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4. évfolyam · 3. szám · 1994. március

IMPAKT

TÉNYEK A TUDOMÁNYOS ALAPKUTATÁSRÓL

Szilárd: Csak a tényeket írom le – nem azért, hogy bárki is elolvassa, csakis a Jóisten számára.
Bethe: Nem gondolod, hogy a Jóisten ismeri a tényeket?
Szilárd: Lehet, hogy ismeri, de a tényeknek nem *ezt* a változatát.

[*Leo Szilard, His version of the Facts. S.R. Weart & Gertrud Weiss Szilard* (Eds), MIT Press, Cambridge, MA, 1978, p.149.]

A tartalomból:

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Szerkesztők:
Braun Tibor *(főszerkesztő)*
Schubert András *(szerkesztő)*
Toma Olga *(munkatárs)*
Zsindely Sándor *(főmunkatárs)*

Postacím:
MTA Könyvtára
1361 Budapest Pf. 7
Telefon: 111-5433
Telefax: 131-6954
Telex: 224132
E-mail: h1533bra@ella.hu

Megjelenik havonta
Évi előfizetési díj: 2400 Ft

Too Many Journals? Nonsense!

Every few weeks I read another journalist's jab at the value and quantity of scientific journals. When discussing the ever-expanding literature, reporters of the popular press frequently indulge in superficial analyses that distort reality, whether through misunderstanding or exaggeration.

Nancy Jeffrey revealed profound misunderstanding in "Mollusks, Semiotics and Dermatology: Narrow Scholarly Journals Are Spreading" (*Wall Street Journal*, August 27, 1987, p. 25). She invites readers to check out college library shelves and tells them "some off-beat periodicals are bound to jump out at you." A litany of journal titles — one carefully drawn up to invite ridicule — follows. This serves only to reinforce a contempt for specialized knowledge and reflects an increasing anti-intellectualism I see in the press and among the public.

How does Jeffrey explain journal proliferation? She says nothing about twigging, the natural fractionation of knowledge and its embodiment in new journals. Nor does she note that more scientists are alive today than ever before, and that the journal is their primary medium of communication. Rather, Jeffrey attributes the appearance of new journals to institutions' pursuit of "glory" and "prestige" or individual researchers' attempts to beef up their vitae.

A misunderstanding of the social process of science and of knowledge accumulation has misled the editors of the *Wall Street Journal* into publishing a shallow and absurd commentary on the exponential growth of journals. To attribute the growth of the journal literature to the pursuit of personal or institutional gain ignores the substance of what is being published in those many new journals. It is instinctive for researchers exploring uncharted terrain to band together to form invisible colleges; it is also quite logical for them to create new journals in which to conduct their specialized discussions. Is Jeffrey suggesting that we abandon new areas like molecular biology for which no journal existed 30 years ago? Are we to expect that superconductivity will be discussed only in existing journals?

Last month William J. Broad took up this same theme (*New York Times*, February 16, 1988, pp. C1, C11). Under the headline "Science Can't Keep Up With Flood of New Journals," Broad claims: "the number of scientific articles and journals being published around the world has grown so large that it is starting to confuse researchers, overwhelm the quality-control systems of science, encourage fraud and distort the dissemination of important findings."

Surely Broad exaggerates. By repeating the unqualified assertion that the there are "40,000 scientific journals now estimated to roll off the presses around the world," he in no way supports the contention that the size of today's scientific literature "is starting to confuse...overwhelm...[or] distort..." I first heard this sort of dire warning as long ago as 1953. And its equivalent can be found as early as the 17th century.

Modern Information Methods

Obviously, no one reads 40,000 or even 400 journals. As is well known among experts whom Broad has the arrogance to ignore, a mere handful of journals accounts for the great majority of significant publications in any field (Bradford's Law). There are probably no more than 25 titles (and often fewer) that an individual researcher needs to follow regularly (Garfield's Law). As a supplement, the organized researcher makes use of modern information retrieval tools to scan the rest of the literature. This is part of being a professional scientist. Moreover, as the literature grows, new methods evolve to lessen the load of keeping current.

As for the contention that quality-control systems are being "overwhelmed," I would point out that the number of journals published elsewhere has nothing to do with the professionalism of a particular journal's editorial staff.

Although Broad concedes that "much of the growth is seen as a healthy part of the success and expansion of the scientific enterprise in the 20th century," he prefers more dramatic explanations. He emphasizes dark personal motivations and the impact of the publish-or-perish syndrome: "undertaking trivial studies because they yield rapid results, and needlessly reporting the same study in installments, magnifying the apparent scientific output." He mentions simultaneous submission of the same paper to two or more journals and the practice of unwarranted co-authorship.

Deviant behavior certainly exists in science. But does Broad seriously believe that this is the fuel driving the dynamic growth of scientific journals? Apparently so, for he states, after detailing such misdeeds: "The upshot of all this is a continuing surge in the number of new journals." Consider that non sequitur! Certainly such behavior accounts for some articles, but I doubt that journals have been launched because of it.

Broad also claims that the bigger the literature is, the greater the likelihood of fraud. Fraud and other forms of deviant behavior occurred in the age of little science and they will also occur in the age of big science. Broad, however, cites not a shred of empirical evidence for an increase in such deviance, whether owing to the proliferation of journals or to any other factor. He fails to do so because the evidence just doesn't exist.

The misdeeds of scientists, like those of any other profession, deserve careful investigation. I welcome the news that a number of forums are planned to examine publication and research practices and how they might be improved to guard against these problems. But merely asserting that journal publishing is out of control does nothing to explain the growth phenomenon or to solve the problems that do exist.

I find it ironic that reporters so often use evidence of the success of science to limit more of that success by raising the cry of "too many journals." Allegations of misconduct may sell newspapers, but they may also cause a backlash that even the science muckrakers may one day regret.

E. Garfield, The Scientist 2 (5)(7 March 1988) 11

Nem érdemes a Nobel díjra

Ha a Nobel díjat tekintjük a természettudományos kutatás mércéjének, akkor Japán jelenleg is rosszul áll. Az a három Nobel díj, melyet az elmúlt 25 év alatt japán tudósok vehettek át, sovány vigaszt jelentenek: ez idő alatt az USA-ban 77 kutató nyerte el ezt a kitüntetést. Az említett három japán Nobel díjas — *Leona Esaki* (fizika, 1973), *Kenichi Fukui* (kémia, 1981) és *Susumu Tonegawa* (orvostudomány, 1987) — szerint nem valószínű, hogy a jövőben ezen a téren változás következzen be.

