
Identifying Nobel Class Scientists and the Uncertainties thereof

Presented by
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Abstract

Out of about one million or so scientists who have published to date, 10,000 can be considered to be “of Nobel Class.” Approximately 750 of them have won Nobel Prizes. While there are exceptions due to the vagaries of the subjective (non-random) selection process, Nobel Laureates publish five times the average number of papers but their work is cited 30 to 50 times the average. Nobelists will invariably publish several *Citation Classics*. A few have published super methodology classics like the polymerase chain reaction of Kerry Mullis. Unlike the latter, most Nobel Prize winners have high H-Indexes. Many also appear on ISI’s “HighlyCited” authors listings. Authors of “hot papers” may also be leading candidates for future awards. Following the Law of Concentration, Nobel class scientists publish in a small group of high impact journals. These journals also account for a large percentage of the papers published and an even larger percentage of citations. Scientists like Albert Einstein and James Watson have published relatively few highly cited papers, but their work is characterized by being cited by other super-cited Nobel class scientists. This can be visualized by historiograhic analyses using *HistCite* for algorithmic historiography.

About one year ago I was contacted about addressing this conference about conducting research assessment through citation analysis. When I saw the list of speakers in January, I realized that the meeting is primarily concerned with open access publications, which is quite another matter, although there are many claims that open access not only increases readership but citation impact as well. However, we have leading open access experts here, including my old friends Steve Harnad and Jan Velterop. So I will have very little to say about open access or research assessment per se.

I suspect the organizers wanted my name on the program to inject a note of nostalgia if not controversy. Whatever their motivation I interpreted my remit to be the topic I have discussed in dozens of *Current Contents* essays about the Nobel Prize as well as "scientists of Nobel Class."[1] Not surprisingly, everything related to the Nobel Prize fascinates most scientists, journalists, and librarians.[2]

Last year I attended the 10th International Conference of the International Society for Scientometrics and Informatics in Stockholm. The library director of the Karolinska Institute, Per Olsson, showed me the building where the Nobel committees meet. Shortly thereafter, I sent him a letter by Wilhelm Odelberg,[3] the former Chief Librarian of the Royal Swedish Academy of Sciences, written in 1965. I had found the letter last year when I was weeding some old files. Odelberg wrote to ISI a year or so after the launch of the *Science Citation Index* in 1964, suggesting that we add several additional Academy journals in the *Arkiv* series then published for mathematics, botany, etc. He gratuitously volunteered the comment that:

> **"the *SCI* is very useful, and it is of great value to us especially when we make the preliminary investigations for the election of Nobel Prize winners."**

When I tried to contact Odelberg last year I learned that he had passed away in 2002. It is noteworthy that he was editor of several volumes on "The Nobel Prize" published by Elsevier.

Why do I mention this 40 years after we began the *SCI?* During those four decades I was asked repeatedly whether the Nobel committees make use of the *SCI* data in their deliberations. Odelberg made no bones about the fact that *SCI* was "used" by him in connection with the committees' deliberations. This is quite similar to my own use of *SCI* on hundreds of occasions to help select and authenticate nominees in Philadelphia for the Franklin Institute Medals and the John Scott Awards of the City of Philadelphia.[4] The *SCI* has also helped to suggest additional names that might be considered. In the case of the Nobel Prize, nominations are supported by expert testimony of other scientists often of Nobel Class themselves.

Had I known about Oldeberg's letter back in the 1960's I would surely have referred to it frequently but I would have had to note its ambiguity. Odelberg's comments notwithstanding, he and the Nobel Committees did not consult or use the *SCI* as a systematic selection tool to generate lists of candidates, but rather to help confirm the impact of their work and the accuracy of their bibliographies.

In the seventies, I was asked to tour local chapters of the American Chemical Society to discuss information retrieval systems. Not being certain what would interest the diverse audiences involved I prepared six different lectures and read their titles to the audience. Almost invariably, instead of “Chemical Information Retrieval,” they would chose the topic “How to forecast Nobel Prize Winners.”

How did I have the hubris to take up this subject? In the late sixties, Irving Sher and I had performed a simple bibliometric exercise on the 1966 *SCI* database. This analysis showed that Nobel prize winners publish five times as often as the average author but they are cited 30 to 50 times the average.[5] By using the word “forecast,” I was of course hedging from the more arrogant suggestion that one could “predict” the Nobel Prizes as is often attempted by journalists. To predict is really out of the question because the process by which Nobel, and other prizes, are selected is not in fact systematic. How the selections occur is too involved to discuss here but the process is the subject of dozens of papers and books. Especially noteworthy is Harriet Zuckerman’s classic, *The Scientific Elite*.[6] The Nobel choices depend upon the subjective vagaries of the committees involved, both with respect to the field chosen and the individuals chosen to represent the field.

Each year ISI creates lists of highly cited authors that have a high probability of being selected as Nobelists in biomedicine, physics, chemistry, and economics. We have never attempted to forecast the prize in literature or peace. We have found, that inevitably the committees choose scientists and scholars that the worldwide scientific community has already implicitly recognized as being of Nobel class. This recognition is expressed through the “elections” that take place regularly in the published literature. Robert K. Merton used this voting metaphor to describe how literature citations reflect the influence of individual scientists.

A few years after we reported to the 1967 ONR Conference on Research effectiveness the publication output and citation frequencies of Nobel Prize winners, we published a list of the 50 most cited authors of 1967 in *Nature*[7]. Of these, Murray Gellman and DHR Barton received the Nobel in 1969. Eleven additional authors on the list had or subsequently received the prize in the year indicated in parens. And that was at a time when we were limited to using so-called first author data. We missed a few whose names were usually not listed as first authors, an example being 1955 co-winner Jacques Monot of France who regularly published together with Francois Jacob. Subsequently, ISI was able to expand the citation database to include all authors.

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Slide #1:

50 MOST CITED AUTHORS FOR 1967

RANK	AUTHOR	TIMES CITED	RANK	AUTHOR	TIMES CITED
1	LOWRY OH	2921	26	ELIEL EL	121
2	CHANCE B	1374	27	STREITWIESER A	717
3	*LANDAU LD	1174	28	MULILIKEN RS	712
4	*BROWN HC (1979)	1150	29	*JACOB F (1965)	711
5	*PAULING L(54 & 62)	1063	30	*BORN M (1954)	710
6	*GELLMANN M (1969)	942	31	BRACHET J	706
7	COTTON FA	940	32	WINSTEIN S	702
8	*POPLE JA (1998)	933	33	ALBERT A	687
9	BELLAMY LJ	906	34	LUFT JH	674
10	SNEDECOR GW	904	35	DEDUVE C	673
11	*BOYER PD (1997)	893	36	VONEULER US	668
12	BAKER BR	876	37	FIESER LF	666
13	KOLTHOFF IM	853	38	HUISGEN R	667
14	*HERZBERG G (1971)	842	39	NOVIKOFF AB	655
15	FISCHER F	826	40	GOODWIN TW	643
16	SEITZ F	822	41	*BARTON DHR(1969)	632
17	DJERASSI C	801	42	FISHER RA	631
18	BERGMEYER HU	754	43	BATES DR	627
19	WEBER G	750	44	*FLORY PJ (1974)	626
20	REYNOLDS ES	748	45	STAHL E	626
21	*MOTT NF (1977)	741	46	DEWAR MJS	619
22	*ECCLES JC (1963)	737	47	GILMAN H	618
23	FEIGL F	729	48	FOLCH J	618
24	FREUD S	727	49	DISCHE Z	614
25	PEARSE AGE	726	50	GLICK D	609

* = Author has received a Nobel Prize.

The number of Nobel Prize winners is miniscule in comparison to the total population of scientists. Only 776 people have been awarded the Nobel prize in its 100 year history. But for every Nobel Prize winner there are far more scientists "of Nobel Class." The relevant National Academies of the United States include the National Academy of Sciences (NAS), the National Academy of Engineering, and the Institute of Medicine. Their total membership is about 5,000, of which about 2,000 are in the NAS. Many decades ago I discussed these numbers with the President of the NAS. He volunteered that for almost every elected academy member there were probably several more equally deserving non-members both in the United States and abroad. So if we want to round off the numbers and take into account the worldwide population of pure and applied scientists, engineers, and mathematicians there are probably 5,000 to 10,000 who should be considered as "of Nobel Class." That represents about 1% of the million or more scientists who publish. Derek deSolla Price demonstrated long ago that a large number of scientists publish once and then are never heard from again. Many of these published papers based on their doctoral dissertations, and are never heard from again.[8]

A further manifestation of my estimate of Nobel Class scientists is found in a free web site posted by Thomson ISI called *HighlyCited Authors*. This database presently lists about 7,000 authors including from 200 to 300 in each of 21 categories such as molecular biology, engineering, agricultural science, pharmacology, clinical medicine, and mathematics. And the threshold for inclusion in each category varies since the citation and publication productivity in each field varies. The *HighlyCited Authors* database would be increased significantly were it not limited to the past ten years of *SCI* data. Many living Nobel class scientists who published their highest impact work in previous decades do not show up on these lists.

