From Bibliographic Coupling to Co-Citation Analysis via Algorithmic Historio-Bibliography

A Citationist's Tribute to Belver C. Griffith

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by

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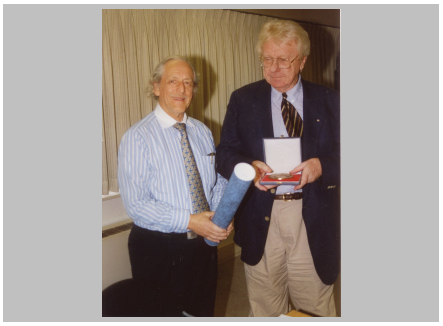


This is my first visit to Drexel since the Belver Griffith memorial was held in January 2000, a few months after his death on October 23, 1999. Since then, I have worked with Dean David E. Fenske to establish the Belver C. Griffith Memorial Doctoral Research Award and the Belver C. Griffith Memorial Lectureship (http://www.cis.drexel.edu/news/page5.html). I look forward to the first lecture in 2002. The first recipient of the Doctoral Award is Jan Buzydlowski. And I was pleased to learn that his wife Carolyn Adams has endowed the Belver C. Griffith Memorial Fund for Graduate Students in the College of Information Science and Technology.

Of course, the life and work of Belver Griffith is known to many of the faculty and students here at Drexel. Professor Kate McCain recently edited the Belver C. Griffith memorial issue of *Scientometrics*, which contains not only a short biography, but also a selective bibliography of 124 of his articles.[1] About half of these are included in the *Science Citation Index*® (*SSCI*®) or *Social Sciences Citation Index*® (*SSCI*®). Also in that special issue, one of Belver's former students, Professor Heting Chu, of Long Island University, used the *SCI* and *SSCI* to perform a citation analysis of his work in information science.[2] Other papers in that special issue are devoted to co-citation studies of philosophy authors,[3] information science,[4] and human behavioral ecology.[5] The emphasis on co-citation is only natural considering Belver's long association with Henry Small. Henry has described how they met in his delightful paper entitled "Belver and Henry."[6] Last but not least, Howard D. White has done a wonderful Cameo of Belver's work in his article about "author-centered bibliometrics."[7]

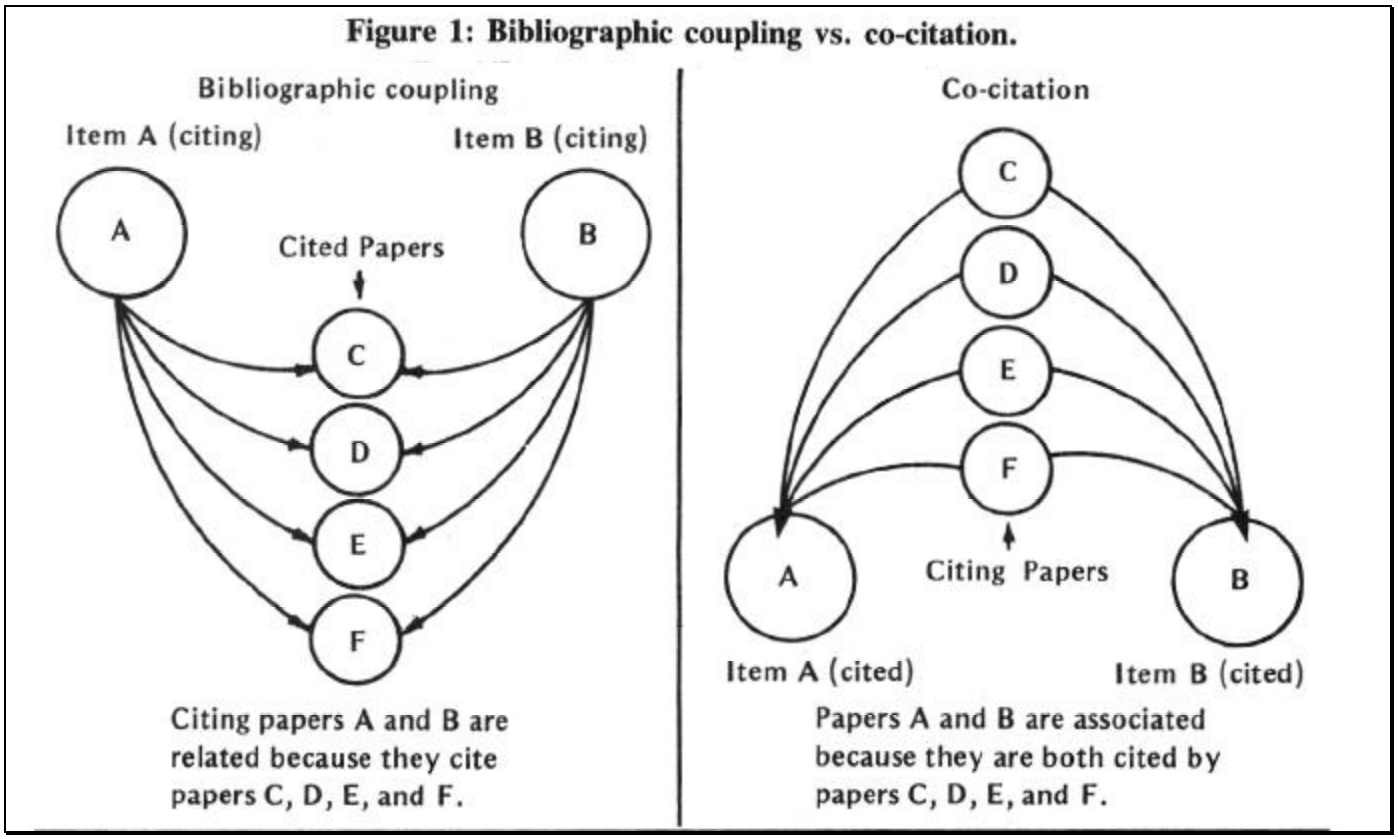
It is significant that Belver's earliest collaborative work with Henry Small, published in two issues of *Science Studies in 1974,* proved to be Belver's most-cited work in the field of information science. This two-part paper was published about one year after Henry's primordial paper on co-citation in *JASIS* in1973.[8] (See Henry's *Citation Classic* commentary tracing its origins.[9])

Closely related to the subject of co-citation is that of bibliographic coupling. Two months ago at the University of Pittsburgh I presented a historiographic citation analysis of Michael M. Kessler's 1963 work on Bibliographic Coupling.[10] That paper was one of the key historical antecedents of co-citation analysis. As will be shown, in later years, bibliographic coupling was essentially displaced by co-citation clustering as a tool for mapping science. However, after another 15 years, bibliographic coupling would assume a highly significant role in information retrieval when the Institute for Scientific Information (ISI) implemented "*Related Records*.®" This application of bibliographic coupling first appeared in the CD ROM version of *SCI* and *SSCI* in 1988. [11]

Co-citation analysis has had an enormous and measurable impact on the field of information science itself as well as outside the field by scholars who have used it as a tool for mapping their disciplines or specialties. The impact of bibliographic coupling on information retrieval, is more difficult to quantify. Based on over 1.5 million cited reference searches on *ISI Web of Science,*® only about 1% of users used the *Related Records* feature.[12] The *Related Records* feature was originally available in the CD-ROM version. Its use may have been limited because it could only be used for a year-by-year perspective. On *ISI Web of Science*, a *Related Record* search now covers the literature from 1945 to the present, so its retrospective value has increased enormously. Just as it took decades for citation searching to become routine, new generations of users will have to learn how related records can be used to pinpoint relevant research

To facilitate an historical analysis of bibliographic coupling and co-citation analysis research, I shall shortly demonstrate to you some software developed by two Russian colleagues and myself. This is the culmination of work begun by Irv Sher and myself over 35 years ago.

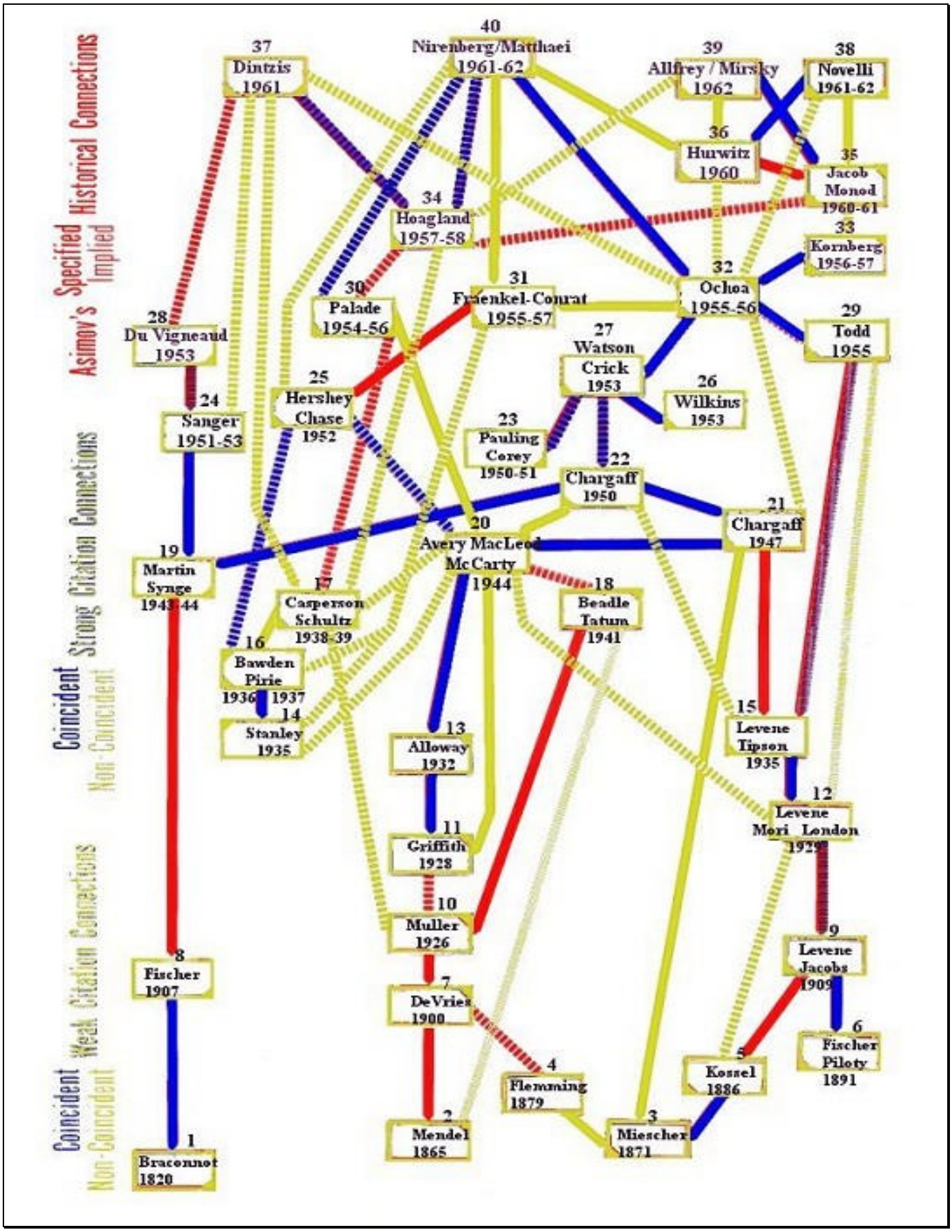
SLIDE 1: BIBLIOGRAPHIC COUPLING VS. CO-CITATION



The differences between these two methodologies were discussed in my first essay about the CD-ROM version of the *SCI* [*Essays*, Volume 11].[11] Papers are bibliographically coupled when different authors cite one or more papers in common. On the other hand, co-citation analysis is based primarily on identifying pairs of highly-cited papers. These prove to be accurate markers for the emergence of new topics. Bibliographic coupling is retrospective whereas co-citation is essentially a forward-looking perspective.

Let's go back now to the earliest days of citation indexing. Its potential ramifications for historical and sociological analysis were evident from the outset. My 1955 paper in *Science*[13] suggested that the putative *Science Citation Index* would be a great asset in measuring impact and facilitating historiography. It would take a decade for these ideas to mature to the point where in 1964 Irv Sher and I could propose to Harold Wooster at the U.S. Air Force Office of Scientific Research that we do a study on "Use of Citation Data in Writing the History of Science."[14] During the previous three years, we had not only created the first prototype "Genetics Citation Index," but also the 1961 Annual *Science Citation Index*. And we had just launched the *SCI* as a quarterly commercial venture. A limited number of copies of our final report were distributed, but it was only his year that I posted the full text to my website (http://www.garfield.library.upenn.edu/papers/useofcitdatawritinghistofsci.pdf).

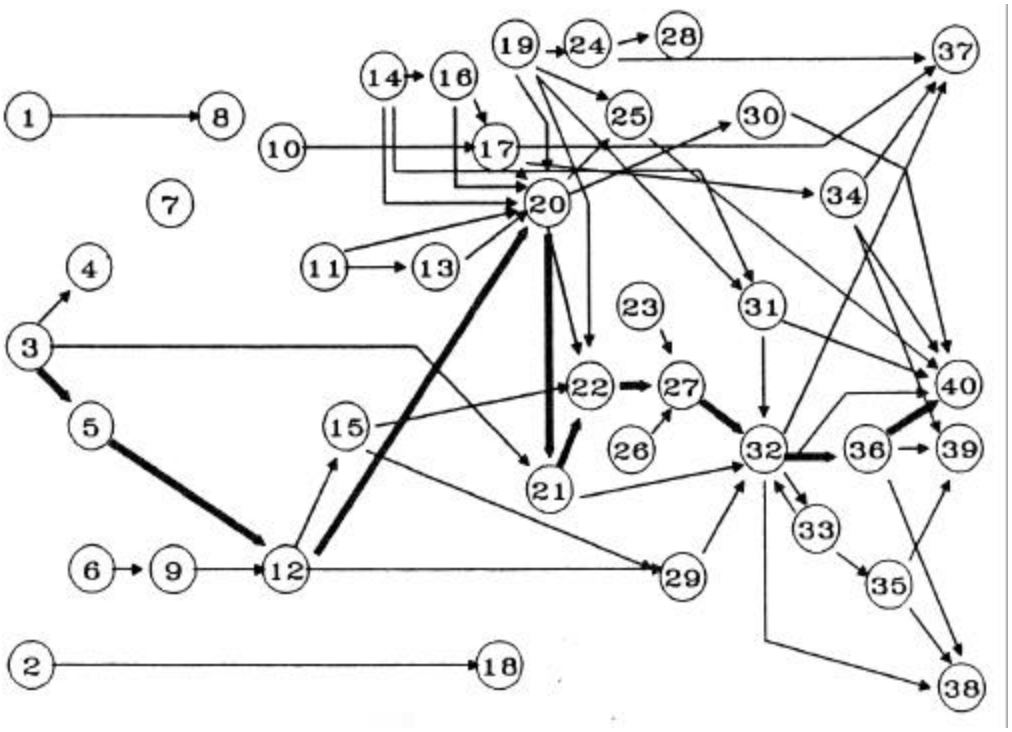
SLIDE 2: DNA HISTORIOGRAPH (Color Map) From Mendel to Nirenberg



The essence of that report is reflected in Slide 2 (color map). This is the historiograph that we created from our analyses of 40 key milestone events in the history of DNA from Mendel to Niremberg, 1962. This map was drawn manually after we had compiled a mini-citation index of the 65 key papers involved in those events. Time does not permit me to go into the full details of this project. Suffice it to say that we selected the key papers by using a small popular book, *The Genetic Code*, written in 1963 by Isaac Asimov,[15] the well-known science fiction writer. Isaac was also a professor of biochemistry and became our "informant" for this project. The citation analysis confirmed his choices of key developments but it also revealed certain gaps in his account which was based primarily on his prodigious memory. In all the years I knew Asimov, I never heard him mention doing literature searches. His behavior was typical of a class of scholars who rarely use information services or seek the support of librarians.