Esaki kulcsfontosságú munkáit 1956 és 1960 között a Sony-nál készítette el. A fizikai Nobel díj birtokosa nyíltan bevallja, hogy csak azért tudta a félvezetőkre vonatkozó kutatásait elvégezni, mert meg tudta győzni a vállalatot arról, hogy a tisztán elméleti kutatási eredményei gazdaságilag hasznosak lesznek. 1960-ban az USA-ba ment. A közelmúltig az IBM laboratóriumaiban működött. Most Esaki a Tsukuba Egyetem elnöke.

Kollégája, Fukui a Kiotoi Egyetemről jött. Alig harminc éves korában lett professzor. Ez Japánban abszolút kivételt jelent. Általában a teljes jogú professzorságot és az ezzel együttjáró kutatási szabadságot kb. ötven évesen lehet megszerezni.

A harmadik japán Nobel díjas, Tonegawa, teljes egészében Japánon kívül tevékenykedett, és jelenleg a *Massachusetts Institute of Technology* (*MIT*), professzora. Arra a kérdésre, hogy a Nobel díjjal jutalmazott munkáit Japánban is elvégezhette volna-e, azt válaszolta, hogy "valószínűleg nem".

Emellett Tonegawa-nak pontos elképzelései vannak arra vonatkozóan, hogyan lehetne Japánban az alapkutatást a talpára állítani.

• Meg kell szüntetni a "beltenyészetet". — A legtöbb japán professzor valamikor az általa vezetett osztály abszolvense volt. Az iparban dolgozó kollégáikhoz hasonlóan egy életen át ugyanazon az osztályon tevékenykednek.

• A hierarchiákat fel kell oszlatni. — A hatalmi piramis csúcsán a vezető professzor áll. A többi professzor és az asszisztensek nem követhetik saját kezdeményezéseiket.

• Ne legyen egész életre szóló foglalkoztatási garancia. — Jelenleg nem lehet egy gyenge képességű professzornak felmondani és őt egy alkalmasabbal felváltani.

A japán tudományos tanács, a miniszterelnök magasszintű tanácsadó testülete a Nobel díjasok kritikai megjegyzéseivel messzemenően egyetért. A tanács egy olyan táglátókörű alapkutatás kiépítését szorgalmazza, mely az embert tekinti a legfontosabb paraméternek.

A legégetőbb kérdés, mint mindenütt, a pénz. Miért kettőzzük meg az államilag finanszírozott kutatás költségvetését, ha a nagy pénzügyi támogatások egyébként elapadnak? Ilyen nagy önzetlenséget a többi minisztériumtól nem lehet elvárni.

Egyébként is, a kutatásra fordítandó pénzeket, mint eddig is, a szenioritás alapján osztják szét. Japánban még a legkiválóbb kutató is húsz évig a főnöke dicsőségét segíti elő. Ismét számos kutató tett statikus beállítottságáról bizonyságot, amikor a Nobel díjas Esaki-t a nagytekintélyű Tsukuba Egyetem rektorává nevezték ki. Több professzor szóvá tette, hogy

MAGYAR TUDOMÁNYOS AKADÉMIA KÖNYVTÁRA

majdnem harminc évig az Egyesült Államokban élt és az ilyen "szabálytalanságon" fel voltak háborodva.

Japánban kevés a Max Planck intézethez hasonló intézmény létezik, ez alól két kivétel az Institute of Molecular Science Okazaki-ban, és a Bioscience Institute Osaka-ban. Fontos lenne, hogy az alapkutatást az egyetemeken végezzék. Az egyetemek hivatali elöljárója, az oktatási minisztérium, azonban elsősorban a nevelésre helyezi a hangsúlyt.

Az utánpótlási problémák közül még fontosabb szerepet játszik az ifjúság értékrendjének szubtilis változtatása: a rosszul fizetett professzorokat régen a társadalom nagy csodálattal fogadta, de időközben ez a konfuciánus csodálat gyengült. "A kutatóknak hosszú munkaidejük van, de nincsen havi fizetésük", szokták a japán egyetemi kampuszokon mondani.

Japán minden kereskedelmi kutató laboratóriumában fájdalommal tapasztalják, hogy a tudományos utánpótlás toborzása egyre nehezebb. A magángazdaság viszont csak keveset áldoz erre a célra. Így pl. a japán vállalatok a Massachusetts Institute of Technology-n több tanszéket támogatnak, mint az összes japán egyetemen együttvéve.

Dr. Botskor Iván, a "Japaninfo" belső szolgálatának főszerkesztője,
Bild der Wissenschaft 4 (1993) 27

Citation data: their use as quantitative indicators for science and technology evaluation and policy making

Publication and citation data offer the potential to develop new quantitative, objective indicators of S&T performance. The limitations of these indicators is discussed. The conclusion is that they provide a valuable and revealing addition to conventional methods of S&T evaluation.

Few would dispute the claim that nation's science and technology (S&T) base is a critical element of its economic strength, political stature, and cultural vitality. In recent years, efforts to evaluate and assess research activity have increased. Government policymakers, corporate research managers, and university administrators need valid and reliable S&T indicators for a variety of purposes: for example, to measure the effectiveness of research expenditures, identify areas of strength and excellence, set priorities for strategic planning, monitor performance relative to peers and competitors, target emerging specialties and new technologies for accelerated development, and so on.

One of the many quantitative indicators available for S&T evaluation and assessment is the published research literature — that is, primary research journal articles. Publication counts have traditionally been used as indicators of the "productivity" of nations, corporations and institutions, departments, and individuals. However, judgement of the *influence*, *significance* or *importance* of research publications requires the qualitative analysis by experts in the field, and often time-consuming and expensive process.

But the advent of citation databases — which track how often papers are referenced in subsequent publications, and by whom — has created new tools for indicating the impact of primary research papers. By aggregating citation data, it is then possible to indicate the relative impact of individuals, journals, departments, institutions, and nations. In addition, citation data can be used to identify emerging specialties, new technologies, and even the structure of various research disciplines, fields, and science as a whole.

