

Historiographic Mapping of Knowledge Domains Literature

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Keynote Address

Arthur M. Sackler Colloquium on

"Mapping Knowledge Domains"

Beckman Center of the National Academy of Sciences,

Irvine, CA

May 9-11, 2003.

Abstract:

To better understand the topic of this colloquium, we have created a series of databases related to knowledge domains [dynamic systems (small world/Milgram), information visualization (Tufte), co-citation (Small), bibliographic coupling (Kessler), and scientometrics (*Scientometrics*)]. I have used a software package called *HistCite*[™] which generates chronological maps of subject (topical) collections resulting from searches of the *ISI Web of Science*[®] or ISI citation indexes (*SCI*, *SSCI*, and/or *AHCI*) on CD-ROM. When a marked list is created on *WoS*, an export file is created which contains all cited references for each source document captured. These bibliographic collections, saved as ASCII files, are processed by *HistCite* in order to generate chronological and other tables as well as historiographs which highlight the most-cited works in and outside the collection.

HistCite also includes a module for detecting and editing errors or variations in cited references as well as a vocabulary analyzer which generates both ranked word lists and word pairs used in the collection. Ideally the system will be used to help the searcher quickly identify the most significant work on a topic and trace its year-by-year historical development.

In addition to the collections mentioned above, historiographs based on collections of papers that cite the Watson-Crick 1953 classic paper identifying the helical structure of DNA were created. Both year-by-year as well as month-by-month displays of papers from 1953 to 1958 were necessary to highlight the publication activity of those years..

I was reluctant to accept Katy Borner's invitation to give this keynote talk since I had never heard the term "Knowledge Domains" before. Furthermore, I am not an expert on the subject of visualization. Her misperception on that point was probably due to a paper I recently published in the special issue of the *Journal of the American Society for Information Science and Technology* on visualization.¹ The issue editor Chaomei Chen of Drexel University had roped me into that contribution since he had heard about my interest in mapping from colleagues Howard White and Kate McCain at Drexel.²

Over a several month period, my staff worked with Katy to identify various literature sub-sets she perceived as being relevant to the knowledge domain literature. To facilitate that process, we used a software package still in development called *HistCite*. This system has evolved over the past several years and traces its roots to a project in 1964 conducted by me and Irving Sher³, who died several years ago and sponsored by Harold Wooster of the U.S. Air Force. "The Uses of Citation Data in Writing the History of Science," is available at my web page at www.eugenegarfield.org. We interested Wooster in the idea when we completed our NIH-sponsored work on the *Genetics Citation Index* project. The *GCI* eventually led to publication of the 1961 volumes of the *Science Citation Index* in 1964. Sher and I had speculated on the possibility that the cited references in scholarly papers could be used to create topological maps of science. To test this theory, we used Isaac Asimov's book *The Genetic Code*⁴ as a model. Asimov, a professor of biochemistry, better known as the prolific science fiction writer, identified the 40 key scientific events in the development of DNA science from the time of Gregor Mendel until the 1961 Nobel work of Marshall Nirenberg at NIH. We used about 60 published papers mentioned by Asimov to create a mini citation index from the 1,000 odd references they cited.

From these data we were able to draw the first citation-based historiograph shown in Figure 1 (<http://garfield.library.upenn.edu/papers/finaloverlay.pdf>). Our interest in the graph theoretical aspects of citation networks was further reflected in a thesis by Ralph Garner at Drexel University in 1967 (<http://www.garfield.library.upenn.edu/rgarner.pdf>),⁵ an ISI employee at that time.

Each box in this historiograph is a key event. The colored connecting lines indicate various levels or strengths of citation linkage. Two decades later, the DNA project data were used as a model in a paper by two social networks researchers at the University of Pittsburgh, Norman P. Hummon and Patrick Doreian.⁶ Except for their work, the original idea was basically ignored until a few years ago when my long-time colleague, geneticist Alexander I. Pudovkin and I discussed the possibility of reviving the original idea of writing a program that would create historiographs algorithmically. This led to the *HistCite*TM software described below. The process was first publicly discussed at a University of Pittsburgh conference⁷ and then at the ASIST Annual Meeting in November 2002.⁸ The ASIS&T paper includes, among others, a *HistCite* analysis for "gene flow," an area in population genetics of interest to Pudovkin. From those initial trials, the software has evolved to its present form.

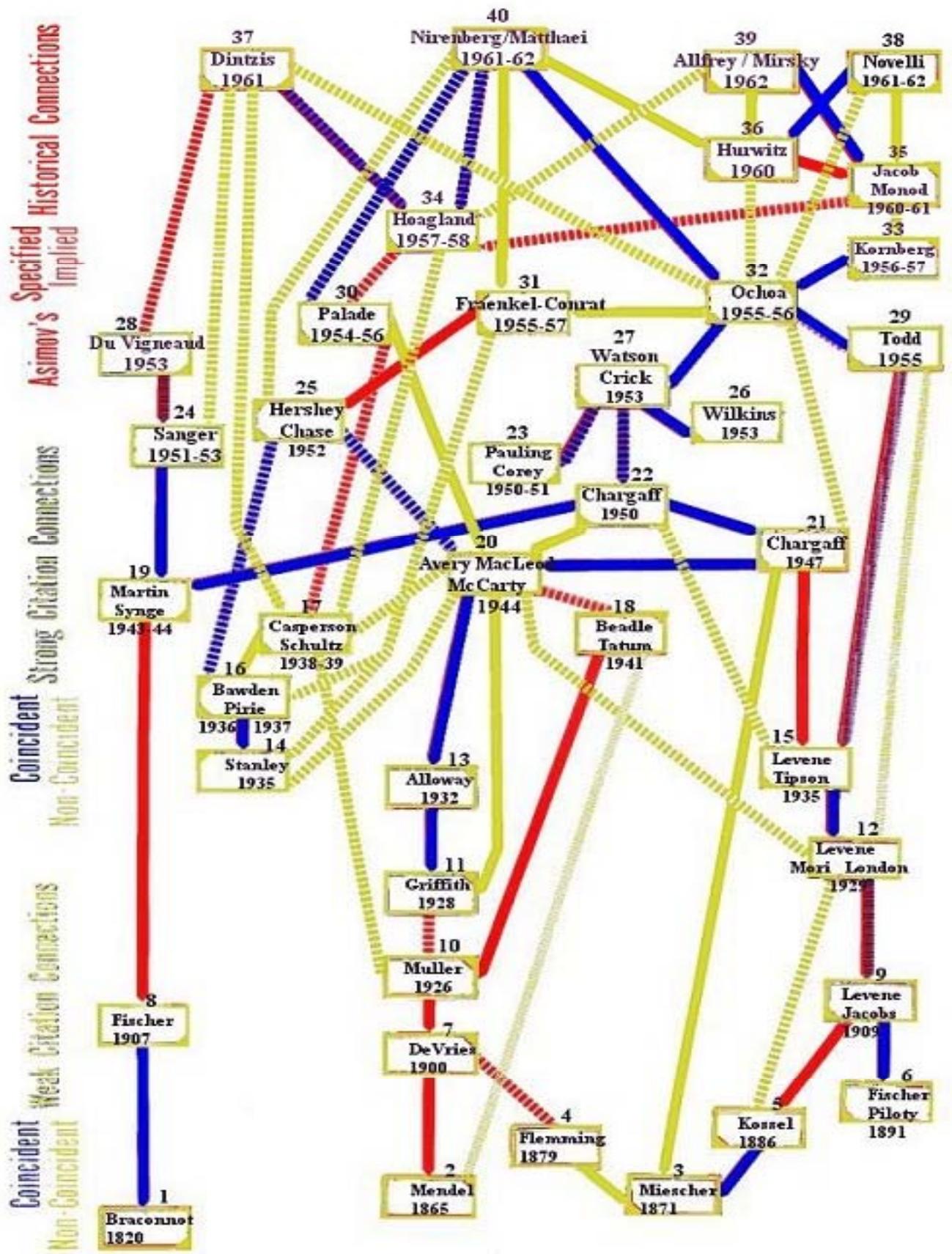


Figure 1: Historiograph: From Mendel to Nirenberg

To create a topical *HistCite* collection, one must first conduct a search of the *ISI Web of Science*[®] or similar database. In the following example a search was conducted in the *WoS* for literature on the “Small World” problem, by using a combination of cited reference search, that is, papers which cite Stanley Milgram’s 1967 paper in *Psychology Today*, and a general title word search on “Small World.” This led to the creation of a marked list. (See Figure 2) The arrows indicate several of the variants we included to retrieve about 160 citing papers.



Cited Reference Search

11 references matched query:
 Cited Author=milgram s AND Cited Year=1967
 Database(s)=SCI-EXPANDED, SSCI, A&HCI; Timespan=1945-2003

STEP 2: CITED REFERENCE SELECTION

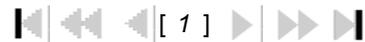
The table lists all of the cited references that match your search request and the number of times each variation has been cited. Select all desired references (including variants) by clicking the checkboxes or SELECT PAGE. Then press SEARCH. The search is added to the [Search History](#).

[Set language and document type limits.](#)

or select specific references from list.

to find articles that cite selected references.

References 1 -- 11



Hits	Cited Author	Cited Work	Volume	Page	Year
<input type="checkbox"/>	1 MILGRAM S	MEGAMOT	15	31	1967
<input type="checkbox"/>	9 MILGRAM S	PATTERNS PREJUDICE	1	3	1967
<input type="checkbox"/>	1 MILGRAM S	PATTERNS PREJUDICE	1	5	1967
<input type="checkbox"/>	3 MILGRAM S	POLITISCHE GESELLSCH		170	1967
<input type="checkbox"/>	1 MILGRAM S	PSYCHOL TODAY			1967
<input type="checkbox"/>	16 MILGRAM S	PSYCHOL TODAY	2	60	1967
<input type="checkbox"/>	<u>148 MILGRAM S</u>	<u>PSYCHOL TODAY</u>	<u>1</u>	<u>61</u>	<u>1967</u>
<input type="checkbox"/>	2 MILGRAM S	PSYCHOL TODAY	1	62	1967
<input type="checkbox"/>	6 MILGRAM S	PSYCHOL TODAY MAY		61	1967
<input type="checkbox"/>	1 MILGRAM S	PSYCHOLOGY TODAY MAY			1967
<input type="checkbox"/>	1 MILGRAM S	READINGS SOCIAL PSYC			1967

Note: Hits are for all references -- not just for the current database and year selections.

