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Current Comments®

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New Scientist Examines AIDS Research with ISI®'s Citation Data

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Introduction: A Citationist Perspective on AIDS

Recently, 12,000 scientists met at the Berlin International Conference on AIDS. In the 13 years since "severe acquired immunodeficiency" was first described as a clinical syndrome,[1-4] basic research has advanced our understanding of the molecular biology and life cycle of the HIV virus. But little progress has been made on the clinical front. A cure, vaccine, or even effective treatment to arrest or slow the disease's progress is still beyond reach.[5,6] This is especially alarming considering HIV's relentless spread. Fourteen million people today are HIV infected, and some 30 to 40 million may be by the year 2000, according to the World Health Organization.[7] And most of the 2 million adults infected to date have died.[7]

Not surprisingly, the science news media are devoting a lot of attention to the AIDS research effort—how far it has come to date and where it ought to be directed in the future. For example, *Science* devoted a recent issue to the "unanswered questions" about AIDS.[8] It surveyed 150 AIDS researchers, of whom 74 responded, to identify the basic questions that need to be answered to develop a cure or vaccine. Incidentally, as a guide to the 800 presentations and 4,500 posters at the Berlin conference, *Science* published lists of the 10 most productive, most-cited, and highest impact authors of 1988-1992 AIDS papers, which ISI® provided from its Science Indicators Database.[9]

Phyllida Brown

Recently, *New Scientist* also published an analysis of the "epidemic" of AIDS research, which is reprinted below.[10] Based on citation data on 36,000 AIDS papers in ISI's 1981-1992 database, senior reporter Phyllida Brown asked how well the AIDS research effort is being "mobilized." Her article represents a turning point in the use of citation data by journalists to support an informed opinion on where research activity is going. Citation analysis is not just a question of "pop chart" ratings. Its careful use can help the researcher and science

journalist gain a balanced perspective on rapidly developing fields. Particularly because the scientific literature and enterprise is so large, it is easy to be swayed by anecdotal impressions rather than qualitative judgments based on solid quantitative data.

The *New Scientist* report is by no means the first citation analysis of AIDS research. In 1989, Henry Small, ISI®'s director of research, published an interesting retrospective on AIDS research.[11] He presented a series of annual maps from 1982 to 1987 generated by a co-citation analysis of clusters of AIDS papers. These maps effectively traced the development of research on this topic and identified both major discoveries and dynamic shifts in research emphasis over time.

In addition, *Science Watch®*, the ISI monthly newsletter that tracks trends in research, has identified many landmark AIDS papers in its Hot Papers feature. Interested readers may refer to the May 1993 issue.[12] The cover story presents citation and impact rankings of AIDS research institutions and also lists the highest impact papers published each year from 1988 through 1991.

The Uncitedness Bugaboo

One point in Brown's report deserves comment. She states that 11 to 15 percent of AIDS papers published in 1981-1984 and 1987-1992 were uncited. She finds this level of uncitedness both surprising and shocking. This reaction is typical but *not* surprising to specialists in citation analysis. It recalls an earlier tempest in a test tube stirred by *Science* reporter David Hamilton in his stories reporting raw data on uncitedness in various fields of research and scholarship.[13,14] The knee-jerk conclusion is that uncited papers are worthless and a waste of research grant money. However, these flawed interpretations were rebutted by David Pendlebury, editor of *Science Watch*, and others.[15-23]

It is surprising that science journalists and scientists themselves would find these data on uncitedness troubling. They ought to know better: *No* system, whether physical or natural or social, operates at 100 percent efficiency. Science publishing is no exception. So much research is being published today that there is a high probability that many papers will never be cited. And it is a certainty that most will be cited only a few times.

Very little is known about uncitedness and what it signifies. But a few possible reasons are: language of publication; unavoidable and even appropriate duplication or replication; delayed recognition of premature ideas; relative visibility of a journal or even inadequate use of information retrieval services by authors and referees; and so on. Much of the uncited literature may well be cited in low impact journals not covered in ISI's databases.