This is *not* to say that citation data *replace* or *obviate* the need for qualitative analysis by experts in the field. Rather, they *supplement* expert judgements by providing a unique perspective on the S&T enterprise. Indeed, citation data themselves require careful and balanced interpretation to contribute most effectively to S&T evaluation and assessment.

Citation databases of ISI

The Institute for Scientific Information's (ISI) *Science Citation Index* (*SCI*) was developed primarily for the purpose of information retrieval. However, its quantitative citation databases are especially wellsuited for application as S&T indicators for a number of reasons. For example, they are *multidisciplinary*, representing virtually all fields of science and the social sciences. Thus, ISI's databases can accommodate S&T analyses whose scope ranges from the narrowest focus on a particular subspecialty to the broadest perspective on science as a whole.

Also, ISI's databases are *comprehensive*, indexing all types of items that a journal publishes. These include not only original research papers, review articles, and technical notes but also letters, corrections, and retractions, editorials, news features, and so on. ISI studies have shown that these items are significant means of scholarly communication [1]. Thus the S&T analyst has great flexibility in choosing which types of items to include in an evaluation.

In addition, ISI *fully indexes* these items — including all authors' names, institutional affiliations and addresses, article titles, journal, volume, issue, year, and pages. This enables S&T analyses of individual researchers, institutions and departments, cities or states or nations, journals, established and emerging specialties, and so on.

As noted earlier, ISI indexes not only all journal source items but also all the references they cite. This provides the basis for developing a variety of quantitative S&T indicators — not just output or productivity (number of papers) but also "impact" (average number of citations per paper, journal, author, institution, and so on), "citedness" (percent of total publication output that was later cited), and so on.

(Continued on next page)

At present, ISI's databases include about 15,000,000 papers published since 1945 and more than 200,000,000 references they cited. This offers the potential for extended time-series analyses of S&T trends to policymakers, administrators, and managers as well as historians, sociologists, and information scientists.

The following sections illustrate the variety of analyses at different levels of specificity — from individual authors to entire nations — that are possible using citation data. The examples are taken from *Science Watch*, a monthly ISI newsletter reporting on citation-based trends and developments [2].

Most-cited authors

Over the years, ISI has published several studies identifying the most-cited authors in various fields and covering different time periods. It should be noted that authors in larger fields achieve higher citation rates. Thus, undifferentiated citation rankings tend to be dominated by molecular biologists, geneticists, biochemists, and other life scientists while fewer authors in physics and chemistry, for example, are represented.

Table 1.
Most-cited authors of the 1980s, ranked by citations to papers indexed in the 1981-1990 *Science Citation Index (SCI)*

Author	Field	1981-1990 Citations	1981-1990 Papers
Gallo, R.C.	Virology	36,789	591
Schlossman, S.F.	Immunology	21,682	348
Nishizuka, Y.	Biochemistry	20,143	181
Hood, L.E.	Molecular biology	18,288	324
Messing, J.	Molecular biology	18,229	35
Fauci, A.S.	Immunology	17,756	563
Bloom, S.R.	Gastroenterology	16,543	1,468
Vale, W.	Neuroendocrinology	16,422	348
Dinarello, C.A.	Immunology	16,143	483
Berridge, M.J.	Biochemistry	16,004	93
Rosenberg, S.A.	Surgery/oncology	15,922	430
Rivier, J.	Endocrinology	15,893	320
Seeburg, P.H.	Neuroendocrinology	14,454	124
Irvine, R.F.	Biochemistry	14,431	108
Chambon, P.	Molecular biology	14,190	246
Reinherz, E.L.	Immunology	14,067	220
Wong-Staal, F.	Virology	13,910	254
Baltimore, D.*	Virology	13,847	222
Goldstein, J.L.*	Genetics	13,120	202
Brown, M.S.*	Biochemistry	13,031	171
Franke, W.W.	Cell biology	12,930	280
Hokfelt, T.	Neuropharmacology	12,881	381
Strominger, J.L.	Virology	12,817	253
Ullrich, A.	Biochemistry	12,670	199
Bishop, J.M.*	Virology	12,427	162
Thomas, E.D.*	Oncology	12,306	412
Snyder, S.H.	Pharmacology	12,302	308
Witten, E.	Physics	12,105	96

Note: * Nobel Prize winner

Table 1 identifies 28 authors who received more than 12,000 citations to papers indexed in the 1981-1990 *SCI*. It is interesting to note that five authors (18%) are Nobel Prize winners. In fact, this and previous most-cited author rankings have been shown to effectively identify groups or sets of authors "of Nobel class" [3]. That is, not only are actual Nobelists identified, but authors who later go on to win the prize are also included. It is remarkable, that a simple, quantitative, and objective algorithm can consistently anticipate a highly subjective and qualitative selection process. But this is not surprising, because citation data have been shown to correlate highly with other qualitative indicators of "prestige" or "eminence", such as peer ratings, academy memberships, and so on [4-9].

While rankings of the *most*-cited authors are fairly straightforward, great care must be taken when using citation data to evaluate the impact of the *average* individual. These evaluations can be both revealing and reliable, but only when performed properly — with expert interpretation, peer assessment, and recognition of potential artifacts and limitations [10].

Highly impact papers and journals

One of the most obvious uses of citation data is to indicate particular papers that have attracted the highest attention from other peer S&T authors. By varying the time span of citation and/or publication, historical "classics" and currently "hot" papers are readily identified. For example, ISI has published a series of essays on the most-cited papers in the 1945-1988 *SCI* database [11,12]. They provide an interesting perspective on formal research communication for S&T historians, sociologists, authors, editors, publishers, and so on.

Identifying "hot" papers through citation data enables S&T analysts to monitor current breakthroughs at the forefront of research in various specialties. For example, Table 2 lists the ten hottest biology papers at year-end 1991. These and other hot papers in different fields, specialties, and particular research topics are derived from a special ISI database. It is a cumulative three-year file, updated bimonthly, of about 1,000,000 papers that meet two criteria. They were published within the previous 24 months in *SCI*-indexed journals, and they were highly cited in the most-recent two months.