Each box in this diagram or map represents a milestone consisting of one or more papers. The dark blue lines indicate that there is a direct citation link between the nodes involved. The dotted lines represent implicit links.

SLIDE 3: HUMMON AND DOREIAN – MAIN PATH ANALYSIS



Main path analysis by Hummon / Doreian

Table 1
The 40 milestone events of DNA research from Garfield et al. (1964) after Asimov (1963)

Event	Date	Author(s)	Event	Date	Author(s)
1	1820	Bracconot	21	1947	Chargaff
2	1860s	Mendel	22	1950	Chargaff
3	1869	Miescher	23	1951	Pauling & Corey
4	1880	Flemming	24	1953	Sanger
5	1886	Kossel	25	1952	Hershey & Chase
6	1891	Fischer & Piloty	26	1953	Wilkins
7	1900	DeVries	27	1953	Watson & Crick
8	1900-10	Fischer	28	1953	DuVigneaud
9	1909	Levene	29	1955	Todd
10	1926	Muller	30	1953	Pallade
11	1928	Griffith	31	1955	Fraenlal-Conrat
12	1929	Levene	32	1955	Ochoa
13	1931	Alloway	33	1956	Kornberg
14	1935	Stanley	34	1957-8	Hoagland
15	1935	Levene	35	1960	Jacob & Monod
16	1936	Bawden & Pirie	36	1961	Hurwitz
17	1938	Caspersson & Schulz	37	1961	Dintzis
18	1941	Beadle & Talum	38	1961	Norvelli
19	1944	Martin & Synge	39	1962	Mirsky & Alibrey
20	1944	Avery et al.	40	1961	Nirenberg & Maltaei

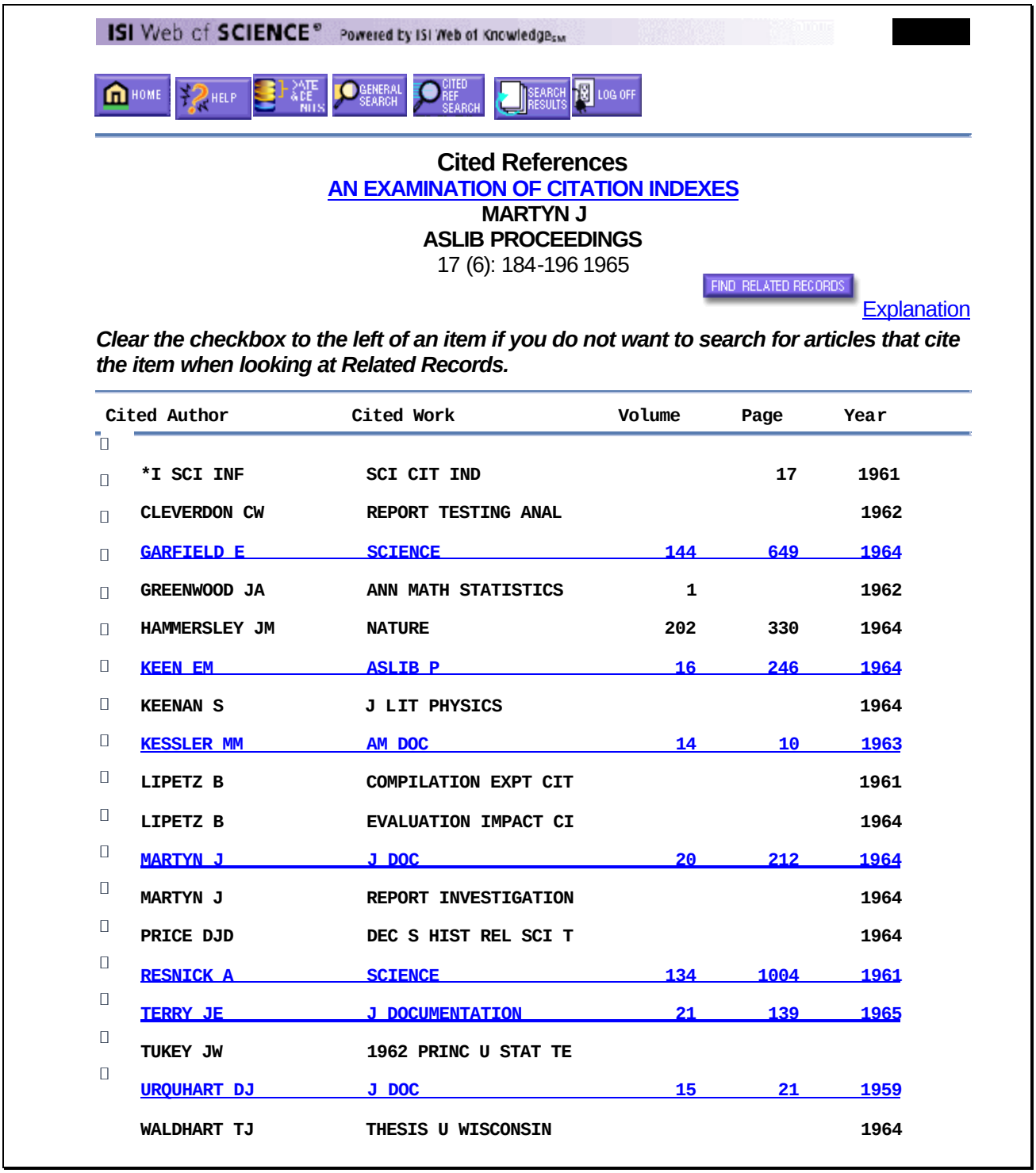
Another method of interpreting these data was provided by Norman Hummon and Patrick Doreian at the University of Pittsburgh. They used our data to illustrate the method of critical path analysis to portray these same developments.[16] In their map of the history of DNA in Slide 3 each milestone is represented by numbers one to forty.

Over the years, Irv Sher and I discussed the idea of automating this process so that users of the *SCI* and *SSCI* could "automatically" obtain graphical histories of any field chosen. There are many ways

one can define what is meant by that. Citationists do not usually think of such mapping in a genealogical sense, that is, displaying papers that descend from a starting primordial paper – from parent to offspring. My 1963 paper on "Citation Indexes in Sociological and Historical Research,"[17] outlined a critical path method of measuring the impact for a primordial paper. That method involved the idea of following the genealogical tree by using the *SCI* to search forward on a year-by-year basis from the primordial paper. If one were to limit the exercise to counting, this could be a manageable exercise. But if one actually retrieves records for every descendant paper in a literature search, one runs into storage limitations, especially when highly cited works are encountered which overload the system. For example, in our map of DNA, Watson & Crick's 1953[18] paper has been cited a few thousand times. Many of those citing papers are also heavily cited. So one has to be selective in retrieving subsequent generations of unusually highly-cited items, if the results are not to become unwieldy.

After a 36-year lapse, I decided to go back to our earlier plan to automate this process. Together with my two Russian colleagues, Alexander Pudovkin and Vladimir Istomin, we developed software that simulated a genealogical search procedure. Once we have identified a starting paper or term, we obtain a starting collection of papers. The complete source record for each paper is found in the *Science Citation* Index on the *Web of Science* or in the CD-ROM version. The algorithm uses the lists of cited references in the collection to create a mini-citation index of the topic, as was done for the history of DNA. The software produces a basic chronological matrix of the bibliography. On command the program generates listings of most-cited (core) papers in the input network as well as globally. However, it also produces a list of the most-cited papers outside the input network. By an editing procedure the user can then decide whether to add any of these outside non-nodal papers to the input group and thereby to the map. Let me show you how we obtain and process records for our analyses.

SLIDE 4: *WoS* SOURCE RECORD SHOWING CITED REFERENCES



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HOME | HELP | DATE & CE MITS | GENERAL SEARCH | CITED REF SEARCH | SEARCH RESULTS | LOG OFF

Cited References

AN EXAMINATION OF CITATION INDEXES
MARTYN J
ASLIB PROCEEDINGS
17 (6): 184-196 1965

FIND RELATED RECORDS

Explanation

Clear the checkbox to the left of an item if you do not want to search for articles that cite the item when looking at Related Records.

Cited Author	Cited Work	Volume	Page	Year
*I SCI INF	SCI CIT IND		17	1961
CLEVERDON CW	REPORT TESTING ANAL			1962
GARFIELD E	SCIENCE	144	649	1964
GREENWOOD JA	ANN MATH STATISTICS	1		1962
HAMMERSLEY JM	NATURE	202	330	1964
KEEN EM	ASLIB P	16	246	1964
KEENAN S	J LIT PHYSICS			1964
KESSLER MM	AM DOC	14	10	1963
LIPETZ B	COMPILATION EXPT CIT			1961
LIPETZ B	EVALUATION IMPACT CI			1964
MARTYN J	J DOC	20	212	1964
MARTYN J	REPORT INVESTIGATION			1964
PRICE DJD	DEC S HIST REL SCI T			1964
RESNICK A	SCIENCE	134	1004	1961
TERRY JE	J DOCUMENTATION	21	139	1965
TUKEY JW	1962 PRINC U STAT TE			
URQUHART DJ	J DOC	15	21	1959
WALDHART TJ	THESIS U WISCONSIN			1964

A search of the *Web of Science* produces this type of source record. In this example, a 1965 paper by John Martyn has been retrieved. Each such retrieved record would be added to a "marked list." In the examples I will illustrate, from several hundred papers to over 1,000 will be retrieved. Those of you who have used the *WoS* will recognize this feature. The entries in blue are hot-linked to their corresponding source records in the *WoS*.

SLIDE 5: TYPICAL EXPORT FORMAT OF RECORD FROM THE WEB OF SCIENCE

```
FN ISI Export Format
VR 1.0
PT Journal
AU MARTYN, J
TI AN EXAMINATION OF CITATION INDEXES
SO ASLIB PROCEEDINGS
NR 18
CR *I SCI INF, 1961, SCI CIT IND, P17
   CLEVERDON CW, 1962, REPORT TESTING ANAL
   GARFIELD E, 1964, SCIENCE, V144, P649
   GREENWOOD JA, 1962, ANN MATH STATISTICS, V1
   HAMMERSLEY JM, 1964, NATURE, V202, P330
   KEEN EM, 1964, ASLIB P, V16, P246
   KEENAN S, 1964, J LIT PHYSICS
   KESSLER MM, 1963, AM DOC, V14, P10
   LIPETZ B, 1961, COMPILATION EXPT CIT
   LIPETZ B, 1964, EVALUATION IMPACT CI
   MARTYN J, 1964, J DOC, V20, P212
   MARTYN J, 1964, REPORT INVESTIGATION
   PRICE DJD, 1964, DEC S HIST REL SCI T
   RESNICK A, 1961, SCIENCE, V134, P1004
   TERRY JE, 1965, J DOCUMENTATION, V21, P139
   TUKEY JW, 1962 PRINC U STAT TE
   URQUHART DJ, 1959, J DOC, V15, P21
   WALDHART TJ, 1964, THESIS U WISCONSIN
BP 184
EP 196
PG 13
JI Aslib Proc.
PY 1965
VL 17
IS 6
GA CDN98
J9 ASLIB PROC
UT ISI:A1965CDN9800001
ER
```

Once the search of the *WoS* is completed, the *Marked List* is “saved to file.” In this step, the marked list is converted to the *Export Format* which contains tags for all the informational elements. Note that this paper cites M. M. Kessler, among others. The new “saved file” is basically a Microsoft Word Document in “txt” format. This file is now run against our *Histcomp* Software which is our code name for “compiled Historiography” program

SLIDE 6: CHRONOLOGICAL FILE OF PAPERS CITING KESSLER 1963

Chronological File

Outer nodes Missing links? Journal list All-Author list

Citations to Kessler's Bibliographic Coupling and papers with BC in title/abstract

Nodes: 223

Sorted by **year, journal, volume, page**.

Cited nodes	Nodes / Authors	GCS	LCS
0	0 1963 AMERICAN DOCUMENTATION 14(1):10-& **KESSLER MM** *Bibliographic Coupling Between Scientific Papers*	128	134
1	1 1963 AMERICAN DOCUMENTATION 14(4):289-& **GARFIELD E** *Citation Indexes in Sociological and Historical Research*	61	5
0	2 1963 IEEE TRANSACTIONS ON INFORMATION THEORY 9(1):49-& **KESSLER MM** *An Experimental Study of Bibliographic Coupling Between Technical Papers*	8	8
1	3 1963 INFORMATION STORAGE AND RETRIEVAL 1(4):169-187 **KESSLER MM** *Bibliographic Coupling Extended in Time - 10 Case Histories*	14	15
1	4 1964 ASLIB PROCEEDINGS 16(2):48-63 **[Anon]** *ASLIB 37th Annual Conference - University of St Andrews, 24th - 26th September 1963*		0
1	5 1964 ASLIB PROCEEDINGS 16(4):132-152 **LANCASTER FW** *Mechanized Document Control - A Review of Some Recent Research*	3	0
2	6 1964 ASLIB PROCEEDINGS 16(8):246-251 **KEEN EM** *Citation Indexes*	5	2
0	7 1964 JOURNAL OF DOCUMENTATION 20(4):236-236 **MARTYN J** *Bibliographic Coupling*	12	7
1	8 1964 NACHRICHTEN FUR DOKUMENTATION 15(3):122-130 **MODEL F** *Citation Index and Retrospective Cataloging - Examples of Citation Documentation*	5	0
1	9 1964 SCIENCE 144(361):649-& **GARFIELD E** *Science Citation Index - New Dimension in Indexing - Unique Approach Underlies Versatile Bibliographic Systems*	92	19

Our search in this case was on the subject of bibliographic coupling. We created a marked list by looking for papers that cited M. M. Kessler or contained the words bibliographic coupling in their titles. Slide 6 shows the first page of the *Histcomp* analysis of the file on bibliographic coupling.