These and other variables need to be carefully studied before one can definitively conclude anything about uncitedness and what it really means. And until we know more about the phenomenon, journalists and scientists ought to refrain from unsubstantiated claims that uncited papers are useless, of low quality, or a waste of funds.

About the Author

Phyllida Brown earned a bachelor's degree at the University of Oxford in 1983, concentrating on human genetics, epidemiology, and population studies. She also trained and practiced as a registered general nurse before earning a postgraduate diploma in journalism from City University, London. She joined *New Scientist* in 1988, where she covers medical science news and specializes in AIDS and tropical medicine topics.

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Has the AIDS research epidemic spread too far?

As the effort to tackle HIV runs into billions of dollars, a study of scientists' published work raises some tricky questions about how the research is organised

Phyllida Brown

AIDS researchers around the world are under greater pressure than ever before to justify their existence. With no vaccine or cure in sight, the public on both sides of the Atlantic is becoming increasingly impatient. At the same time, politicians and the media are asking whether AIDS research has not turned into a gravy train with too much money too easily won.

Some scientists are worried too. Although they believe that the public's perception of failure is unfair and can be blamed on those who created unrealistic expectations, there is a heated debate over whether AIDS research is of poorer quality than research in other fields. Some critical scientists say that AIDS researchers have tended to be self-serving and their science sloppy.

"This is a field with a reputation that frightened away good scientists," says John Moore, at the Aaron Diamond AIDS Research Center in New York. But he stresses that attitudes are changing. "The attitude of 'Think not what you can do for AIDS

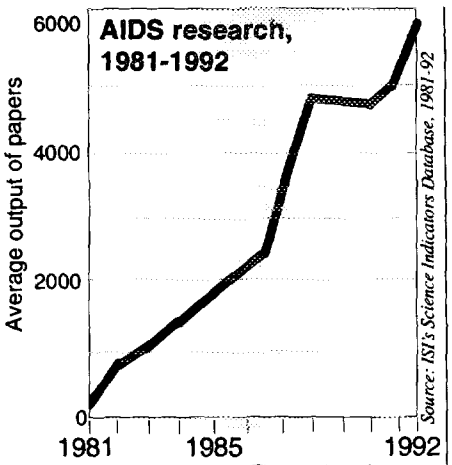

Figure 1: Up, up and away? The number of papers being published on AIDS is still rising fast

research; think what AIDS research can do for you' is largely a thing of the past," he says. "Cooperation between scientists is the norm nowadays." Malcolm Martin at the National Institutes of Health has a bleaker view: he says AIDS remains "a laughing stock field" characterised by faddishness and sloppy science. "It's too uncritical: anything goes," he says. "No one ever stands up and says, 'That's rubbish'."

But some respected scientists, including those outside the field, claim that standards in AIDS research are as high as in other fields. For example, Barry Bloom, a leading TB researcher at the Albert Einstein College of Medicine in New York, points out that competition for funds is on a par with other disciplines: grants are awarded to only about 14 per cent of those who apply to the National Institutes of Health for AIDS research money.

Despite the strength of these opposing views, there is a limit to what can be learnt about the quality and organisation of AIDS research merely by canvassing opinion. Yet the debate is an important one—not just because of the seriousness of the AIDS epidemic or the estimated $6 billion spent on studying it so far, but also because of the lessons it may hold for scientists about the best way to mobilise a large-scale research effort.

Opinions aside, there are several ways to assess research: peer review, the accepted gold standard; analysis of competition for funds; and citation analysis. This last is a means of measuring the way that scientists pay their "intellectual debts" as they publish papers, by citing those whose earlier work they relied on. On the whole, papers that receive a large number of citations from other scientists are often regarded as the more influential papers. No single measure gives a complete picture of research impact and each has its weaknesses, but all can provide pointers.

In an attempt to bring a new dimension to the AIDS debate, *New Scientist* has commissioned a wide-ranging citation analysis of AIDS research published between 1981 and 1992.