Incidentally, the University of Lund is represented by three of the 55 Swedish scientists in the database –10 them in agricultural science, 8 in neuroscience, 7 in pharmacology, 6 in biology and biochemistry, 3 in materials science.

Some of you may recall the series of essays I published on each crop of annual Nobel Prizes during the eighties and nineties.[9] These reports demonstrated that Nobel Prize winners almost invariably publish *Citation Classics.* Last year I posted a searchable full text database at www.citationclassics.org [10] Slide #2 shows the commentary by Oliver H. Lowry on his blockbuster – the most cited paper in history with 300,000 explicit citations. He also published three other *Citation Classics.*

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Number 1 January 3, 1977

Citation Classics

Lowry O H, Rosebrough N J, Farr A L & Randall R J. Protein measurement with the Folin phenol reagent. *J. Biol. Chem.* **193**:265, 1951.

...The authors assert that the use of the Folin phenol reagent for the measurement of proteins "has not found great favor for general biochemical purposes." This study is concerned with modifying the Folin phenol reagent procedure by treating protein solutions "with copper in alkali." By recording the color change after the copper treatment, and measuring the quantity of protein present with a Beckman spectrophotometer, the authors determined that "measurement of protein with copper

reaction some more, and came up with a revised procedure which we felt was an improvement, particularly in regard to application to a variety of situations. Actually, however, we had made few fundamental changes from the method of Herriot, and had never really intended to publish it.

"When I came to St. Louis in 1947 Earl Sutherland, who was here then, adopted our procedure, but for several years complained that he had to cite it as 'personal

CC/NUMBER 23
JUNE 10, 1985

This Week's Citation Classic®

Bessey O A, Lowry O H & Brock M J. A method for the rapid determination of alkaline phosphatase with five cubic millimeters of serum. *J. Biol. Chem.* 164:321-9, 1946.

[Div. Nutrition and Physiology, Public Health Res. Institute of the City of New York, NY]

This Week's Citation Classic®

Lowry O H, Passonneau J V, Hasselberger F X & Schulz D W. Effect of ischemia on known substrates and cofactors of the glycolytic pathway in brain. *J. Biol. Chem.* 239:18-30, 1964.

[Dept. Pharmacology and Beaumont-May Inst. Neurology, Washington University, St. Louis, MO]

This Week's Citation Classic

CC/NUMBER 31
AUGUST 3, 1981

Lowry O H & Lopez J A. The determination of inorganic phosphate in the presence of labile phosphate esters. *J. Biol. Chem.* **162**:421-8, 1946.

[Div. Nutrition and Physiol., Public Health Res. Inst., New York, NY]

Earlier colorimetric methods for inorganic phosphate, based on phosphomolybdate reduction, caused rapid cleavage of labile organic phosphates such as phosphocreatine or acetyl phosphate. This problem was solved by using a more powerful reducing agent, ascorbic acid, at a much less acid pH. [The *SCI®* indicates that this paper has been cited over 970 times since 1961.]

Oliver H. Lowry
Department of Pharmacology
School of Medicine
Washington University
St. Louis, MO 63110

Citation Classic in those days —and perhaps still is?). I knew both Fiske and Subbarow quite well, and Fiske had told me (between long pauses to puff on his pipe) some of the ways this exceedingly complex and versatile system can be manipulated.

"Four variables affect the reduction of molybdate and phosphomolybdate: pH, temperature, molybdate concentration, and the reducing agent. The first three affect hydrolysis of most organic phosphates. We started by tampering with pH, using the reducing agent of Fiske and Subbarow (sulfite with aminonaphtholsulfonic acid catalyst). When the pH was raised from that recommended (0.65) to the range between 0.8 and 1.8,

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SLIDE 3: CITATION FREQUENCY DISTRIBUTION 1900-AUGUST 2005

To give you an idea of the frequency of putative *Citation Classics*, consider slide # 3.

About one half of one percent of cited papers were cited over 200 times. Out of about 38 million source items, about half were not cited at all. Only 5,000 papers were cited over 1,000 times, my arbitrary definition of a super citation classic.

As demonstrated in Slide 3, *Citation Classics* represent less than one tenth of one percent of papers published. Nevertheless in absolute terms, there are over twenty thousand that were cited over five hundred or more times

CITATION FREQUENCY DISTRIBUTION 1900-AUGUST, 2005
(articles cited at least once)

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

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SLIDE 4: MOST-CITED JOURNALS 2004 *JCR* TOTAL CITES

Another characteristic of Nobel class work is the small list of journals in which their classic articles are published. While prolific Nobel prize winners may publish once or twice in hundreds of different journals their most cited works are invariably published in the small core of high impact journals. This phenomena is sometimes called the law of scattering but in the case of classic work, my Law of Concentration is more relevant.[11] Slide 4 is based on the 2004 *JCR*. The column for total cites identifies the journals most cited based on 100 years of cited data.

JCR 2004 SORTED BY TOTAL CITES TO ALL YEARS

Rank	Journal Title	2004 Total Cites	Impact	2004 Cites to 2003/02	Rank 2003/02	2004 Total Articles
1	J BIOL CHEM	405,017	6.36	82,355	1	6,585
2	NATURE	363,374	32.18	56,255	3	878
3	PNAS	345,309	10.45	58,905	2	3,084
4	SCIENCE	332,803	31.85	55,297	4	845
5	J AMER CHEM SOC	231,890	6.90	39,170	6	3,167
6	PHYS REV LETT	229,765	7.22	42,753	5	3,575
7	PHY REVIEW B	185,905	3.08	31,270	7	4,964
8	NEJM	159,498	38.57	28,696	9	316
9	ASTROPHYSICAL J	144,264	6.24	29,524	8	2,478
10	J CHEM PHYSICS	138,693	3.11	16,015	18	2,772
11	CELL	136,472	28.39	17,800	17	288
12	LANCET	126,002	21.71	22,147	13	415
13	CIRCULATION	115,133	12.56	26,320	11	1,129
14	APPLIED PHYS LETT	112,516	4.31	27,596	10	3,731
15	J IMMUNOLOGY	108,602	6.49	21,203	14	1,793
16	J GEOPHYS RES	105,601	2.84	14,151	19	2,085
17	CANCER RESEARCH	105,196	7.69	18,402	16	1,253
18	BLOOD	97,885	9.78	25,139	12	1,206
19	BIOCHEMISTRY	96,809	4.01	13,591	20	1,687
20	J NEUROSCIENCE	93,263	7.91	19,624	15	1,233

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SLIDE 5: MOST-CITED JOURNALS BASED ON CITES TO TWO YEARS TO 2002-03 ARTICLES

Slide 5 shows the same list but the data are sorted by citations to the two years used to calculate the 2004 impact factor. The list is identical but the rankings change somewhat. For example, *Applied Physics Letters* is 14th on the first list but moves to 10th on the second list.