The randomly organized *Export File* has been sorted by the software to produce a precise chronological file of papers that show all papers that have cited M. M. Kessler or have used the term “Bibliographic Coupling” in their titles. For a variety of reasons, the output of large *WoS* files is not in exact chronological sequence. It is usually in approximate reverse chronological order since most users are interested in retrieving the most current research first. Furthermore, over the years back-

year material was added to the database long after it was current, especially when compiling five- and ten-year cumulations. Future versions of *WoS* will undoubtedly rectify this anomaly.

SLIDE 7: MOST-CITED PAPERS FROM THE STARTING BIBLIOGRAPHY RANKED BY LOCAL CITATION SCORE

Outer nodes Missing links? Journal list All-Author list

Citations to Kessler's Bibliographic Coupling and papers with BC in title/abstract

Nodes: 223
Sorted by **LCS**.

Cited nodes	Nodes / Authors	GCS	LCS
0	0 1963 AMERICAN DOCUMENTATION 14(1):10-& **KESSLER MM** *Bibliographic Coupling Between Scientific Papers*	128	134
3	75 1973 JOURNAL OF THE AMERICAN SOCIETY FOR INFORMATION SCIENCE 24(4):265-269 **SMALL HG** *Cocitation in Scientific Literature - New Measure of Relationship Between 2 Documents*	235	82
3	10 1965 AMERICAN DOCUMENTATION 16(3):223-233 **KESSLER MM** *Comparison of the Results of Bibliographic Coupling and Analytic Subject Indexing*	42	43
2	15 1965 PHYSICS TODAY 18(3):28-& **KESSLER MM** *MIT Technical Information Project*	36	39
2	88 1974 SCIENCE STUDIES 4(1):17-40 **SMALL HG; GRIFFITH BC** *Structure Of Scientific Literatures . 1. Identifying And Graphing Specialties*	212	37
1	78 1973 NAUCHNO-TEKHNICHESKAYA INFORMATSIYA SERIYA 2-INFORMATSIONNYE PROTSESSY I SISTEMY 2(6):3-8 **MARSHAKOVA IV** *System Of Document Connections Based On References*	24	22
1	9 1964 SCIENCE 144(361):649-& **GARFIELD E** *Science Citation Index-New Dimension in Indexing - Unique Approach Underlies Versatile Bibliographic Systems for Communicating and Evaluating Information*	92	19
4	58 1971 INFORMATION STORAGE AND RETRIEVAL 6(6):417-& **SCHIMINOVICH S** *Automatic Classification and Retrieval of Documents by Means of Bibliographic Pattern Discovery Algorithm*	27	16
1	3 1963 INFORMATION STORAGE AND RETRIEVAL 1(4):169-187 **KESSLER MM** *Bibliographic Coupling Extended In Time - 10 Case Histories*	14	15

In slide 7, we see the list of papers sorted by citation frequency within the “local,” that is, the starting bibliography. Note that LCS means *Local Citation Score*.

When you click on the LCS hot link you get a ranked display of the citing papers.

SLIDE 8: PAPERS THAT CITE NODE: #78 IV MARSHAKOVA, 1973

78 1973 NAUCHNO-TEKHNICHESKAYA INFORMATSIYA SERIYA 2-INFORMATSIONNYE PROTSESSY I SISTEMY 2(6):3-8
MARSHAKOVA IV
System Of Document Connections Based On References

cited by:

81 1974 INFORMATION STORAGE AND RETRIEVAL 10(5-6):189-196
WEINBERG BH
Bibliographic Coupling - Review

101 1978 NAUCHNO-TEKHNICHESKAYA INFORMATSIYA SERIYA 2-INFORMATSIONNYE PROTSESSY I SISTEMY (12):1-3
NIKITINA LN
Content Relations between Documents Identified by Means Of References

109 1980 JOURNAL OF THE AMERICAN SOCIETY FOR INFORMATION SCIENCE 31(4):278-282
BICHTELER J; EATON EA
The Combined Use of Bibliographic Coupling and Cocitation for Document-Retrieval

110 1981 CURRENT CONTENTS (42):5-13
GARFIELD E
Introducing the ISI Atlas of Science - Biochemistry and Molecular-Biology, 1978-80

113 1981 SCIENTOMETRICS 3(1):13-25
MARSHAKOVA IV
Citation Networks in Information-Science

117 1982 JOURNAL OF THE AMERICAN SOCIETY FOR INFORMATION SCIENCE 33(4):208-216
BONZI S
Characteristics of a Literature As Predictors of Relatedness between Cited and Citing Works

118 1982 NAUCHNO-TEKHNICHESKAYA INFORMATSIYA SERIYA 2-INFORMATSIONNYE PROTSESSY I SISTEMY (2):1-5
MARSHAKOVA IV
Determination of Tendencies n the Development of Science and Technology by the Analysis of Documentary Data

123 1983 NAUCHNO-TEKHNICHESKAYA INFORMATSIYA SERIYA 1-ORGANIZATSIYA I METODIKA INFORMATSIONNOI RABOTY (10):25-27
APOYAN G
Use of Reference Indexes for the Problems of Information- Retrieval and Analysis of Scientific Activity

In slide 8, we see the list of citing papers to node #78, the 1973 paper by Irina Marshakova in 1993.[19]

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SLIDE 9: PAPERS THAT CITE KESSLER 1963 RANKED BY GLOBAL CITATION SCORE

Outer nodes Missing links? Journal list All-Author list

Citations to Kessler's Bibliographic Coupling and papers with BC in title/abstract
Nodes: 223
Sorted by **GCS**.

Cited nodes	Nodes / Authors	GCS	LCS
3	65 1971 MINERVA 9(1):66-100 **ZUCKERMAN H; MERTON RK** *Patterns of Evaluation In Science - Institutionalisation, Structure and Functions of Referee System*	275	2
3	75 1973 JOURNAL OF THE AMERICAN SOCIETY FOR INFORMATION SCIENCE 24(4):265-269 **SMALL HG** *Cocitation in Scientific Literature - New Measure of Relationship Between 2 Documents*	235	82
1	27 1967 AMERICAN SOCIOLOGICAL REVIEW 32(3):377-390 **COLE S; COLE JR** *Scientific Output and Recognition - Study in Operation of Reward System in Science*	233	9
2	88 1974 SCIENCE STUDIES 4(1):17-40 **SMALL HG; GRIFFITH BC** *Structure of Scientific Literatures .1. Identifying and Graphing Specialties*	212	37
0	0 1963 AMERICAN DOCUMENTATION 14(1):10-& **KESSLER MM** *Bibliographic Coupling Between Scientific Papers*	128	134
12	111 1981 LIBRARY TRENDS 30(1):83-106 **SMITH LC** *Citation Analysis*	97	10
1	46 1969 AMERICAN SOCIOLOGICAL REVIEW 34(3):335-352 **CRANE D** *Social Structure in a Group of Scientists - Test of Invisible College Hypothesis*	96	9
1	9 1964 SCIENCE 144(361):649-& **GARFIELD E** *Science Citation Index-New Dimension In Indexing - Unique Approach Underlies Versatile Bibliographic Systems for Communicating and Evaluating Information*	92	19
1	149 1987 JOURNAL OF INFORMATION SCIENCE 13(5):261-276 **KING J** *A Review of Bibliometric and Other Science Indicators and Their Role in Research Evaluation*	65	4

In Slide 9, we see the file ranked by *Global Citation Score*, that is, the total citation frequency for each nodal paper in the *SCI*.

SLIDE 10: SOURCE RECORD FOR ZUCKERMAN AND MERTON NODE #65

65

Author(s)	**ZUCKERMAN H; MERTON RK**
Title	**PATTERNS OF EVALUATION IN SCIENCE - INSTITUTIONALISATION, STRUCTURE AND FUNCTIONS OF REFEREE SYSTEM**
Journal	**MINERVA 9(1):66-100**
Year	**1971**
Type	**Article**
Address	**COLUMBIA UNIV,DEP SOCIOL,NEW YORK,NY COLUMBIA UNIV,PROGRAM SOCIOL SCI, NEW YORK,NY**
Abstract	
WoS CS	**275**
LCS	**2**
cites	**3**
CR[65]	**1969, AM SCHOLAR, V38, P197** **1969, AM SCIENTIST, V57, P1** **CORRESPONDENCE H OLD, V4, P223** **1963, EUROPEAN J SOCIOLOGY, V4, P237** ***INT COUNC SCIENT, 1962, TENTATIVE STUDY PUBL** **BARBER B, 1952, SCIENCE SOCIAL ORDER, PCH4** **BARNES SB, 1936, OSIRIS, V1, P155** **BARNES SB, 1934, SCI MONTHLY, V38, P257** **BERELSON B, 1960, GRADUATE EDUCATION U** **BOYLE, CORRESPONDENCE H OLD, V4, P94** **BOYLE, CORRESPONDENCE H OLD, V3, P145** **BOYLE, CORRESPONDENCE H OLD, V2, P291** **BOYLE, 1772, WORKS HONOURABLE R B, V1** **BROWN H, 1934, SCIENTIFIC ORGANISAT** **CAHNMAN WJ, 1967, AM SOCIOLOGIST, V2, P97** **CHASE JM, 1970, AM SOCIOL, V5, P262** **COLE J, 1969, THESIS COLUMBIA U, PCH6** **COLE S, 1968, AM SOCIOL REV, V33, P397** **COLE S, 1967, AM SOCIOL REV, V32, P377** **COURNARD A, 1970, STUDIUM GENERALE, V23, P941** **CRANE D, 1967, AM SOCIOL, V2, P195** **EISENSTEIN E, 1969, PAST PRESENT, P19** **FRANTZ TT, 1968, PERS GUID J, V47, P384** **GARRISON FH, 1934, B I HIST MED, V2, P285** **GOUDSMIT SA, 1969, PHYS TODAY, V22, P23** **GOUDSMIT SA, 1968, PHYSICAL REV LETT, V21, P1425** **GOUDSMIT SA, 1967, PHYSICS TODAY, V20, P12** **HAGSTROM WO, 1965, SCIENTIFIC COMMUNITY, P18** **HALL AR, 1966, CORRESPONDENCE H OLD, V2, P319** **HUXLEY L, 1900, LIFE LETT TH HUXLEY, V1, P97** **KENISTON H, 1959, GRADUATE STUDY RESEA** **KENNAN S, 1968, J LITERATURE COVERED, P68** **KESSLER MM, 1965, PHYS TODAY, V18, P28** **KESSLER MM, 1957, TECHNICAL INFORMATIO, P247** **KRONICK DA, 1962, HISTORY SCIENTIFIC T** **LIBBEY MA, 1967, ROLE DISTRIBUTION WR, P49**

In Slide 10, we clicked on node #65 by Zuckerman and Merton to show its source record. Note that it is cited only twice in the local network but 275 times in the global file which covers *SCI*, *SSCI*, and *A&HCI*.

SLIDE 11: ALL-AUTHOR LIST

Ranked All-Author list
Total: 217
Sorted by **Pubs**

Name	TGCS	TLCS	Pubs
GARFIELD E	197	26	11
SMALL HG	488	125	10
KESSLER MM	228	239	5
SALTON G	85	15	5
KWOK KL	29	8	4
PAO ML	51	5	4
BICHTELER J	25	16	3
BRAUN T	33	1	3
CAWKELL AE	26	6	3
MARSHAKOVA IV	46	24	3
MIYAMOTO S	27	0	3
SAVOY J	14	6	3
SHARABCHIEV YT	10	1	3
VLACHY J	47	3	3
CLEVELAND DB	15	4	2
COLE JR	288	11	2
COLE S	288	11	2
EATON EA	13	10	2
GATRELL AC	19	3	2
JONES WT	7	2	2
KOCHTANEK TR	9	5	2
LANCASTER FW	11	1	2
LICKLIDER JCR	29	0	2
LOGAN EL	6	2	2
MARTYN J	33	11	2
MCCAIN KW	24	1	2
MERTON RK	280	2	2
MIDORIKAWA N	11	1	2
OCONNOR J	13	4	2
OVERHAGE CF	32	0	2
PERITZ BC	15	2	2

By clicking on the all-author hot link, the most-published authors related to bibliographic coupling are ranked by number of papers in the bibliography. TGCS and TLCS refer to the Total Citation Scores for the papers by that author.

SLIDE 12: MARSHAKOVA – PAPERS PUBLISHED

MARSHAKOVA IV

78 1973 NAUCHNO-TEKHNICHESKAYA INFORMATSIYA SERIYA 2-INFORMATSIONNYE PROTSESSY I SISTEMY 2(6):3-8
MARSHAKOVA IV
System Of Document Connections Based On References

113 1981 SCIENTOMETRICS 3(1):13-25
MARSHAKOVA IV
Citation Networks In Information-Science

118 1982 NAUCHNO-TEKHNICHESKAYA INFORMATSIYA SERIYA 2-INFORMATSIONNYE PROTSESSY I SISTEMY (2):1-5
MARSHAKOVA IV
Determination of Tendencies in the Development of Science and Technology by the Analysis of Documentary Data

Click on I. V. Marshakova's "Pubs" -- you see the three papers she has published including the one mentioned earlier. The titles for these papers only give a hint of their connection to co-citation analysis.

SLIDE 13: JOURNAL LIST RANKED BY PAPERS PUBLISHED

Ranked Journal list
Total: 80

Title	Pubs
JOURNAL OF THE AMERICAN SOCIETY FOR INFORMATION SCIENCE	29
SCIENTOMETRICS	21
INFORMATION PROCESSING & MANAGEMENT	13
INFORMATION STORAGE AND RETRIEVAL	13
PROCEEDINGS OF THE AMERICAN SOCIETY FOR INFORMATION SCIENCE	8
NAUCHNO-TEKHNICHESKAYA INFORMATSIYA SERIYA 2-INFORMATSIONNYE PROTSESSY I SISTEMY	8
JOURNAL OF DOCUMENTATION	7
LIBRI	5
AMERICAN DOCUMENTATION	5
NAUCHNO-TEKHNICHESKAYA INFORMATSIYA SERIYA 1-ORGANIZATSIYA I METODIKA INFORMATSIONNOI RABOTY	4
ASLIB PROCEEDINGS	4
LIBRARY QUARTERLY	4
ANNUAL REVIEW OF INFORMATION SCIENCE AND TECHNOLOGY	4
PHYSICS TODAY	4
SCIENCE	3
CZECHOSLOVAK JOURNAL OF PHYSICS	3
JOURNAL OF CHEMICAL DOCUMENTATION	3
JOURNAL OF INFORMATION SCIENCE	3
AMERICAN SOCIOLOGICAL REVIEW	3
LIBRARY RESOURCES & TECHNICAL SERVICES	3
PROCEEDINGS OF THE ASIS ANNUAL MEETING	3
LIBRARY TRENDS	3
MINERVA	2
MEDICINA CLINICA	2
COMMUNICATIONS OF THE ACM	2
JOURNAL OF LIBRARIANSHIP	2
NACHRICHTEN FUR DOKUMENTATION	2
AMERICAN PSYCHOLOGIST	2
COMPUTER NETWORKS	2
NAUCHNO-TEKHNICHESKAYA INFORMATSIYA	1

By clicking on the “journal list” hot link, we see that *JASIS* and *Scientometrics* have published the most papers on this topic.