The Institute for Scientific Information® in Philadelphia produced the information for *New Scientist*, using its Science Indicators Database which contains information on 3200 of the world's leading science journals. The results could well prove controversial, and stimulate debate about ways to assess the relative contributions of different countries, disciplines and institutions.

Measuring impact

Using a list of keywords, ISI® identified just over 36,000 papers on AIDS published between 1981 and 1992 in the major scientific journals and specialist AIDS journals. The data were sorted to produce information on the total number of papers, total number of citations and average citations per paper—a weighted measure that can be used to assess the influence or impact of research.

ISI calculated the contributions of different countries, institutions and individuals. As one means to assess the significance of research in the field, the institute also gauged what proportion of AIDS papers in any given period receives high levels of citation and what proportion receives little or no attention. The results were compared with biological research in general, to provide a "baseline" against which to measure AIDS research. For this comparison, ISI considered only so-called "discovery papers"—in other words, original research. Letters, reviews, editorials and notes were excluded.

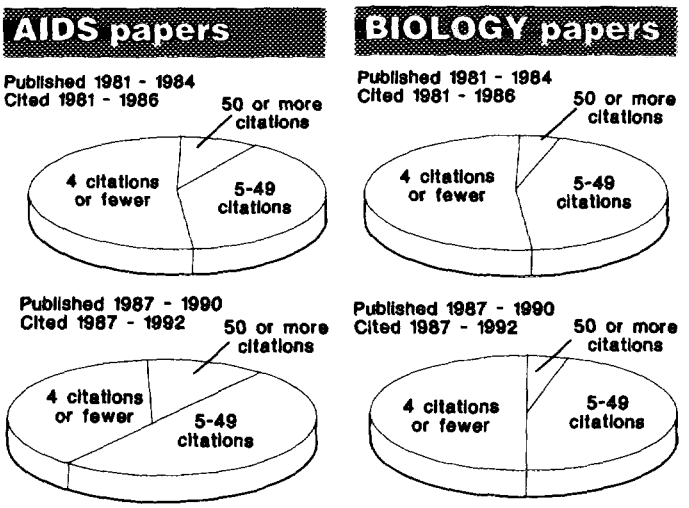

Figure 2: Almost 40 per cent of AIDS papers are cited just four times or fewer. But biology in general has even more rarely cited papers.

AIDS research has grown explosively over its first decade (see Figure 1). The first apparent surprise is the amount of AIDS research that has attracted no formal recognition whatever. In the period 1981-86, 15·37 per cent of AIDS papers published during 1981-84 received no citations at all—not a single person mentioned them in up to six years. Since ISI®'s database does not eliminate self-citing by scientists, this means that these papers languished without even the attention of their own authors.

Does this imply that AIDS research is of lower quality than average? Not when you compare these figures with those for general biology. In the same period, 14·59 per cent of general biology papers received no citations.

The shock, then, is not that so many AIDS papers go uncited but that so many go uncited in both AIDS and general biological research. "This is amazing," says Simon Wain-Hobson, a highly cited AIDS researcher at the Pasteur Institute in Paris. All these papers must be based on funded research. "Who is paying for them?" he asks.

AIDS researchers can take comfort—superficially at least—that in their field, the percentage of uncited papers is falling. In 1987-92, the proportion of AIDS papers published during 1987-90 without a single citation has been markedly lower—at 11·32 per cent—while the proportion for general biology has stayed virtually unchanged at 14·37 per cent.

That could suggest that, contrary to the critics' claims, AIDS research is steadily improving. The ISI analysis contains some data to support that view: between the early to mid-1980s and the late 1980s the percentage of highly cited AIDS papers—those with 50 or more citations—has almost doubled, from 5·43 to 10·04 per cent (see

1	Zaire	19·58	125
2	Belgium	15·70	573
3	US	15·24	18 495
4	Sweden	11·16	609
5	Switzerland	10·93	520
6	Netherlands	10·83	628
7	France	10·60	2260
8	Denmark	9·65	342
9	Finland	9·10	142
10	Canada	8·52	1064
11	Japan	8·36	1291
12	UK	8·14	3483
13	Israel	7·54	216
14	Austria	7·13	276
15	Germany	6·76	1774

Source: ISI's Science Indicators Database, 1981-92

Figure 3: A league of nations: whose voice is loudest?

