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THE RELATIONSHIP BETWEEN INTERNATIONAL SCIENCE INDICATORS, NOBEL CLASS SCIENCE, AND SCIENCE MAPPING IN THE FORMATION OF SCIENCE POLICY

STATEMENT BEFORE:
HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE & TECHNOLOGY
SCIENCE POLICY TASK FORCE
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by

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The Institute for Scientific Information is a private company organized almost thirty years ago to provide scientific information to industrial and academic researchers. ISI is best known to the scientific community as the publisher of Current Contents, which has appeared weekly for the past 29 years. We also publish the Science Citation Index (SCI). This bi-monthly publication is cumulated annually and then every five years. SCI now covers over thirty years of the literature. We've indexed over 10 million articles. We also produce a number of other services, including Current Abstracts of Chemistry and Current Chemical Reactions, Social Sciences Citation Index and the Arts & Humanities Citation Index.

Since many of you are trained as attorneys, SCI can be described simply as the Shepards Citations of science. Indeed, our Social Sciences Citation Index (SSCI) covers over 3,000 journals, including 200 law reviews.

Were there adequate time, I could explain how these compilations facilitate the retrieval and dissemination of scientific information. I would also explain how SCISEARCH and SOCIAL SCISEARCH, the electronic versions of these databases, are used throughout the world. However, my primary purpose today is to explain how these databases are used for the study and formation of science policy. Indeed, together with colleagues like the late Professor Derek deSolla Price, among others, we have pioneered the field called "Scientometrics." Incidentally, the bi-annual reports of the National Science Board called "Science Indicators," include many indicators that are derived from the Science Citation Index. These generalized indicators do not, however, provide detailed intelligence about specific research areas where the U.S. may be lagging or pioneering, some times unbeknownst to policy making bodies who are unable to cope with the information flood.

Productivity vs Impact

Some of the more elementary uses of SCI involve straight publication counts. In these studies, publication output for each country is measured as an indicator of relative strength. A more sophisticated measure, the relative impact of these publications, is measured by determining how often they are cited. These data can be sorted by country, language, subject, etc. Through these unobtrusive studies, some rather remarkable insights on international and national research effort can be obtained. As an extension of these data, ISI has also pioneered a technique called "science mapping." The appended maps cover 1983 and 1984. The information for 1985 will be available within a few weeks. This type of information can also be examined on personal computers. The analyst can obtain a detailed view of any research area. He can focus in from a broad area like molecular biology down through various generic levels to a specific "research front." Each front is associated with a group of individuals, institutions and their publications--- the so called invisible colleges. In the examples, we've zeroed in on the Beta Thalassemia gene in one case and human interferon gene cloning in the other.

In yet another appendix, year-to-year changes can be observed in what we call "historiographs." (Monoclonal antibodies).

One can use these data to observe the contribution of each country to small or larger research fronts. For example, one can find out who is producing the highly cited publications in an area and who is publishing and citing in this area. This way we can identify the specific areas in which a country is pioneering and those in which it may be following or lagging behind.

There are almost infinite ways these data can be used for science policy. As one example, I have appended a reprint from Science and Public Policy, showing an analysis of Third World research.

There are some important caveats in the potential use of these kinds of statistical data. All such data should be used carefully by understanding the limitations. Like all statistical data, they can be used and misused. The information can aid policy makers by indicating where the action is and even possibly where it seems to be going---certainly, where it has been. But the data should only be used to make better informed decisions about which areas should or should not be funded. Whether to accelerate funding in rapidly emerging fields of research or not, is dependent upon many other subjective factors.

Scientists and science research deals in ideas and concepts. It is difficult to measure productivity and originality of ideas directly. However, the basis of scientific progress is the publication of scientific papers, and the scientific paper can be taken as an accurate measure for analyzing the research activity, creativity and impact of individuals and countries.

Nobel Prizes vs Of Nobel Class

The Nobel Prize has become the universal symbol of excellence in science. But the public is unaware that Nobelists represents a tiny fraction of the individuals I have described as being of Nobel Class.

Over 25 years ago, ISI studied data for Nobel Prize winners and found that there is a publication pattern which is repeated in over 90% of the winners. Nobel winners published ten times the number of papers and were cited at least 50 times as often as the average scientist. Put another way, all Nobel Prize winners fall into the top one half percent of cited authors---90% are found among the top one-tenth percent. A Nobelist is literally one in a thousand!