References 1 -- 11

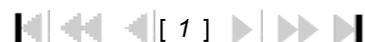


Figure 2: Cited Reference Search On Milgram’s 1967 *Psychology Today* Article.

Figure 3 shows one of the retrieved tagged records in the ISI Export Format – a paper by Egghe and Rousseau recently published in *JASIST* which cited the Milgram 1967 paper. Once a marked list is created from *WoS*, it can be exported as a text file in the ISI Export Format. The address for the saved file is used by the software to retrieve the relevant text file. Within a few moments the system opens up a chronological table.

```
PT Journal
AU Egghe, L
   Rousseau, R
TI A measure for the cohesion of weighted networks
SO JOURNAL OF THE AMERICAN SOCIETY FOR INFORMATION SCIENCE AND
   TECHNOLOGY
NR 34
CR BARABASI AL, 1999, SCIENCE, V286, P509
   BJORNEBORN L, 2001, P 12 ACM C HYP HYP, P133
   BOTAFOGO RA, 1992, ACM T INFORM SYST, V10, P142
   BRIN S, 1998, P 7 INT WORLD WID WE, P107
   CHAKRABARTI S, 1999, SCI AM, V280, P54
   DEBRA P, 2000, SCIENTOMETRICS, V47, P227
   DEVOCHT J, 1994, THESIS EINDHOVEN U T
   EGGHE L, 2002, IN PRESS MATH COMPUT
   FANG Y, 2001, SCIENTOMETRICS, V50, P273
   GARNER R, 1967, COMPUTER ORIENTED GR
   GIBBONS A, 1985, ALGORITHMIC GRAPH TH
   HARARY F, 1969, GRAPH THEORY
   HENZIGNER MR, 2001, IEEE INTERNET COMPUT, V5, P45
   JOHNSON S, 1995, COMMUN ACM, V38, P87
   KHAN KS, 1998, J AM SOC INFORM SCI, V49, P176
   KLEINBERG JM, 1999, J ACM, V46, P604
   KOCHEN M, 1989, SMALL WORLD
   LEAZER GH, 1999, P 62 ANN M AM SOC IN, P345
   MENDES E, 1998, J UNIVERSAL COMPUTER, V4, P4
   MILGRAM S, 1967, PSYCHOL TODAY, V1, P61
   NEWMAN MEJ, 2000, J STAT PHYS, V101, P819
   NEWMAN MEJ, 1999, PHYS REV E B, V60, P7332
   NG AY, 2001, P 17 INT JOINT C ART, P903
   PINSKI G, 1976, INFORMATION PROCESSI, V12, P297
   PRICE DJD, 1965, SCIENCE, V149, P510
   PRITCHARD A, 1984, THESIS POLYTECHNIC N
   RANDIC M, 1975, J AM CHEM SOC, V97, P6609
   RIVLIN E, 1994, COMMUN ACM, V37, P87
   ROUSSEAU R, 1987, SCIENTOMETRICS, V11, P217
   SMALL H, 1973, J AM SOC INFORM SCI, V24, P265
   TRINAJSTIC N, 1992, CHEM GRAPH THEORY
   WATTS DJ, SMALL WORLDS
   WIENER H, 1947, J AM CHEM SOC, V69, P17
   WILSON RJ, 1972, INTRO GRAPH THEORY
TC 0
BP 193
EP 202
PG 10
JI J. Am. Soc. Inf. Sci. Technol.
PY 2003
PD FEB 1
VL 54
IS 3
GA 642YJ
J9 J AM SOC INF SCI TECHNOL
UT ISI:000180834700001
ER
```

Figure 3: .txt Export Record from Small World Collection

The initial *HistCite* display is chronological and alphabetical by journal (See Figure 4). The 1967 Milgram paper is the fourth one listed. On the right, the *Local Citation Score* of 167 indicates how often it is cited in the collection. The *Global Citation Score* of 148 is the count reported in *WoS* for the first variant as shown in Figure 2. By adding the other variants in the text file and rerunning the program, the LCS score becomes 167.

[Outer References](#) [Missing Links?](#) [Journal list](#) [All-Author list](#) [Citation Matrix](#) [Graphs](#)

[HistCite Guide](#)

Papers citing "Small World Problem" by Milgram S., 1967, *Psychology Today*, V1, P61 and papers with "Small World" in the title from 1967 to present

Nodes: 424

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

Page 1: 1

#	Cited nodes	Nodes / Authors	GCS	LCS
1	0	1 1967 AMERICAN JOURNAL OF SOCIOLOGY 72(4):422-423 VARMA BN <i>Small World of Khanh-Hau - Hendry,JB</i>	2	1
2	1	2 1967 AMERICAN JOURNAL OF SOCIOLOGY 73(1):115-115 EVERS HD <i>Small World of Khanh-Hau - Comment</i>	0	0
3	0	3 1967 JOURNAL OF DEVELOPING AREAS 1(4):547-549 AUCHTER EL <i>Small World of Khanh Hau - Hendry,JB</i>	0	0
4	0	4 1967 PSYCHOLOGY TODAY 1(1):61-67 MILGRAM S <i>Small World Problem</i>	148	167
5	0	5 1969 FORTUNE 80(4):121-& ZALAZNICK S <i>Small World Of Big Washington Lawyers</i>	0	0
6	1	6 1969 SOCIOMETRY 32(4):425-443 TRAVERS J; MILGRAM S <i>Experimental Study Of Small World Problem</i>	64	43
7	1	7 1970 BRITISH JOURNAL OF SOCIAL PSYCHIATRY 4(2):83-87 HART JW <i>Sociometry of Poverty</i>	0	0
8	0	8 1970 ENGLISH JOURNAL 59(3):416-420 SOFFER RS <i>Its A Small World</i>	1	0
9	2	9 1970 JOURNAL OF PERSONALITY AND SOCIAL PSYCHOLOGY 15(2):101-& KORTE C; MILGRAM S <i>Acquaintance Networks between Racial Groups - Application of Small World Method</i>	38	31
10	2	10 1970 SOCIAL FORCES 49(2):259-+ WHITE HC <i>Search Parameters for Small World Problem</i>	22	14

Figure 4: Chronological *Histcite* File of "Small World" Collection

Using the mouse, one can then proceed to view a series of tables sorted by local or global citation score, by journal, author, or outer references.

The journal display in Figure 5 shows how this topic is dominated by physics. This was not the case when Stanley Milgram first published. A current examination of the entries from 1967 to the 1990's shows this topic was primarily of interest to psychologists and social scientists. Then from about 1997, most of the literature is dominated by physicists.

Small World Ranked Journal List for Local Collection

Ranked Journal list.

Total: 253

Sorted by **pubs**

#	Title	Pubs
1	PHYSICAL REVIEW E	45
2	SOCIAL NETWORKS	13
3	PHYSICAL REVIEW LETTERS	10
4	AMERICAN JOURNAL OF SOCIOLOGY	9
5	NATURE	9
6	PHYSICA A	8
7	EUROPEAN PHYSICAL JOURNAL B	7
8	PNAS	7
9	EUROPHYSICS LETTERS	6
10	SOCIAL FORCES	6
11	NEW YORK TIMES BOOK REVIEW	5
12	SCIENCE	4
13	FORBES	4
14	AMERICAN SOCIOLOGICAL REVIEW	3
15	NATION	3
16	PHYSICAL REVIEW B	3
17	JOURNAL OF CHEMICAL PHYSICS	3
18	FORTUNE	3
19	INTERNATIONAL JOURNAL OF BIFURCATION AND CHAOS	3
20	TLS-THE TIMES LITERARY SUPPLEMENT	3
21	PHYSICS LETTERS A	3
22	NEW REPUBLIC	3
23	ENVIRONMENT AND PLANNING A	3
24	PMLA-PUBS OF MODERN LANGUAGE ASSOC OF AMERICA	2
25	AAA-ARBEITEN AUS ANGLISTIK UND AMERIKANISTIK	2
26	CONTEMPORARY SOCIOLOGY-A JOURNAL OF REVIEWS	2
27	LIBRARY TRENDS	2
28	NEW YORK REVIEW OF BOOKS	2
29	HISTOIRE	2
30	LANDSCAPE ARCHITECTURE	2

Figure 5: Ranked Journal List for “Small World” Local Collection

Figure 6 ranks the collection by author. For example, early pioneers, Manfred Kochen and Stanley Milgram only appear as 27th and 31st. It also includes the GCS and LCS totals. If that sort key is used, then Barabasi and Albert would move to the top of the list.

Small World All-Author List for Local "Inner" Nodes

Ranked All-Author list.

Total: 494

Sorted by pubs

#	Name	TGCS	TLCS	Pubs
1	[Anon]	0	0	15
2	Newman MEJ	357	176	12
3	Blumen A	71	31	9
4	Bernard HR	85	24	8
5	Killworth PD	85	24	8
6	Barabasi AL	624	109	6
7	Kim BJ	18	0	6
8	Watts DJ	555	238	6
9	Albert R	621	109	5
10	Amaral LAN	243	98	5
11	Kuperman M	31	16	5
12	Mccarty C	59	11	5
13	Barthelemy M	206	90	4
14	Bochner S	23	10	4
15	Choi MY	9	0	4
16	Elgazzar AS	2	0	4
17	Jasch F	9	1	4
18	Jeong H	263	48	4
19	Kertesz J	16	0	4
20	Zanette DH	6	0	4
21	Abramson G	31	16	3
22	Ahmed E	3	1	3
23	Holme P	14	0	3
24	Hong H	8	0	3
25	Hunter Je	17	7	3
26	Jespersen S	50	28	3
27	Kochen M	4	1	3
28	Lai YC	0	0	3
29	Latora V	11	4	3
30	Marchiori M	11	4	3
31	Milgram S	250	241	3

Figure 6: All-Author List ranked by publications

The outer works in Figure 7 are not included in the local collection because they have neither cited Milgram nor have they used “Small World” as a title word. These cited references are outside the retrieved collection. The sorted list of outer nodes is a virtual citation index of everything cited by the papers in the local or inner collection. The outer works will include any papers or books cited whether or not they are covered in *WoS* as sources. The full bibliographic data for each item can be looked up by clicking on *WoS*. This link takes one into the cited reference section of *WoS*. Note that numbers 3, 5, 7, 8, and 10 are cited books. To include them in the main collection and historiograph, their text records would have to be created manually. This would also be true for any cited papers not included in *WoS*.