Figure 4a: Classic papers picked out by citation analysis neatly fit the history of the disease

The classics: top cited paper for year
1981 Gottlieb et al: *Pneumocystis carinii* pneumonia in previously healthy homosexual men, *New England Journal of Medicine*
1982 Friedman-Kien et al: Kaposi's sarcoma in homosexual men, *Annals of Internal Medicine*
1983 Barré-Sinoussi et al: Isolation of a T-lymphotropic retrovirus from a patient at risk for acquired immunodeficiency syndrome/AIDS, *Science*
1984 Gallo et al: Frequent detection and isolation of cytopathic retroviruses (HTLV-III) in patients with AIDS or at risk for AIDS, *Science*
1985 Ratner et al: Complete nucleotide sequence of the AIDS virus, *Nature*
1986 Gartner et al: The role of mononuclear phagocytes in HTLVIII/LAV infection, *Science*
1987 Fischl et al: The efficacy of AZT in the treatment of AIDS and AIDS-related complex, *New England Journal of Medicine*
1988 Fauci: HIV infectivity and mechanisms of pathogenesis, *Science*
1989 Larder et al: HIV with reduced sensitivity to zidovudine isolated in prolonged therapy, *Science*
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Figure 2). In contrast, highly cited biology papers rose much more slowly, from 2·31 to 3·10 per cent. The middle ground remained virtually unchanged for biology, while its share increased for AIDS.

These changes cannot fully be explained by "expansion"—the fact that as a field grows, there are more papers to cite and more people to cite them. Although the average number of citations per paper increased from 14·87 for papers published before 1984 and cited up to 1986, to 20·26 for papers published between 1987 and 1990 and cited up to 1992, this should not affect the extreme top and bottom of the distribution. Overall, the pattern would be expected to remain roughly the same unless some genuine change were afoot.

But the changes do not necessarily imply that AIDS research is improving. One alternative explanation might be that researchers are increasingly concentrating their activity on fashionable areas of the science that are seen as intellectually glamorous. These areas may pick up disproportionately high numbers of citations as scientists crowd into areas with Nobel potential.

Another possible explanation is that the field may be "overheating". All authors need to do to escape the lowest category is cite their own work once a year for five years—and that may be easier in AIDS than in other fields because of the proliferation of specialist journals. Overheating could also explain part of the increase in highly cited papers, says Robin Weiss at the Insti-

Figure 4a (continued)

A brief history of AIDS

1981	AIDS first recognised in US in gay men
1982	Blood transmission detected AIDS recognised in Zaire in heterosexuals
1983	HIV-1 first isolated AIDS spreads in East Africa
1984	HIV-1 confirmed as cause Prototype antibody tests CD4 identified as receptor
1985	Blood donor screening introduced SIV found in monkeys
1986	Clinical trials of AZT (zidovudine) in AIDS patients HIV-2 found in West Africa
1987	Recombinant vaccinia with HIV envelope tested as immune therapy. AIDS in Brazil and Southeast Asia AZT licensed for treating AIDS
1988	AZT-resistant HIV-1 found in AIDS patients Less than half of new AIDS cases in New York are gay men
1989	SIV vaccines claimed to protect monkeys HIV spread by needles in Soviet Union and Romania
1990	AZT approved for treatment of symptom-free people with HIV Clinical trials of soluble CD4 and DD1 Attempts to bank different strains of HIV-1 from around the world
1991	SIV vaccine protection found to be partially due to host cell components. HIV-1 spreads rapidly in India
1992	AIDS deaths top 500,000 Monkeys protected from SIV by inoculation with live, gene-deleted form of virus
1993	AZT does not delay AIDS

tute of Cancer Research in London. Because of the strong interest AIDS has aroused, important papers on AIDS are more likely than other biological papers to be accepted for publication in the highly cited journals such as *Science* and *Nature*.