SLIDE 14: LIBRARY QUARTERLY PAPERS

LIBRARY QUARTERLY

64 1971 LIBRARY QUARTERLY 41(4):275-&
VIRGO JA
Review Article - Characteristics and Problems

85 1974 LIBRARY QUARTERLY 44(3):189-205
SWANSON DR
Selective Dissemination of Biomedical Information - Series of Studies and a Model System

146 1986 LIBRARY QUARTERLY 56(3):258-271
MCCAIN KW
The Paper Trails of Scholarship - Mapping the Literature of Genetics

189 1994 LIBRARY QUARTERLY 64(2):130-161
SU SF
Dialog with an OPAC - How Visionary Was Swanson in 1964

Click on *Library Quarterly* Pubs to display the four papers from that journal which cite Kessler.

SLIDE 15: OUTER NODES – MOST-CITED WORKS OUTSIDE ORIGINAL BIBLIOGRAPHY

Web of Science location:

Cited references outside of this network

Total: 6314 (top 30 shown).

LCS	Reference
31	PRICE DJD, 1965, SCIENCE, V149, P510 WoS
26	GARFIELD E, 1955, SCIENCE, V122, P108 WoS
17	GARFIELD E, 1964, USE CITATION DATA WR WoS
17	GARFIELD E, 1979, CITATION INDEXING WoS
16	GRIFFITH BC, 1974, SCI STUD, V4, P339 WoS
14	MARGOLIS J, 1967, SCIENCE, V155, P1213 WoS
14	GARFIELD E, 1972, SCIENCE, V178, P471 WoS
14	SALTON G, 1983, INTRO MODERN INFORMA WoS
14	MORAVCSIK MJ, 1975, SOC STUD SCI, V5, P86 WoS
13	SALTON G, 1963, J ACM, V10, P440 WoS
13	CRANE D, 1972, INVISIBLE COLLEGES WoS
12	SMALL HG, 1977, SOC STUD SCI, V7, P139 WoS
11	NARIN F, 1976, EVALUATIVE BIBLIOMET WoS
10	KWOK KL, 1975, INFORMATION PROCESSI, V11, P201 WoS
10	PRITCHARD A, 1969, J DOC, V25, P348 WoS
10	WHITE HD, 1981, J AM SOC INFORM SCI, V32, P163 WoS
10	KAPLAN N, 1965, AM DOC, V16, P179 WoS
10	LOTKA AJ, 1926, J WASHINGTON ACADEMY, V16, P317 WoS
10	CHUBIN DE, 1975, SOC STUD SCI, V5, P423 WoS
10	GARFIELD E, 1979, CITATION INDEXING IT WoS
10	KUHN TS, 1970, STRUCTURE SCI REVOLU WoS
10	WESTBROOK JH, 1960, SCIENCE, V132, P1229 WoS
9	GARFIELD E, 1980, CURRENT CONTENT 0609, P5 WoS
9	SMALL HG, 1978, SOC STUD SCI, V8, P327 WoS
9	VANRIJSBERGEN CJ, 1979, INFORMATION RETRIEVA WoS
9	NARIN F, 1972, J AM SOC INFORM SCI, V23, P323 WoS
9	PRICE DJD, 1966, AM PSYCHOL, V21, P1011 WoS
8	GARFIELD E, 1970, NATURE, V227, P669 WoS
8	GRIFFITH BC, 1972, SCIENCE, V177, P959 WoS

And in this slide we have a list of highly cited works outside the initial nodal bibliography. This will include not only additional source articles indexed in the *SCI* but also cited articles, books, and patents not covered in the *SCI* source indexes. To facilitate looking up outer nodes in the *WoS*, a hot link is provided which takes you to the corresponding cited reference entry in the *WoS*. If the article is hot linked to a full source entry, the user can add it to the original marked list. After deciding which of the outer node items should be added, the program can be run again. Derek Price's classic 1965

paper on "Networks of Scientific Papers"[20] has been cited by 31 papers. It is the most-cited outer node of which only 100 have been listed out of 6,314 references cited in the main file.

SLIDE 16: NODAL PAPERS THAT CITE PRICE 1965 NETWORKS PAPER

PRICE DJD, 1965, SCIENCE, V149, P510
cited by:

17 1966 AMERICAN PSYCHOLOGIST 21(11):1061-&
PARKER EB; PAISLEY WJ
Research for Psychologists At Interface of Scientist and His Information System

30 1967 METHODS OF INFORMATION IN MEDICINE 6(3):136-&
TAGLIACOZZO R
Citations and Citation Indexes - A Review

36 1968 FRONTIERS OF LIBRARIANSHIP-SYRACUSE UNIVERSITY (8):169-&
GARFIELD E
World Brain or Memex - Mechanical and Intellectual Requirements for Universal Bibliographic Control

46 1969 AMERICAN SOCIOLOGICAL REVIEW 34(3):335-352
CRANE D
Social Structure in a Group of Scientists - Test of Invisible College Hypothesis

47 1969 COMMUNICATIONS OF THE ACM 12(2):111-&
SALTON G
Information Science in a PhD Computer Science Program

57 1971 CURRENT CONTENTS/LIFE SCIENCES 14(27):M27-&
WEINSTOCK M
Citation Indexes .3.

59 1971 INFORMATION STORAGE AND RETRIEVAL 7(1):1-&
ZUNDE P
Structural Models of Complex Information Sources

63 1971 JOURNAL OF DOCUMENTATION 27(2):98-&
SALTON G
Automatic Indexing Using Bibliographic Citations

69 1972 JOURNAL OF THE AMERICAN SOCIETY FOR INFORMATION SCIENCE 23(2):100-&
LEHNUS DJ
Who Cited What - Citation Analysis of 4 Basic Cataloging Texts

72 1972 JOURNAL OF THE AMERICAN SOCIETY FOR INFORMATION SCIENCE 23(5):313-&
DONOHUE JC
Bibliometric Analysis of Certain Information Science Literature

By clicking on the LCS hot link, #31, you can see all the nodal papers that have cited Derek Price's classic 1965 paper. Since this paper is important to the history of the topic, its full source record needs to be added to the nodal bibliography. To do this you click on *WoS* which takes you to the *WoS* cited reference entry.

SLIDE 17: CITED REFERENCE SEARCH ON PRICE DJD 1965

ISI Web of SCIENCE® Powered by ISI Web of Knowledge℠

HOME | HELP | DATE & DF LIMITS | GENERAL SEARCH | CITED REF SEARCH | LOG OFF

Cited Reference Search

4 references matched query: Cited Year=1965; Cited Author=Price DJD; Cited Work=Science; Databases=SCI-EXPANDED, SSCI, A&HCI; Timespan=All Years

STEP 2: CITED REFERENCE SELECTION

The table lists all of the cited references that match your search request and the number of times each variation has been cited. Select all desired references (including variants) and then press Search.

Set language and document type limits and sort option.

SELECT PAGE or select specific references from list.

SEARCH to find articles that cite selected references.

References 1 -- 4 [1]

	Hits	Cited Author	Cited Work	Volume	Page	Year
☐	1	PRICE DJD	SCIENCE	169	510	1965
☐	363	PRICE DJD	SCIENCE	149	510	1965
☐	1	PRICE DJD	SCIENCE	49	510	1965
☐	1	PRICE DJD	SCIENCE	30	510	1965

References 1 -- 4 [1]

SELECT PAGE

SEARCH or select specific references from list.

to find articles that cite selected references.

This shows the result of a cited reference search activated by *Histcomp*. It clearly identifies the correct paper by Price cited 342 times. It also shows some of the variants or errors in citations of that paper.

SLIDE 18: TRUNCATED CITED REFERENCE SEARCH ON PRICE D* 1965

ISI Web of SCIENCE® Powered by ISI Web of Knowledge℠

HOME | HELP | DATE & DB LIMITS | GENERAL SEARCH | CITED REF SEARCH | LOG OFF

Cited Reference Search

5 references matched query: Cited Year=1965; Cited Author=Price D*; Cited Work=Science; Databases=SCI-EXPANDED, SSCI, A&HCI; Timespan=All Years

STEP 2: CITED REFERENCE SELECTION

The table lists all of the cited references that match your search request and the number of times each variation has been cited. Select all desired references (including variants) and then press Search.

Set language and document type limits and sort option.

SELECT PAGE or select specific references from list.

SEARCH to find articles that cite selected references.

References 1 -- 5 [1]

Hits	Cited Author	Cited Work	Volume	Page	Year
1	PRICE DJD	SCIENCE	169	510	1965
363	PRICE DJD	SCIENCE	149	510	1965
1	PRICE DJD	SCIENCE	49	510	1965
1	PRICE DJD	SCIENCE	30	510	1965
3	PRICE DK	SCIENCE	148	743	1965

References 1 -- 5 [1]

SELECT PAGE or select specific references from list.

SEARCH to find articles that cite selected references.

It is important to realize that a generic truncated search may bring in additional citing papers which contain additional citation errors or page variants. In a future version of this software, the user can also obtain fuller descriptions of cited books by hot linking to library web sites or even Amazon.com.

SLIDE 19: MISSING LINKS

Potentially missed citations
9 nodes have citations that may potentially refer to other nodes.

12 1965 ASLIB PROCEEDINGS 17(6):184-196
MARTYN J
AN EXAMINATION OF CITATION INDEXES

MARTYN J, 1964, J DOC, V20, P212 may refer to 7 MARTYN-J-1964-V20-P236

42 1968 LIBRARY RESOURCES & TECHNICAL SERVICES 12(4):415-&
HUANG TS
EFFICACY OF CITATION INDEXING IN REFERENCE RETRIEVAL

BROWN SC, 1966, PHYSICS TODAY, V19, P60 may refer to 24 BROWN-SC-1966-V19-P59
BROWN SC, 1966, PHYSICS TODAY, V19, P61 may refer to 24 BROWN-SC-1966-V19-P59
BROWN SC, 1966, PHYSICS TODAY, V19, P64 may refer to 24 BROWN-SC-1966-V19-P59
GARFIELD E, 1963, AM DOC, V14, P290 may refer to 1 GARFIELD-E-1963-V14-P289
GARFIELD E, 1964, SCIENCE, V144, P651 may refer to 9 GARFIELD-E-1964-V144-P649

67 1971 PHYSICS TODAY 24(7):28-&
ZUCKERMAN H; MERTON RK
SOCIOLOGY OF REFEREEING

COLE S, 1968, AM SOCIOLOGICAL REV, V33, P412 may refer to 33 COLE-S-1968-V33-P397

102 1978 SCIENTOMETRICS 1(1):9-34
GILBERT GN
MEASURING THE GROWTH OF SCIENCE - REVIEW OF INDICATORS OF SCIENTIFIC GROWTH

COLE S, 1968, AM SOC REV, V33, P297 may refer to 33 COLE-S-1968-V33-P397
GARFIELD E, 1963, AM DOC, V14, P290 may refer to 1 GARFIELD-E-1963-V14-P289

131 1984 NAUCHNO-TEKHNICHESKAYA INFORMATSIYA SERIYA 1-ORGANIZATSIYA I METODIKA INFORMATSIONNOI RABOTY (12):6-11
SHARABCHIEV YT
APPLICATION OF CLUSTER-ANALYSIS IN SCIENTIFIC INVESTIGATIONS

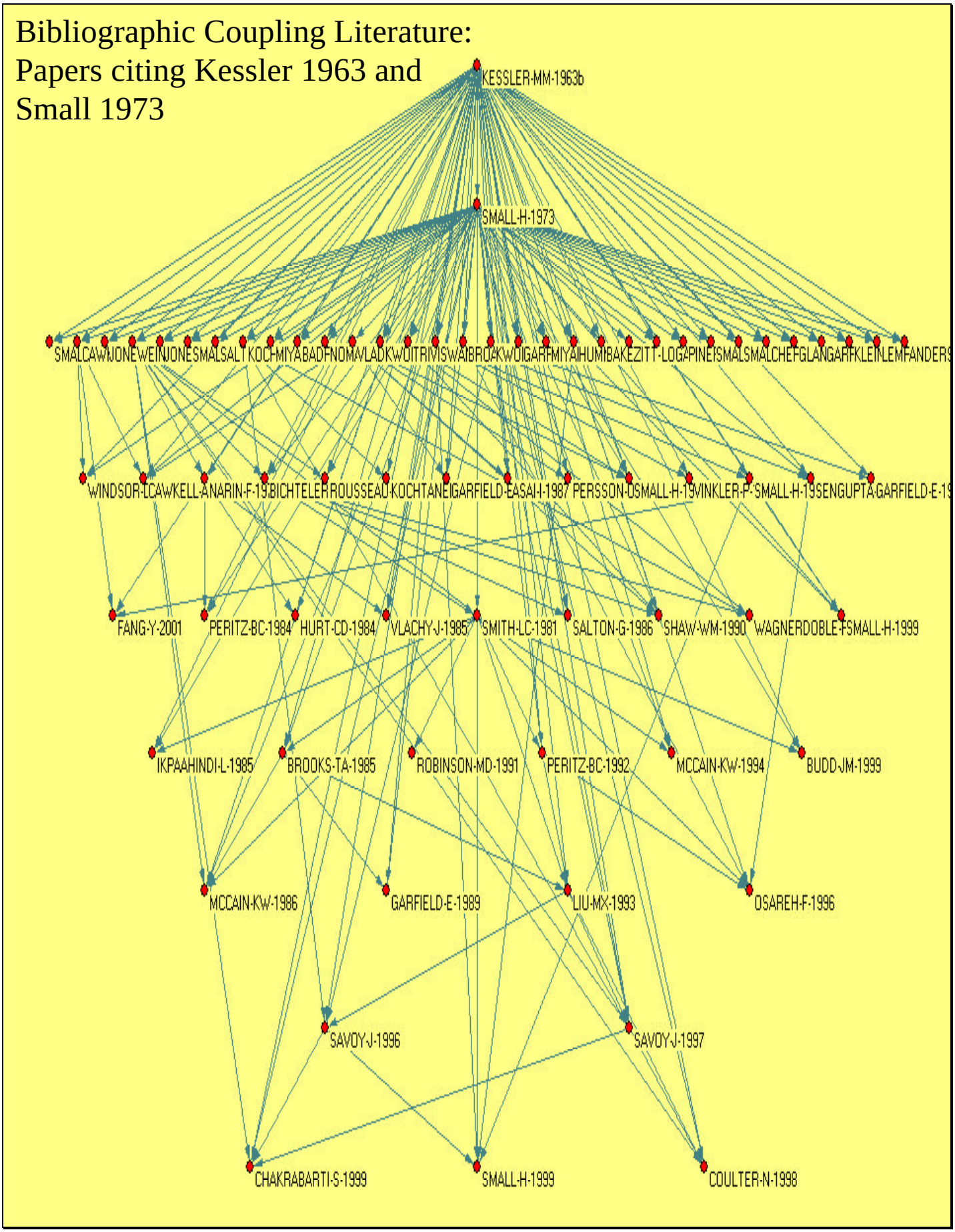
KESSLER MM, 1963, J AM DOC, V14, P99 may refer to 0 KESSLER-MM-1963-V14-P10

138 1985 CZECHOSLOVAK JOURNAL OF PHYSICS 35(12):1389-1436
VLACHY J

An important part of the system involves an error correction routine wherein doubtful cited references are checked against the main file. Errors and variations can be corrected or unified. In the case of the Kessler file we found that citations to Irina Marshakova, the co-discoverer of co-citation clustering, would have been obscured had we not detected the variations in the citations of the Russian journal in which she published. We have already made these corrections. However, we have not yet corrected the variations in T. S. Huang's citations of S.C. Brown. These are not errors but variants involving specific page references. The first page number of the cited article is needed in order to properly unify it for the local citation score.