ISI Web of Science
 Cited references outside of this network
 Total: 6719 (top 100 shown)
 Sorted by **LCS**.

#	LCS	Reference
1	45	ALBERT R, 1999, NATURE, V401, P130 WoS
2	45	NEWMAN MEJ, 2001, PHYS REV E 2, V64 WoS
3	41	BOLLOBAS B, 1985, RANDOM GRAPHS WoS
4	39	GRANOVETTER MS, 1973, AM J SOCIOL, V78, P1360 WoS
5	30	WATTS DJ, 1999, SMALL WORLDS WoS
6	26	MOUKARZEL CF, 1999, PHYS REV E, V60, P6263 WoS
7	25	WASSERMAN S, 1994, SOCIAL NETWORK ANAL WoS
8	23	KOCHEN M, 1989, SMALL WORLD WoS
9	22	LAGOFERNANDEZ LF, 2000, PHYS REV LETT, V84, P2758 WoS
10	22	WATTS DJ, 1999, SMALL WORLDS DYNAMIC WoS
11	21	JEONG H, 2000, NATURE, V407, P651 WoS
12	21	ERDOS P, 1960, PUBL MATH I HUNG, V5, P17 WoS
13	19	REDNER S, 1998, EUR PHYS J B, V4, P131 WoS
14	15	GUARE J, 1990, 6 DEGREES SEPARATION WoS
15	14	FALOUTSOS M, 1999, COMP COMM R, V29, P251 WoS
16	13	POOL ID, 1978, SOC NETWORKS, V1, P5 WoS
17	12	DEMENEZES MA, 2000, EUROPHYS LETT, V50, P574 WoS
18	12	HUBERMAN BA, 1999, NATURE, V401, P131 WoS
19	11	BRODER A, 2000, COMPUT NETW, V33, P309 WoS
20	10	MITCHELL JC, 1969, SOCIAL NETWORKS URBA WoS
21	10	POOL ID, 1978, SOC NETWORKS, V1, P1 WoS
22	10	MOLLOY M, 1995, RANDOM STRUCT ALGOR, V6, P161 WoS
23	9	GRANOVETTER MS, 1974, GETTING JOB STUDY CO WoS
24	9	WILLIAMS RJ, 2000, NATURE, V404, P180 WoS
25	9	DOROGVTSEV SN, 2001, PHYS REV E 1, V63 WoS

Figure 7: Outer Nodes – Most-Cited Works Outside Local Collection

In the latest version of the software, it is also possible to sort this file not only by citation frequency but also by journal, author or year. In Figure 8, we see that 110 papers from *Physical Review Letters* have been cited by 77 of the papers in the collection. The journal number is the alphabetical rank.

Small World Ranked Outer Journal List

Ranked Outer Journal list.

Total:1087

Journal:

Sorted by **PUBS**

50 shown.

Num	Journal NUM	Title	Cited Pubs	TLCS	TLCS/t	CITING NODES
1	838	PHYS-REV-LETT →	<u>110</u>	220	46.17	<u>77</u> ←
2	67	AM-SOCIOL-REV	<u>109</u>	145	6.60	<u>38</u>
3	59	AM-J-SOCIOL	<u>91</u>	173	8.03	<u>55</u>
4	746	NATURE	<u>91</u>	212	42.66	<u>85</u>
5	942	SCIENCE	<u>66</u>	108	16.60	<u>57</u>
6	480	J-AM-SOC-INFORM-SCI	<u>45</u>	58	6.87	<u>11</u>
7	943	SCIENTOMETRICS	<u>43</u>	49	7.30	<u>9</u>
8	960	SOC-FORCES	<u>35</u>	45	1.89	<u>22</u>
9	963	SOC-NETWORKS	<u>35</u>	72	3.77	<u>40</u>
10	607	J-PERS-SOC-PSYCHOL	<u>34</u>	36	1.50	<u>13</u>
11	792	P-NATL-ACAD-SCI-USA	<u>34</u>	45	9.03	<u>26</u>
12	832	PHYS-REV-E	<u>28</u>	64	12.25	<u>45</u>
13	503	J-CHEM-PHYS	<u>27</u>	31	3.24	<u>13</u>
14	526	J-DOC	<u>27</u>	31	4.84	<u>2</u>
15	1005	SOCIOMETRY	<u>27</u>	43	1.08	<u>23</u>
16	831	PHYS-REV-B	<u>24</u>	34	3.34	<u>15</u>
17	64	AM-PSYCHOL	<u>22</u>	25	1.01	<u>11</u>
18	840	PHYSICA-A	<u>22</u>	28	5.99	<u>17</u>
19	17	ADMIN-SCI-QUART	<u>20</u>	22	2.51	<u>9</u>
20	836	PHYS-REV-E-A	<u>19</u>	29	5.93	<u>19</u>
21	766	NUCLEIC-ACIDS-RES	<u>18</u>	23	5.44	<u>6</u>
22	16	ADM-SCI-Q	<u>17</u>	18	0.60	<u>8</u>
23	582	J-MATH-SOCIOL	<u>17</u>	33	1.53	<u>15</u>
24	892	PUBLIC-OPIN-QUART	<u>17</u>	20	0.55	<u>12</u>
25	643	J-SOC-ISSUES	<u>16</u>	18	0.56	<u>9</u>

Figure 8: “Small World” Outer References Ranked by Cited Journal Publications

Figure 9 shows the outer references to papers in *Nature* sorted chronologically.

Small World
Outer References to *Nature*

Cited references outside of this network.
Total: 6713 (top 100 shown)

Author: Journal: Number: Year:

Num	OR Num	LCS	Reference/Journal/Year	LCS/t
1	1716	1	DOMB-C-1959-NATURE-V184-P509	0.02
2	2453	1	GOFFMAN-W-1966-NATURE-V212-P449	0.03
3	6648	1	ZAIKIN-AN-1970-NATURE-V225-P535	0.03
4	5020	1	PIMM-SL-1977-NATURE-V268-P329	0.04
5	5214	1	REJMANEK-M-1979-NATURE-V280-P311	0.04
6	179	1	ANDERSON-RM-1982-NATURE-V318-P323	0.05
7	181	1	ANDERSON-RM-1985-NATURE-V318-P323	0.05
8	2584	1	GRAY-CM-1989-NATURE-V338-P334	0.07
9	6174	2	VANRAAN-AFJ-1990-NATURE-V347-P626	0.14
10	520	1	BENTLEY-GA-1990-NATURE-V348-P254	0.07
11	5024	4	PIMM-SL-1991-NATURE-V350-P669	0.31
12	4861	2	PAINE-RT-1992-NATURE-V355-P73	0.17
13	4770	4	NOWAK-MA-1992-NATURE-V359-P826	0.33
14	2729	1	HAMERSCASTERMAN-C-1993-NATURE-V363-P446	0.09
15	4769	1	NOWAK-M-1993-NATURE-V364-P56	0.09
16	1783	2	DOUGLASS-JK-1993-NATURE-V365-P337	0.18
17	2533	2	GOULD-SJ-1993-NATURE-V366-P223	0.18
18	5818	1	STEINBOCK-O-1993-NATURE-V366-P322	0.09
19	852	1	BRAUN-HA-1994-NATURE-V367-P270	0.10
20	2819	1	HASSELL-MP-1994-NATURE-V370-P290	0.10
21	6473	1	WIESENFELD-K-1995-NATURE-V373-P33	0.11
22	1389	2	COLLINS-JJ-1995-NATURE-V376-P236	0.22
23	584	1	BEZRUKOV-SM-1995-NATURE-V378-P362	0.11
24	842	2	BRAIMAN-Y-1995-NATURE-V378-P465	0.22
25	2206	1	FRETTE-V-1996-NATURE-V379-P49	0.12

Figure 9: “Small World” Outer References to *Nature* Ranked by Cited Year

Figure 10 provides a ranked author listing for outer references. 61 papers by Milgram have been cited, including variants. Only 18 citing papers are involved.

Small World Outer Authors Ranked by Pubs Cited

Ranked Outer author list.

Author:

Sorted by **Cited pubs**

4266 Total
Top 50 shown.

Num	Name	TLCS	TLCS/t	CITED PUBS	CITING NODES
1	COLLINE-P	70	0.75	<u>70</u>	<u>1</u>
2	MILGRAM-S	72	2.39	<u>61</u>	<u>18</u>
3	NEWMAN-MEJ	88	20.57	<u>32</u>	<u>45</u>
4	DOROGOVTSSEV-SN	59	12.83	<u>31</u>	<u>23</u>
5	BURT-RS	48	2.70	<u>26</u>	<u>21</u>
6	GARFIELD-E	34	1.70	<u>25</u>	<u>9</u>
7	LODGE-D	38	0.83	<u>19</u>	<u>24</u>
8	COLEMAN-JS	31	1.07	<u>18</u>	<u>19</u>
9	WELLMAN-B	23	1.52	<u>18</u>	<u>14</u>
10	BERNARD-HR	22	1.20	<u>17</u>	<u>14</u>
11	GRANOVETTER-M	33	1.45	<u>17</u>	<u>26</u>
12	BARRAT-A	26	2.52	<u>16</u>	<u>18</u>
13	WHITE-HC	21	0.56	<u>16</u>	<u>10</u>
14	CRONIN-B	15	2.17	<u>15</u>	<u>2</u>
15	LAUMANN-EO	29	1.06	<u>15</u>	<u>18</u>
16	ALBERT-R	66	12.15	<u>14</u>	<u>50</u>
17	BLAU-PM	21	0.83	<u>14</u>	<u>10</u>
18	FREEMAN-LC	28	1.35	<u>14</u>	<u>20</u>
19	ZANETTE-DH	20	5.54	<u>14</u>	<u>14</u>
20	HOLLAND-PW	24	0.81	<u>13</u>	<u>12</u>
21	KLEINBERG-J	14	3.26	<u>13</u>	<u>9</u>
22	GOULD-P	12	0.36	<u>12</u>	<u>2</u>
23	MARSDEN-PV	26	1.49	<u>12</u>	<u>15</u>
24	SCHWEIZER-T	12	1.15	<u>12</u>	<u>1</u>
25	SMALL-H	24	1.91	<u>12</u>	<u>5</u>



Figure 10: “Small World” Outer Authors Ranked by Publications Cited

In Figure 11, the outer references have been sorted by year and then alphabetically by author. The 1967 paper by R. P. Abelson has been cited in three papers but one of them has omitted the page number.