Aggregated at the next level, citation data can also be used to indicate the highest-impact journals in different fields and specialties and over varying time frames. ISI's *Journal Citation Reports* (*JCR*) volumes of the *SCI* and *Social Sciences Citation Index* (*SSCI*) present a variety of quantitative rankings on thousands of journals annually. From these data, sophisticated time-series comparisons between journals can be made, as shown in Figure 1.*

The chart shows the relative rankings by citation impact — average citations per paper — of the five leading clinical medicine journals in the *SCI* database. In this example, impact was calculated for six successive and overlapping five-year periods of publication and citation, from 1981-1985 to 1986-1990. The impact of each journal was then compared relative to the average for all *SCI*-indexed clinical medicine journals.

* Az ábrák összegyűjtve a cikk végén, a 8. oldalon találhatóak.

Rank	Paper	Citations this period (Nov-Dec 91)	Rank last period (Sep-Oct 91)
1	**T.A.Springer**, Adhesion receptors of the immune system, *Nature*, 346(6283):425-34, 2 August 1990. [Harvard U. Sch. Med. Cambridge, Mass.]	68	3
2	**A. Ulrich, J. Schlessinger**, Signal transduction by receptors with tyrosine kinase activity, *Cell*, 61(2):203-12, 20 April 1990. [Max Planck Inst. Biochem., Martinsreid, Germany; New York U. Med. Ctr., N.Y.]	54	2
3	**P. Nurse**, Universal control mechanism regulating onset of M-phase, *Nature*, 344(6266):503-8, 5 April 1990 [U. Oxford, U.K.]	36	8
4	**D.F. Fiorentino, M.W. Bond, T.R. Mosmann**, Two types of mouse T. helper cell. IV. Th2 clones secrete a factor that inhibits cytokine production by Th1 clones, *J. Exp. Med.*, 170(6):2081-95, 1 December 1989. [DNAX, Inc., Palo Alto, Calif.]	34	*
5	**J.E. Rothman**, Polypeptide chain binding proteins: Catalysts of protein loding and related processes in cells, *Cell*, 59(4):591-601, 17 November 1989 [Princeton U. N.J.]	31	*
6	**P. Sokoloff, B. Giros, M.-P. Martres, M.-L. Bouthenet, J.-C. Schwartz**, Molecular cloning and characterization of a novel dopamine receptor (D3) as a target for neuroleptics, *Nature*, 347(6289):146-51, 13 September 1990 [INSERN, Paris, France, U. René Descartes, Paris]	31	7
7	**H.R. Bourne, D.A. Sanders, F. McCormick**, The GTPase super-family: Conserved structure and molecular mechanism, *Nature*, 349(6305):117-27, 10 January 1991. [U. California, San Francisco; Cetus Corp., San Francisco; Whitehead Inst., Cambridge, Mass.]	31	*
8	**J.H. Exton**, Signaling through phosphatidylcholine breakdown, *J. Biol. Chem.*, 265(1):1-4, 5 January 1990. [Howard Hughes Med. Inst., Vanderbilt U., Nashville, Tenn.]	30	*
9	**M.E. Hemler**, VLA proteins in the integrin family: Structures, functions, and their role on leukocytes, *Ann. Rev. Immunol.*, 8:365-400, 1990. [Dana-Farber Cancer Inst., Boston, Mass.]	30	*
10	**B.J. Bachmann**, Linkage map of Escherichia coli K-12, edition 8, *Microbiol. Rev.*, 54(2):130-97, June 1990. [Yale U., New Haven, Conn.]	28	5

Table 2. What's hot in biology

Source: ISI's Hot Papers Database

Leading universities and corporations

From the author affiliation and address data on articles indexed and cited in ISI's databases, time-series rankings of leading institutions in different fields and specialties are available for S&T analyses. For example, the highest-impact universities and companies in electrical engineering are shown in Table 3. Figure 2 compares the relative impact of eight biotechnology firms from 1984 through 1990.

The applications of these citation-based institutional rankings and trends as S&T indicators is obvious. For example, university administrators and corporate managers can compare their performance with peers and competitors. Government and private funding sources can monitor the return on their S&T investment. And policymakers can identify relative strengths and weaknesses in strategically important S&T sectors.

National comparisons

Of course, citation data can also be aggregated to the national level, enabling comparisons of entire countries on a variety of quantitative indicators for S&T analyses. In Figure 3, the impact of the Group of Seven (G7) nations in engineering, technology, and the applied sciences is charted from 1981 to 1990. The trends provide a new perspective on relative S&T performance and an additional quantitative basis for assessing and evaluating nations.

Analyses of relative performance in "hot" research areas at the forefront of particular specialty are also possible through ISI's citation databases. For example, Table 4 lists ten research fronts in which Japan and Germany dominate and the USA is underrepresented. They were derived from a 1990 file of more than 8,000 specialty areas identified through co-citation analysis [13,14].

Basically, each consists of a "core" of papers cited together frequently by authors in 1990, and the current citing papers. The proportion of core papers from Japan and Germany is at least twice the level expected from their average representation in the entire 1990 file. In this example, the research fronts are also ranked by three-year immediacy — the percentage of core papers published in the previous three years. These and other research front rankings enable S&T analysts to compare national performance in various areas of intrinsic interest, commercial potential, or strategic importance.

Potential limitations

As stated earlier, citation data require careful and balanced interpretation to be most effective in S&T analyses [15,16]. Like any quantitative indicator, citation data have inherent limitations. They are most obvious at the individual level — studies of particular author or journal, for example. But their importance wanes at higher levels of data aggregation and larger sample populations: for example, comparisons of authors, journals, institutions, and nations against appropriate baselines.

