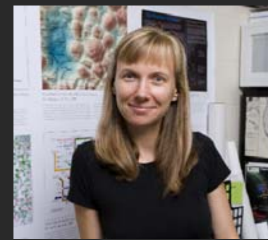
Mapping the Structure and Dynamics of Science



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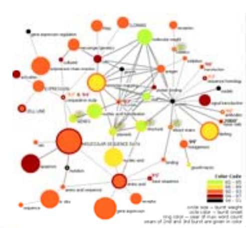
School of Information, North Campus, Atkins Room #1202, 1075 Beal Avenue
Video broadcast available at Central Campus, Ehrlicher Room #411
University of Michigan, Ann Arbor, MI

Nov 19, 2008

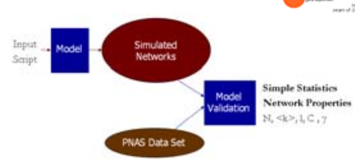
Overview



Computational Scientometrics

Case Studies:

- Information Diffusion Among Major U.S. Research Institutions
- Identifying Research Topics and Trends
- Modeling the Co-Evolving Author-Paper Networks



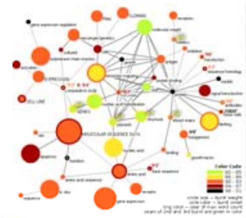
Science of Science Cyberinfrastructures

- Scholarly Database
- Network Workbench Tool

- Mapping Science Exhibit

Overview

Computational Scientometrics



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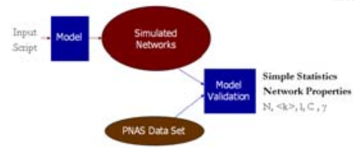


Science of Science Cyberinfrastructures

- Scholarly Database
- Network Workbench Tool

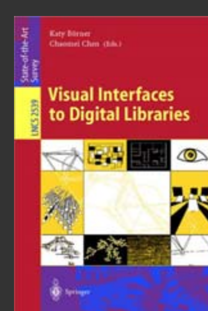
SDB | SCHOLARLY DATABASE

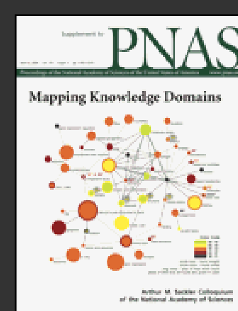
NetworkWorkbench

- Mapping Science Exhibit

Computational Scientometrics: Studying Science by Scientific Means

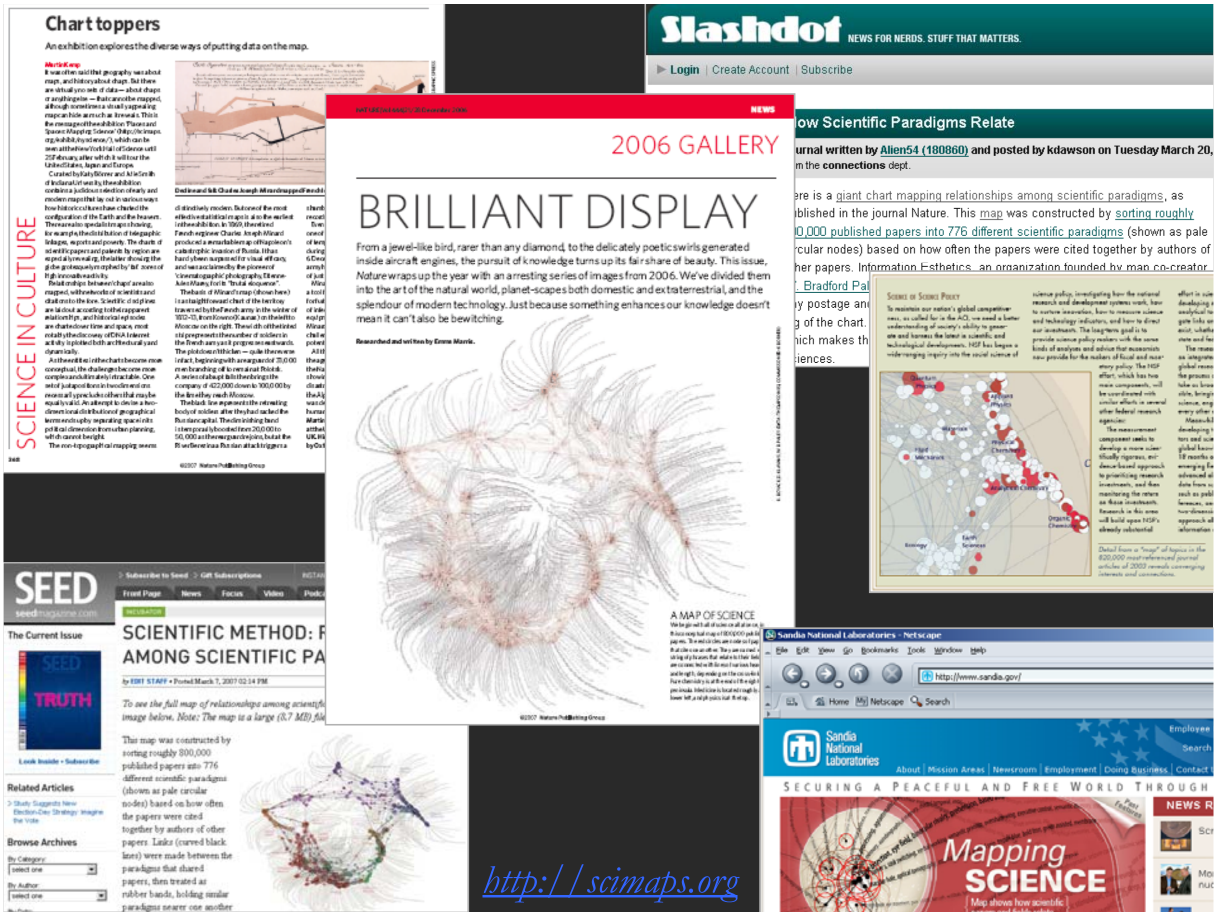
Results are frequently communicated via 'Science Maps'.