SMALL WORLD
Cited references outside of this network
Sorted by Year 1967

Total: 6713 (top 25 shown)

Author: Journal: Number: Year:

Num	OR Num	LCS	Reference/Journal/Year	LCS/t
1	7	1	ABELSON-RP-1967-ADV-EXPT-SOCIAL-PSYC-V3	0.03
2	8	2	ABELSON-RP-1967-ADV-EXPT-SOCIAL-PSYC-V3-P1	0.05
3	196	1	ANTONOVSKY-A-1967-J-NEUROL-NEUROSUR-PS-V30-P1	0.03
4	477	1	BECKER-E-1967-BEYOND-ALIENATION	0.03
5	535	2	BERGER-PL-1967-SOCIAL-CONSTRUCTION	0.05
6	617	1	BIRKHOFF-G-1967-LATTICE-THEORY	0.03
7	659	1	BLAU-PM-1967-AM-OCCUPATIONAL-STRU	0.03
8	673	1	BLISHEN-BR-1967-CANADIAN-REV-SOCIOLO-V4-P41	0.03
9	904	1	BROWN-D-1967-MOBILE-PROFESSORS	0.03
10	947	1	BULLOUGH-BL-1967-AM-J-SOCIOL-V70-P469	0.03
11	1095	1	CARZO-R-1967-FORMAL-ORGANIZATIONS	0.03
12	1287	1	COLE-S-1967-AM-SOCIOL-REV-V32-P377	0.03
13	1419	1	COOPERSMITH-S-1967-ANTECEDENTS-SELF-EST	0.03
14	1503	1	CROSS-HA-1967-PSYCHON-SCI-V7-P233	0.03
15	1571	8	DAVIS-J-1967-HUM-RELAT-V20-P181	0.22
16	1718	1	DOMHOFF-GW-1967-WHO-RULES-AM	0.03
17	1719	1	DOMHOFF-GW-1967-WHO-RULES-AM-P54	0.03
18	1794	1	DREW-EB-1967-ATLANTIC-MONTHLY-V220-P75	0.03
19	1807	1	DUFFIN-R-1967-GEOMETRIC-PROGRAMMIN	0.03
20	1844	1	EASTON-D-1967-AM-POLIT-SCI-REV-V61-P25	0.03
21	1887	1	EISENSTADT-SN-1967-ISRAELI-SOC-BACKGROU	0.03
22	2096	1	FISHER-CS-1967-ARCH-EUR-SOCIOL-V8-P216	0.03
23	2098	1	FISHER-ME-1967-REP-PROGR-PHYS-V30-P615	0.03
24	2150	1	FOUCAULT-M-1967-MADNESS-CIVILIZATION	0.03
25	2207	1	FRIED-M-1967-J-AM-I-PLANNERS-V33	0.03



Figure 11: “Small World” Outer References for 1967 Sorted by Author

Figure 12 presents the final product of the *HistCite* program, namely the historiograph for the most-cited papers in the local collection. The citation links between papers appear as a line with an arrow. Thus, paper 6 cited paper 4. The threshold number of papers included is set by the user; in this case, 17. The sizes of the circles are proportional to citation frequency. The Milgram paper is at the top (node #4) while the 1998 paper by Watts (node #94) is at the center. Had we mapped these papers based on global score, the Watts paper would appear even larger due to its higher global citation score.

HISTORIOGRAPH OF SMALL WORLD LCS PAPERS 1967-2002

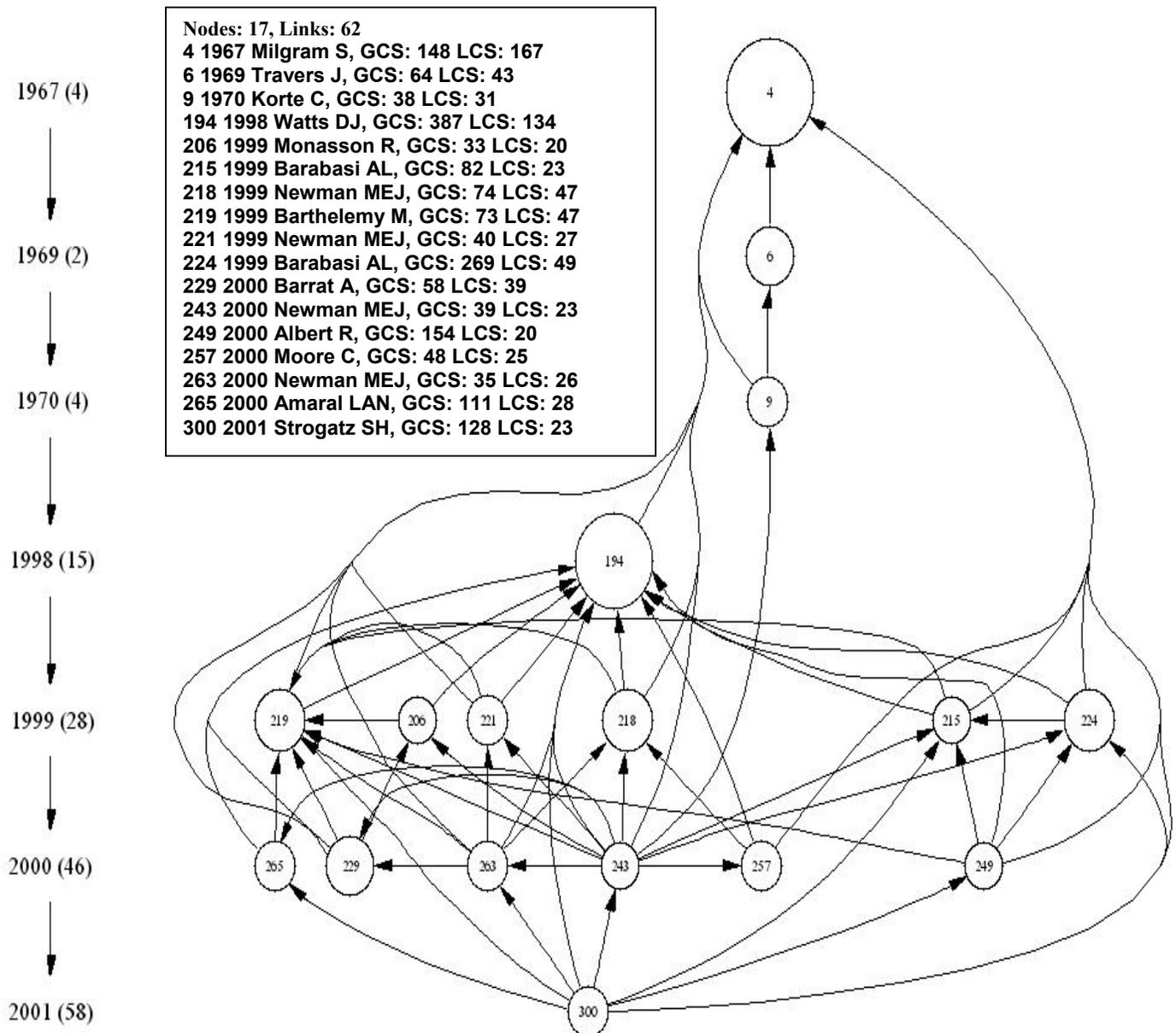


Figure 12: Historiograph Of 17 “Small World” Key LCS Papers, 1967-2002

Having illustrated the basic format of *HistCite*, let's now examine a collection on "Knowledge Domains." We conducted a *WoS* general search for papers on "knowledge and Domain*" and found 280 papers.

The first paper listed appeared in 1977 in the journal *Communication and Cognition*. The author is J. B. Grize (See Figure 13). It is interesting that this paper has neither been cited in the collection nor by the author himself.

The gray areas indicate papers that are neither cited in the collection, nor do they cite anything in the collection which may be a criterion for eliminating papers of low relevance.

[Outer References](#) [Missing Links?](#) [Journal list](#) [All-Author list](#) [Citation Matrix](#) [Graphs](#)

[HistCite Guide](#)

Articles containing "knowledge" and "domain*" in the title

Nodes: 280

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

Page 1: 1

#	Cited nodes	Nodes / Authors	GCS	LCS
1	0	1 1977 COMMUNICATION AND COGNITION 10(2):93-95 GRIZE JB <i>Domains Of Knowledge</i>	0	0
2	1	2 1979 JOURNAL OF VERBAL LEARNING AND VERBAL BEHAVIOR 18(3):257-273 CHIESI HL; SPILICH GJ; VOSS JF <i>Acquisition of Domain-Related Information in Relation To High and Low Domain Knowledge</i>	199	8
3	1	3 1979 JOURNAL OF VERBAL LEARNING AND VERBAL BEHAVIOR 18(3):275-290 SPILICH GJ; VESONDER GT; CHIESI HL; VOSS JF <i>Text Processing of Domain-Related Information for Individuals with High and Low Domain Knowledge</i>	222	7
4	0	4 1979 SCIENTOMETRICS 1(2):171-193 CHUBIN DE; STUDER KE <i>Knowledge and Structures of Scientific Growth - Measurement of a Cancer Problem Domain</i>	11	0
5	0	5 1982 BULLETIN OF THE PSYCHONOMIC SOCIETY 20(3):148-148 POST T; BRUDER G; GREENE T; VOSS JF <i>Domain Knowledge and Priming Effects on Sentence Recognition Time</i>	0	0
6	0	6 1983 BULLETIN OF THE PSYCHONOMIC SOCIETY 21(5):346-346 VOSS JF; POST TA; FINCHER RH; GREENE TR <i>Relation of Domain Knowledge and Working Memory in Text- Processing</i>	0	0
7	0	7 1983 SCANDINAVIAN JOURNAL OF PSYCHOLOGY 24(1):89-91 OHLSSON S <i>On Natural and Technical Knowledge Domains</i>	4	0

Figure 13: *HistCite* Chronological Table "Knowledge and Domain*" papers

The paper most-cited within this small collection is the one by Alexander and Judy in *Review of Educational Research* (See Figure 14). In addition to the 9 local cites, the paper has been cited globally in 114 papers.

[Outer References](#) [Missing Links?](#) [Journal list](#) [All-Author list](#) [Citation Matrix](#) [Graphs](#)

[HistCite Guide](#)

Articles containing "knowledge" and "domain*" in the title

Nodes: 280

Sorted by LCS.