(Continued on next page)

Table 3. Highest-impact universities and corporations in electrical engineering, 1986-1990 (at least 50 papers)

Universities					Industrial firms			
Rank	Name	Papers 1986-90	Citations 1986-91	Citations Per Paper	Name	Papers 1986-90	Citations 1986-91	Citations Per Paper
1	Stanford University	243	1,283	5.28	AT&T	754	5,366	7.12
2	University of Rochester	51	269	5.27	Fujitsu	151	814	5.39
3	University of Illinois, Urbana	211	1,100	5.21	GTE	71	327	4.61
4	Columbia University	74	343	4.64	Bellcore	223	994	4.46
5	Caltech	69	294	4.26	IBM	316	1,402	4.44
6	University of Southampton	150	631	4.21	Rockwell	61	270	4.43
7	Purdue University	95	366	3.85	Hughes	148	513	3.47
8	Cornell University	97	351	3.62	Plessey	109	363	3.33
9	University of Tokio	82	293	3.57	British Telecom	469	1,227	2.62
10	Univ. of Southern California	58	195	3.36	Hewlett Packard	253	650	2.57
11	Univ of Calif., Santa Barbara	66	210	3.18	GEC	140	356	2.54
12	MIT	175	548	3.13	NTT	882	2,183	2.48
13	Georgia Inst. Tech.	86	269	3.13	GE	188	462	2.46
14	University of Calif., Berkeley	211	658	3.12	Hitachi	313	753	2.41
15	University of Arizona	64	193	3.02	Honeywell	86	205	2.38
16	University of Wisconsin, Madison	52	157	3.02	Toshiba	212	492	2.32
17	Univ. of Florida, Gainesville	102	296	2.90	Matsushita Electric	135	302	2.24
18	University of Sheffield	92	265	2.88	TRW	83	183	2.20
19	Univ. of Calif., Los Angeles	109	308	2.83	Sony	69	151	2.19
20	Pennsylvania State University	70	193	2.76	RCA	80	164	2.05
21	Univ. of Minnesota, Minneapolis	85	233	2.74	Texas Instruments	229	445	1.94
22	University of Surrey	77	210	2.73	Mitsubishi Electric	133	257	1.93
23	Univ. London, Imperial College	88	231	2.63	Intel	89	164	1.84
24	Univ. of Michigan, Ann Arbor	136	356	2.62	Philips	249	366	1.47
25	Arizona State University	61	152	2.49	NEC	512	733	1.43

Source: ISI's Science Indicators Database, 1986-1991.

Table 4. Ten fields targeted by both Germany and Japan

Rank	Field	Three-year immediacy	Percent of papers from: Japan	FRG	USA
1	Synthesis of alpha-fluoro derivatives	50%	14.8	40.7	18.5
2	Characterization of chicken anemia agent	50%	24.0	12.0	16.0
3	Controlled creation of microscopic solids	50%	23.3	13.3	16.7
4	Immunohistochemical studies of amyloidosis	50%	30.8	15.4	3.9
5	Iminophosphorane-mediated syntheses	38%	15.4	14.3	17.6
6	Combination chemotherapy in non-small-cell lung cancer	33%	23.2	24.6	7.3
7	Adrenoceptor-blocking activity and hemodynamic effects of carvedilol	25%	44.2	25.6	11.6
8	Endoscopic ultrasonography for clinical staging of esophageal carcinoma	17%	18.0	13.1	14.8
9	Low-temperature transport in amorphous semiconductors	17%	23.8	15.9	15.9
10	Performance characteritics of LaNi5 electrodes	15%	17.2	19.4	16.1

Source: ISI's Research Front Database, 1990.

A frequently raised question is *whether citations reflect agreement or disagreement* with the referenced paper. In the hard sciences, citations generally tend to be positive, representing the formal acknowledgment of prior sources that contributed to the citing author's research. Of course, there are occasional exceptions, such as cold fusion controversy, but these are well known and obvious. In social sciences, however, critical citations are more common. Thus, raw citation counts may not be indicative of an author's or paper's positive impact in the social sciences, and the *context* and *content* of citations should be examined.

Self-citation is another frequently raised caveat. That an author cites his or her own prior research is a legitimate and expected practice, since science is a cumulative process that builds on past findings. But excessive self-citation may lead to inflated impact rankings of authors or papers. Presumably, excessive self-citation would become apparent, and corrected, in the editorial and peer review process. In any case, self-citations are readily identified and can be subtracted from or otherwise weighted against an author's or paper's total citation count.

Citation circles are related to the phenomenon of self-citation. That is, groups of researchers might theoretically "conspire" to preferentially cite only the work of authors in the group. However, in order for this to unfairly "skew" citation and impact rankings, authors in a purported citation circle must be rather prolific, that is, they must publish a substantial number of papers in order to "inflate" the group's ranking.

While citations circles are much talked about, they are rarely, if ever, documented and identified. The problem is, it would be difficult to distinguish between a citation circle and an invisible college — that is, colleagues who legitimately share common research interests and build on (and cite) one another's papers. This is especially true in small and emerging subspecialties in which a comparatively small group of authors are active.

Another purported shortcoming of citation analyses is that *methods tend to be identified far more frequently than theoretical papers*. This perception is not necessarily supported by ISI studies of the most-cited papers or authors in various fields — breakthrough theoretical contributions appear in these rankings. This perception also reflects a curious prejudice of scientists, who seem to value theory more highly than methods.

Practically speaking, new methods and technologies that enable researchers to study phenomena previously inaccessible by conventional techniques or that allow them to conduct research more quickly, efficiently, and cost-effectively are indeed valuable contributions that deserve recognition. In fact, the Nobel Prizes have honored breakthrough methods and technologies — for example, computerized axial tomography, scanning and tunnelling electron microscopy, and so on.

The *obliteration phenomenon* must also be taken into account when applying citation data to S&T evaluations. This refers to a well-known process in which breakthrough advances — for example, Einstein's theory of relativity or Watson and Crick's description of DNA's double-helix structure — are paradoxically cited *less* frequently over time.

Such landmark discoveries are quickly incorporated into the generally accepted body of scientific knowledge, and authors no longer feel the need to explicitly cite the original paper. However, citation obliteration tends to occur many years after the paper was published; in the first few years, these papers achieve extraordinary citation frequencies and are thus easily identified as "hot" or breakthrough contributions.

Lastly, publication and citation data are *"lagging indicators"* of research that has already been completed and passed through the peer review and publishing cycle, which can take as long as two years, depending on the field. Of course, especially important papers can appear in print within weeks of submission to a journal, and they become "hot" or very highly cited almost immediately. In any case, citation data still represent the scientific community's current assessment of the impact of earlier research. Thus, citation data retain their value for S&T evaluations since they indicate what is considered important in the opinion of investigators currently active in the field.