- *Börner, Katy, Chen, Chaomei, and Boyack, Kevin. (2003).* ***Visualizing Knowledge Domains.*** *In Blaise Cronin (Ed.), Annual Review of Information Science & Technology, Medford, NJ: Information Today, Inc./American Society for Information Science and Technology, Volume 37, Chapter 5, pp. 179-255.* http://ivl.slis.indiana.edu/km/pub/2003-borner-arist.pdf
- *Shiffrin, Richard M. and Börner, Katy (Eds.) (2004).* ***Mapping Knowledge Domains.*** *Proceedings of the National Academy of Sciences of the United States of America, 101(Suppl_1).* http://www.pnas.org/content/vol101/suppl_1/
- *Börner, Katy, Sanyal, Soma and Vespignani, Alessandro (2007).* ***Network Science.*** *In Blaise Cronin (Ed.), Annual Review of Information Science & Technology, Information Today, Inc./American Society for Information Science and Technology, Medford, NJ, Volume 41, Chapter 12, pp. 537-607.* http://ivl.slis.indiana.edu/km/pub/2007-borner-arist.pdf

- ***Places & Spaces: Mapping Science*** *exhibit, see also* http://scimaps.org.

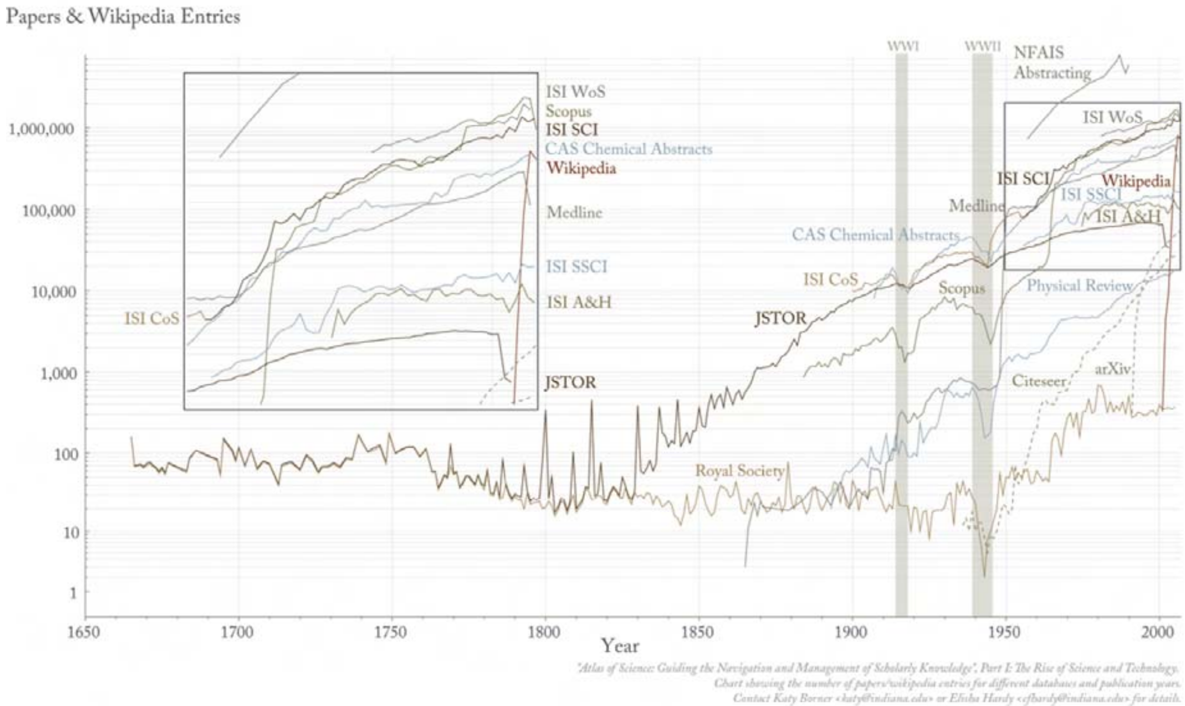


General Process of Analyzing and Mapping Science

DATA EXTRACTION	UNIT OF ANALYSIS	MEASURES	LAYOUT (often one code does both similarity and ordination steps)		DISPLAY
			SIMILARITY	ORDINATION	