Page 1: 1



#	Cited nodes	Nodes / Authors	GCS	LCS
1	1	31 1988 REVIEW OF EDUCATIONAL RESEARCH 58(4):375-404 ALEXANDER PA; JUDY JE <i>The Interaction of Domain-Specific and Strategic Knowledge in Academic Performance</i>	114	9
2	1	2 1979 JOURNAL OF VERBAL LEARNING AND VERBAL BEHAVIOR 18(3):257-273 CHIESI HL; SPILICH GJ; VOSS JF <i>Acquisition of Domain-Related Information in Relation to High and Low Domain Knowledge</i>	199	8
3	1	3 1979 JOURNAL OF VERBAL LEARNING AND VERBAL BEHAVIOR 18(3):275-290 SPILICH GJ; VESONDER GT; CHIESI HL; VOSS JF <i>Text Processing of Domain-Related Information for Individuals with High and Low Domain Knowledge</i>	222	7
4	0	14 1986 HUMAN LEARNING 5(2):75-90 HASSELHORN M; KORKEL J <i>Metacognitive Versus Traditional Reading Instructions - The Mediating Role of Domain-Specific Knowledge on Children's Text- Processing</i>	24	5
5	0	18 1987 INTERNATIONAL JOURNAL OF MAN-MACHINE STUDIES 26(1):105-121 MUSEN MA; FAGAN LM; COMBS DM; SHORTLIFFE EH <i>Use of a Domain Model to Drive an Interactive Knowledge-Editing Tool</i>	59	4
6	2	36 1989 JOURNAL OF EDUCATIONAL PSYCHOLOGY 81(3):306-312 SCHNEIDER W; KORKEL J; WEINERT FE <i>Domain-Specific Knowledge and Memory Performance - A Comparison of High-Aptitude and Low-Aptitude Children</i>	48	4
7	5	67 1992 EDUCATIONAL PSYCHOLOGIST 27(1):33-51 ALEXANDER PA <i>Domain Knowledge - Evolving Themes And Emerging Concerns</i>	43	4
8	2	16 1986 JOURNAL OF MEMORY AND LANGUAGE 25(4):431-444 MCCUTCHEN D <i>Domain Knowledge and Linguistic Knowledge in the Development of Writing Ability</i>	55	3

Figure 14: "Knowledge Domain" Papers Sorted by Local Citation Score (LCS)

When the file is sorted by GCS a paper by J. M. Berg turns up but it is really not related to the main knowledge domain theme and should be deleted (See Figure 15). Note that it is not cited at all in the local collection nor does it cite anything – hence the gray area. The next paper by Spilich et al is indeed relevant and is cited by seven papers in the file.

[HistCite Guide](#)

[Outer References](#) [Missing Links?](#) [Journal list](#) [All-Author list](#) [Citation Matrix](#) [Graphs](#)

Articles containing "knowledge" and "domain*" in the title

Nodes: 280
Sorted by **GCS**.
Page 1: 1

#	Cited nodes	Nodes / Authors	GCS	LCS
1	0	39 1990 ANNUAL REVIEW OF BIOPHYSICS AND BIOPHYSICAL CHEMISTRY 19():405-421 BERG JM <i>Zinc Finger Domains - Hypotheses and Current Knowledge</i>	246	0
2	1	3 1979 JOURNAL OF VERBAL LEARNING AND VERBAL BEHAVIOR 18(3):275-290 SPILICH GJ; VESONDER GT; CHIESI HL; VOSS JF <i>Text Processing of Domain-Related Information for Individuals with High and Low Domain Knowledge</i>	222	7
3	1	2 1979 JOURNAL OF VERBAL LEARNING AND VERBAL BEHAVIOR 18(3):257-273 CHIESI HL; SPILICH GJ; VOSS JF <i>Acquisition of Domain-Related Information in Relation to High and Low Domain Knowledge</i>	199	8
4	0	183 1998 JOURNAL OF COGNITIVE NEUROSCIENCE 10(1):1-34 CARAMAZZA A; SHELTON JR <i>Domain-specific knowledge systems in the brain: The animate- inanimate distinction</i>	158	2
5	1	31 1988 REVIEW OF EDUCATIONAL RESEARCH 58(4):375-404 ALEXANDER PA; JUDY JE <i>The Interaction of Domain-Specific and Strategic Knowledge in Academic Performance</i>	114	9
6	0	38 1989 MERRILL-PALMER QUARTERLY-JOURNAL OF DEVELOPMENTAL PSYCHOLOGY 35(1):27-62 CHI MTH; HUTCHINSON JE; ROBIN AF <i>How Inferences about Novel Domain-Related Concepts Can Be Constrained by Structured Knowledge</i>	71	1
7	0	18 1987 INTERNATIONAL JOURNAL OF MAN-MACHINE STUDIES 26(1):105-121 MUSEN MA; FAGAN LM; COMBS DM; SHORTLIFFE EH <i>Use of a Domain Model to Drive an Interactive Knowledge-Editing Tool</i>	59	4
8	2	16 1986 JOURNAL OF MEMORY AND LANGUAGE 25(4):431-444 MCCUTCHEN D <i>Domain Knowledge and Linguistic Knowledge in the Development of Writing Ability</i>	55	3

Figure 15: “Knowledge Domain” Papers Sorted by Global Citation Score (GCS)

In the latest version of the software it is possible to obtain a vocabulary analysis of the title words in the collection (See Figure 16). This provides clues for expanding the *WoS* search.

RANKED KNOWLEDGE DOMAIN TITLE WORDS LISTING

Words dictionary.
Total No.: 843
Sorted by: **frequency.**

Word:

Top 25 shown.

Num	<u>Word</u>	<u>raw / freq.</u> <u>%</u>
1	KNOWLEDGE	265 / 11.726
2	DOMAIN	172 / 7.611
3	DOMAINS	56 / 2.478
4	DOMAIN-SPECIFIC	30 / 1.327
5	USING	28 / 1.239
6	ACQUISITION	27 / 1.195
7	SYSTEMS	22 / 0.973
8	EXPERT	21 / 0.929
9	SYSTEM	20 / 0.885
10	LEARNING	19 / 0.841
11	KNOWLEDGE-BASED	19 / 0.841
12	DEVELOPMENT	14 / 0.619
13	ANALYSIS	14 / 0.619
14	USE	13 / 0.575
15	TEXT	13 / 0.575
16	MODEL	13 / 0.575
17	COMPLEX	13 / 0.575
18	PROBLEM	11 / 0.487
19	REPRESENTATION	10 / 0.442
20	MEDICAL	10 / 0.442
21	DISCOVERY	10 / 0.442
22	DESIGN	10 / 0.442
23	APPLICATION	10 / 0.442
24	MODELS	9 / 0.398
25	MODELING	9 / 0.398

Figure 16: “Knowledge Domain” Title Words Listing Ranked by Frequency

Depending upon the size of the files involved, it may be more useful to view the permutations of title word pairs (See Figure 17). This is reminiscent of the *Permuterm Subject Index* in the print editions of the *Science Citation Index*.

KNOWLEDGE DOMAIN TITLE WORD PAIRS

Word pairs dictionary.
Total No.: 1480
Sorted by: **frequency**.

Word1:

Word2:

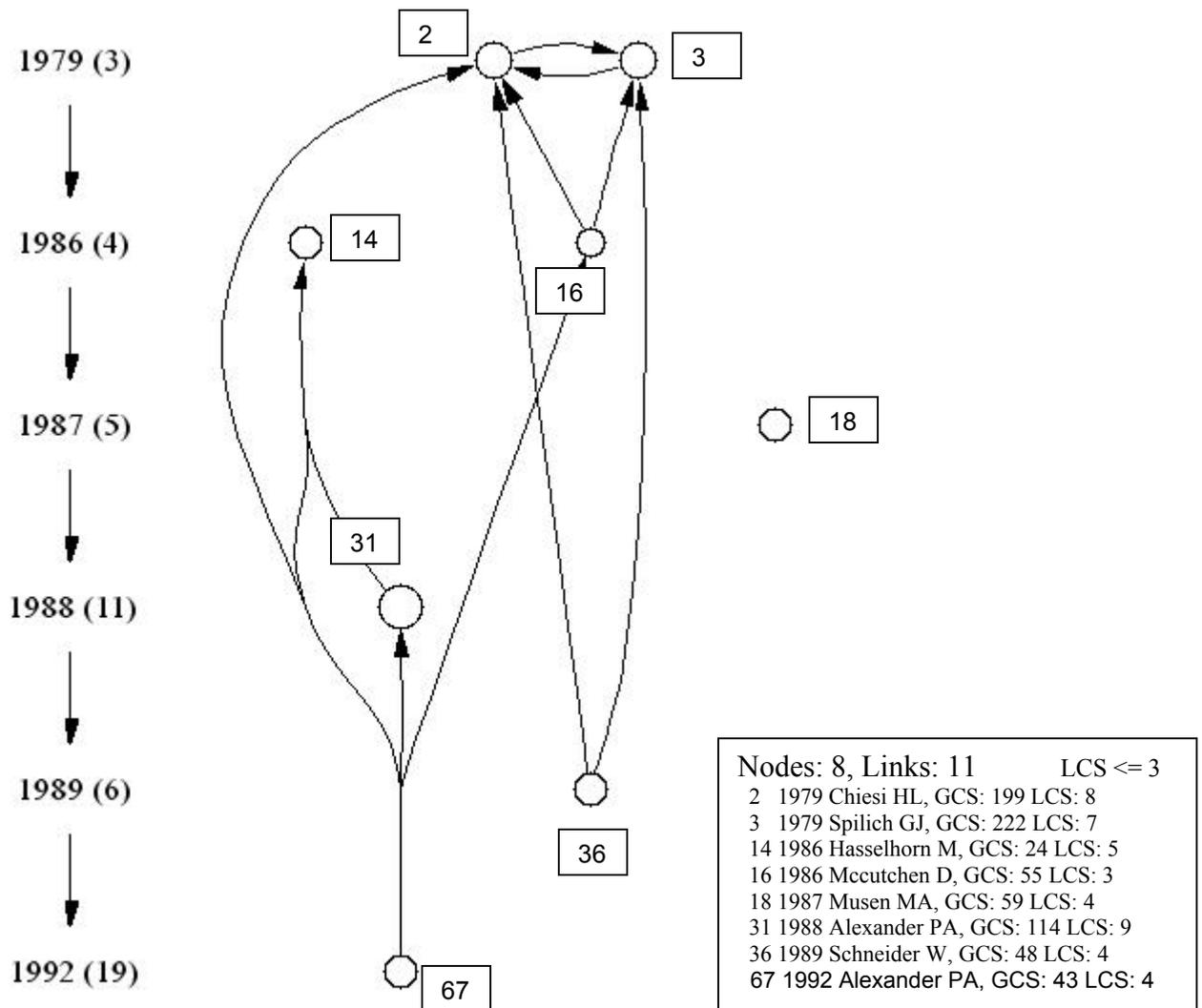
Top 25 shown.