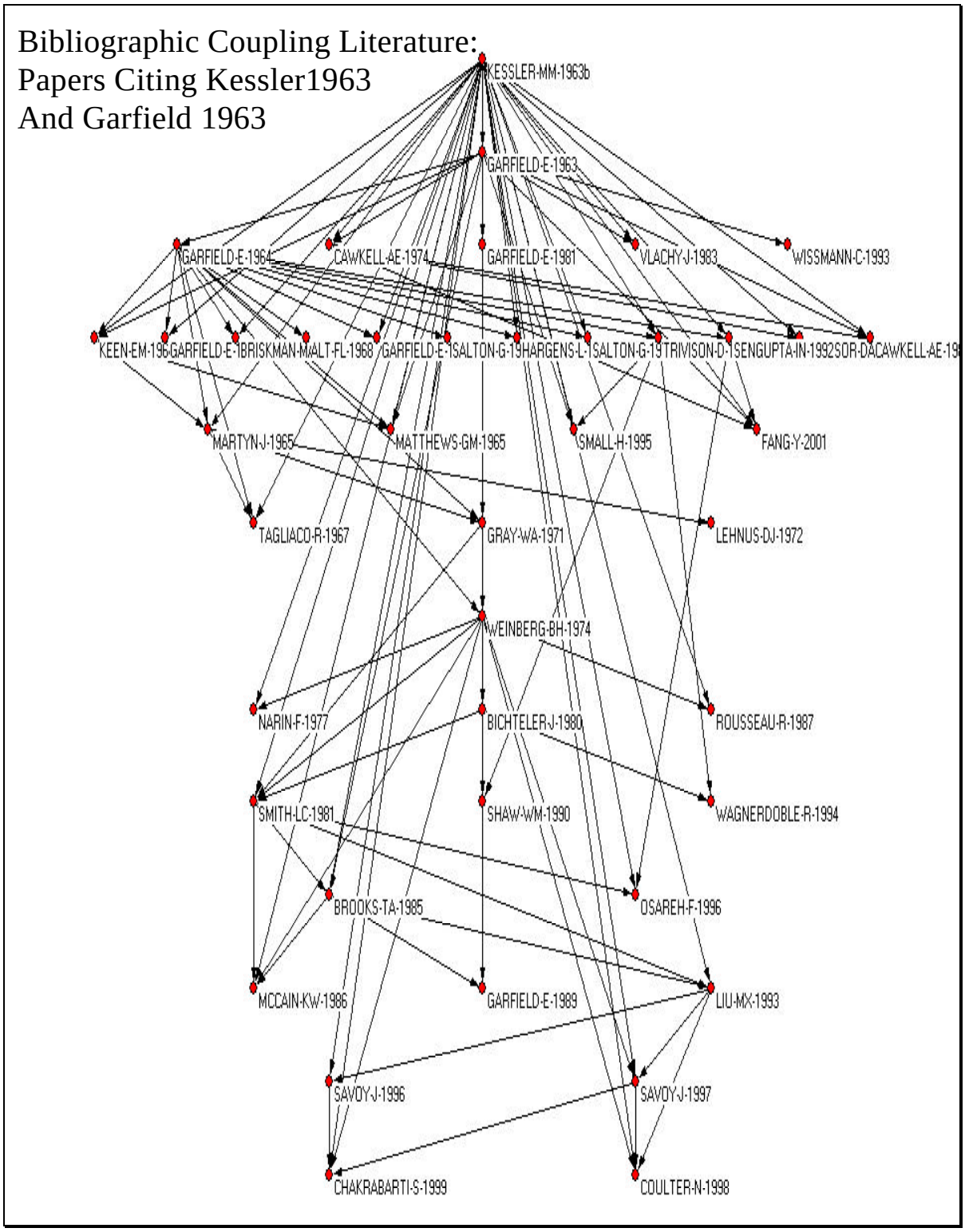
This completes the description of the various features of the *Histcomp* software. However, having shown you how we compiled the output file for the history of bibliographic coupling, there is still the question of visualizing the data.

SLIDE 20: BIBLIOGRAPHIC COUPLING HISTORIOGRAPH BY HOWARD WHITE



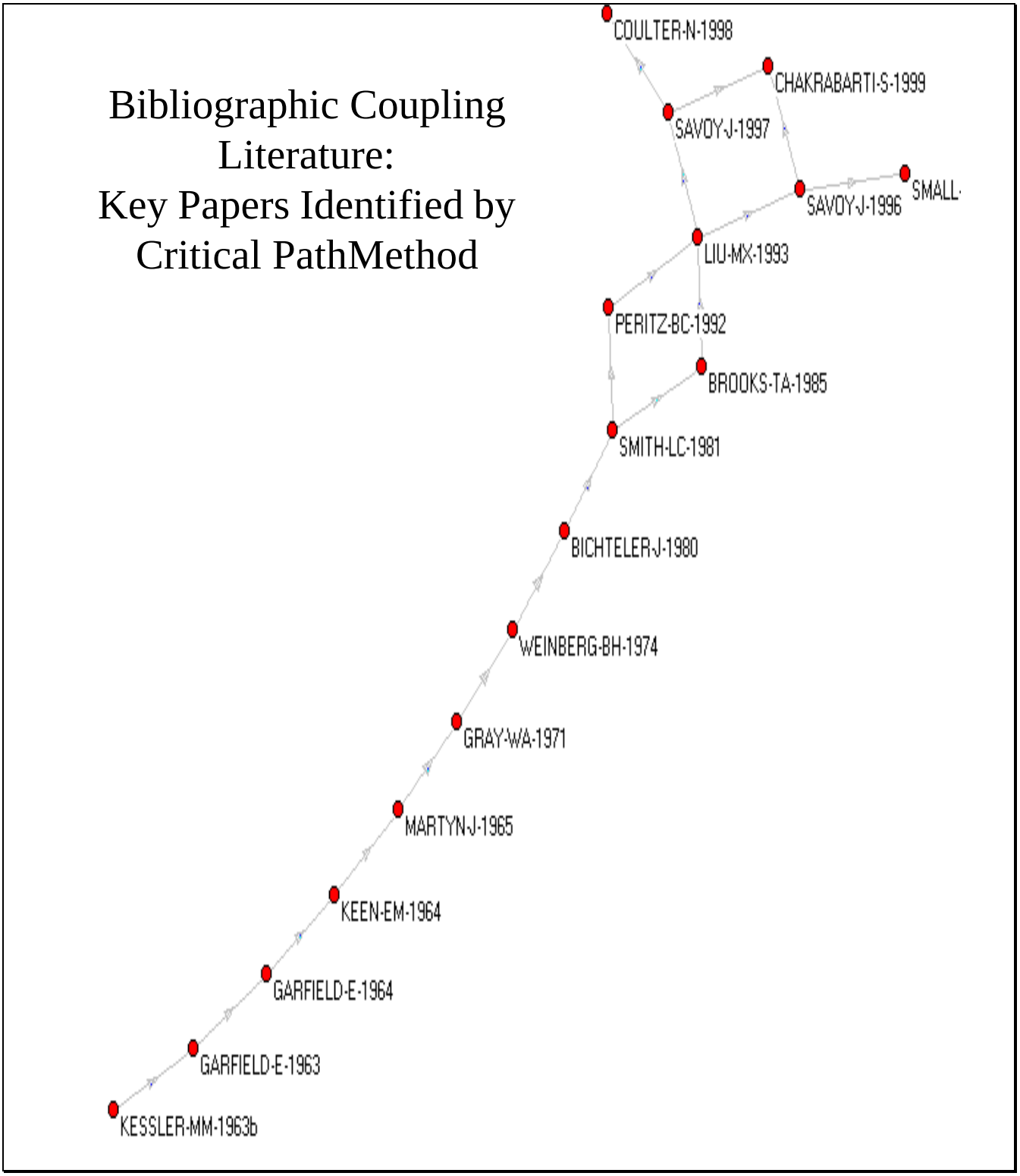
A variety of methods may be used to visualize these outputs. Using the data in our bibliographic coupling file, Howard White was able to create the co-author based map in Slide 20, based on Kessler and Small. However, this does not preserve the precise chronological sequence of events.

SLIDE 21: BIBLIOGRAPHIC COUPLING LITERATURE: PAPERS CITING KESSLER 1963 AND GARFIELD 1963



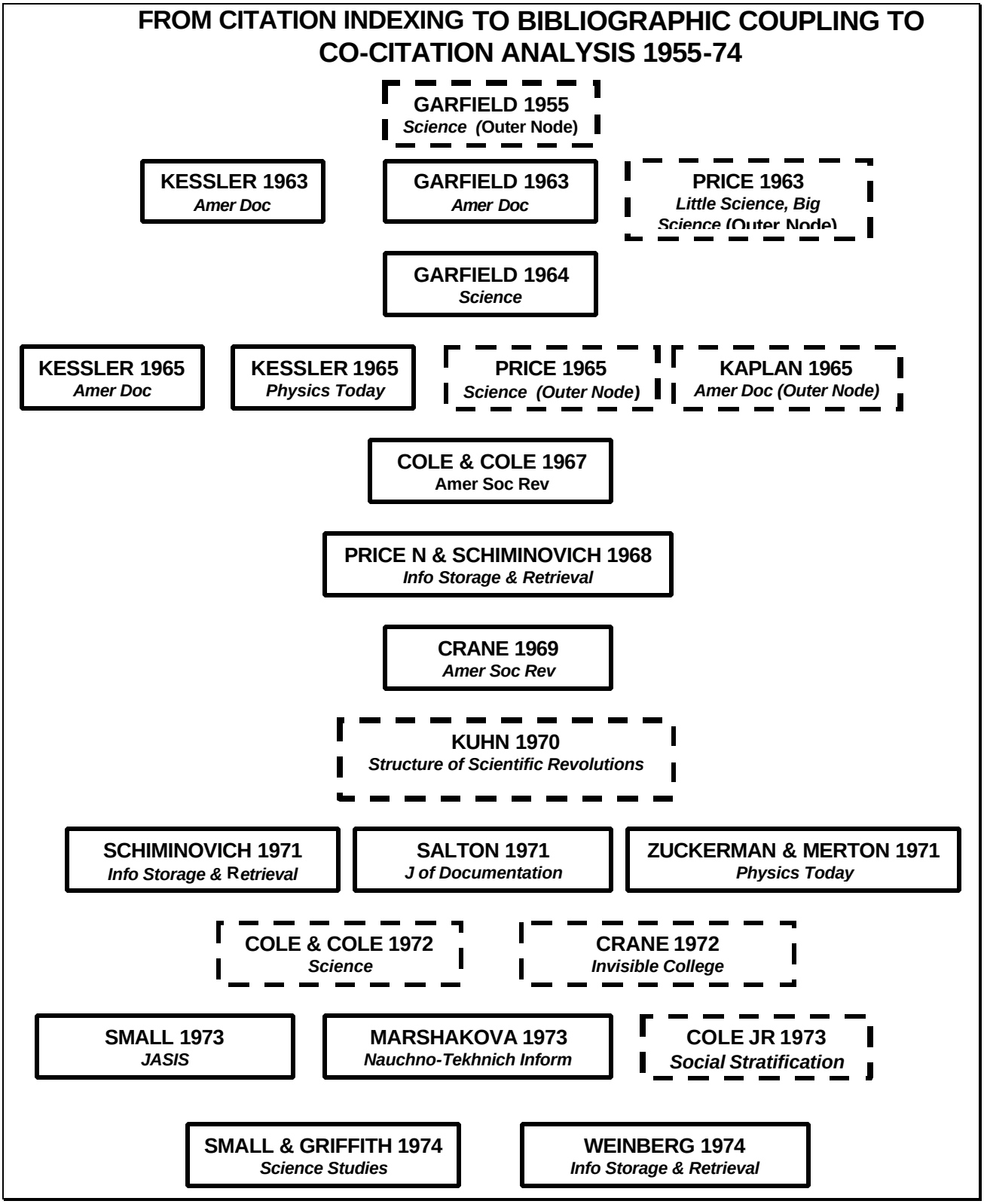
In Slide 21, Howard used Kessler and Garfield to produce yet another co-author based map and gives the impression of a genealogical chart if one follows individual paths.

SLIDE 22: BIBLIOGRAPHIC COUPLING LITERATURE: KEY PAPERS IDENTIFIED BY CRITICAL PATH METHOD



In Slide 22, using the Critical Path Method, he obtained another portrait of the evolution of this field which is completely chronological. However, none of these gives a complete picture of the field which I have highlighted in the next slide.

SLIDE 23: FROM CITATION INDEXING TO BIOBLIOGRAPHIC COUPLING TO CO-CITATION ANALYSIS, 1955-74



In slide 23, I have shown the evolution from citation indexing in 1955 through bibliographic coupling in 1963 through to co-citation in 1973 and onwards. In this map, the doted lines indicate papers that are outer nodes in the earlier slides.

We have often heard of the possible consequences of an author's failure to cite relevant work. For example, eight years after my 1955 primordial paper on citation indexing, Kessler did not think it relevant to cite it in his 1963 paper. Nevertheless, a few months later, in *American Documentation*[21] and again in 1964 in *Science*,[22] I cited him making it difficult for new readers to miss the connection. Subsequent researchers were much more complete in their documentation. I have selected for this "map" the group of papers which I believe were critical or important to the history of this topic. My selections were based mainly on citation frequency.

SLIDE 24: DEREK PRICE FOOTNOTE

the scientist (particularly, I presume, in physics and molecular biology) needs an alerting service that will keep him posted, probably by citation indexing, on the work of his peers and colleagues. (ii) The random scattering of Fig. 6 corresponds to a drawing upon the totality of previous work. In a sense, this is the portion of the network that treats each published item as if it were truly part of the eternal record of human knowledge. In subject fields that have been dominated by this second attitude, the traditional procedure has been to systematize the added knowledge from time to time in book form, topic by topic, or to make use of a system of classification optimistically considered more or less eternal, as in taxonomy and chemistry. If such classification holds over reasonably long periods, one may have an objective means of reducing the world total of knowledge to fairly small parcels in which the items are found to be in one-to-one correspondence with some natural order.