Conclusion

In conclusion, publication and citation data offer the potential to develop new quantitative, objective indicators of S&T performance. While they have their limitations as do any quantitative indicators, most, if not all, of these limitations can be statistically weighted, controlled, or otherwise compensated. Properly applied, interpreted, and analyzed, citation data are a valuable and revealing addition to conventional methods — both quantitative and qualitative — used in the S&T evaluation and assessment process.

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(Continued on next page)

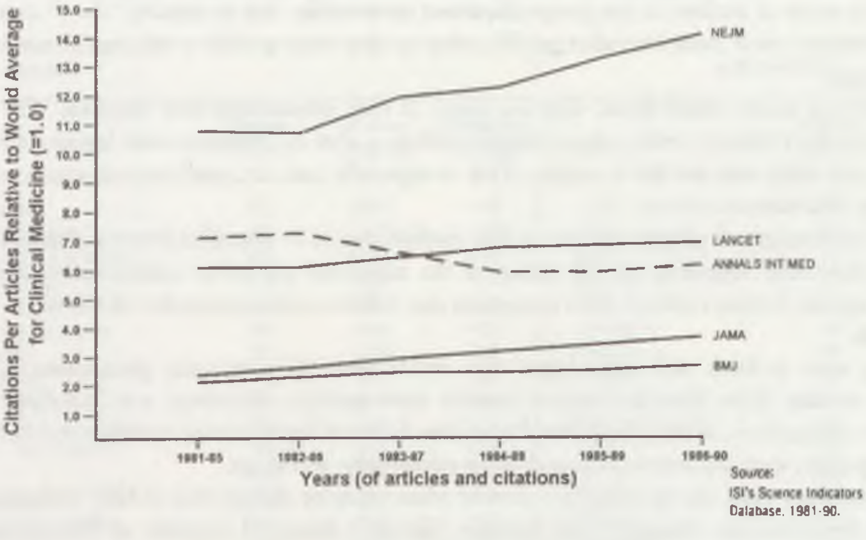

Figure 1. *Citation impact of leading journals of clinical medicine*

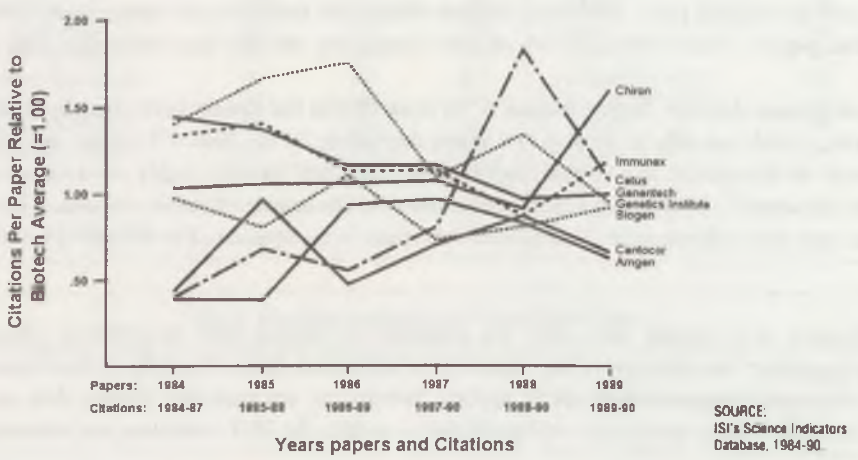

Figure 2. *Citation impact of leading biotechnology companies*

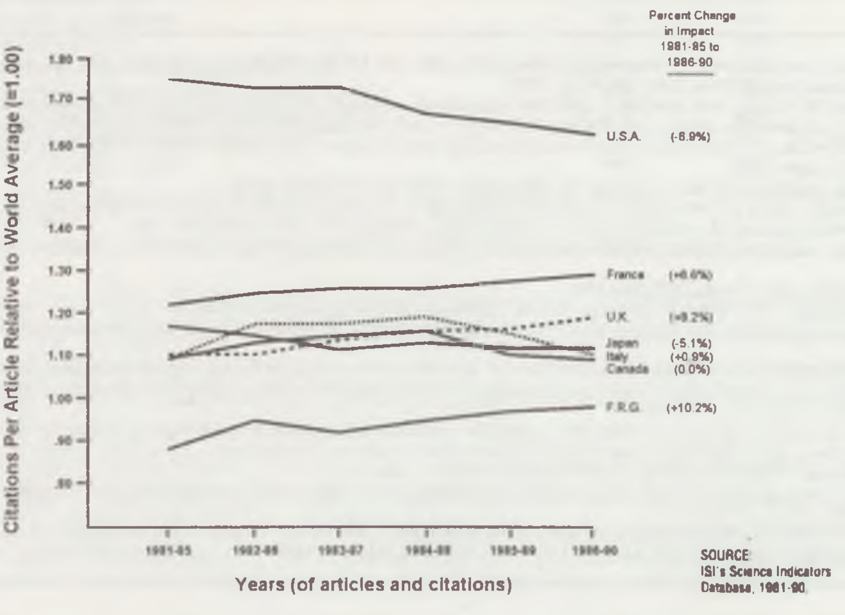

Figure 3. *Citation impact of journal articles in engineering, technology, and applied sciences for G7 nations, 1981-1990*

An unwelcome export success

Is India now one of the world's chief sources of migratory technical skill? According to two recent studies, three out of ten engineering graduates produced by the Indian Institute of Technology (IIT) Bombay since 1970 have settled abroad, while the brain drain from IIT Madras varied from 20 per cent during 1963-67 to 35 per cent in 1983-87. The five ITT's are the country's most distinguished engineering schools.

Things are much the same at all five IITs. Thus Professor M.C. Nigam, director of IIT Delhi, estimates that the exodus from his institute has been steady at 30 per cent. And it is generally agreed that nearly a quarter of the engineers trained at all the five IITs (the others are at Kanpur and Karagpur) take a plane to the West each year.

Computer scientists head the list. In a recent study, Robert K. Perkins of the University of California, Berkeley, found that 91 per cent of first-year computer science students of IITs and the Jadhavpur University planned to emigrate when they were qualified. In fact, 70 per cent of them at Jadhavpur ended up going abroad.

