scope. For example, of the 49 journals covered in 1981, 14 (29%) were published in the US, 6 (12%) each in the UK and West Germany, 3 (6%) each in East Germany, France, Japan, and the Netherlands, 2 (4%) each in Czecho-

Correspondence to: A. Welljams-Dorof, ISI, 3501 Market Street, Philadelphia, PA 19104, USA.

slovakia, Italy, and the USSR, and 1 (2%) each in Canada, Denmark, Hungary, India, and Poland. Of the 59 *SCI*-indexed journals in 1991, 14 (24%) were published in the UK, 13 (22%) in the US, 10 (17%) in Germany, 8 (14%) in the Netherlands, 3 (5%) in the USSR, 2 (3%) each in Czechoslovakia, France, and Japan, and 1 (2%) each in Canada, Denmark, Hungary, India, and Israel.

3.2 Trends in publication output

While the *SCI* comprehensively indexes all journal items, this study was restricted to original research papers, review articles, and technical notes. These are generally considered the most substantive items by authors and editors, and tend to be the most frequently cited. However, it should be noted that ISI studies have shown that letters, corrections and retractions, editorials, and other types of scholarly communications are also significant [5].

The annual compact disk (CD-ROM) editions of the *SCI* were used to obtain data on the yearly number of papers (i.e. articles, reviews, and notes only) published in microbiology journals from 1981-1991. The total annual outputs were then disaggregated by language of publication and calculated on a percentage basis. The results are shown in Table 1.

3.3 Trends in citation impact

The average citation frequency (impact) of microbiology papers in various languages was derived from a special ISI database called the Integrated Citation File. It tracks the number of papers published, and the citations they received, in successive, overlapping multiyear 'windows' that advance one year at a time. In this study, five-year windows were used, moving from 1981-1986 inclusive to 1987-1991. By aggregating papers and citations over five-year periods, the sometimes wide fluctuations that may occur on an annual basis are avoided.

In this study, impact factors were calculated in two ways. The first is a simple ratio of citations to *all* microbiology papers published in a given five-year period. For example, if 1000 papers were published in 1981-1985 and they received 2000 citations in that same time period, the *total* impact would be 2.0. Trends in *total* impact for microbiology papers in various languages are shown in Fig. 1.

The second impact factor divides citations by just the number of papers that were actually cited. That is, uncited papers are excluded. Thus, if 1000 papers were published in 1981-1985 and 500 of these were cited 2000 times in this period, the *cited* impact factor would be 4.0. Trends in *cited* impact are shown in Fig. 2.

3.4 Interlingual citation patterns

An interesting question is: to what extent are papers published in a given language cited by papers in other languages? The answer may provide insights into whether or not there is a language 'barrier'

Table 1

Annual number of microbiology papers indexed in the *SCI* and percentage distribution by language, 1981-1991

Year	Papers	English (%)	Russian (%)	German (%)	French (%)	Italian (%)
1981	6213	89.6	4.7	3.8	1.4	0.5
1982	6939	90.4	4.7	2.9	1.3	0.7
1983	7362	91.0	4.9	2.4	1.2	0.5
1984	7248	92.1	4.9	1.9	0.8	0.4
1985	8078	90.6	6.1	2.1	0.8	0.4
1986	8121	90.9	6.4	2.1	0.6	0.1
1987	8307	92.6	5.3	1.8	0.4	—
1988	8662	91.8	6.7	1.1	0.4	—
1989	9087	93.1	5.9	0.8	0.2	—
1990	9318	93.9	5.7	0.2	0.2	—
1991	9481	94.9	4.6	0.4	0.1	—

in scientific communication. This question was examined by cumulating all 1981-1991 citations to *SCI*-indexed microbiology papers published in various languages during this time. The citations were then disaggregated by the language of the *citing* papers and calculated on a percentage basis. The results are shown in Table 2.

4. RESULTS AND DISCUSSION

The number of microbiology papers annually indexed in the *SCI* increased from 6213 in 1981 to 9481 in 1991 (see Table 1). This represents a growth of 52.6 percent. In comparison, the number of *SCI*-indexed papers (i.e. research articles, reviews, and technical notes) in all fields of science grew by 21.6 percent over the same time.

The *SCI*-indexed microbiology literature was published in five languages: English, Russian, German, French, and Italian (see Table 1). English-language papers clearly dominated. They represented 89.6 percent in 1981, and increased to 94.9 percent in 1991. Russian-language papers ranked second, accounting for 4.7 percent in 1981, as much as 6.7 percent in 1988, and 4.6 percent in 1991. Papers published in German ranked third, and showed the largest decline. They amounted to 3.8 percent in 1981 and just 0.4 percent by 1991. French-language microbiology papers followed, representing 1.4 percent in 1981 and 0.1 percent in 1991. Italian-language papers trailed, accounting for 0.5 percent in 1981 and declining to 0.1 percent in 1986. From 1987 to 1991, no Italian-language microbiology papers were indexed in the *SCI*.