Num	<u>pair</u>	<u>raw / freq. %</u>
1	DOMAIN & KNOWLEDGE	98 / 4.949
2	DOMAIN-SPECIFIC & KNOWLEDGE	23 / 1.162
3	DOMAINS & KNOWLEDGE	22 / 1.111
4	ACQUISITION & KNOWLEDGE	20 / 1.010
5	DOMAIN & USING	12 / 0.606
6	EXPERT & SYSTEMS	10 / 0.505
7	KNOWLEDGE & REPRESENTATION	6 / 0.303
8	KNOWLEDGE & PRIOR	6 / 0.303
9	DOMAIN & USE	6 / 0.303
10	DOMAIN & SPECIFIC	6 / 0.303
11	DOMAIN & PUBLIC	6 / 0.303
12	DOMAIN & MODEL	6 / 0.303
13	DISCOVERY & KNOWLEDGE	6 / 0.303
14	COMPLEX & SKILLS	6 / 0.303
15	COMPLEX & KNOWLEDGE	6 / 0.303
16	BASES & KNOWLEDGE	6 / 0.303
17	PLANNING & PUBLIC	5 / 0.253
18	INSTRUCTION & LEARNING	5 / 0.253
19	ELICITATION & KNOWLEDGE	5 / 0.253
20	CONTENT & DOMAIN	5 / 0.253
21	ACTION & KNOWLEDGE	5 / 0.253
22	PROBLEM & SOLVING	4 / 0.202
23	KNOWLEDGE & STRUCTURES	4 / 0.202
24	KNOWLEDGE & SHARING	4 / 0.202
25	KNOWLEDGE & MEDICAL	4 / 0.202

Figure 17: “Knowledge Domain” Title Word Pairs Ranked by Frequency

The historiograph (see Figure 18) for this collection illustrates the problem of conducting a search based solely on the terms knowledge and domain. In a collection of 280 papers, only 8 were cited locally three or more times. Based on this simplistic approach, the terms used are inadequate to the task. Clearly the scope of the field had to be interpreted differently. That task was left to Katy Borner. Recognizing this need for subjectivity, in order to capture literature relevant to the “mapping of knowledge domains,” Borner and her student Raghaveer Mukkamalla decided to create a multi-domain collection.. They used five different *HistCite* data sets covering the topics of Information Visualization (Ed Tufte), Dynamic Systems (Stanley Milgram), Co-Citation (Henry Small), Bibliographic Coupling (Kessler), and *Scientometrics* (the journal). Once these data sets were merged, about 6,000 papers were collected. However, by filtering out papers based on citation and other criteria, the file was reduced to about 3,600 papers.

KNOWLEDGE AND DOMAIN



G1

Figure 18: Map of “Knowledge Domain” Papers Cited Three or More Times

Figure 19 shows the *HistCite* file, sorted by LCS, for the 5643 papers included in the multi-domain file. Note that manually created entries for the Tufte books include psuedo journal, volume, and issue numbers in cited nodes 1, 2, and 5.

[Outer References](#) [Missing Links?](#) [Journal list](#) [All-Author list](#) [Citation Matrix](#) [Graphs](#)

[HistCite Guide](#)

Multi-Domain

Nodes: 5643

Sorted by **LCS**.

Page 1: 1 [2](#) [3](#) [4](#) [5](#) [6](#) [7](#) [8](#) [9](#) [10](#) [11](#) [12](#)

#	Cited nodes	Nodes / Authors	GCS	LCS
1	0	480 1983 VISUAL DISPLAY OF QUANTITATIVE INFORMATION 1(1):1-1 TUFTE ER <i>Visual Display of Quantitative Information</i>	879	879
2	0	1389 1990 ENVISIONING INFORMATION 1(1):1-2 TUFTE ER <i>Envisioning Information</i>	446	446
3	3	98 1973 JOURNAL OF THE AMERICAN SOCIETY FOR INFORMATION SCIENCE 24(4):265-269 SMALL HG <i>Co-citation in Scientific Literature - New Measure of Relationship Between 2 Documents</i>	235	228
4	3	122 1974 SCIENCE STUDIES 4(1):17-40 SMALL HG; GRIFFITH BC <i>Structure of Scientific Literatures .F. Identifying and Graphing Specialties</i>	212	213
5	0	3706 1997 VISUAL EXPLANATIONS: IMAGES AND QUANTITIES, EVIDENCE AND NARRATIVES 1(1):1-2 TUFTE ER <i>Visual Explanations: Images and Quantities, Evidence and Narratives</i>	171	171
6	0	39 1967 PSYCHOLOGY TODAY 1(1):61-67 MILGRAM S <i>Small-World Problem</i>	47	150
7	0	2 1963 AMERICAN DOCUMENTATION 14(1):10-& KESSLER MM <i>Bibliographic Coupling between Scientific Papers</i>	128	144
8	1	3976 1998 NATURE 393(6684):440-442 Watts DJ; Strogatz SH <i>Collective dynamics of 'small-world' networks</i>	260	106
9	4	141 1975 SOCIAL STUDIES OF SCIENCE 5(1):86-92 MORAVCSIK MJ; MURUGESAN P <i>Some Results on Function and Quality Of Citations</i>	161	105
10	5	1322 1989 SCIENTOMETRICS 16(1-6):3-& SCHUBERT A; GLANZEL W; BRAUN T <i>Scientometric Datafiles - A Comprehensive Set of Indicators on 2649 Journals and 96 Countries in All Major Science Fields and Subfields 1981-1985</i>	104	105

Figure 19: “Multi-Domain” *HistCite* Collection Ranked by LCS

The limitations of space preclude a detailed explanation here of how Borner compiled the collection of knowledge domain literature used to create the map in the next figure. The description of that process will be found at:

http://garfield.library.upenn.edu/histcomp/multi-domain_master-file/k_borner_supplement.doc

Figure 20 is but one of several maps at different citation thresholds which can be found at:

http://garfield.library.upenn.edu/histcomp/multi-domain_extra-graphs/graph/list.html

In Figure 20, the paper at the top, #2, is Kessler 1963. The map is dominated by papers in bibliometrics. Directly below is #97, Henry Small's 1973 paper. To the right of the map is paper #39 by Milgram, followed by Travers, #60, Gramovetter, #93, and Watts 1998, #3976. On the far right near the bottom is the work of Tufte, #480, and Cleveland, #540. In order to see additional papers, we must change the threshold. See the following URLs for larger maps at lower LCS citation thresholds::

LCS > 45 - http://garfield.library.upenn.edu/histcomp/multi-domain_extra-graphs/graph/2.html

LCS > 39 - http://garfield.library.upenn.edu/histcomp/multi-domain_extra-graphs/graph/3.html

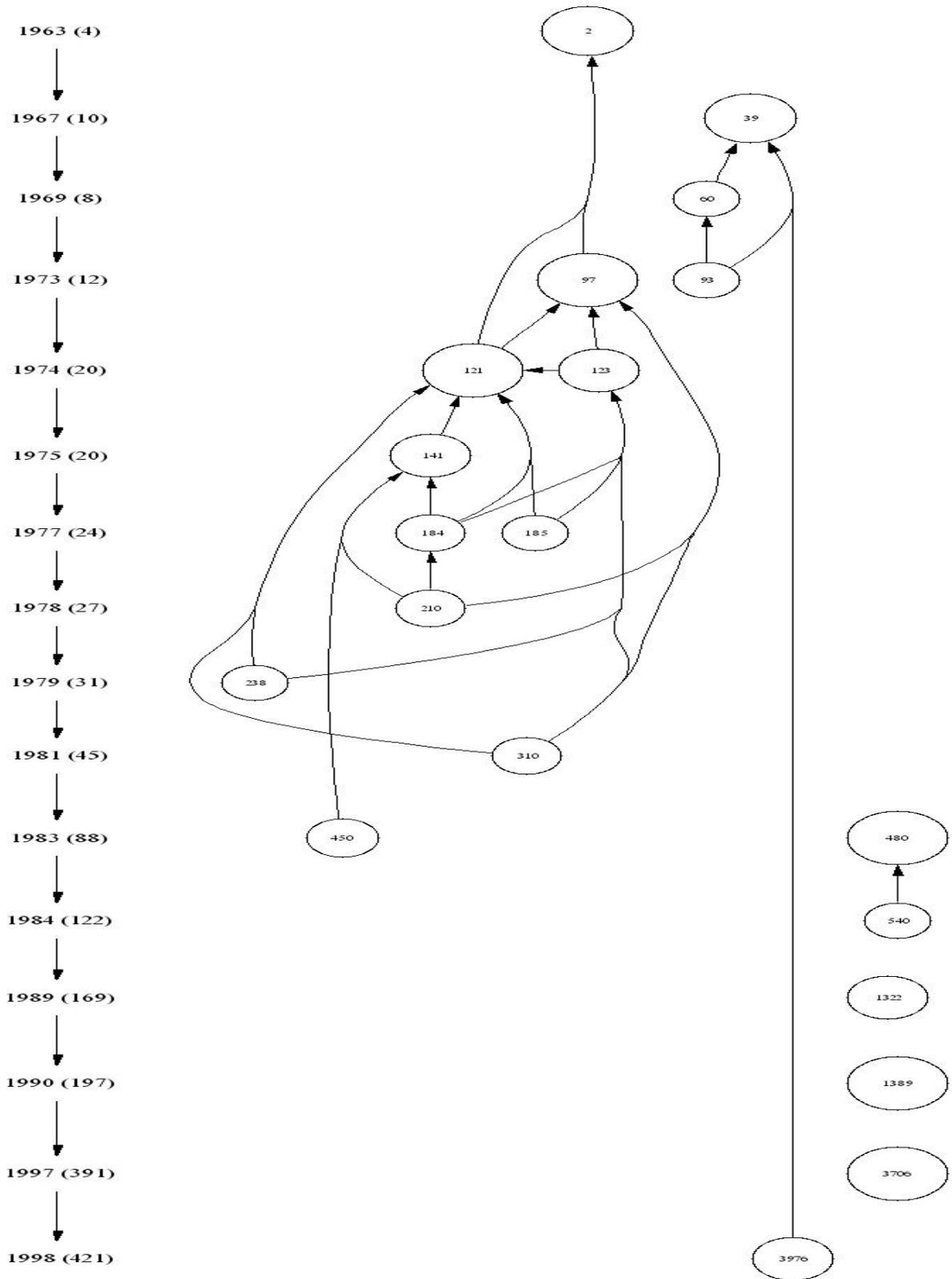
LCS > 35 - http://garfield.library.upenn.edu/histcomp/multi-domain_extra-graphs/graph/3.html