The situation is much the same in medicine. A recent study by Professor Veena Kalra of the All-India Institute of Medical Sciences (AIIMS) in New Delhi discovered that 45 per cent of graduates from the institute since 1971 have emigrated. She says that the brain drain, which reached a peak at 80 per cent ten years ago, continues but at a lower rate.

"Considering that it costs taxpayers £3,000 to educate one IIT graduate and twice that amount for a medical student, India has repaid through export of human capital more than the total aid it received from abroad," says S. Biswas, an education consultant in Delhi. "India, no doubt, produces more professionals than it needs," he says, "but the 2 per cent of professionals who leave each year represent the cream."

Meanwhile there are fears that the brain drain will accelerate because of the recent economic reforms, which encourage the entry of multinational corporations into India. "When multinationals come to India in a big way, they will draw on local talent and, after a few years, relocate them to Singapore, Korea or the United States," says Professor Nigam.

While the migration continues, its pattern is changing. Thus there has been a recent growth of migration towards Australia, which has opened its doors to technically qualified people, and to Singapore, which has begun giving work permits to Indians. Nigam believes that the brain drain will continue unless Indian industries modernize and unless the government offers world-class facilities and opportunities.

One feature of the migration from India now apparent is that people seize the earliest opportunities to leave. Thus the bulk of the exodus from India to the United States is made up of fresh graduates from IITs and other institutions of higher learning. Once people are established in posts at universities, the Council of Scientific and Industrial Research (CSIR) or the councils of medical or agricultural research, the risk that they will migrate appears to be negligible.

Past schemes to stem migration appear to have had little success. Indeed, the Indian government does not seem to be unduly worries; its new technology policy statement offers no prescription for reducing the brain drain.

"The brain drain is a natural process and cannot be plugged", says S.C. Mazumdar of CSIR, who is in charge of the TOKTEN (transfer of knowledge through expatriate nationals) project to reverse the brain drain. But in 13 years, he has been able to tempt only 500 expatriates to accept short-term assignments in Indian laboratories. The projects is in any case to be wound up in December 1994. Another government scheme, launched two years ago to lure expatriates to industry, has yet to yield results. The 35-year-old "scientists pool scheme", designed to find jobs for returning scientists, has so far succeeded in resettling about 7,000 Indians, but many have since emigrated again.

Mazumdar nevertheless emphasizes that even when Indian expatriates in the United States do not want to return, they are eager to help in other yaws. He mentions for example, their willingness "unofficially" to arrange for training of their countrymen who happen to be visiting the United States.

Even so, the government's hopes that it would keep able people at home by the creation of new technical agencies, in fields such as ocean development, environment and biotechnology, appear to have been disappointed.

But there are some exceptions. The National Informatics Centre (NIC), which has 3,200 computer professionals, boasts of having lost only 60 in 15 years. In contrast, 15 per cent of the staff of Tata Consultancy Service, a private computer company, have gone abroad despite better pay than those at NIC, even though their paychecks are not thick," says N. Seshagiri, NIC's chief. "We give them intellectually challenging problems in frontier areas of technology, and we have the best equipment and a good personnel and promotion policy. We have proved that brain drain can be stopped under the right conditions," he says.

K.S.J.,
Nature 366 (16 December, 1993) 618

Delors white paper puts research firmly on Europe's political map

Europe's political leaders have given their formal endorsement to proposals that would enlarge their common research programmes encourage the joint construction of new 'information highways' and increase incentives to persuade industry to invest in research.

At their summit meeting in Brussels last weekend, the leaders of the 12 member states of the European Union (EU) approved a white paper (policy document) on competitiveness, growth and unemployment prepared by Jacques Delors, the president of the commission. The paper is aimed at creating 15 million jobs in the EU by 2000.

Three of its ten chapters dealt exclusively with research and development (R&D). The EU's acknowledgement of the importance of R&D to its plans for economic recovery was further reinforced at the summit, when the heads of government also broke the deadlock over the funding of the EU's next five-year Framework programme, by approving a budget of ECU12 billion (US$13.6 billion).

In his white paper, Delors sets the EU the ambitious target of increasing spending on R&D to three per cent of gross national product (GNP). It now spends just 2 per cent (ECU104 billion) in contrast with the United States, which spends 2.8 per cent (ECU124 billion) and Japan three per cent (ECU77 billion).

Such a large increase in spending seems improbable, given that member states have either frozen or cut science spending because of the economic downturn. Nevertheless, Delors is confident that the private sector could make up the difference. Companies fund just over half of all science spending in Europe, compared with more than three-quarters in Japan.

To this end, Delors encourages member states to provide tax and other incentives to companies to invest in research. He also wants the EU to make its rules for cofunding industrial research more flexible (*see Nature* **365**, 775; 1993).

Delors also criticizes the lack of coordination between national research policies. His remedy would be to formalize cooperation within some form of European science agency, but it is too soon to say how this would operate. He also wants member states to take joint measures to improve technology transfer.

He recommends that national research organizations, companies and social groups need to develop a European strategy for biotechnology as a matter of urgency. He has also instructed the commission to consider revising legislation biotechnology products.

The white paper proposes that governments encourage companies to work together on several big projects in the fields of information technology, biotechnology and environmental technology. The European Round Table, which brings together 40 leading industrialists, backs the plan. The paper suggests ECU150 billion should be spent on information technology infrastructure over the next ten years. Furthermore, it accords priority to eight projects, including building a high-speed communications network and developing databases and electronic mail, requiring ECU67 billion in 1994-98.

Delors wants the EU to set up a highlevel "Task Force on European Information Infrastructure" to plan the programme and start it by the middle of next year. Although EU has agreed to provide ECU12 billion a year for six years to create networks in transport, energy and telecommunications, it anticipates that most of the money for the electronic highway will come from the private sector.

It is too soon too say what effect the EU summit's adoption of the Delors plan will have on science and technology. Although the member states have committed themselves to implementing the white paper's recommendations, these are non-binding and will inevitably be subject to change.

Declan Butler, Nature 366 (16 December, 1993) 599

A gold mine of information

Russian science to the West India's National Informatics Centre (NIC) in New Delhi is planning to exploit Russia's need of cash by acting as an information broker.