Interest on the wane

But whatever the reasons for the apparent flourishing of AIDS research overall, one large segment of it is wilting badly. Clinical AIDS research—studies of patients, rather than basic science conducted in the laboratory—appears to be steadily losing scientists' interest and attention. The share of clinical papers receiving more than 100 citations has more than halved between the early 1980s and the present. And at the bottom, an astonishing two-thirds of papers are cited four or fewer times, with more than a third receiving no citations whatever. David Ho at the Aaron Diamond AIDS Research Center in New York has an explanation for the trend: the syndrome of AIDS itself was described early on, with relatively little to say since. As for the testing of drugs and vaccines, there have been few recent breakthroughs to attract interest.

This might make laboratory scientists feel smug, but the study's summary of different countries' performance will almost certainly provoke debate among them (see Figure 3). The US will be piqued to find itself following Zaire and Belgium, and Britain, with the second biggest output, may be worried to find itself ranked only 12th in terms of impact—particularly when the Medical

Figure 4b: Some names appear year after year among the authors of the 10 most cited papers

Consistent performers

Scientists who appeared in the year's 10 most highly cited papers for four or more years between 1981 and 1992

Anthony Fauci (5 years)
Henry Masur (4 years)
Margaret Fischl (4 years)
Michael Gottlieb (4 years)
Richard Price (4 years)
Paul Volberding (4 years)

Marathon runners

Scientists who appeared in the year's 10 most highly cited papers for four or more years between 1981 and 1992, including at least one appearance since 1988

Anthony Fauci
Margaret Fischl
Paul Volberding
Richard Price

Research Council is conducting an international review of its AIDS work.

ISI®'s analysts point out that Zaire's place needs explanation: the country has generated just 125 papers, but some of them, produced in Kinshasa by the US-financed international collaborative research programme, Projet SIDA, provided highly significant information, for example on the heterosexual transmission of HIV. With such a small total number of papers, a few highly cited papers have skewed Zaire's ranking.

Getting results with limited funds

Beyond this anomaly, the list has raised some eyebrows among scientists. Most had expected the US to come first, followed by a clump of European and Scandinavian countries of roughly equal rank: France, Sweden, the Netherlands and Britain.

Do the national rankings contain clues as to the best way to organise AIDS research? The British might, for example, be able to learn some lessons from the highly-ranked Dutch. The Dutch AIDS research budget is tiny at 5·4 million guilders (£1·8 million), and the country has just three main teams of AIDS scientists. But they work closely together, concentrating on a small segment of the field. Should Britain similarly concentrate its limited funds on a small number of its best-respected laboratories?