With the exception of Russian, all other non-English language papers showed a steady decline in their proportion of the *SCI*-indexed microbiology literature. The most obvious possible reason for this trend is changes in *SCI* coverage, with perhaps a 'preference' for English-language journals. However, as noted earlier, *SCI*'s coverage of microbiology journals was consistently international from 1981 through 1991. Journals published in nations where English is the native language, e.g. the US, UK, Canada, etc., amounted to between 45 and 50 percent of *SCI*-indexed microbiology journals. A more probable reason for this trend, therefore, is that journals from nations where English is *not* the native language increasingly published in English over the past decade.

The incentive to do so is both practical and economical, from the publishers' perspective. English currently is the most common language of scientific communication.

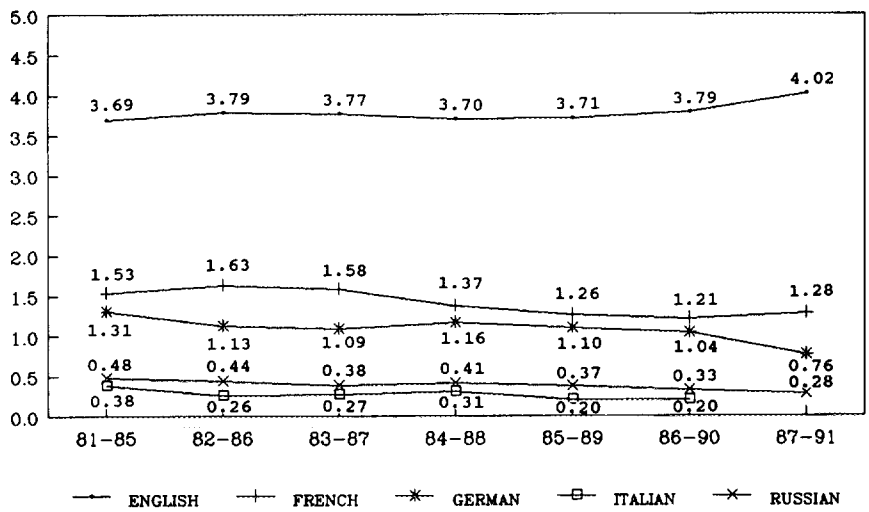

Fig. 1. Impact (average citations per paper) of *SCI*-indexed microbiology papers. See section 3.3 for discussion of impact calculation.

Multilingual or non-English-language journals face the prospect of smaller circulation, lower readership, and fewer manuscript submissions compared to English-language journals. Thus, as a matter of survival and viability, publishers recognize the advantages of adopting English as the primary language of publication today.

These advantages are exemplified in the average citation frequency of microbiology papers published in different languages (see Fig. 1). The impact of English-language papers steadily increased from 3.69 in 1981-1985 to 4.02 in 1987-1991. French-language papers ranked second in impact. Yet they were cited about 65 percent less often than English-language papers. German-language papers followed closely, but Russian- and Italian-language papers lagged significantly. They were cited about 85 to 95 percent less often than English-language papers.

Excluding uncited papers, the comparative *cited* impact trends are only marginally better (see Fig. 2). The cited impact of English-language microbiology papers increased from 5.86 in 1981-1985 to 6.18 in 1987-1991. French-language papers again ranked second, yet they were still cited 50 to 65 percent less often than English-language papers. German-language papers followed closely, and Russian- and Italian-language papers lagged. They were cited about 70 to 80 percent less often than English-language microbiology papers.

Examination of interlingual citation patterns reinforces the dominance of English as the lingua franca of international research in microbiology (see Table 2). With the exception of Russian, the majority of citations *to* papers in each language was *from* English-language papers. For example, of the 3831 citations received by German-language papers, 2205 (57.6%) were from English-language papers and 1512 (39.5%) were from German-language papers. This deflates the popular perception that English-language papers ignore or avoid papers published in other languages.

Russian is the anomaly: of the 3552 citations received by Russian-language papers, 92.1 percent were from Russian-language papers. This seems to indicate a significant barrier to the Russian-language literature. That is, the Russian-language microbiology literature is virtually impenetrable to all other languages except Russian.