JCR 2004 SORTED BY TOTAL CITES TO 2003/02

↓

Rank	Journal Title	2004 Cites to 2003/02	2004 Total Cites	Impact	2004 Total Articles	Rank 2004 Total
1	J OF BIOL CHEM	82,355	405,017	6.36	6,585	1
2	PNAS	58,905	345,309	10.45	3,084	3
3	NATURE	56,255	363,374	32.18	878	2
4	SCIENCE	55,297	332,803	31.85	845	4
5	PHYS REV LETT	42,753	229,765	7.22	3,575	6
6	J AMER CHEM SOC	39,170	231,890	6.90	3,167	5
7	PHYSICAL REVIEW B	31,270	185,905	3.08	4,964	7
8	ASTROPHYSICAL J	29,524	144,264	6.24	2478	9
9	NEJM	28,696	159,498	38.57	316	8
10	APPLIED PHYSICS LETT	27,596	112,516	4.31	3,731	14
11	CIRCULATION	26,320	115,133	12.56	1,129	13
12	BLOOD	25,139	97,885	9.78	1,206	18
13	LANCET	22,147	126,002	21.71	415	12
14	J OF IMMUNOLOGY	21,203	108,602	6.49	1,793	15
15	J OF NEUROSCIENCE	19,624	93,263	7.91	1,233	20
16	CANCER RESEARCH	18,402	105,196	7.69	1,253	17
17	CELL	17,800	136472	28.39	288	11
18	J OF CHEM PHYSICS	16,015	138,693	3.11	2,772	10
19	J OF GEOPHYS RES	14,151	105,601	2.84	2,085	16
20	BIOCHEMISTRY	13,591	96,809	4.01	1,687	19

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SLIDE 6: *JCR* 2004 SORTED BY NUMBER OF PUBLISHED ARTICLES

In contrast to citation impact, Slide 6 provides a ranking by number of articles published in 2004, and produces yet another perspective. The asterisked journals are new to the top 20 list.

JCR 2004 SORTED BY NUMBER OF ARTICLES

Journal	Articles	Total Cites	Impact Factor
LECT NOTES COMPUT SC*	16,370	32,739	0.51
J BIOL CHEM	6,585	405,017	6.36
PHYSICAL REVIEW B	4,964	185905	3.08
APPLIED PHYSICS LETT	3,731	112,516	4.31
PHYSICAL REVIEW LETT	3,575	229765	7.22
J AMER CHEM SOC	3,167	231,890	6.90
PNAS	3,084	345,309	10.45
J CHEM PHYSICS	2,772	138,693	3.11
J APPLIED PHYSICS	2,684	84,947	2.26
J PHYSICAL CHEM B*	2,570	46,122	3.83
ASTROPHYSICAL J	2,478	144,264	6.24
BIOCHEM BIOPH RES CO*	2,312	64,346	2.90
JPN J APPL PHYS*	2,289	25,949	1.14
PHYSICAL REVIEW E*	2,282	42,737	2.35
PHYSICAL REVIEW D*	2,277	78,709	5.16
TETRAHEDRON LETT*	2,133	67,752	2.48
J GEOPHYS RES	2,085	105,601	2.84
LECT NOTES ARTIF INT*	1,877	3,905	0.25
ASTRON ASTROPHYS*	1,870	63,293	3.69
MATER SCI FORUM*	1,869	6,018	0.50

* = Not on previous slides

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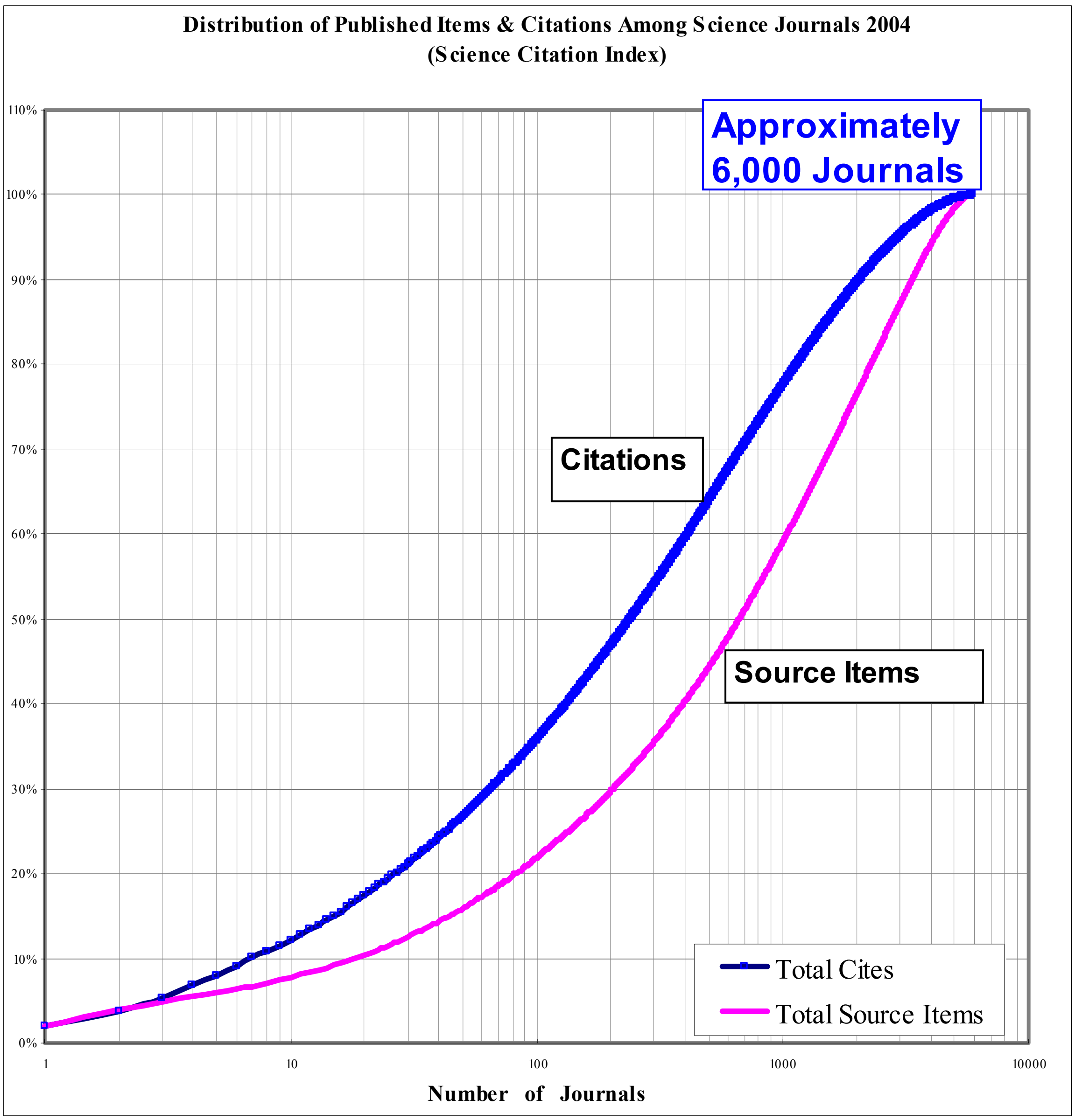
SLIDE 7: DISTRIBUTION OF PUBLISHED ITEMS AND CITATIONS

Indeed, as documented repeatedly, a small percentage of journals accounts for a large percentage of everything published while accounting for an even larger percentage of citations. Whether open access will change these characteristics or not remains to be seen, but in the meantime don't expect to find Nobel class scientists publishing in obscure journals.



SLIDE 8: HISTCITE

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Back in the 1960's, just shortly after we began to publish the *SCI,* we proposed using citation data to algorithmically construct historical maps of scientific fields in the form of historiographs. In our first experiment we traced the evolution of genetics research from Mendel to Watson-Crick and subsequent key events to 1960. That work has now been translated into software called *HistCite. HistCite* produces a series of tables and historiographs which identify various bibliometric features but one in particular turns out to be characteristic of Nobel Class work -- its multi-generational impact, an idea which originally was discussed by Irv Sher and me a l963 paper "Citation Indexing in Sociological and Historical Research.[12]

HISTCITE™

Bibiliographic Analysis and Visualization Software

Home | Features | Feedback | Web of Science

HistCite is a flexible software solution to aid researchers in visualizing the results of literature searches in the *Web of Science*. It provides additional perspectives on information retrieval from the *Web of Science*.

HistCite creates data tables and historiographs in an HTML format readable in a web browser.

What Can I Do With HistCite?

Identify the key literature in a research field
By analyzing the results of a keyword search you can identify:

- papers important to the development of the topic
- important papers "missed" by your keyword search
- most prolific and most cited authors and journals on the topic
- other keywords that can be used to expand the collection

Analyze publication productivity and citation rates within a collection of research papers
Compare characteristics such as:

- countries and institutions that authors publish from
- most prolific and most cited authors within the groups
- citation statistics for groups and subgroups (mean and median citation rates of papers, number of authors per paper, etc.)

Reconstruct the history and development of a research field
Analyze the content of an author search to find:

- highly cited articles
- important co-author relationships
- earlier publications and documents important to the development of the author's work time line of the authors' publications
- graphs showing the key papers and timeline of a research field.