It seems clear that in any classification into research-front subjects and taxonomic subjects there will remain a large body of literature which is not completely the one or the other. The present discussion suggests that most papers, through citations, are knit together rather tightly. The total research front of science has never, however, been a single row of knitting. It is, instead, divided by dropped stitches into quite small segments and strips. From a study of the citations of journals by journals I come to the conclusion that most of these strips correspond to the work of, at most, a few hundred men at any one time. Such strips represent objectively defined subjects whose description may vary materially from year to year but which remain otherwise an intellectual whole. If one would work out the nature of such strips, it might lead to a method for delineating the topography of current scientific literature. With such a topography established, one could perhaps indicate the overlap and relative importance of journals and, indeed, of countries, authors, or individual papers by the place they occupied within the map, and by their degree of strategic centralness within a given strip.

Journal citations provide the most readily available data for a test of such methods. From a preliminary and very rough analysis of these data I am tempted to conclude that a very large fraction of the alleged 35,000 journals now current must be reckoned as merely a distant background noise, and as very far from central or strategic in any of the knitted strips from which the cloth of science is woven.

References and Notes

1. E. Garfield and I. H. Sher, "New factors in the evaluation of scientific literature through citation indexing," *Am. Doc.* **14**, 191 (1963); ———, *Genetics Citation Index* (Institute for Scientific Information, Philadelphia, 1963). For many of the results discussed in this article I have used statistical information drawn from E. Garfield and I. H. Sher, *Science Citation Index* (Institute for Scientific Information, Philadelphia, 1963), pp. ix, xvii-xviii.
2. I wish to thank Dr. Eugene Garfield for making available to me several machine printouts of original data used in the preparation of the 1961 *Index* but not published in their entirety in the preamble to the index.
3. **I am grateful to Dr. M. M. Kessler, Massachusetts Institute of Technology, for data for seven research reports of the following titles and dates: "An Experimental Study of Bibliographic Coupling between Technical Papers" (November 1961); "Bibliographic Coupling Between Scientific Papers" (July 1962); "Analysis of Bibliographic Sources in the *Physical Review* (vol. 77, 1950, to vol. 112, 1958) (July 1962); "Analysis of Bibliographic Sources in a Group of Physics-Related Journals" (August 1962); "Bibliographic Coupling Extended in Time: Ten Case Histories" (August 1962); "Concerning the Probability that a Given Paper will be Cited" (November 1962); "Comparison of the Results of Bibliographic Coupling and Analytic Subject Indexing" (January 1963).**
4. J. W. Tukey, "Keeping research in contact with the literature: Citation indices and beyond," *J. Chem. Doc.* **2**, 34 (1962).
5. C. E. Osgood and I. V. Xhignesse, *Characteristics of Bibliographical Coverage in Psychological Journals Published in 1950 and 1960* (Institute of Communications Research, Univ. of Illinois, Urbana, 1963).
6. D. J. de Solla Price, *Little Science, Big Science* (Columbia Univ. Press, New York, 1963).
7. R. E. Burton and R. W. Kebler, "The 'half-life' of some scientific and technical literatures," *Am. Doc.* **11**, 18 (1960).

One may wonder why Price's 1965 paper was an outer node since he was quite aware of Kessler's work. A footnote appeared in Derek's *Science* paper titled "Networks of Scientific Papers" in 1965,[15] mentioned earlier. It escaped the initial search for papers that cited Kessler 1963. This may have been due to the timing of Derek's original manuscript. But the example emphasizes the need to take into account the outer-nodes. Derek cited several technical reports by Kessler on bibliographic coupling which had preceded the formal 1963 paper. But even those citations were missed by the ISI indexer since they were buried in the footnote.

Having completed the analysis of bibliographic coupling, my next step was to trace the history of co-citation by performing the same type of Histcomp analysis on the primordial papers for that subject.

In the next slide is shown the first page of the output file for the topic of "co-citation analysis." The bibliography here is based upon retrieving papers which cite the key papers by Henry Small and Belver Griffith as well as papers that use the term co-citation in their titles.

Whereas the Kessler bibliography involved 220 papers, the initial co-citation file based on Small and Griffith is twice as large. Clearly, co-citation has had a much greater impact on information research.

SLIDE 25: CHRONOLOGICAL DISPLAY OF PAPERS THAT CITE SMALL (1973) AND/OR SMALL/GRIFFITH (1974) OR USE CO-CITATION IN TITLE

Outer nodes Missing links? Journal list All-Author list

H Small, B Griffith Source and Papers That Cite Them/ Co-Citation Title Sources
Nodes: 414
Sorted by **year, journal, volume, page**.

Cited nodes	Nodes / Authors	GCS	LCS
0	0 1973 JOURNAL OF THE AMERICAN SOCIETY FOR INFORMATION SCIENCE 24(4):265-269 **SMALL HG** *Cocitation in Scientific Literature - New Measure of Relationship between 2 Documents*	239	232
1	1 1974 ANNUAL REVIEW OF INFORMATION SCIENCE AND TECHNOLOGY 9():221-284 **WILLIAMS ME** *Use of Machine-Readable Data Bases*	16	0
1	2 1974 CURRENT CONTENTS (21):5-7 **GARFIELD E** *Routes To Immortality*		0
0	3 1974 CURRENT CONTENTS (7):7-10 **SMALL HG** *Co-Citation in Scientific Literature - New Measure of Relationship between 2 Documents*	3	0
1	4 1974 INFORMATION STORAGE AND RETRIEVAL 10(5-6):189-196 **WEINBERG BH** *Bibliographic Coupling - Review*	14	11
3	5 1974 INFORMATION STORAGE AND RETRIEVAL 10(11-1):393-402 **SMALL HG** *Multiple Citation Patterns in Scientific Literature - Circle and Hill Models*	16	13
1	6 1974 JOURNAL OF DOCUMENTATION 30(1):105-106 **CAWKELL AE** *Manual and Automatic Construction of Citation Networks*		0
1	7 1974 JOURNAL OF THE AMERICAN SOCIETY FOR INFORMATION SCIENCE 25(2):123-130 **CAWKELL AE** *Search Strategy, Construction and Use of Citation Networks, With a Socioscientific Example - Amorphous-Semiconductors and Ovshinsky,SR*	16	9
1	8 1974 PROCEEDINGS OF THE AMERICAN SOCIETY FOR INFORMATION SCIENCE 11():160-162 **JONES WT** *ADAPTIVE SYSTEMS-APPROACH TO LITERATURE ANALYSIS*		1
1	9 1974 SCIENCE STUDIES 4(1):17-40 SMALL HG; GRIFFITH BC *Structure of Scientific Literatures .1. Identifying and Graphing Specialties*	214	207

This slide shows the first page of a search based on retrieving 414 papers that cite Small, 1973, and/or Small/Griffith, 1974. We also include papers that use the term co-citation in the titles. This is in chronological order.

SLIDE 26: OUTER NODES FOR SMALL/GRIFFITH BIBLIOGRAPHY

1973-2001

Web of Science location:
Cited references outside of this network.
Total: 10450 (top 100 shown).

LCS	Reference
79	KESSLER MM, 1963, AM DOC, V14, P10 WoS
65	PRICE DJD, 1965, SCIENCE, V149, P510 WoS
38	GARFIELD E, 1979, CITATION INDEXING WoS
36	CRANE D, 1972, INVISIBLE COLLEGES WoS
30	NARIN F, 1976, EVALUATIVE BIBLIOMET WoS
30	KUHN TS, 1970, STRUCTURE SCI REVOLU WoS
29	GARFIELD E, 1972, SCIENCE, V178, P471 WoS
28	CHUBIN DE, 1975, SOC STUD SCI, V5, P423 WoS
28	GARFIELD E, 1955, SCIENCE, V122, P108 WoS
27	GRIFFITH BC, 1972, SCIENCE, V177, P959 WoS
26	GARFIELD E, 1964, USE CITATION DATA WR WoS
25	PRICE DJD, 1963, LITTLE SCI BIG SCI WoS
23	CALLON M, 1986, MAPPING DYNAMICS SCI WoS
23	SALTON G, 1983, INTRO MODERN INFORMA WoS
21	EDGE D, 1979, HIST SCI, V17, P102 WoS
20	KESSLER MM, 1965, AM DOC, V16, P223 WoS
20	MARSHAKOVA IV, 1973, NTI 2, P3 WoS
20	GARFIELD E, 1978, METRIC SCI ADVENT SC, P179 WoS
18	CRANE D, 1972, INVISIBLE COLLEGES D WoS
18	MULLINS NC, 1973, THEORIES THEORY GROU WoS
18	PRITCHARD A, 1969, J DOC, V25, P348 WoS
18	KRUSKAL JB, 1964, PSYCHOMETRIKA, V29, P1 WoS
17	GARFIELD E, 1980, CURRENT CONTENT 0609, P5 WoS
17	GARFIELD E, 1979, CITATION INDEXING IT WoS
17	KAPLAN N, 1965, AM DOC, V16, P179 WoS
16	KUHN TS, 1962, STRUCTURE SCI REVOLU WoS
16	COLE S, 1967, AM SOCIOL REV, V32, P377 WoS
16	NARIN F, 1972, J AM SOC INFORM SCI, V23, P323 WoS
16	COLE S, 1978, METRIC SCI, P209 WoS
16	PRICE DJD, 1970, COMMUNICATION SCI EN, P3 WoS
16	COLE JR, 1973, SOCIAL STRATIFICATIO WoS
15	CHUBIN D, 1976, SOCIOLOGICAL Q, V17, P448 WoS

Where one chooses to begin an historical account can be somewhat arbitrary. But this shows how the key works are identified, even though our search is based on papers published 10 years later. The outer nodes now include Kessler 1963, Derek Price 1965, but also Diana Crane's 1972 book *Invisible Colleges* and Narin's 1976 *Evaluative Bibliometrics*. Ultimately, I believe both searches should be combined since the topics are inextricably connected.

SLIDE 27: EXPANDED HISTORIOGRAPH. 1973-2001 CITATIONS TO SMALL AND GRIFFITH AND DESCENDENTS

Outer nodes Missing links? Journal list All-Author list

Citations to Small & Griffith and Descendants, 1973-2001

Nodes: 1059

Sorted by **year, journal, volume, page**.

Cited nodes	Nodes / Authors	GCS	LCS
0	0 1973 JOURNAL OF THE AMERICAN SOCIETY FOR INFORMATION SCIENCE 24(4):265-269 **SMALL H** *Cocitation in Scientific Literature - New Measure of Relationship between 2 Documents*	239	232
1	1 1974 ANNUAL REVIEW OF INFORMATION SCIENCE AND TECHNOLOGY 9():221-284 **WILLIAMS ME** *Use of Machine-Readable Data Bases*	16	1
1	2 1974 CURRENT CONTENTS (7):5-6 **GARFIELD E** *ISI is Studying Structure of Science Through Co-Citation Analysis*		0
0	3 1974 CURRENT CONTENTS (7):7-10 **SMALL H** *Co-Citation in Scientific Literature - New Measure of Relationship between 2 Documents*	3	0
1	4 1974 INFORMATION STORAGE AND RETRIEVAL 10(5-6):189-196 **WEINBERG BH** *Bibliographic Coupling - Review*	14	12
3	5 1974 INFORMATION STORAGE AND RETRIEVAL 10(11-1):393-402 **SMALL H** *Multiple Citation Patterns in Scientific Literature - Circle and Hill Models*	16	15
1	6 1974 JOURNAL OF DOCUMENTATION 30(1):105-106 **CAWKELL AE** *Manual and Automatic Construction of Citation Networks*		0
1	7 1974 JOURNAL OF THE AMERICAN SOCIETY FOR INFORMATION SCIENCE 25(2):123-130 **CAWKELL AE** *Search Strategy, Construction And Use Of Citation Networks, With A Socioscientific Example - Amorphous-Semiconductors And Ovshinsky,Sr*	16	11
1	8 1974 PROCEEDINGS OF THE AMERICAN SOCIETY FOR INFORMATION SCIENCE 11():160-162 **JONES WT** *Adaptive Systems-Approach To Literature Analysis*		1
1	9 1974 SCIENCE STUDIES 4(1):17-40 **SMALL H; GRIFFITH BC** *Structure of Scientific Literatures .1. Identifying and Graphing Specialties*	214	206

The initial search on Small and Griffith 1973-4 demonstrates the early growth of the field of co-citation but when we incorporate later descendents of their work, the number of papers retrieved goes from 414 to 1059. Slide 27 includes citations to the later generation of co-citation researchers, especially White and McCain. This file is in chronological order.

SLIDE 28: BICHTELER AND EATON, NODE #144

144

Author(s)	**BICHTELER J; EATON EA**
Title	**THE COMBINED USE OF BIBLIOGRAPHIC COUPLING AND COCITATION FOR DOCUMENT-RETRIEVAL**
Journal	**JOURNAL OF THE AMERICAN SOCIETY FOR INFORMATION SCIENCE 31(4):278-282**
Year	**1980**
Type	**Article**
Address	**UNIV TEXAS,GRAD SCH LIB SCI,AUSTIN,TX 78712 EMORY UNIV,DIV LIBRARIANSHIP,ATLANTA,GA 30322**
Abstract	
WoS CS	**10**
LCS	**10**
cites	**4**
CR[14]	**AMSLER R, 1972, 7212 U TEX AUST LING** **BICHTELER J, 1974, INFORMATION STORAGE, V10, P267** **BICHTELER J, 1977, J AM SOC INFORM SCI, V28, P192** **CAWKELL AE, 1976, INFORMATION SCI, V10, P3** **CLEVERDON C, 1966, FACTORS DETERMINING** **HUANG TS, 1968, LIBRARY RESOURCES TE, V12, P415** **KESSLER MM, 1963, AM DOC, V14, P10** **MARSHAKOVA IV, 1973, NAUCHNO TEKNICHESK 2, P2** **SALTON G, 1971, J DOC, V27, P98** **SCHIMINOVICH S, 1971, INFORMATION STORAGE, V6, P417** **SMALL H, 1973, J AM SOC INFORM SCI, V24, P265** **SMALL H, 1977, SOC STUD SCI, V7, P139** **WEINBERG BH, 1974, INFORMATION STORAGE, V10, P189** **WEINSTOCK M, 1971, ENCY LIBRARY INFORMA, V5, P16**

In this slide, I've called out Node #144, the 1980 paper by Bichteler and Eaton at the University of Texas.[23] It combined both techniques of bibliographic coupling and co-citation and symbolizes a midpoint in the evolution of this field.