There are over 1,000,000 publishing scientists in the world; about 325,000 in the USA. If 0.5% of these are of Nobel Class, then about 5,000 scientists in the world and 1,600 in the USA are involved. Obviously, the small number of Nobel prizes each year is too small a sample of Nobel Class scientists, to have statistical validity for science policy analysis and do not accurately reflect national strengths in science. By using the comprehensive files of ISI indexes, you can study national strengths by viewing a much larger portion of the scientific landscape and in greater detail.

How do you go about determining which of the world's 1,000,000 scientists are of Nobel Class? There is a kind of electoral process that goes on in science in which scientists cast their votes. These are the citations or references that appear in the papers they publish. Statistical analyses show that in spite of occasional deviant citation behavior, citation distributions follow, what is commonly called, the 80/20 rule. A small percentage of journals or authors produce a large percentage of the papers. Similarly, an even smaller percentage of authors or institutions or countries receive a large percentage of the citations. For example, I have appended a ten-part essay from Current Contents which includes a list of 1,000 Citation Classics. These papers received 100 times as many citations as the average paper. ("1,000 Most-Cited Articles" - 10 part essay.)

I do not have the time to explain how we can standardize our data so as to take into account the varying sizes of fields like mathematics and medicine. But this is certainly relevant and possible. When using our data, we adjust thresholds of publication productivity and / or citation frequency according to the field involved.

However, there is no doubt in my mind that a study of the national origin of the papers written by the authors of Nobel Class would give reliable indicators of relative strengths and weaknesses.

It is not generally known that there has never been a complete census of scientific publications. None of the traditional abstracting services is absolutely comprehensive. The National Science Foundation sponsored studies which demonstrated that there were major gaps in coverage by a combination of discipline oriented services. Coverage must be multi-disciplinary or gaps occur in covering Nature, Science, and hundreds of other journals. Many dynamic areas involve many disciplines. That is why ISI implemented the unprecedented policy of absolutely complete coverage of the world's most important journals. While we cover the cream of Soviet, Japanese and Third World literature, there are many more one would include for a complete census. Thus, important trends and currents in certain research activity of these major scientific communities may be underrepresented. Our database needs to be enlarged both currently and retrospectively to facilitate indepth chronologic studies over long periods. In that way, we can observe the growth and decline of science productivities in various fields.

In conclusion---there can be no doubt that our comprehensive citator files can be used to aid in science policy decisions. Our data are already used regularly by several U.S. and foreign government agencies. We are now seeking to establish a permanent International Science Indicators Database. A small group of U.S.

and foreign government agencies will be asked to support and monitor this system. Each country would then have access to a computerized database that would permit science policy makers to conduct econometric-like studies in response to questions from groups like your own. ISI's existing coverage of 1,000,000 papers per year could be expanded, as deemed necessary, to take in more Third World or other foreign literature.

Not coincidentally, we are launching, in August, The Scientist--a newspaper for professional researchers. We expect to publish, regularly, news and opinions on science policy data of wide interest to the scientific community and to the public. This will take various forms including an extensive op-ed section, statistical reports, survey reviews such as provided in the ISI Atlas of Science and a wide variety of editorial features based on Citation Classics, most-cited authors, etc. We expect this newspaper to be an authoritative source for science policy information of interest to the scientific community and all those concerned with its funding and impact on society.

All of these activities are consistent with ISI's mission to remain, in the future, as in the past, at the forefront of science policy analysis.

EG/mm

Nobelists in the 300 Most-Cited Authors, 1961-76

		TOTAL CITATIONS 1961 - 1976
ANDERSON, PW	NOBEL/PHYSICS/77	3,838
ANFINSEN, CB	NOBEL/C/72	4,942
AXELROD, J	NOBEL/M or P/70	15,769
BALTIMORE, D	NOBEL/M or P/75	5,270
★BENACERRAF , B	NOBEL/M or P/80	9,197
★BERG, P	NOBEL/C/80	5,307
BLUMBERG, BS	NOBEL/M or P/76	6,029
★BROWN, HC	NOBEL/C/79	10,288
DEDUVE, CR	NOBEL/M or P/74	4,178
ECCLES, JC	NOBEL/M or P/63	4,579
EDELMAN, GM	NOBEL/M or P/72	6,797
FLORY, PJ	NOBEL/C/74	5,538
GELL-MANN, M	NOBEL/PHYSICS/69	4,912
GUILLEMIN, R	NOBEL/M or P/77	4,200
★HOFFMAN, R	NOBEL/C/81	7,969
★HUBEL, DH	NOBEL/M or P/81	4,474
JACOB, F	NOBEL/M or P/65	10,383
KHORANA, HG	NOBEL/M or P/68	6,620
KORNBERG, A	NOBEL/M or P/59	6,706
KREBS, HA	NOBEL/M or P/53	5,146
LIPMANN, F	NOBEL/M or P/53	5,019
LIPSCOMB, WN	NOBEL/C/76	6,364
MONOD, J	NOBEL/M or P/65	6,945
MOORE, S	NOBEL/C/72	5,619
OCHOA, S	NOBEL/M or P/59	4,172
PERUTZ, MF	NOBEL/C/62	4,734
PALADE, GE	NOBEL/M or P/74	11,242
★SAMUELSSON B	NOBEL/M or P/82	5,849
SCHALLY, AV	NOBEL/M or P/77	10,386
SUTHERLAND, EW	NOBEL/M or P/72	11,644
★VANE J R	NOBEL/M or P/82	6,292
★WEINBERG, S	NOBEL/PHYSICS/79	7,349
★WIESEL, TN	NOBEL/M or P/81	4,605
WOODWARD, RB	NOBEL/C/65	4,044
YALOW, RS	NOBEL/M or P/77	5,595