SLIDE 9: PAPERS BY ALBERT EINSTEIN

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Unlike the average modern Nobelist, Einstein published a relatively small number of papers. This year we have been celebrating the four classic papers he published in 1905. They were well cited during his lifetime but most citations to his work were made many years later.

Slide 9 shows you a page from a *HistCite* analysis of Albert Einstein's papers. The number of times his classic papers are cited is significant. Indeed even his H-Index of 53 is remarkable for that time.

PAPERS AND BOOKS BY ALBERT EINSTEIN (1900-1955)

Missing Links?: 6 Citation Matrix Historiographs Glossary HistCite Guide About

Nodes: 186, Authors: 39, Journals: 35, Outer References: 159, Words: 483

Yearly output | Document Type | Language | Institution | Institution with Subdivision | Country

Collection span: 1901 - 1961

View: Overview Sorted by **year, source, volume, issue, page**.

Page **1** of 2: [1 2]

#	LCR	NCR	Node / Date / Journal / Author	LCS	GCS
1	0	0	1 1901 ANNALEN DER PHYSIK 4 (3): 513-523 **EINSTEIN A** *Conclusions from capillarity phenomena*	1	33
2	1	1	2 1902 ANNALEN DER PHYSIK 8 (8): 798-814 **EINSTEIN A** *The thermodynamic theory of the potential differences between metals and complete dissociation solutions of their salts and an electrical method towards the probing of molecular power*	0	6
3	0	1	3 1902 ANNALEN DER PHYSIK 9 (10): 417-433 **EINSTEIN A** *Kinetic theory of the heat equilibrium and the second fundamental theorem of the thermodynamics*	1	25
4	0	0	4 1903 ANNALEN DER PHYSIK 11 (5): 170-187 **EINSTEIN A** *A theory on the basics of thermodynamics*	5	40
5	0	0	5 1904 ANNALEN DER PHYSIK 14: 354 **EINSTEIN A** *Zur allgemeinen molekularen Theorie der Waerme*	0	29
6	0	4	6 1905 ANNALEN DER PHYSIK 17 (6): 132-148 **EINSTEIN A** *On a Heuristic Viewpoint Concerning the Production and Transformation of Light*	2	372
7	3	4	7 1905 ANNALEN DER PHYSIK 17 (8): 549-560 **EINSTEIN A** *On the motion of elements of Small Particles Suspended in Stationary Liquids as required by the Molecular-Kinetic Theory of Heat*	3	1507
8	0	0	8 1905 ANNALEN DER PHYSIK 17 (10): 891-921 **EINSTEIN A** *On the Electrodynamics of Moving Bodies*	7	713
9	1	1	9 1905 ANNALEN DER PHYSIK 18 (13): 639-641 **EINSTEIN A** *Does the Inertia of a Body Depend Upon Its Energy Content?*	2	106
10	1	2	10 1906 ANNALEN DER PHYSIK 19 (2): 289-306 **EINSTEIN A** *A new determination of molecular dimensions*	1	1620

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SLIDE 10: PAPERS AND BOOKS BY EINSTEIN AND THE PAPERS CITING HIM.

What is even more significant about Einstein's work is the second generation of citation impact as demonstrated in slide # 10. The twenty super Citation Classics that cited Einstein include papers by Nobelists like Chardrasekhar (1983), Onsager (1968), and Phil Anderson (1977). Paradigm breaking work of this kind is not only cited by super-cited papers but may also be subject to the phenomenon called OBI.

Let's turn from Einstein to the work of Watson and Crick. I'll return to Einstein again later.

Missing Links? Citation Matrix Graphs Glossary HistCite Guide About

PAPERS AND BOOKS BY ALBERT EINSTEIN (1900-1955)
AND PAPERS CITING ALBERT EINSTEIN (1900-1955)

Nodes: 16544, Authors: 17854, Journals: 2479, Outer References: 377380, Words: 15829

Collection span: 1901 - 2005
View: Overview. Sorted by **GCS**.

Page **1** of 166: [1 2 3 4 5 6 7 8 9 10] 11 21 31 41 51 61 71 81 91 | 101

#	LCR	NCR	Node / Date / Journal / Author	LCS	GCS
1	14	101	1092 1943 REVIEWS OF MODERN PHYSICS 15 (1): 1-89 **CHANDRASEKHAR S** *Stochastic problems in physics and astronomy*	206	4509
2	0	0	882 1935 PHYSICAL REVIEW 47 (10): 777-780 **EINSTEIN A; PODOLSKY B; ROSEN N** *Can quantum-mechanical description of physical reality be considered complete?*	2430	2430
3	2	38	11433 1995 SCIENCE 269 (5221): 198-201 **ANDERSON MH; ENSHER JR; MATTHEWS MR; WIEMAN CE; CORNELL EA** *Observation of Bose-Einstein Condensation in a Dilute Atomic Vapor*	131	2342
4	1	2	11 1906 ANNALEN DER PHYSIK 19 (2): 289-306 **EINSTEIN A** *A new determination of molecular dimensions*	1703	1703
5	18	720	9516 1990 REVIEWS OF MODERN PHYSICS 62 (2): 251-341	28	1669

			HANGGI P; TALKNER P; BORKOVEC M *Reaction-Rate Theory - 50 Years after Kramers*		
6	4	12	769 1931 PHYSICAL REVIEW 38 (12): 2265-2279 **ONSAGER L** *Reciprocal relations in irreversible processes. II.*	90	1564
7	11	25	10552 1993 PHYSICAL REVIEW LETTERS 70 (13): 1895-1899 **BENNETT CH; BRASSARD G; CREPEAU C; JOZSA R; PERES A; et al.** *Teleporting an Unknown Quantum State Via Dual Classicala and Einstein-Podolsky-Rosen Channels*	406	1563
8	3	4	7 1905 ANNALEN DER PHYSIK 17 (8): 549-560 **EINSTEIN A** *The motion of elements of small particles suspended in stationary liquids as required in the molecular-kinetic theory of heat*	1536	1536
9	1	17	2470 1963 PROCEEDINGS OF THE IEEE 51 (1): 89-& **JAYNES ET; CUMMINGS FW** *Comparison of Quantum and Semiclassical Radiation Theories with Application To Beam Maser*	47	1520
10	1	34	1097 1944 BELL SYSTEM TECHNICAL JOURNAL 23: 282-332 **RICE SO** *Mathematical analysis of random noise*	25	1433

SLIDE 11: YEAR-BY-YEAR CITATIONS TO WATSON-CRICK PAPER

Slide 11 shows the year by year citation frequency to the historic 1953 paper on the "Double Helix structure of DNA" paper by Watson and Crick. It has been explicitly cited only about 3,000 times in its 50 year lifetime. This is characteristic of paradigm breaking papers which suffer the fate of obliteration by incorporation (OBI). The double helix structure of DNA suffered this fate when it became common wisdom in molecular biology within a decade or two. But then remarkably, citations to that paper have gone up significantly in the last decade as seen in the *HistCite* historiogram for year-by-year citations for 1953 to 2005. Note especially the right hand column since 1993.

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Slide #11
YEAR-BY-YEAR CITATIONS TO WATSON-CRICK 1953

Year	Count	Percent
1953	16	0.5
1954	31	1.1
1955	36	1.2
1956	50	1.7
1957	32	1.1
1958	44	1.5
1959	42	1.4
1960	44	1.5
1961	52	1.8
1962	53	1.8
1963	82	2.8
1964	52	1.8
1965	44	1.5
1966	42	1.4
1967	29	1.0
1968	37	1.3
1969	35	1.2
1970	29	1.0
1971	30	1.0
1972	30	1.0
1973	35	1.2
1974	23	0.8
1975	21	0.7
1976	32	1.1
1977	26	0.9
1978	30	1.0
1979	27	0.9
1980	24	0.8
1981	42	1.4
1982	33	1.1
1983	46	1.6
1984	45	1.5
1985	47	1.6
1986	39	1.3
1987	35	1.2
1988	36	1.2
1989	42	1.4
1990	55	1.9
1991	38	1.3
1992	48	1.6
1993	86	2.9
1994	57	2.0
1995	60	2.1
1996	80	2.7
1997	73	2.5
1998	86	2.9
1999	73	2.5
2000	94	3.2
2001	88	3.0
2002	109	3.7
2003	221	7.6
2004	189	6.5
2005	163	5.6
2006	3	0.1

Items: 54
Number of publications: 2916
Bar charts are proportional to percentage, and scaled.