SLIDE 29: CALLON AND CO-WORD ANALYSIS, NODE #262

262

Author(s)	**CALLON M; COURTIAL JP; TURNER WA; BAUIN S**
Title	**FROM TRANSLATIONS TO PROBLEMATIC NETWORKS - AN INTRODUCTION TO CO-WORD ANALYSIS**
Journal	**SOCIAL SCIENCE INFORMATION SUR LES SCIENCES SOCIALES 22(2):191-235**
Year	**1983**
Type	**Article**
Address	**ECOLE NATL SUPER MINES,CTR SOCIOL INNOVAT,62 BD ST MICHEL,F- 75006 PARIS,FRANCE CNRS,CTR DOCUMENTAT SCI & TECH,F-75270 PARIS 06,FRANCE**
Abstract	
WoS CS	**54**
LCS	**55**
cites	**13**
CR[70]	**1978, J PLANT FOODS, V3 BARNES B, 1979, NATURAL ORDER HIST S BARNES B, 1982, TS KUHN SOCIAL SCI BARNES B, 1981, WHY IS CASSOWARY BIR BOURDIEU P, 1975, SOC SCI INFORM, V14, P19 CALLON M, 1982, ACTEURS RESEAUX PROD CALLON M, 1979, ACTION CONCERTEE CHI CALLON M, 1981, ADV SOCIAL THEORY ME, P277 CALLON M, 1981, EC HUMANISME NOV, P53 CALLON M, 1981, FUNDAMENTA SCI, V2, P381 CALLON M, 1975, INCIDENCE RAPPORTS S, P105 CALLON M, 1980, RES POLICY, V9, P358 CALLON M, 1982, SOC STUD SCI, V12, P615 CALLON M, 1980, SOCIAL PROCESS SCI I, V4, P197 COLE S, 1978, METRIC SCI, P209 COLE S, 1981, SCIENCE, V214, P881 COURTIAL JP, 1978, COMMUNATION LANGAGES, V39, P19 CRANE D, 1972, INVISIBLE COLLEGES D CRANE D, 1980, SOC STUD SCI, V10, P23 DERRIDA J, 1977, GRAMMATOLOGY EDGE D, 1979, HIST SCI, V17, P102 GARFIELD E, 1978, METRIC SCI ADVENT SC, P179 GILBERT GN, 1977, SOC STUD SCI, V7, P113 GILBERT S, 1974, SCI STUDIES, V4, P279 GRIFFITH RC, 1974, SCI STUDIES, V4, P339 HEATON KW, 1978, J PLANT FOODS, V3 HESSE M, 1974, STRUCTURE SCI INFERE KNORR KD, 1980, SOCIOLOGY SCI YB, V4 KNORRCETINA K, 1982, SOC STUD SCI, V12, P101 KNORRCETINA KD, 1981, MANUFACTURE KNOWLEDG KUHN TS, 1970, STRUCTURE SCI REVOLU LATOUR B, 1976, 1ST SOC SOC STUD SCI**

In 1983, the impact of co-word analysis by Callon[24] in France (node 262) gives added impetus to the field.

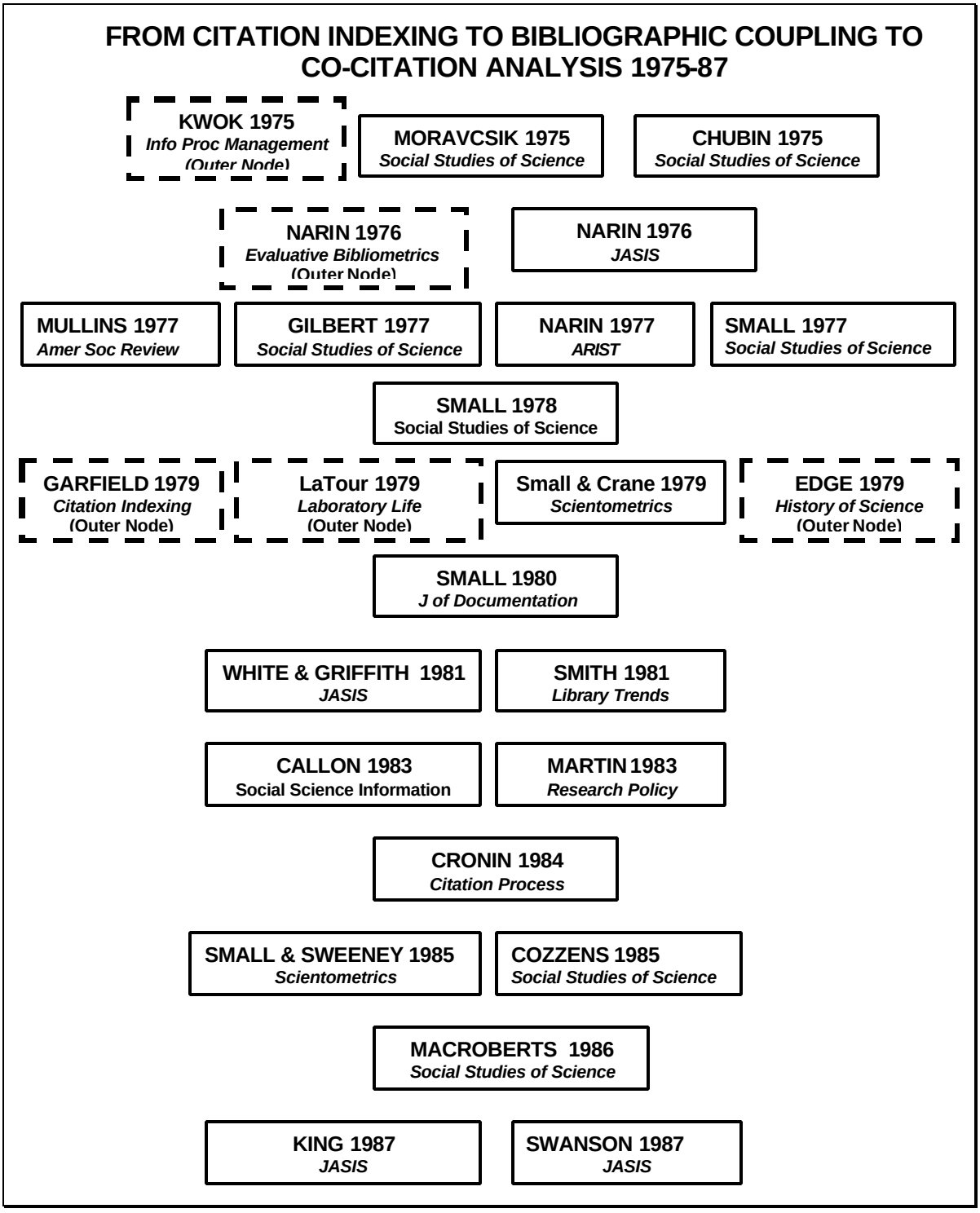
SLIDE 30: BRAAM, MOED, VANRAAN – NODE #597 – COMBINED CO-WORD AND CO-CITATION ANALYSIS

597

Author(s)	BRAAM RR; MOED HF; VANRAAN AFJ
Title	MAPPING OF SCIENCE BY COMBINED COCITATION AND WORD ANALYSIS .1. STRUCTURAL ASPECTS
Journal	JOURNAL OF THE AMERICAN SOCIETY FOR INFORMATION SCIENCE 42(4):233-251
Year	1991
Type	Article
Address	UNIV LEIDEN,CTR SCI & TECHNOL STUDIES,WASSENAARSEWEG 52,POB 9555,2300 RB LEIDEN,NETHERLANDS
Abstract	The claim that co-citation analysis is a useful tool to map subject-matter specialties of scientific research in a given period, is examined. A method has been developed using quantitative analysis of content-words related to publications in order to: (1) study coherence of research topics within sets of publications citing clusters, i.e., (part of) the "current work" of a specialty; (2) to study differences in research topics between sets of publications citing different clusters; and (3) to evaluate recall of "current work" publications concerning the specialties identified by co- citation analysis. Empirical support is found for the claim that co-citation analysis identifies indeed subject-matter specialties. However, different clusters may identify the same specialty, and results are far from complete concerning the identified "current work." These results are in accordance with the opinion of some experts in the fields. Low recall of co-citation analysis concerning the "current work" of specialties is shown to be related to the way in which researchers build their work on earlier publications: the "missed" publications equally build on very recent earlier work, but are less "consensual" and/or less "attentive" in their referencing practice. Evaluation of national research performance using co-citation analysis appears to be biased by this "incompleteness."
WoS CS	30
LCS	31
cites	17
CR[39]	*ADV BOARD RES COU, 1986, SCI POL STUD, P137 *ISI DEUTSCH I MED, 1987, SCISEARCH US MAN ENG, P8 BRAAM RR, 1988, INFORMETRICS 87 88, P15 BRAAM RR, 1990, MAPPING SCI COMBINED, V2 BRAAM RR, 1987, MAPPING SCI CRITICAL BRAAM RR, 1988, NEWS LETTER EUROPEAN, V38, P360 BRAAM RR, 1989, SCI TECHNOLOGY INDIC, P307 CALLON M, 1983, SOC SCI INFORM, V22, P191 COZZENS SE, 1985, SCIENTOMETRICS, V7, P431 FRANKLIN JJ, 1988, SOC STUD SCI, V18, P365 GARFIELD E, 1978, METRIC SCI ADVENT SC, P179 GRIFFITH BC, 1974, SCI STUD, V4, P339 HEALEY P, 1986, RES POLICY, V15, P233 HICKS D, 1988, SOC STUD SCI, V18, P375 HICKS D, 1987, SOC STUD SCI, V17, P295 JONES WP, 1987, J AM SOC INFORM SCI, V38, P420 KING J, 1987, J INFORM SCI, V13, P261 KUHN TS, 1970, STRUCTURE SCI REVOLU LAUDAN L, 1977, PROGR ITS PROBLEMS MOED HF, 1988, INFORMETRICS 87 88, P133 MOMBERS C, 1985, SCIENTOMETRICS, V7, P341 MULLINS N, 1988, HDB QUANTITATIVE STU, P85 OBERSKI JEJ, 1988, HDB QUANTITATIVE STU, P431 PRICE DJ, 1970, COMMUNICATION SCI EN, P1 PRICE DJD, 1965, SCIENCE, V149, P510 RIP A, 1988, HDB QUANTITATIVE STU, P253 RIP A, 1984, SCIENTOMETRICS, V6, P381

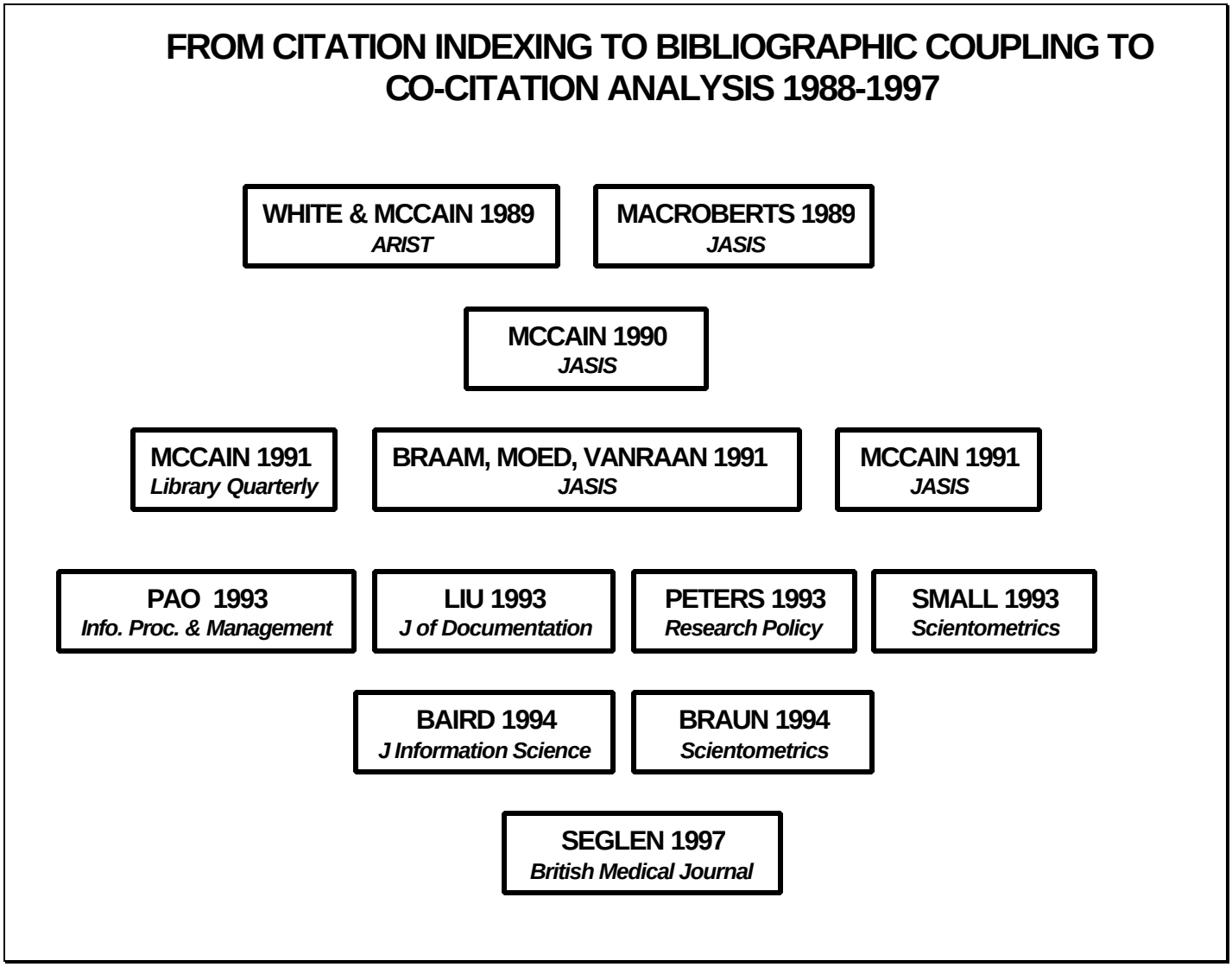
Later this leads to the work of Van Raan[25] (node 597) in which co-word analysis is combined with co-citation analysis.

SLIDE 31: CITATION INDEXING TO BIBLIOGRAPHIC COUPLING TO CO-CITATION 1975-87



To extend my earlier map (Slide 23) of the 1960-80's period, we now have to extend the map into the 1980-90 decade. Beginning with 1975, the map has been expanded to include papers by Moravcsik[26] and Chubin,[27] then Narin 1976[28] and 1977,[29] along with Mullins,[30] Gilbert,[31] and Small,[32] also in 1977, and then Small in 1978.[33] The dotted lines are outer nodes.

SLIDE 32: CITATION INDEXING TO BIBLIOGRAPHIC COUPLING TO CO-CITATION 1988-97



In this further extension of the historiograph, the work of Kate McCain is quite prominent. The work of MacRoberts is included not because it is directly relevant to co-citation analysis, but because it has been such a highly cited negational paper in the overall field.