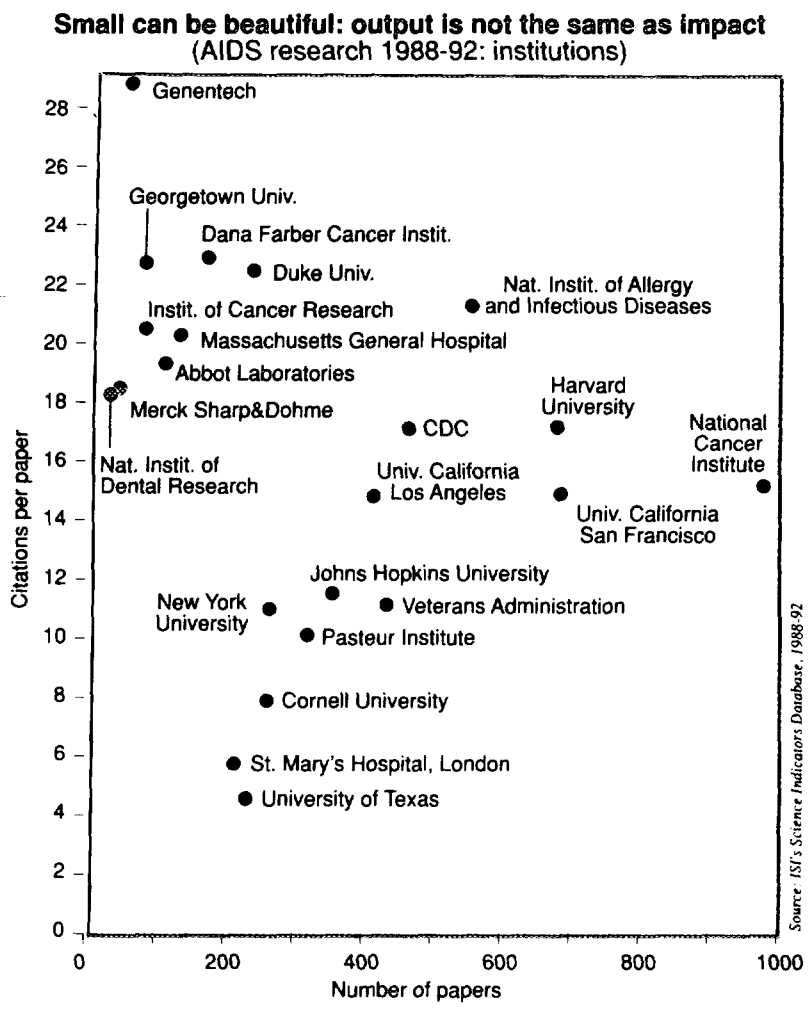
In the end, the contribution of different nations is built on the work of specific laboratories, teams and individuals. Yet measuring the contributions of individual scientists is probably the most difficult aspect of citation analysis. We found that some prolific individuals did not necessarily have much impact, and conversely, others with very high impact ratings may have won their place on the basis of just a few key papers in many years' work.

In order to offer different "snapshots" of who the key contributing scientists may be, we have listed both the most highly cited papers for each year, and the consistent performers—authors whose names appear year after year in the top 10 cited papers for each year (see Figures 4a and 4b).

ISI's findings on institutions showed once again that output does not necessarily equate with impact (see Figure 5). A few institutions which have published relatively small numbers of papers, such as Britain's Institute of Cancer Research, outstrip many of the giants in terms of impact. Others produce enormous numbers of papers, but fail to have a high impact. Only a few of the giants—notably the US National Institute of Allergy and Infectious Diseases—manage to hit the vein of combining quantity and influence. By contrast, might the US National Cancer Institute have had more impact if it had published fewer papers?

The results of the study leave scientists inside and outside AIDS with some important questions about how they should organise themselves. Tougher peer review was the action recommended by Wain-Hobson when he saw the figures on zero-cited papers. Another researcher took a

Figure 5: Some of the research institutions which publish least are cited most



more personal lesson: "I should publish less," he said. Another said that citation analysis might help scientists in specific branches of AIDS research to set their priorities. Mark Harrington, a leading AIDS activist from the Treatment Action Group in New York, says that power should be handed to the younger scientists whose work is now beginning to change AIDS research. But one point is beyond dispute: a multibillion dollar research effort should be monitored as efficiently as possible. The debate about how to do it is—astonishingly—only just beginning.

Readers may obtain further ISI® data from New Scientist's *Washington DC office (fax number [0101] 202 331 2082) on: the distribution of low, medium and high-cited papers; country rankings; institutional rankings from 1981 to 1992 and from 1988 to 1992; and the top 20 authors with more than 3000 citations ranked by total papers, total citations, and average citations per paper. Specific inquiries about additional data may be addressed to David Pendlebury at ISI, 3501 Market Street, Philadelphia PA 19104, USA.*