LCS > 31 - http://garfield.library.upenn.edu/histcomp/multi-domain_extra-graphs/graph/4.html

LCS > 30 - http://garfield.library.upenn.edu/histcomp/multi-domain_extra-graphs/graph/5.html

LCS > 24 - http://garfield.library.upenn.edu/histcomp/multi-domain_extra-graphs/graph/6.html

**Figure 20: “Multi-Domain” Historiograph of 20 LCS Papers Cited 63 or More Times
(See Key on next page)**



Key to Figure 20:

2 1963 KESSLER MM, GCS: 128 LCS: 144
39 1967 MILGRAM S, GCS: 47 LCS: 150
60 1969 TRAVERS J, GCS: 62 LCS: 63
93 1973 GRANOVETTER MS, GCS: 1196 LCS: 65
97 1973 SMALL HG, GCS: 235 LCS: 228
121 1974 SMALL HG, GCS: 212 LCS: 213
123 1974 GRIFFITH BC, GCS: 99 LCS: 102
141 1975 MORAVCSIK MJ, GCS: 161 LCS: 105
184 1977 GILBERT GN, GCS: 124 LCS: 73
185 1977 SMALL HG, GCS: 74 LCS: 63
210 1978 SMALL HG, GCS: 104 LCS: 80
238 1979 GARFIELD E, GCS: 65 LCS: 64
310 1981 WHITE HD, GCS: 84 LCS: 73
450 1983 MARTIN BR, GCS: 129 LCS: 82
480 1983 TUFTE ER, GCS: 879 LCS: 879
540 1984 CLEVELAND WS, GCS: 114 LCS: 67
1322 1989 SCHUBERT A, GCS: 104 LCS: 105
1389 1990 TUFTE ER, GCS: 446 LCS: 446
3706 1997 TUFTE ER, GCS: 171 LCS: 171
3976 1998 Watts DJ, GCS: 260 LCS: 106

Since *HistCite* was originally developed as a tool for historiographic analysis, the closing example is related to the original DNA project. However, in Figure 21, the focus is on the much discussed 1953 paper by Watson and Crick⁹ which identified the helical structure of DNA. This paper has been explicitly cited 2,316 times in the past 50 years.¹⁰ We have found, however, that for extremely active fields with high immediacy, it is necessary to do the historical analysis in 5-year segments. In that way, the significant works of the period under study can be seen in their proper chronological context.

[Outer References](#) [Missing Links?](#) [Journal list](#) [All-Author list](#) [Citation Matrix](#) [Graphs](#)

[HistCite Guide](#)

Articles from 1953-1958 citing Watson and Crick's 1953 paper, "Molecular Structure of DNA" and selected outer references

Nodes: 210

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

Page 1: 1

#	Cited nodes	Nodes / Authors	GCS	LCS
1	0	1 1944 JOURNAL OF EXPERIMENTAL MEDICINE 79():137-157 AVERY OT; MACLEON CM; MCCARTY M <i>Studies on the Chemical Nature of the Substance Inducing Transformation of Pseumococcal Types. Induction of Transformation by A Deoxyribonucleic Acid Fraction Isolated from Pneumococcus Type III</i>	331	148
2	0	2 1952 JOURNAL OF GENERAL PHYSIOLOGY 36(1):39-56 HERSHEY AD; CHASE M <i>Independent Functions of Viral Protein and Nucleic Acid in Growth of Bacteriophage</i>	747	23
3	2	3 1953 ACTA CRYSTALLOGRAPHICA 6(8-9):673-677 FRANKLIN RE; GOSLING RG <i>The Structure of Sodium Thymonucleate Fibres .1. The Influence of Water Content</i>	14	11
4	3	4 1953 ACTA CRYSTALLOGRAPHICA 6(8-9):678-685 FRANKLIN RE; GOSLING RG <i>The Structure of Sodium Thymonucleate Fibres .2. The Cylindrically Symmetrical Patterson Function</i>	10	8
5	1	5 1953 ARCHIVES OF BIOCHEMISTRY AND BIOPHYSICS 46(1):12-17 SMITH CL <i>The Breakdown of Desoxyribonucleic Acid Under Deuteron and Electron Bombardment</i>	5	1
6	2	6 1953 BIOCHEMICAL JOURNAL 55(5):774-782 WYATT GR; COHEN SS <i>The Bases of the Nucleic Acids of Some Bacterial and Animal Viruses - The Occurrence of 5-Hydroxymethylcytosine</i>	57	8
7	3	7 1953 COLD SPRING HARBOR SYMPOSIA ON QUANTITATIVE BIOLOGY 18():123-131 WATSON JD; CRICK FHC <i>The Structure Of DNA</i>	61	21
8	1	8 1953 COLD SPRING HARBOR SYMPOSIA ON QUANTITATIVE BIOLOGY 18():133-134 WYATT GR <i>The Quantitative Composition Of Deoxypentose Nucleic Acids As Related To The Newly Proposed Structure</i>	9	4

Figure 21: *HistCite* Chronological Listing of Papers Citing Watson-Crick 1953

Using 50-year citation counts gives greater emphasis to more recent highly-cited papers. After a few decades, a landmark paper will become the common wisdom of the field and citations to it will rarely occur.

To overcome this distortion we created a *HistCite* file of the 200 odd papers published from 1953 to 1958 which cited the Watson-Crick paper. We added a few additional key papers from the outer references such as Avery-McCarty-McLeod 1944¹¹ and Hershey 1952.¹²

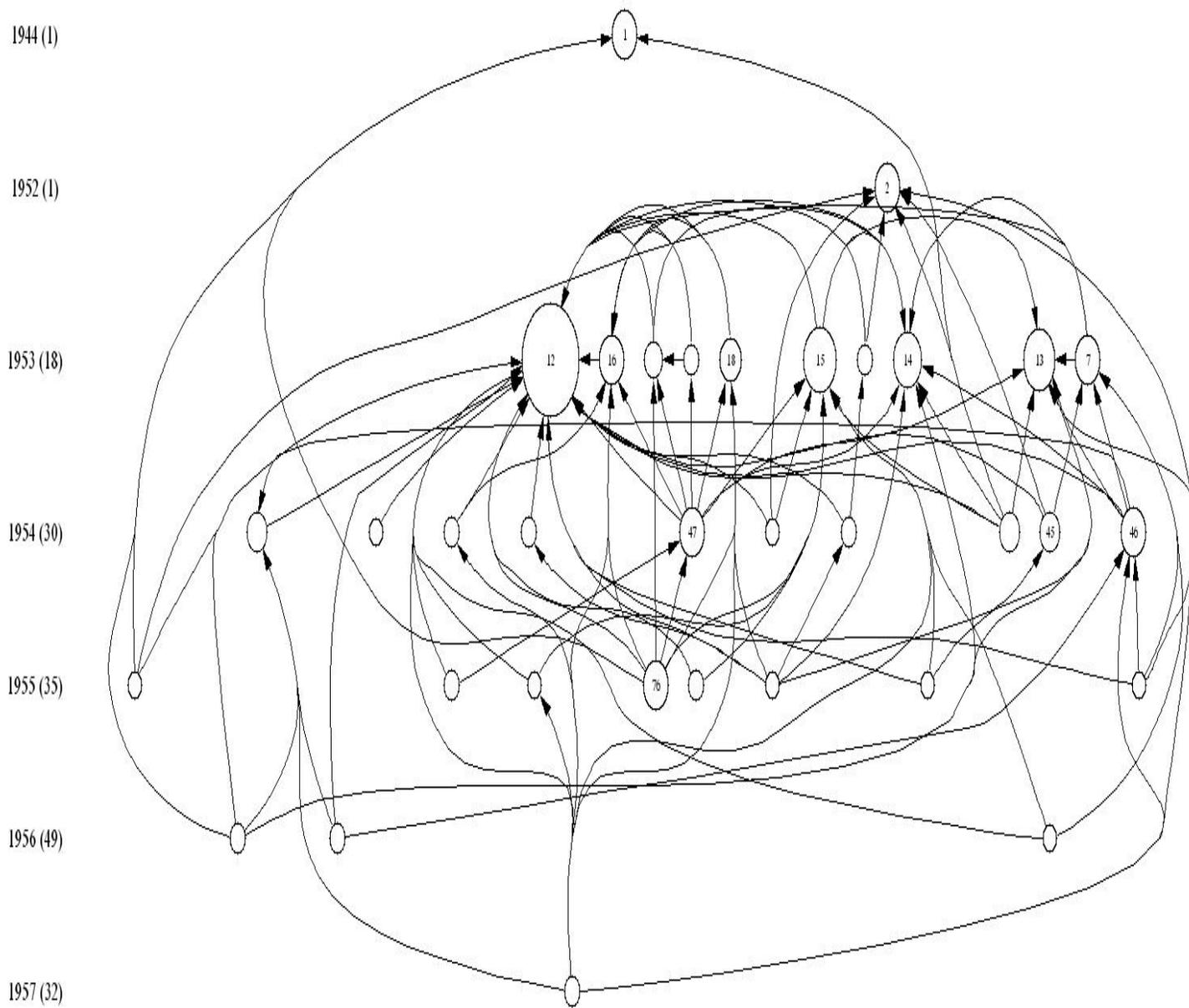
Figure 22 provides the year-by-year mapping of the most-cited papers. This map makes it visually apparent that many well cited papers published in 1953 were related to Watson-Crick. They appear on the map in a single row for 1953. This map includes a dozen of the earlier key papers, including Avery et al 1944 which is so important in the history of DNA. In the first iteration, it appeared as an outer node as did Hershey 1952 and other key authors, all of whom were frequently cited by the authors who cited Watson and Crick. While this is interesting, the year-by-year display does not show the rapid month-by-month sequence of publishing events. So we modified the *HistCite* graphical program to accommodate more precise publication dates.

In order to expand the scope of the collection, we created a new collection consisting of 975 papers that cited the Watson-Crick paper itself but also an additional 745 papers that cited the 210 papers in the previous example. We call this chained citation indexing. All of the papers listed chronologically in Figure 23 were published before 1953 and were added from the list of Outer References.