The calculation is that there is a huge amount of saleable information on science and technology (S&T) which the world is not aware of because it is all in Russian. And several companies in the United States are ready to pay money for translated Russian literature in the belief that it contains ideas or inventions they can exploit commercially. According to N. Seshagiri, NIC's director-general, there is a goldmine of information in theses, laboratory reports, journals and other Russian-language documents that the Russians now wish to sell.

NIC has worked out a two-way arrangement under which it will translate the Russian reports, create appropriate databases and then make these available to vendors in the United States. We are just a middleman, says Seshagiri. From whatever the US companies pay, NIC will subtract a service charge and hand over the rest to the Russians. Seshagiri says it will be a handsome amount.

Four Russian institutions, all in Moscow, have entered into this deal with NIC. They are ICAD (Institute of Computer-Aided Design) and VINITE (a science and technology information organization), and two institutes of the Russian Academy of Sciences. Initially, the agreement will run for two years, but will be extended if there is a sufficient demand for it. NIC has negotiated with three US companies, who will be in Delhi this month to finalize the agreement.

NIC is opening an office in Moscow and installing computer terminals that will be linked to NIC's Cyber-730 host computer. Full translation of Russian texts will be provided on request. To start with, NIC will prepare databases on fluid mechanics, aerodynamics and informatics.

According to Seshagiri, India and Russia will invest 1 million each in this joint venture, which he says will give a return of 10 million annually beginning in 1994. The profits will be shared between Russia and India in the ratio of 60:40.

K.S.J., Nature 366 (16 December, 1993) 618

MAGYAR TUDOMÁNYOS AKADÉMIA KÖNYVTÁRA

Der Forschungs Index

A kutatási index
A német kutatás vezető intézetei

Publikációs és idézettségi rangsorok

Előző számainkban gyakran közöltünk az Egyesült Államokban kiadott *Science Watch című folyóiratból átvett publikációs idézettségi rangsorokat. Újabban hasonló rangsorokat közöl minden számában a németországi *Bild der Wissenschaft** is. A jövőben ezekből is átveszünk majd válogatott részeket. (Az első részt lásd: *Impakt*, 3 (12)(1993) 12.) A rangsorokat, legyenek azok amerikai vagy német eredetűek, természetesen sem fetisizálni, sem túlbecsülni nem szabad. De úgy gondoljuk, hogy a gondolatébresztéshez és más szempontok szerinti elemzésekhez, illetve értékelésekhez hasznosnak bizonyulhatnak.**

** A folyóirat hozzáférhető az MTA Könyvtárában*

Az ipari kutatás megelőzi az egyetemeket

1985 óta Németországban egy tízéves támogatási program van folyamatban, amely az anyagkutatást egymilliárd márkával kívánja elősegíteni. A világ vezető anyagkutatási folyóirataiban (a súlypontban a fémek és a kerámia állnak) évente 1300 dolgozat jelenik meg német szerzők tollából. A legtöbbet publikáló intézmények a stuttgarti Max Planck Fémkutató Intézet és a Jülichi Kutatóközpont (KfA). A "befolyásosak" jegyzéke — vagyis azoké, akiket a legtöbbször idéznek — azt mutatja, hogy a kutatás négy nagy szektora érdekelt az anyagkutatásban: a Max Planck Intézetek, a nagy kutató intézmények, u.m. a KfA, az ipar (Siemens) és a főiskolák (Aacheni Műszaki Főiskola). Az ipari kutatást a "hatékonyak" jegyzéke (egy közleményre eső idézetek száma) világítja meg: Philips, AEG és Leybold részvételével az első öt helyen három vállalat található.

Az értékelésben nem vettük figyelembe a polimer kutatást, mely a szakfolyóiratokban és a az adatbankokban a többi anyagkutatástól nagymértékben elkülönült.

Anyagkutatás (polimerkutatás nélkül)

A befolyásosak

	Intézmény	Idézetek száma 1990-tól 1993 jún.-ig	Publikációk száma 1990-tól 1993 márc.-ig
1	Stuttgarti Max Planck Fémkutató Intézet	354	202
2	Jülichi Kutatóközpont	307	141
3	Siemens, München	222	89
4	Aacheni Műszaki Főiskola	192	133
5	Mainzi egyetem	175	62
6	Erlangen-Nürnbergi egyetem	153	102
7	Karlsruhei egyetem	127	69
8	Düsseldorfi Max Planck Vaskutató Intézet	120	50
9	Marburgi egyetem	119	49
10	Saarvidéki egyetem	110	37

(Folytatás a következő oldalon)

Az aktívak		
	Intézmény	Publikációk száma
1	Stuttgarti Max Planck Fémkutató Intézet	202
2	Jülichi Kutatóközpont	141
3	Aacheni műszaki főiskola	133
4	Erlangen-Nürnbergi egyetem	102
5	Siemens, München	89
6	Drezdai Központi Szilárdtestfizikai és Anyagkutató Intézet	83
7	Német Légiközlekedési és Űrutazási Társaság	76
8	Karlsruhei egyetem	69
9-11	Stuttgarti egyetem	68
9-11	Berlini műszaki egyetem	68
9-11	Stuttgarti Max Planck Sziládtestfizikai Kutató Intézet	68

A hatékonyak			
	Intézény	Egy publikációra eső idézetek száma	Publikációk száma
1	Philips, Hamburg	4,3	15
2	AEG, Frankfurt	3,8	12
3	Göttingeni Max Planck Biofizikai Kémiai Intézet	3,6	14
4	Würzburgi Fraunhofer Szilikátkutató Intézet	3,5	12
5	Leybold, Hanau	3,1	11
6	Saarvidéki egyetem	3,0	37
7	Mainzi egyetem	2,8	62
8	Mainzi Max Planck Polimerkutató Intézet	2,7	37
9	Siemens	2,5	89
10	Düsseldorfi Max Planck Vaskutató Intézet	2,4	50

Bild der Wissenschaft (10/1993) 6
(Forrás: Institut für Wissenschaft- und Technikforschung, Bielefeld,
a Science Citation Index alapján.

Készült az Argumentum Könyv- és Folyóiratkiadó Kft. nyomdájában

Felelős kiadó: az MTAK főigazgatója