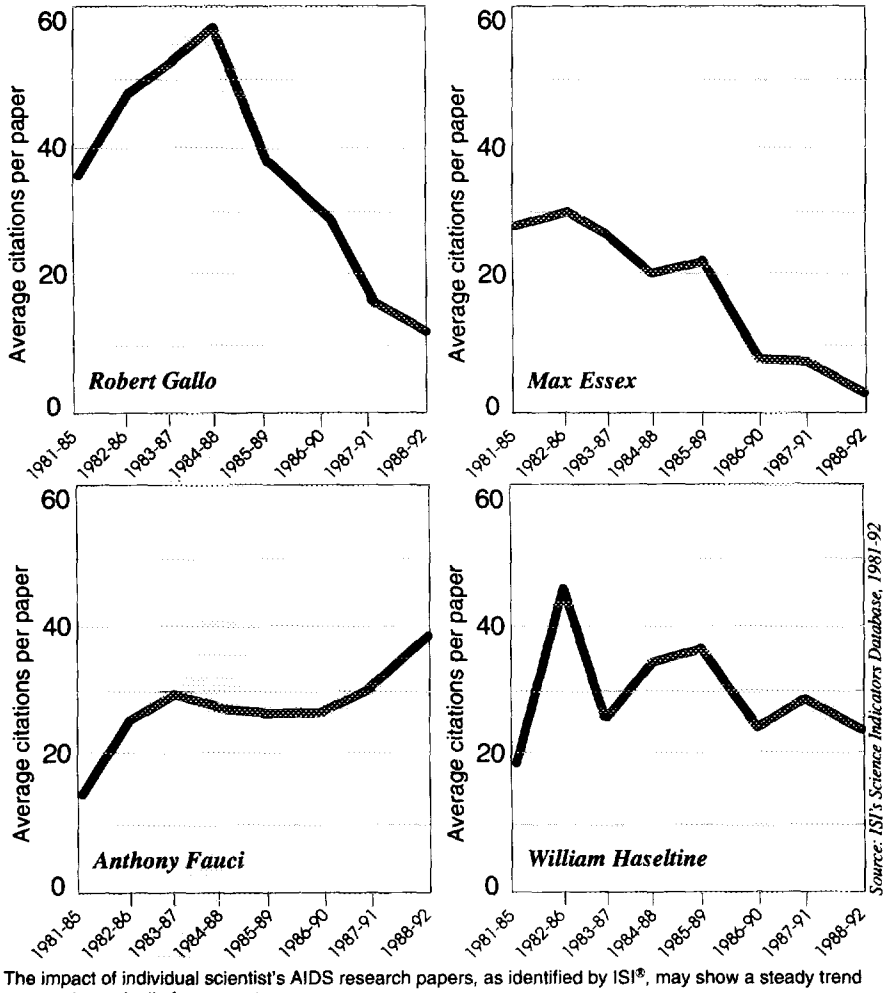
Can a single scientist's impact be measured by citation analysis?

AN INDIVIDUAL'S contribution to science is traditionally measured by peer review. If fellow scientists judge a researcher's work to be good, the researcher's work is published and grant-makers give it funding to continue. Citation analysis is a supplementary measure. Can it help to assess performance?

The Institute for Scientific Information® in Philadelphia can produce data on individual scientists' citation records. Here we show examples of the records of certain well-known AIDS researchers.

The graphs show, for those papers identified as AIDS-related, the average citations per paper for each scientist over five-year intervals since the beginning of the AIDS epidemic. They show a variety of patterns: some scientists have had more than one "peak" in the impact of their research; others have had steadily increasing impact; and for others, there has been a downward trend after an early peak.

This relatively new way of monitoring individuals should not be taken as a measure of quality, because there are numerous factors that affect scientists' work and the impact of their publications is only one measure of their overall influence. Scientists who spend much time teaching may contribute in unseen ways to the future achievements of staff in their laboratories. Others may go for years without publishing significant work and then make a vital contribution. Nevertheless, policy makers and scientists themselves are almost invariably keen to see this kind of information.



The impact of individual scientist's AIDS research papers, as identified by ISI®, may show a steady trend or vary dramatically from year to year.