Figure 24 provides a month-by-month display for 1953 papers.

In a recent interview,¹³ James Watson apologized for not having cited Avery in the primordial *Nature* paper on the DNA helical structure. But as we have seen, this omission on his part made little difference in the algorithmic mapping of the development of DNA science. But in view of Watson's comment, I have added a dotted line from Watson-Crick to Avery indicating that key link. However, to obtain a more accurate picture of Avery between 1944 and 1945, we would have to create a citation index for the 1944 literature, since the *SCI* source data begins with 1945. There is some controversy as to how much the significance of the Avery work was appreciated by the scientific community at that time.^{14,15,16,17,18,19} I believe our data indicate that it had a substantial impact before and after the Watson-Crick paper appeared.

Figure 22: Year-by-Year Map of Watson-Crick 1944-1957 (see key on next page)



Key to Figure 22:

Nodes: 34, Links: 98 LCS \geq 5

1 1944 AVERY OT, GCS: 0 LCS: 23
2 1952 HERSHEY AD, GCS: 747 LCS: 23
3 1953 FRANKLIN RE, GCS: 14 LCS: 11
4 1953 FRANKLIN RE, GCS: 10 LCS: 8
6 1953 WYATT GR, GCS: 57 LCS: 8
7 1953 WATSON JD, GCS: 61 LCS: 21
12 1953 WATSON JD, GCS: 205 LCS: 205
13 1953 WILKINS MHF, GCS: 170 LCS: 41
14 1953 FRANKLIN RE, GCS: 216 LCS: 35
15 1953 WATSON JD, GCS: 87 LCS: 53
16 1953 FRANKLIN RE, GCS: 24 LCS: 21
18 1953 WILKINS MHF, GCS: 24 LCS: 19
29 1954 THOMAS R, GCS: 37 LCS: 12
30 1954 LALAND SG, GCS: 11 LCS: 7
31 1954 PEACOCKE AR, GCS: 15 LCS: 5
33 1954 LEVINHAL C, GCS: 19 LCS: 5
36 1954 CRAMPTON CF, GCS: 28 LCS: 6
41 1954 ELSON D, GCS: 25 LCS: 8
44 1954 RICH A, GCS: 25 LCS: 13
45 1954 DELBRUCK M, GCS: 24 LCS: 15
46 1954 DEKKER CA, GCS: 43 LCS: 21
47 1954 CRICK FHC, GCS: 54 LCS: 21
52 1955 ALLFREY VG, GCS: 36 LCS: 5
59 1955 BLOUT ER, GCS: 12 LCS: 6
60 1955 ELSON D, GCS: 31 LCS: 5
72 1955 STENT GS, GCS: 27 LCS: 5
75 1955 DUNN DB, GCS: 28 LCS: 6
76 1955 FEUGHELMAN M, GCS: 39 LCS: 21
79 1955 COX RA, GCS: 10 LCS: 5
80 1955 PLATT JR, GCS: 7 LCS: 5
95 1956 PAULING L, GCS: 8 LCS: 5
119 1956 THOMAS CA, GCS: 12 LCS: 6
122 1956 CAVALIERI LF, GCS: 14 LCS: 6
154 1957 COX RA, GCS: 10 LCS: 7

Articles citing Watson and Crick's 1953 paper, "Molecular Structure of DNA", the articles citing them (1953-1958), and selected outer references

Nodes: 975

Sorted by year, journal, volume, page.

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#	Cited nodes	Nodes / Authors	GCS	LCS
1	0	1 1938 JOURNAL OF BIOLOGICAL CHEMISTRY 124():425- SEVAG MG <i>[unknown]</i>	216	37
2	1	2 1944 JOURNAL OF EXPERIMENTAL MEDICINE 79():137-157 AVERY OT; MACLEON CM; MCCARTY M <i>Studies on the Chemical Nature of the Substance Inducing Transformation of Pseudococcal Types. Induction of Transformation by a Deoxyribonucleic Acid Fraction Isolated from Pseudococcus Type III</i>	331	43
3	0	3 1945 JOURNAL OF BIOLOGICAL CHEMISTRY 161(1):83-89 SCHMIDT G; THANNHAUSER SJ <i>A Method for the Determination of Deoxyribonucleic Acid, Ribonucleic Acid, and Phosphoproteins in Animal Tissues</i>	696	34
4	1	4 1945 JOURNAL OF BIOLOGICAL CHEMISTRY 161(1):293-303 SCHNEIDER WC <i>Phosphorus Compounds in Animal Tissues .1. Extraction and Estimation of Deoxypentose Nucleic Acid and of Pentose Nucleic Acid</i>	952	30
5	2	5 1946 JOURNAL OF GENERAL PHYSIOLOGY 30(2):117-& MIRSKY AE; POLLISTER AW <i>Chromosin, a Deoxyribose Nucleoprotein Complex of the Cell Nucleus</i>	323	35
6	0	6 1947 JOURNAL OF THE CHEMICAL SOCIETY (SEP):1131-1141 GULLAND JM; JORDAN DO; TAYLOR HFW <i>Deoxypentose Nucleic Acids .2. Electrometric Titration of the Acidic and the Basic Groups of the Deoxypentose Nucleic Acid of Calf Thymus</i>	70	31
7	3	7 1951 BIOCHEMICAL JOURNAL 48(5):584-590 WYATT GR <i>The Purine and Pyrimidine Composition of Deoxypentose Nucleic Acids</i>	276	63
8	0	8 1951 JOURNAL OF BIOLOGICAL CHEMISTRY 189(2):597-605 MARSHAK A; VOGEL HJ <i>Microdetermination of Purines And Pyrimidines in Biological Materials</i>	136	30
9	0	9 1951 PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES OF THE UNITED STATES OF AMERICA 37(4):205-211 PAULING L; COREY RB; BRANSON HR <i>The Structure of Proteins - 2 Hydrogen-Bonded Helical Configurations of the Polypeptide Chain</i>	185	26
10	1	10 1952 BIOCHEMICAL JOURNAL 52(5):558-565 MARKHAM R; SMITH JD <i>The Structure of Ribonucleic Acids .2. The Smaller Products of Ribonuclease Digestion</i>	104	28

Figure 23: Opening Page of *HistCite* Collection of “Chained” Citations to Watson-Crick
WATSON-CRICK AND AVERY

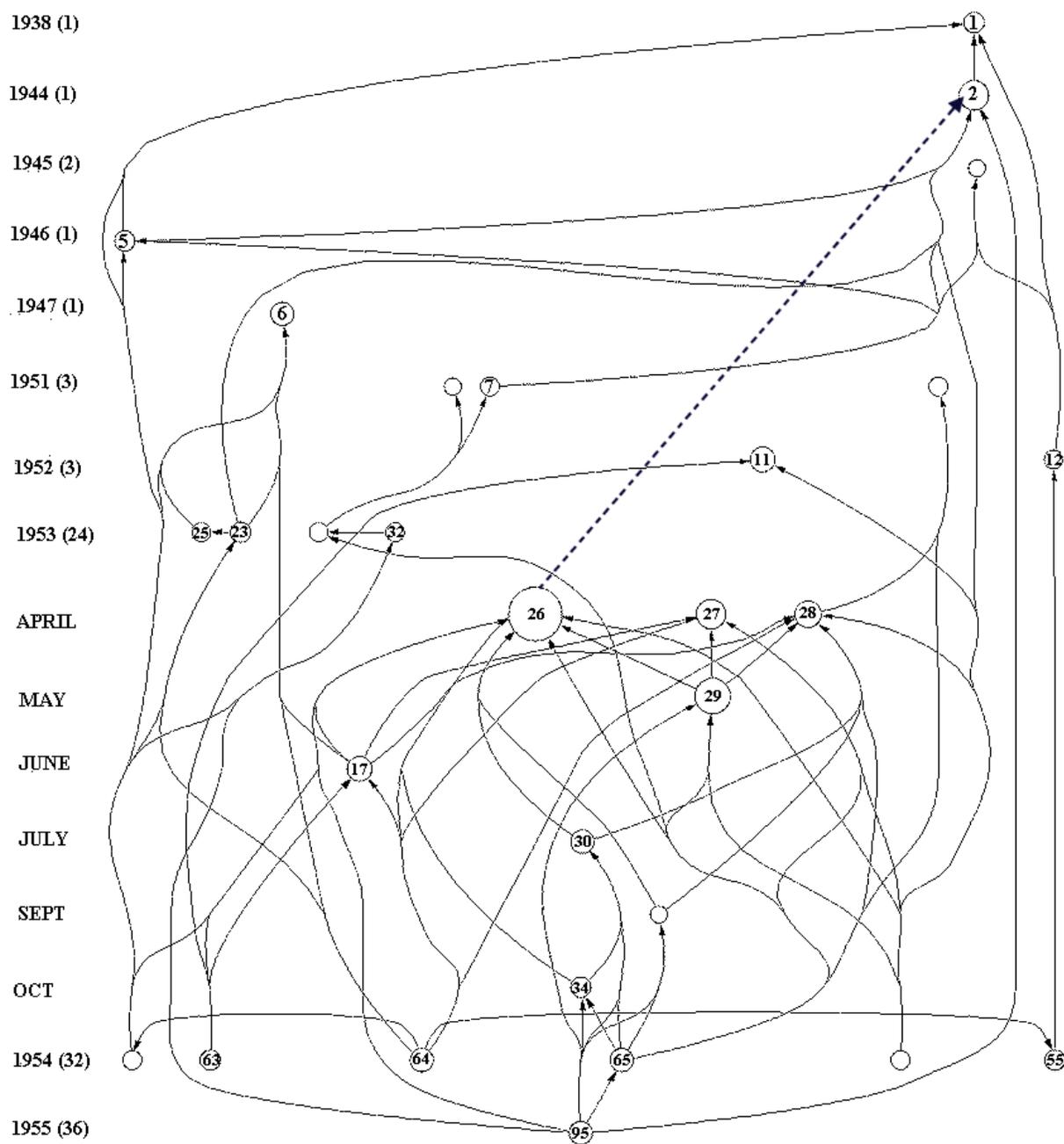


Figure 24: Month-By-Month Historiograph linking Watson-Crick to Avery

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- 2 Over a 25-year period, I published a dozen or more essays on mapping science. See my website at <http://garfield.library.upenn.edu/mapping/mapping.html>.
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