Another illustration of the second order generation citation effect is seen in the work of Francis Crick which has been cited by 50 super-cited papers.

Missing Links? Citation Matrix Graphs Glossary HistCite Guide About

Papers by FHC Crick and papers citing FHC Crick

Nodes: 17001, Authors: 24079, Journals: 2618, Outer References: 483677, Words: 18862
Collection span: 1950 - 2004
View: Overview. Sorted by **GCS**.
Page **1**: 1 (5232) 2 (369) 3 (230) 4 (171) 5 (135) 6 (112) 7 (96) 8 (83) 9 (74) 10 (66) 11 (60) 12 (54) 13 (49)

#	LCR	NCR	Nodes / Date / Journal / Authors	LCS	GCS
1	8	61	13395 1998 ACTA CRYSTALLOGRAPHICA SECTION D-BIOLOGICAL CRYSTALLOGRAPHY 54:905-921 **BRUNGER AT; ADAMS PD; CLORE GM; DELANO WL; GROS P**; et al. *Crystallography & NMR system: A new software suite for macromolecular structure determination*	57	5232
2	5	74	1953 1965 JOURNAL OF MOLECULAR BIOLOGY 12(1):88-& **MONOD J; WYMAN J; CHANGEUX JP** *On Nature of Allosteric Transitions - A Plausible Model*	84	4956
3	12	63	6632 1981 NATURE 290(5806):457-465 **ANDERSON S; BANKIER AT; BARRELL BG; DEBRUIJN MHL; et al.** *Sequence and Organization of the Human Mitochondrial Genome*	80	4184
4	13	44	2677 1968 JOURNAL OF MOLECULAR BIOLOGY 33(2):491-& **MATTHEWS BW** *Solvent Content of Protein Crystals*	86	4135
5	37	301	6364 1981 ANNUAL REVIEW OF BIOCHEMISTRY 50:349-383 **BREATHNACH R; CHAMBON P** *Organization and Expression of Eukaryotic Split Genes-Coding for Proteins*	59	4083
6	14	450	15319 2001 NATURE 409(6822):860-921 **LANDER ES; LINTON LM; BIRREN B; NUSBAUM C; ZODY MC; et al** *Initial sequencing and analysis of the human genome*	108	3441
7	7	271	491 1959 ADVANCES IN PROTEIN CHEMISTRY 14:1-63 **KAUZMANN W** *Some Factors In The Interpretation of Protein Denaturation*	76	3366
8	2	14	4233 1974 GENETICS 77(1):71-94 **BRENNER S** *Genetics Of Caenorhabditis-Elegans*	26	2731
9	1	7	34 1953 NATURE 171(4356):737-738 **WATSON JD; CRICK FHC** *Molecular Structure of Nucleic Acids - A Structure for Deoxyribose Nucleic Acid*	2598	2577
10	5	53	9473 1988 SCIENCE 240(4860):1759-1764 **LANDSCHULZ WH; JOHNSON PF; MCKNIGHT SL** *The Leucine Zipper - A Hypothetical Structure Common To A New Class of DNA-Binding Proteins*	133	2479

While Nobel Class scientists publish many *Citation Classics*, authors of super-cited method papers do not necessarily and indeed usually do not lead to Nobel Prizes. Slide 13 and 14 show the top super-cited method papers. Nobel committees do not ordinarily award prizes for methods per se, but there are exceptions.

Slide #13

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MOST CITED PAPERS Through July 2005

Authors	Title	Source	Yr	Hits
LOWRY OH, et al.	Protein Measurement with the Folin Phenol Reagent, 193:265	Jrnl Biol Chem	1951	**293,328**
LAEMMLI UK	Cleavage f Structural Proteins During Assembly Of Head Of Bacteriophage-T4, 277:680	Nature	1970	**192,022**
BRADFORD MM	Rapid and Sensitive Method for Quantitation of Microgram Quantities of Protein Utilizing Principle of Protein-Dye Binding, 72:248	Analytical Biochem	1976	**120,179**
SANGER F; NICKLEN S; COULSON AR	DNA Sequencing with Chain-Terminating Inhibitors, 74:5463.	PNAS USA	1977	**63,909**
CHOMCZYNSKI P; SACCHI N	Single-Step Method of RNA Isolation by Acid Guanidinium Thiocyanate Phenol Chloroform Extraction, 162: 156.	Analytical Biochem	1987	**55,987**
TOWBIN, H; STAEHELIN, T; GORDON, J	Electrophoretic Transfer of Proteins from Polyacrylamide Gels To Nitrocellulose Sheets - Procedure and Some Applications, 76:4350.	PNAS USA	1979	**48,671**
FOLCH, J; LEES, M; STANLEY, GHS	A Simple Method for the Isolation and Purification of Total Lipides from Animal Tissues	Journal Biol Chem	1957	**35,646**
SOUTHERN, EM	Detection of Specific Sequences among DNA Fragments Separated by Gel-Electrophoresis, 98:503.	Jrnl Molecular Biol	1975	**31,273**
KAPLAN EL; MEIER P	Nonparametric-Estimation From Incomplete Observations	Jrnl Amer Statistical Assoc	1958	**27,698**
WEBER K; OSBORN	Reliability of Molecular Weight Determinations by Dodecyl Sulfate-Polyacrylamide Gel Electrophoresis	Jrnl Biol Chem	1969	**23,225**

MOST CITED PAPERS CONTINUED

Authors	Title	Source	Yr	Hits
CHIRGWIN JM; PRZYBYLA AE; MACDONALD RJ; RUTTER WJ	Isolation of Biologically-Active Ribonucleic-Acid from Sources Enriched in Ribonuclease	Biochemistry	1979	**22,783**
BLIGH EG; DYER WJ	A Rapid Method of Total Lipid Extraction and Purification	Canadian Jrnl Biochem and Physiology	1959	**22,466**
REYNOLDS ES	Use of Lead Citrate at High PH As an Electron-Opaque Stain in Electron Microscopy	Jrnl of Cell Biology	1963	**22,340**
SCATCHARD G	The Attractions of Proteins for Small Molecules and Ions	Annals NY Academy of Sci	1949	**22,260**
MURASHIGE T; SKOOG F	A Revised Medium for Rapid Growth And Bio Assays with Tobacco Tissue Cultures	Physiologia Plantarum	1962	**21,712**
DAVIS BJ	Disc Electrophoresis .2. Method and Application To Human Serum Proteins	Annals New York Acad of Sciences	1964	**21,204**
Fiske CH; Subbarow Y	The Colorimetric Determination of Phosphorus	Jrnl Biol Chem	1925	**21,145**

Slide #15

KARY MULLIS MOST-CITED PAPERS

This was the case with the polymerase chain reaction invented by Kary B. Mullis. His 1988 per cited paper in *Science* on the PCR was one of only five highly cited papers he ever coauthored including one published a year earlier in *Methods of Enzymology*. Unlike the typical life science Nobelist who has published hundreds, he has only published about 50 papers. Slide 15 shows the five most-cited papers published by Mullis. While 14,000 explicit citations might suggest that it has not suffered from OBI, consider that there are over 2 million mentions of the term PCR in a full-text Google search!

To reiterate, from an historical perspective, an important characteristic of Nobel prize work is its multiplier effect. Not only is the primordial work itself highly cited, but its second generation citation impact is demonstrated by the number of supercited papers, often written by other Nobel Class scientists, that cite it.

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GENERAL SEARCH | CITED REF SEARCH | STRUCTURE SEARCH | SEARCH HISTORY | ADVANCED SEARCH

Search Results -- Summary

AU=(mullis kb)
DocType=All document types; Language=All languages; Databases=SCI-EXPANDED, SSCI, A&HCI; Timespan=1900-2006

Search within results: Enter a topic SEARCH

20 results found (Set #3)

Go to Page: 1 of 2 GO

Records 1 -- 10 Show 10 per page

[1 | 2]

Use the checkboxes to select records for output. See the sidebar for options.