The dominance of English-language papers can also be seen from the reverse perspective. That is, the majority of citations *from* papers in each language are *to* English-language papers. For example, En-

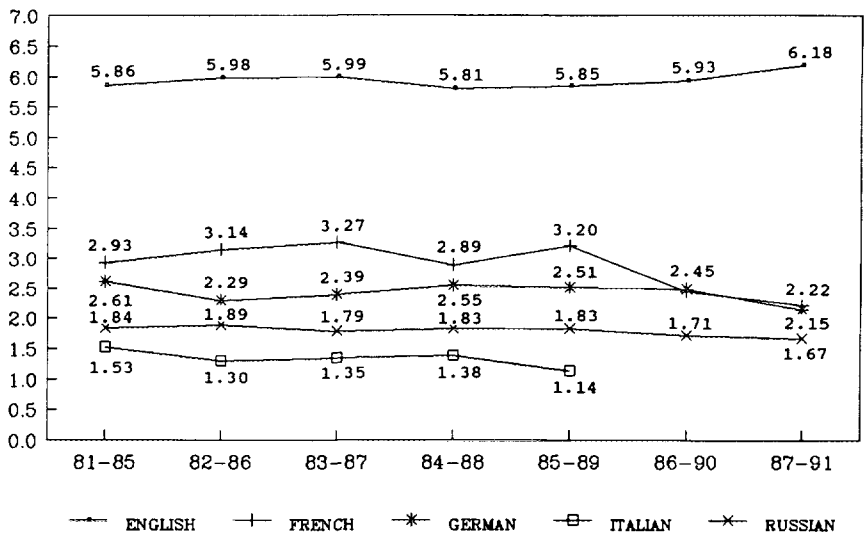

Fig. 2. Cited impact (average citations per *cited* paper) of *SCI*-indexed microbiology papers.

Table 2

Interlingual citation patterns.

Citing Language	Cited Language					
	English	German	French	Russian	Italian	Citing Total
English	646172 (96.6)	2205 (57.6)	1581 (74.3)	264 (7.4)	73 (45.9)	650295
German	7298 (1.1)	1512 (39.5)	46 (2.2)	8 (0.2)	4 (2.5)	8868
French	7479 (1.1)	37 (1.0)	455 (21.4)	1 (—)	3 (1.9)	7975
Russian	6186 (0.9)	69 (1.8)	29 (1.4)	3272 (92.1)	6 (3.8)	9562
Italian	96 (—)	1 (—)	2 (0.1)	0 (—)	72 (45.3)	171
Other	1961 (0.3)	7 (0.2)	16 (0.8)	7 (0.2)	1 (0.6)	1992
Cited total	669192	3831	2129	3552	159	678863

Numbers shown are cumulative citations, 1981-1991, to 1981-1991 *SCI*-indexed microbiology papers in various languages. Percentages in parentheses are of total citations *received* by papers in each language, summed at the bottom of each column.

glish-language papers received 7298 citations from German-language papers. This represents 82.3 percent of the 8868 references to the microbiology literature contained in German-language papers (see column 6 in Table 2). Of the 9562 citations from Russian-language papers, 64.7 percent were to English-language papers. For France and Italy, the proportions are 93.8 percent and 56.1 percent, respectively. This is not surprising, given that English-language papers represented 90-95 percent of the 1981-1991 *SCI* microbiology database.

In conclusion, the data presented here indicate the predominance of English as the primary language of international microbiology research. Far more papers are published in English than any other language, and they have the highest impact by a wide margin. English-language papers also account for the majority of citations *to* papers in all other languages except Russian. In addition, English-language papers receive the majority of citations *from* papers in all other languages, including Russian.

Of course, this should not be taken as an argument for native English speakers to make no effort to become bilingual or multilingual. The analysis presented here reflects just one part of the entire spectrum of scholarly communication: formal publication. However, research at the forefront of science is often communicated in personal conversations, professional conferences, and other verbal exchanges between colleagues well before it appears in print. Conversational fluency in more than one language is therefore a valuable professional asset for researchers. Indeed, bilingualism is also personally enriching. It allows researchers to appreciate the expression of other nations: their culture, arts, and humanities as well as their science.

REFERENCES

1. **Garfield E.** La science française est-elle trop provinciale? (Is French science too provincial?) *Recherche* 7:757-60, 1976. (Reprinted in: *Essays of an information scientist.* Philadelphia: ISI Press, 1980. Vol. 3. p. 89-94.)
2. ----------. Latin American research. Part 1. Where it is published and how often it is cited. *Essays of an information scientist: the awards of science and other essays.* Philadelphia: ISI Press, 1985. Vol. 7. p. 138-43.
3. ----------. Is Japanese science a juggernaut? *Ibid.*, 1989. Vol. 10. p. 342-8.
4. **Garfield E & Welljams-Dorof A.** Language use in international research: a citation analysis. *Ann. Amer. Acad. Polit. Soc. Sci.* 511:10-24, 1990. (Reprinted in: *Ibid.*, 1991. Vol. 13. p. 282-94.)
5. **Garfield E.** Which medical journals have the greatest impact? *Ann. Intern. Med.* 105:313-20. (Reprinted in: *Ibid.*, 1989. Vol. 10. p. 7-13.)