★Awarded Nobel Prize after list published.

Nobel Prizewinners on 1000 most-cited authors list

NAME	YEAR	PRIZE
Anderson, Philip Warren	1977	Physics
Anfinsen, Christian Boehmer	1972	Chemistry
Axelrod, Julius	1970	Medicine
Baltimore, David	1975	Medicine
Barton, Derek Harold Richard	1969	Chemistry
Benacerraf, Baruj	1980	Medicine
Berg, Paul	1980	Chemistry
Bloembergen, Nicolaas	1981	Physics
Blumberg, Baruch Samuel	1976	Medicine
Brown, Herbert C.	1979	Chemistry
Dausset, Jean	1980	Medicine
de Duve, Christian Rene	1974	Medicine
Edelman, Gerald Maurice	1972	Medicine
Fischer, Ernst Otto	1973	Chemistry
Flory, Paul John	1974	Chemistry
Glashow, Sheldon Lee	1979	Physics
Guillemin, Roger	1977	Medicine
Hoffmann, Roald	1981	Chemistry
Hubel, David H.	1981	Medicine
Jacob, Francois	1965	Medicine
Katz, Bernard	1970	Medicine
Khorana, Har Gobind	1968	Medicine
Klug, Aaron	1982	Chemistry
Kornberg, Arthur	1959	Medicine
Krebs, Hans Adolf	1953	Medicine
Lee, Tsung-Dao	1957	Physics
Lipmann, Fritz A.	1953	Medicine
Lipscomb, William Nunn	1976	Chemistry
Mitchell, Peter (Dennis)	1978	Chemistry
Monod, Jacques (Lucien)	1965	Medicine
Mott, Nevill Francis	1977	Physics
Nathans, Daniel	1978	Medicine
Nirenberg, Marshall Warren	1968	Medicine
Ochoa, Severa	1959	Medicine
Palade, George E.	1974	Medicine
Perutz, Max Ferdinand	1962	Chemistry
Richter, Burton	1976	Physics
Samuelsson, Bengt	1982	Medicine
Sanger, Frederick	1958/1980	Chemistry
Schally, Andrew Victor	1977	Medicine
Sutherland, Earl Wilbur	1971	Medicine
Temin, Howard Martin	1975	Medicine
Vane, John R.	1982	Medicine
Weinberg, Steven	1979	Physics
Wiesel, Torsten N.	1981	Medicine
Wilkinson, Geoffrey	1973	Chemistry
Wilson, Kenneth G.	1982	Physics
Woodward, Robert Burns	1965	Chemistry
Yalow, Rosalyn (Sussman)	1977	Medicine

LIST OF APPENDED ITEMS

1. Biography - Eugene Garfield, Ph.D.

2. Maps of Science for 1983 and 1984. Global and other miscellaneous maps (Ref : Page 3)

3. Monoclonal Antibodies - Historiograph. (Ref : Page 3)

4. E. Garfield, "Mapping Science in the Third World," Science & Public Policy, June 1983.

5. E. Garfield, "1,000 Most-cited Articles," Parts 1-10. (Will be brought in by Dr. Garfield)

6. E. Garfield, "Citation Classics - Four Years of the Human Side of Science," #22, Current Contents, June 1, 1986.

7. "Nobelists in the 300 Most-Cited Authors, 1961-76." (list)

8. "Nobel Prizewinners on 1,000 most-cited author list." (list)

9. Atlas of Science brochure.