1. SAIKI RK, GELFAND DH, STOFFEL S, et al.
PRIMER-DIRECTED ENZYMATIC AMPLIFICATION OF DNA WITH A THERMOSTABLE DNA-POLYMERASE
SCIENCE 239 (4839): 487-491 JAN 29 1988
Times Cited: 13952
LINKS VIEW FULL TEXT

2. SAIKI RK, SCHARF S, FALOONA F, et al.
ENZYMATIC AMPLIFICATION OF BETA-GLOBIN GENOMIC SEQUENCES AND RESTRICTION SITE ANALYSIS FOR DIAGNOSIS OF SICKLE-CELL ANEMIA
SCIENCE 230 (4732): 1350-1354 1985
Times Cited: 6132
LINKS VIEW FULL TEXT

3. **MULLIS KB**, FALOONA FA
SPECIFIC SYNTHESIS OF DNA INVITRO VIA A POLYMERASE-CATALYZED CHAIN-REACTION
METHODS IN ENZYMOLOGY 155: 335-350 1987
Times Cited: 3083
LINKS

4. SAIKI RK, BUGAWAN TL, HORN GT, et al.
ANALYSIS OF ENZYMATICALLY AMPLIFIED BETA-GLOBIN AND HLA-DQ-ALPHA DNA WITH ALLELE-SPECIFIC OLIGONUCLEOTIDE PROBES
NATURE 324 (6093): 163-166 NOV 13 1986
Times Cited: 1422
LINKS VIEW FULL TEXT

5. KWOK S, MACK DH, **MULLIS KB**, et al.
IDENTIFICATION OF HUMAN-IMMUNODEFICIENCY-VIRUS SEQUENCES BY USING INVITRO ENZYMATIC AMPLIFICATION AND OLIGOMER CLEAVAGE DETECTION
JOURNAL OF VIROLOGY 61 (5): 1690-1694 MAY 1987
Times Cited: 322
LINKS

Sort by:
Times Cited SORT

Output Records:
Selected records on page
All records on page
Records to
Bibliographic Fields
PRINT E-MAIL SAVE
EXPORT TO REFERENCE SOFTWARE
SAVE TO MY EndNote Web
[Sign in to access EndNote Web]
Or add them to the Marked List for later output and more options.
ADD TO MARKED LIST
[0 articles marked]

Analyze Results:
ANALYZE
View rankings and histograms of the authors, journals, etc. for this set of records.
(Up to 2,000 records at a time.)

ADD TO MARKED LIST

Key: = Structure available
Use the checkboxes to select records for output. See the sidebar for options.

20 results found (Set #3)

Go to Page: 1 of 2 GO

Records 1 -- 10

[1 | 2]

20 documents matched your query of the 36,966,594 in the data limits you selected.

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SLIDE 16 : HIRSCH INDEX FOR RECENT NOBELISTS INMEDICINE

The Hirsch Index has been widely reported.[13] It appeared just shortly after the *Web of Science* made it possible to sort an author's work by citation frequency within seconds. If an author has published 50 papers that are cited 50 or more times, he will have an H-Index of 50. As with any other citation cohort the H-index, like total citation frequency, is valid only within specialties but even that is subject to considerable variation. But it is an interesting and useful number. The H-indexes for recent Nobel prize winners are shown in Slides 16, 17, and 18 grouped in medicine, chemistry, and physics.

In Slide 16, the he work of Nobelist Barry J. Marshall is a case in point. He has published 37 papers cited 37 or more times. His co-winner J. R. Warren has even fewer papers. This variability tells us we must be careful in using the H-Index as a ranking method. Kerry Mullis published about 50 papers and his H-index would be only 18. In contrast consider that Oliver Lowry published 291 papers and had an H-index of 84.

NOBEL PRIZE RECIPIENTS' H-INDEX SCORES - 2001-2005

MEDICINE

Recipient	Date 1st Paper	# of Papers	H-Index Score	Birth Date
2000				
Carlsson, A	**1914**	**736**	**91**	**1923**
Greengard, P	**1954**	**905**	**143**	**1925**
Kandel, ER	**1958**	**402**	**117**	**1929**
2001				
Nurse, PM	**1973**	**308**	**87**	**1949**
Hartwell, LH	**1961**	**92**	**62**	**1939**
Hunt, RT	**1963**	**501**	**65**	**1943**
2002				
Brenner, S	**1945**	**600**	**80**	**1927**
Horvitz, HR	**1973**	**204**	**83**	**1947**
Sulston, JE	**1964**	**60**	**38**	**1942**
2003				
Lauterbur PC	**1955**	**131**	**41**	**1929**
Mansfield P	**1962**	**322**	**43**	**1933**
2004				
Axel, R	**1967**	**44**	**80**	**1946**
Buck, LB	**1991**	**45**	**23**	**1947**
2005				
Marshall, BJ	**1954**	**190**	**38**	**1951**
Warren, JR	**1947**	**187**	**25**	**1937**

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SLIDE 17: HIRSCH INDEX FOR RECENT NOBELISTS IN CHEMISTRY

In Slide 17 in the field of chemistry, Yves Chauvin has an H-index of 25 while co-winners R. H. Grubbs and P. R. Schotz have H-indexes of about 81 and 83.

Time does not permit me to go into modifications of the H-Index proposed by Leo Egghe[14] and others that take into account the differences between authors with the same H Index. One may have published 50 papers cited from 50 to 100 times each, whereas the other has 50 papers cited 50 to 5,000 times each.

NOBEL PRIZE RECIPIENTS' H-INDEX SCORES

CHEMISTRY

Recipient	Date 1st Paper	# of Papers	H-Index Score	Birth Date
2000				
Heeger, HG	1959	995	108	1936
MacDiarmid, AG	1949	640	83	1927
Shirakawa, H	1926	430	44	1936
2001				
Knowles, EX	1942	38	18	1917
Noyori, R	1938	453	90	1938
Sharpless, KB	1962	352	87	1941
2002				
Fenn, JB	1951	96	33	1917
Tanaka K	1989	22	11	1959
Wüthrich K	1963	686	110	1938
2003				
MacKinnon, R	1970	163	58	1956
Agre P	1981	283	62	1949
2004				
Ciechanover A	1971	157	60	1947
Hershko A	1961	134		1937
Rose I	1941	121	10	1926
2005				
Chauvin Y	1964	112	25	1930
Grubbs RH	1967	579	81	1942
Schrock RR	1975	540	83	1945

SLIDE 18: HIRSCH INDEX FOR RECENT NOBELISTS IN PHYSICS

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Consider that Vitaly L. Ginsburg, the Russian physicist won the physics prize at 87 having published over 500 papers and books cited in over 15,000 papers. In contrast, Anthony J. Legget has about 150 papers cited in 9400 papers..

NOBEL PRIZE RECIPIENTS' H-INDEX SCORES

PHYSICS

Recipient	Date 1st Paper	# of Papers	H-Index Score	Birth Date
2000				
Alferov ZI	1955	507	41	1940
Kilby JS	1964	4	1	1923
Kroemer H	1953	292	46	1928
2001				
Cornell EA	1984	79	34	1961
Ketterle W	1965	141	46	1957
Wieman CE	1975	95	38	1951
2002				
Davis R	1973	48	13	1914
Giacomo R	1931	12	12	1931
Koshiba M	174			
2003				
Abrikosov AA	1949	202	30	1928
Ginzburg VL	1945	426	40	1916
Leggett AJ	1964	142	41	1938
2004				
Gross DJ	1964	280	67	1941
Politzer HD	1973	62	37	1949
Wilczek F	1973	307	70	1951
2005				
Chauvin Y	1964	112	24	1930
Grubbs RH	1967	579	82	1942
Schrock RR	1975	540	84	1945

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SLIDES 19 & 20: H-INDEX FOR HIGHLY CITED AUTHORS.

A further source of potential data for studying future Nobel candidates are *ISI's* lists of highly cited authors available on a free web site (http://www.isihighlycited.com). Cancer researcher Bert Vogelstein, often mentioned as a Nobel candidate, has an H-Index of 155, including thirty five papers which are super Classics!