The methodology I have demonstrated today is a far cry from the manual methods that were used by my IR students at Penn when I taught there in order to teach them the meaning of citation networks. Nevertheless, we can see that historiographs probably can never be completely automatic for reasons that are related to citation dynamics. It is possible we can devise means for overcoming the non-trivial problem of dealing with super-cited papers just as we have to deal with them in conducting literature searches using cited authors. Variable citation thresholds can be used to weed out low impact papers during the iterative process, but we must always be alert to key work that for one reason or another is not picked up by these methods and ask why that work has such little impact.

This presentation has been a tribute to the work of Belver Griffith with an emphasis on his collaboration with Henry Small, Howard White, and Kate McCain. I have not had the time to discuss the impact of his earlier research in the field of psychoacoustics. Indeed, his most-cited paper "The Discrimination of Speech Sounds Within and Across Phoneme Boundaries."[34] was published in 1957 Nor have I discussed his classic work with Bill Garvey in 1971 on "Scientific Communication – Its Role in Conduct of Research and Creation of Knowledge."[35]

SLIDE 33: *HISTCOMP* DISPLAY OF PAPERS THAT CITE ALL OF B.C. GRIFFITH'S WORK

Outer nodes Missing links? Journal list All-Author list

BC Griffith Hist

Nodes: 1154
Sorted by **LCS**.

Cited nodes	Nodes / Authors	GCS	LCS
0	1 1957 JOURNAL OF EXPERIMENTAL PSYCHOLOGY 54(5):358-368 **LIBERMAN AM; HARRIS KS; HOFFMAN HS; GRIFFITH BC** *The Discrimination of Speech Sounds Within and Across Phoneme Boundaries*	289	246
1	189 1974 SCIENCE STUDIES 4(1):17-40 **SMALL H; GRIFFITH BC** *Structure of Scientific Literatures .1. Identifying and Graphing Specialties*	215	208
1	138 1972 SCIENCE 177(4053):959-& **GRIFFITH BC; MULLINS NC** *Coherent Social Groups in Scientific Change*	104	103
1	191 1974 SCIENCE STUDIES 4(4):339-365 **GRIFFITH BC; SMALL HG; STONEHIL.JA; DEY S** *Structure of Scientific Literatures .2. Toward a Macrostructure and Microstructure for Science*	100	96
2	103 1971 AMERICAN PSYCHOLOGIST 26(4):349-& **GARVEY WD; GRIFFITH BC** *Scientific Communication - Its Role in Conduct of Research and Creation of Knowledge*	84	83
3	456 1981 JOURNAL OF THE AMERICAN SOCIETY FOR INFORMATION SCIENCE 32(3):163-171 **WHITE HD; GRIFFITH BC** *Author Cocitation - A Literature Measure of Intellectual Structure*	85	83
1	157 1973 PERCEPTION & PSYCHOPHYSICS 13(2):253-260 **PISONI DB** *Auditory and Phonetic Memory Codes in Discrimination of Consonants and Vowels*	197	64
0	366 1979 JOURNAL OF DOCUMENTATION 35(3):179-196 **GRIFFITH BC; SERVI PN; ANKER AL; DROTT MC** *Aging of Scientific Literature - Citation Analysis*	56	56
1	20 1961 JOURNAL OF EXPERIMENTAL PSYCHOLOGY 61(5):379-& **LIBERMAN AM; LANE H; HARRIS KS; KINNEY JA** *Discrimination of Relative Onset-Time of Components of Certain Speech and Nonspeech Patterns*	127	52
3	236 1975 SOCIAL STUDIES OF SCIENCE 5(1):86-92 **MORAVCSIK MJ; MURUGESAN P** *Some Results on Function and Quality of Citations*	161	52
6	270 1976 JOURNAL OF THE ACOUSTICAL SOCIETY OF AMERICA 60(2):410-417 **MILLER JD; WIER CC; PASTORE RE; KELLY WJ; DOOLING RJ** *Discrimination and Labeling of Noise-Buzz Sequences with Varying Noise-Lead Times - Example of Categorical Perception*	123	44

In a search for papers that have cited anything that Belver published, we come up with 1,154 papers. In slide 32, using the LCS link we see his most-cited works. It is significant that the main areas in which he worked are indeed captured in the top part of this list, including psychoacoustics, co-citation mapping, coherent social groups, and scientific communication, all involving a different set of collaborators, from Liberman to Garvey to Small and then Carl Drott, Howard White, and Kate McCain.

APPENDIX:

SLIDE 34: OLD FORMAT OF CHRONOLOGICAL FORMAT

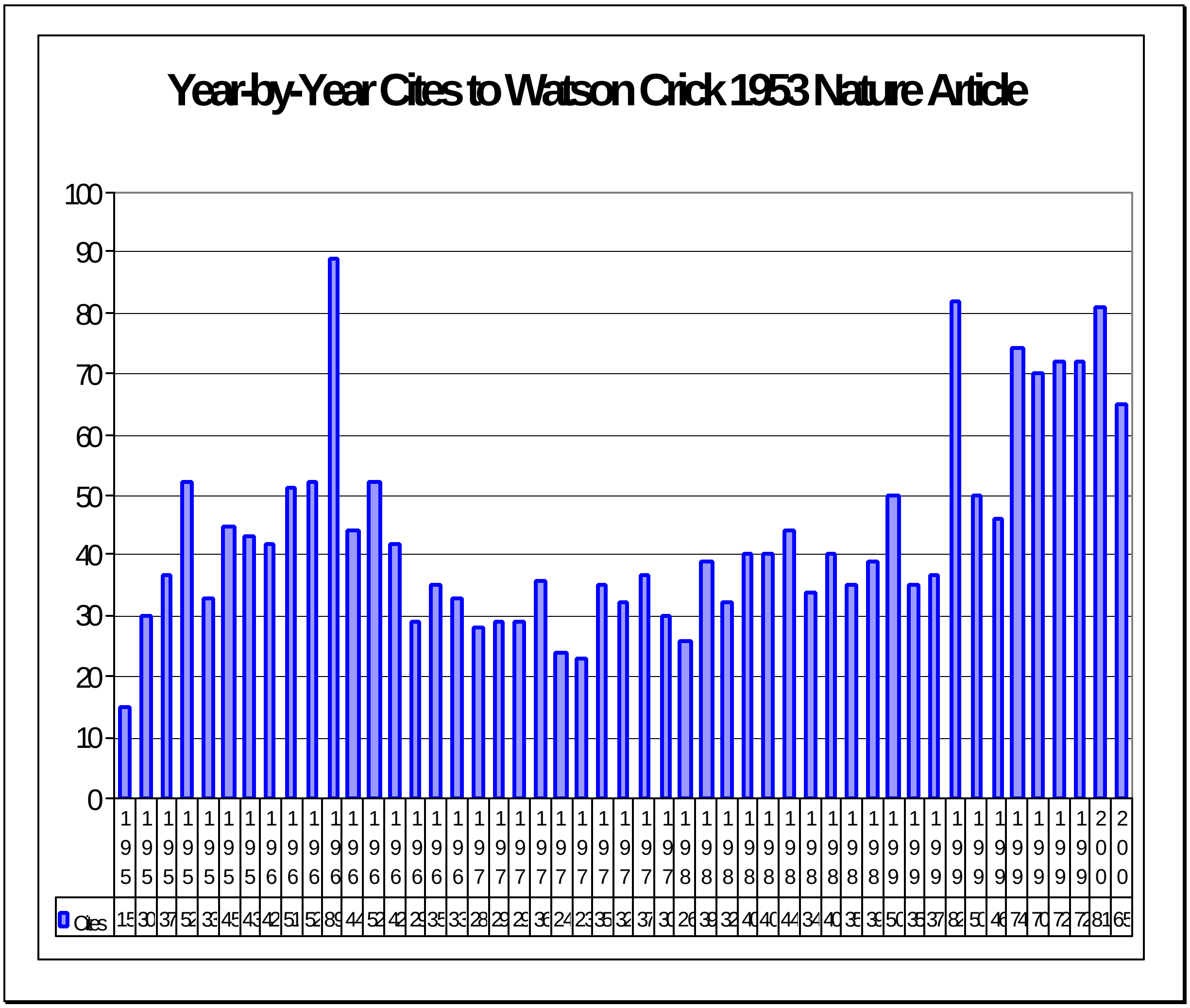
Outer nodes? Missing links? Journal list Author list

cites	nodes	cited
()	0 KESSLER-MM-1963-V14-P10	(1 2 5 7 8 9 10 11 13 14 15 18 19 28 34 38 41 42 45 57 59 64 68 71 72 73 77 78 80 81 83 84 85 87 90 91 93 95 96 97 100 101 105 106 108 109 110 111 112 114 116 117 118 120 121 122 124 126 127 128 130 132 134 138 139 140 141 142 143 144 145 146 148 149 150 151 152 153 154 155 156 157 158 160 162 163 165 166 167 168 170 171 174 175 176 177 178 179 180 181 182 183 184 185 186 188 190 191 192 193 197 198 199 200 201 202 203 204 206 207 208 209 210 211 212 213 215 216 217 218 219 220 221 222) [134]
(0) [1]	1 KESSLER-MM-1963-V1-P169	(6 10 15 25 34 50 54 56 57 61 70 81 121 144 196) [15]
(0) [1]	2 GARFIELD-E-1963-V14-P289	(111 121 143 160 193 222) [6]
()	3 KESSLER-MM-1963-V9-P49	(10 47 74 81 112 125 129 144 153) [9]
()	4 MARTYN-J-1964-V20-P236	(28 81 112 142 143 186 203) [7]
(9 0) [2]	5 KEEN-EM-1964-V16-P246	(13 14) [2]
(1) [1]	6 MODEL-F-1964-V15-P122	()
(0) [1]	7 [ANON]-1964-V16-P48	()
(0) [1]	8 LANCASTER-FW-1964-V16-P132	()
(0) [1]	9 GARFIELD-E-1964-V144-P649	(5 13 14 18 28 36 38 41 50 59 63 81 100 104 105 119 149 175 206) [19]
(0 3 1) [3]	10 KESSLER-MM-1965-V16-P223	(25 27 28 49 52 55 56 57 58 61 65 66 76 79 81 92 99 102 103 104 105 115 119 128 131 133 135 136 142 144 146 147 149 159 164 168 169 187 189 194 195 205 214) [43]
(0) [1]	11 DOYLE-LB-1965-V8-P238	()
(15) [1]	12 [ANON] -1965-V16-P258	()
(9 5 0) [3]	13 MATTHEWS-GM-1965-V9-P478	()
(9 5 0) [3]	14 MARTYN-J-1965-V17-P184	(28 59 63 70) [4]
(0 1) [2]	15 KESSLER-MM-1965-V18-P28	(12 16 19 20 21 22 23 24 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 43 44 51 57 59 62 63 64 67 75 81 82 88 94 98 144) [39]
(15) [1]	16 OVERHAGE-CF-1966-V152-P1032	()
()	17 LINDGREN-N-1966-V3-P62	()
(9 0) [2]	18 GARFIELD-E-1966-V6-P63	(63) [1]

It may make it easier for you to visualize the content of the *Histcomp* matrix by referring to this slide showing an alternative format of similar data.

In this slide, I have shown you the identical information in an alternative format wherein each citing node is indicated by its serial number.

SLIDE 35: YEAR-BY-YEAR COUNTS ON WATSON CRICK NATURE PAPER



I created this chart to show that even the most influential paper of the twentieth century, on a year-by-year basis, does not provide an insurmountable barrier to these analyses. However, without modulation by the user, the citation mapping can go out of control.

[1] McCain KW. Guest Editor, "Belver C. Griffith Memorial Issue," *Scientometrics* 51(3):465-645 (July-August 2001).
[2] Chu H. "Intellectual Activities and Influences of Belver C. Griffith: A Citation Perspective," *Scientometrics* 51(3):481-488 (July-August 2001)
[3] Kreuzman H. "A Co-Citation Analysis of Representative Authors in Philosophy: Examing the relationship between Epistemologists and Philosophers of Science," *Scientometrics* 51(3):525-539 (July-August 2001)
[4] Old LJ. "Utilizing Spatial Information Systems for Non-Spatial-Data Analysis," *Scientometrics* 51(3):563-571 (July-August 2001)
[5] Sandstrom PE. "Scholarly Communication as a Sociological System," 51(3):573-605 (July-August 2001)
[6] Small H. "Belver and Henry," *Scientometrics* 51(3):489-497 (July-August 2001)
[7] White HD. "Author-Centered Bibliometrics Through CAMEOs: Characterizations Automatically Made and Edited Online," *Scientometrics* 51(3):607-637 (July-August 2001)
[8] Small H. "Co-citation In Scientific Literature - New Measure Of Relationship Between 2 Documents," Journal Of The American Society For Information Science, Volume 24, Issue 4, pages 265-269 (1973)
[9] Small H. "Cogitations on Co-Citations," *Current Contents/Social and Behavioral Sciences,* No. 10, page 10 (March 9, 1992).
[10] Garfield E. "From Computational Linguistics to Algorithmic Historiography," paper presented at the Symposium in Honor of Casimir Borkowski at the University of Pittsburgh School of Information Sciences, September 19, 2001.
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Report of research for Air Force Office of Scientific Research under contract F49(638)-1256.
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[17] Garfield E. "Citation Indexes in Sociological and Historical Research." *American Documentation*, 14(4):289-91 (1963). Reprinted in *Current Contents* No. 9 (August 26, 1969). Reprinted in *Essays of an Information Scientist*, Volume 1, pages 42-46. Philadelphia: ISI Press (1977)
http://www.garfield.library.upenn.edu/essays/V1p043y1962-73.pdf
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http://www.garfield.library.upenn.edu/essays/v6p492y1983.pdf
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http://www.garfield.library.upenn.edu/essays/v7p525y1984.pdf
[23] Bichteler J, Eaton EA. "The Combined Use Of Bibliographic Coupling And Cocitation For Document-Retrieval," Journal of the American Society for Information Science 31 (4):278-282 (1980)
[24] Callon M, Courtial JP, Turner WA, Bauin S. "From Translation to Problematic Networks – An Introduction to Co-Word Analysis," *Social Science Information Sur les Sciences Sociales*, 22(2):191-235 (1983).
[25] Braam RR; Moed HF; Vanraan AFJ. "Mapping of Science by Combined Cocitation and Word Analysis . 1. Structural Aspects," *Journal Of The American Society For Information Science 42*(4):233-251 (1991)
[26] Moravcsik MJ and Murugesan P. "Some Results on Function and Quality of Citation," *Social Studies of Science* 5(1):86-92 (1975).
[27] Chubin DE and Moitra SD. "Content-Analysis of References – Adjunct or Alternative to Citation Counting," *Social Studies of Science* 5(4):423-441 (1975)

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[35] Garvey WD, Griffith BC. "Scientific Communication – Its Role in Conduct of Research and Creation of Knowledge," *American Psychologist,* 26(4):349+ (1971).

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