Most-Cited Researchers, 1983-2002

Rank	H-Index	Name	Affiliation	Field	Papers	Citations
1	155	Bert Vogelstein	HHMI/Johns Hopkins	Molecular Biology & Genetics	361	106,401
2	145	Salvador Moncada	U. College London	Pharmacology	541	68,889
3	194	Solomon H. Snyder	Johns Hopkins U.	Pharmacology	625	63,106
4	138	Charles A. Dinarello	U. Colorado	Immunology	862	62,365
5	154	Pierre Chambon	U. Strasbourg	Molecular Biology & Genetics	686	61,884
6	154	Robert C. Gallo	U. Maryland	Immunology	930	61,303
7	163	David Baltimore	Caltech	Molecular Biology & Genetics	386	59,519
8	134	Tadamitsu Kishimoto	Osaku U.	Molecular Biology & Genetics	1,406	58,621
9	122	Axel Ullrich	MPI Biochem.	Molecular Biology & Genetics	525	58,395
10	130	Ronald M. Evans	HHMI, Salk Institute	Molecular Biology & Genetics	442	57,630
11	123	Timothy A. Springer	Ctr. Blood Res.	Immunology	438	54,737
12	87	Michael Karin	UC San Diego	Molecular Biology & Genetics	311	54,390
13	151	Anthony S. Fauci	NIAID	Immunology	781	53,932
14	137	Joseph Schlessinger	Yale U.	Molecular Biology & Genetics	420	53,894
15	141	Steven A. Rosenberg	NCI	Immunology	778	52,463
16	161	Robert J. Lefkowitz	HHMI, Duke U.	Biology & Biochemistry	593	50,473
17	25	Piotr Chomczynski	Molecular Res. Ctr.	Biology & Biochemistry	34	49,794
18	25	Nicoletta Sacchi	U. Milan	Biology & Biochemistry	99	48,685
19	120	Kenneth W. Kinzler	Johns Hopkins U.	Molecular Biology & Genetics	220	48,277
20	121	Peter H. Seeburg	MPI Med. Res.	Neuroscience	264	47,753
21	142	Meir J. Stampfer	Harvard U.	Clinical Medicine	816	47,514
22	122	Tim Hunter	Salk Institute	Biology & Biochemistry	481	46,313
23	142	Walter C. Willett	Harvard U.	Clinical Medicine	988	46,140
24	133	Philip Cohen	U. Dundee	Biology & Biochemistry	1,599	44,875
25	122	John C. Reed	Burnham Inst.	Molecular Biology & Genetics	733	44,421

Most-Cited Researchers, 1983-2002 Continued

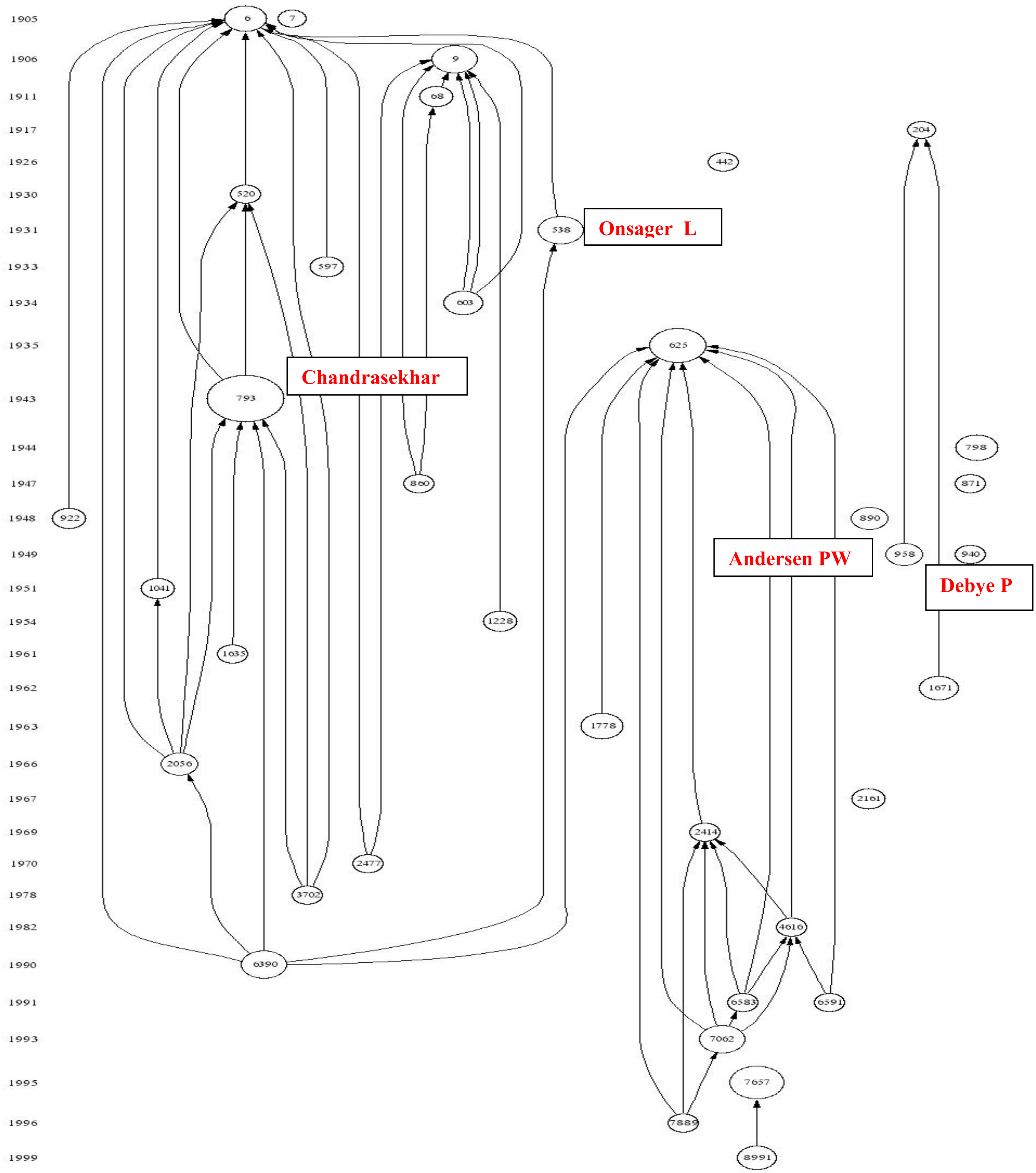
Rank	H-Index	Name	Affiliation	Field	Papers	Citations
26	79	Anthony Cerami	Covalent Group	Biology & Biochemistry	378	44,074
27	132	Ira Pastan	NCI	Molecular Biology & Genetics	794	42,554
28	120	Thomas E. Starzl	U. Pittsburgh	Clinical Medicine	1,633	42,255
29	119	Michael B. Sporn	Dartmouth Med. Sch.	Biology & Biochemistry	329	41,952
30	127	Charles H. Hennekens	U. Miami	Medicine	731	41,758
31	134	Marc G. Caron	HHMI, Duke U	Biology & Biochemistry	510	41,119
32	109	Robert J. Tjian	HHMI, UC Berkeley	Molecular Biology & Genetics	206	40,902
33	104	Yasutomi Nishizuka	Kobe U.	Biology & Biochemistry	196	40,880
34	104	David V. Goeddel	Tularik, Inc.	Molecular Biology & Genetics	177	40,862
35	158	Michael S. Brown	U. Texas SW Med Ctr.	Molecular Biology & Genetics	480	40,545
36	162	Joseph L. Goldstein	U. Texas SW Med Ctr.	Molecular Biology & Genetics	426	40,020
37	110	Ad Bax	NIDDKD	Chemistry	308	39,875
38	60	Richard M.J. Palmer	Alizyme	Biology & Biochemistry	99	39,759
39	119	Joan Massague	HHMI, Mem. Sloan Ket.	Molecular Biology & Genetics	250	39,280
40	108	Peter J. Barnes	Imperial Coll.	Pharmacology	1,311	38,823
41	130	Erkki Ruoslahti	Burnham Inst.	Molecular Biology & Genetics	268	38,367
42	83	Michael J. Berridge	Babraham Inst.	Biology & Biochemistry	191	38,505
43	109	Stanley J. Korsmeyer	HHMI, Dana-Farber Cancer Inst.	Molecular Biology & Genetics	287	38,455
44	105	Neal G. Copeland	NCI	Molecular Biology & Genetics	696	38,032
45	113	Robert A. Weinberg	MIT	Molecular Biology & Genetics	274	38,000
46	123	Michael G. Rosenfeld	HHMI, UC San Diego	Molecular Biology & Genetics	324	37,806
47	108	Nancy A. Jenkins	NCI	Molecular Biology & Genetics	691	37,146
48	147	Tomas Hokfelt	Karolinska Institute	Neuroscience	775	37,123
49	147	Anita B. Roberts	NCI	Molecular Biology & Genetics	344	36,397
50	115	Judah Folkman	Harvard U.	Clinical Medicine	305	36,209

SOURCE: Thomson ISI Web of Science

SLIDE: 21 HISTORIOGRAPH FOR EINSTEIN

Let's return to Albert Einstein. In order to visualize the second order citation impact of Nobel class work, the HistCite software creates an Historiograph showing the genealogy of the field in question. In the case of Albert Einstein we can see in Slide 21 the evolution of citations to his work.

EINSTEIN HISTORIOGRAPH



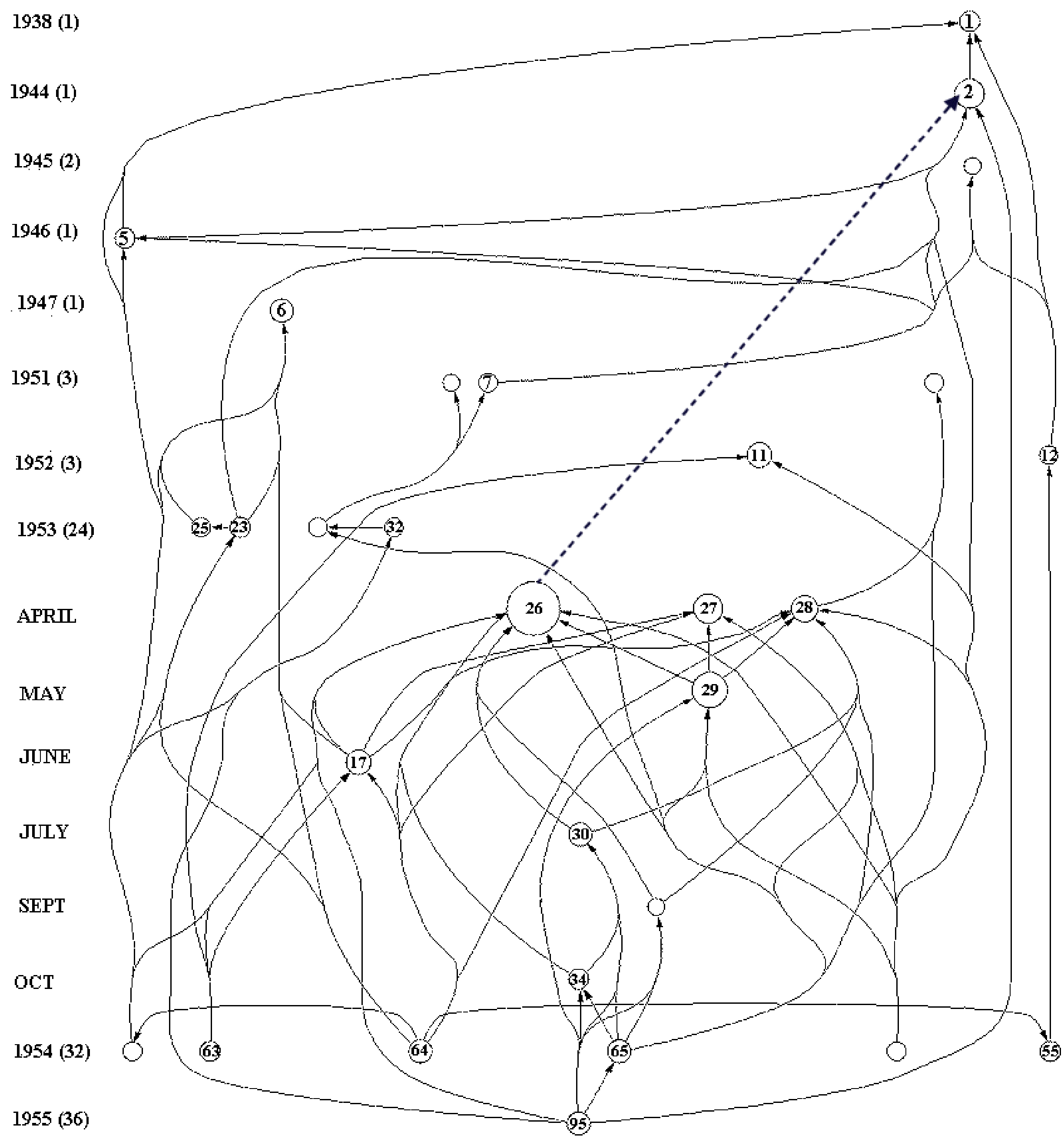
Slide #22 : YEAR-BY-YEAR CITATIONS TO ALBERT EINSTEIN

As in the case for Watson-Crick, # 22 shows Einstein's work has been increasingly cited over the years

Pub Year	Count	%
1901	1	0.0
1902	2	0.0
1903	1	0.0
1904	1	0.0
1905	5	0.0
1906	8	0.0
1907	18	0.1
1908	17	0.1
1909	22	0.1
1910	17	0.1
1911	36	0.2
1912	35	0.2
1913	34	0.2
1914	36	0.2
1915	18	0.1
1916	36	0.2
1917	22	0.1
1918	20	0.1
1919	25	0.2
1920	26	0.2
1921	34	0.2
1922	26	0.2
1923	40	0.2
1924	56	0.3
1925	57	0.3
1926	47	0.3
1927	30	0.2
1928	24	0.1
1929	28	0.2
1930	35	0.2
1931	19	0.1
1932	35	0.2
1933	35	0.2
1934	16	0.1
1935	31	0.2
1936	31	0.2
1937	34	0.2
1938	31	0.2
1939	24	0.1
1940	25	0.2
1941	20	0.1
1942	18	0.1
1943	17	0.1
1944	23	0.1
1945	22	0.1
1946	25	0.2
1947	34	0.2
1948	49	0.3
1949	57	0.3
1950	56	0.3
1951	55	0.3
1952	63	0.4
1953	86	0.5
1954	71	0.4
1955	67	0.4
1956	105	0.6
1957	78	0.5
1958	79	0.5
1959	91	0.6
1960	98	0.6
1961	102	0.6
1962	125	0.8
1963	124	0.7
1964	128	0.8
1965	151	0.9
1966	142	0.9
1967	152	0.9
1968	186	1.1
1969	164	1.0
1970	184	1.1
1971	205	1.2
1972	229	1.4
1973	180	1.1
1974	228	1.4
1975	285	1.7
1976	235	1.4
1977	267	1.6
1978	252	1.5
1979	337	2.0
1980	326	2.0
1981	312	1.9
1982	358	2.2
1983	313	1.9
1984	367	2.2
1985	391	2.4
1986	318	1.9
1987	326	2.0
1988	351	2.1
1989	328	2.0
1990	341	2.1
1991	341	2.1
1992	362	2.2
1993	377	2.3
1994	407	2.5
1995	415	2.5
1996	461	2.8
1997	460	2.8
1998	479	2.9
1999	486	2.9
2000	563	3.4
2001	608	3.7
2002	627	3.8
2003	622	3.8
2004	639	3.9
2005	138	0.8

Slide #23: WATSON-CRICK & AVERY-MCCARTY-MCLEOD

In slide 23, the historiograph depicts the evolution of the five-year period from the time the double helix paper was published in 1953 until 1958. It also demonstrates the link between that work and the 1944 Avery-McCarty-McCleod paper. The dotted-line link between these two papers, represents the implicit citation link between these works even though Watson-Crick themselves did not cite Avery-McCleod in their 1953 paper. But clearly both papers were co-cited by hundreds of citing authors. In a recent interview, Watson acknowledged that it was a serious omission on their part not to have cited Avery et al.[15]



I have given you an impressionistic view of my experience using bibliometric data to study the work of Nobel Class scientists and also to generate lists of candidates for awards and tenure. All of these methods should be used to supplement human judgment. The Nobel Prize itself was created at a time when the idea of the research team as we know it today, did not exist. The limitation of three persons for each category today is certainly an artificial impediment to total fairness and just barely takes into account the fact that multiple, often simultaneous, discovery is quite common. That idea, originally explored by Robert K. Merton, is the norm today.[16] The arbitrary limitation of three persons leads to resentment by those who feel justifiably that their omission is an injustice. Today, recognition by the Nobel is far more important than the monetary amount of the award, so it would better serve the interests of science, I believe, if the awards were shared by the many equally deserving scientists of Nobel Class.

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