SEARCHES ISI INSPEC Eng Index Medline ResearchIndex Patents etc. BROADENING By citation By terms	COMMON CHOICES Journal Document Author Term	COUNTS/FREQUENCIES Attributes (e.g. terms) Author citations Co-citations By year THRESHOLDS By counts	SCALAR (unit by unit matrix) Direct citation Co-citation Combined linkage Co-word / co-term Co-classification VECTOR (unit by attribute matrix) Vector space model (words/terms) Latent Semantic Analysis (words/terms) incl. Singular Value Decomp (SVD) CORRELATION (if desired) Pearson's R on any of above	DIMENSIONALITY REDUCTION Eigenvector/Eigenvalue solutions Factor Analysis (FA) and Principal Components Analysis (PCA) Multi-dimensional scaling (MDS) LSA, Topics Pathfinder networks (PFNet) Self-organizing maps (SOM) includes SOM, ET-maps, etc. CLUSTER ANALYSIS SCALAR Triangulation Force-directed placement (FDP)	INTERACTION Browse Pan Zoom Filter Query Detail on demand ANALYSIS

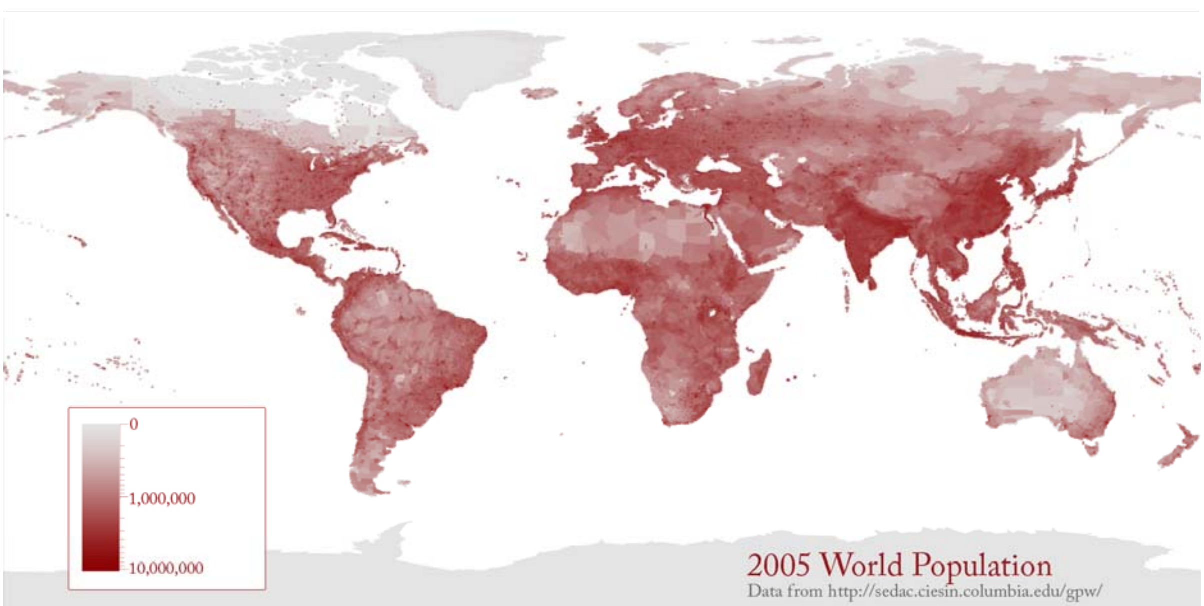
Börner, Katy, Chen, Chaomei, and Boyack, Kevin. (2003) Visualizing Knowledge Domains. In Blaise Cronin (Ed.), Annual Review of Information Science & Technology, Volume 37, Medford, NJ: Information Today, Inc./American Society for Information Science and Technology, chapter 5, pp. 179-255.

Growth of Scientific Knowledge, 1665 to 2006



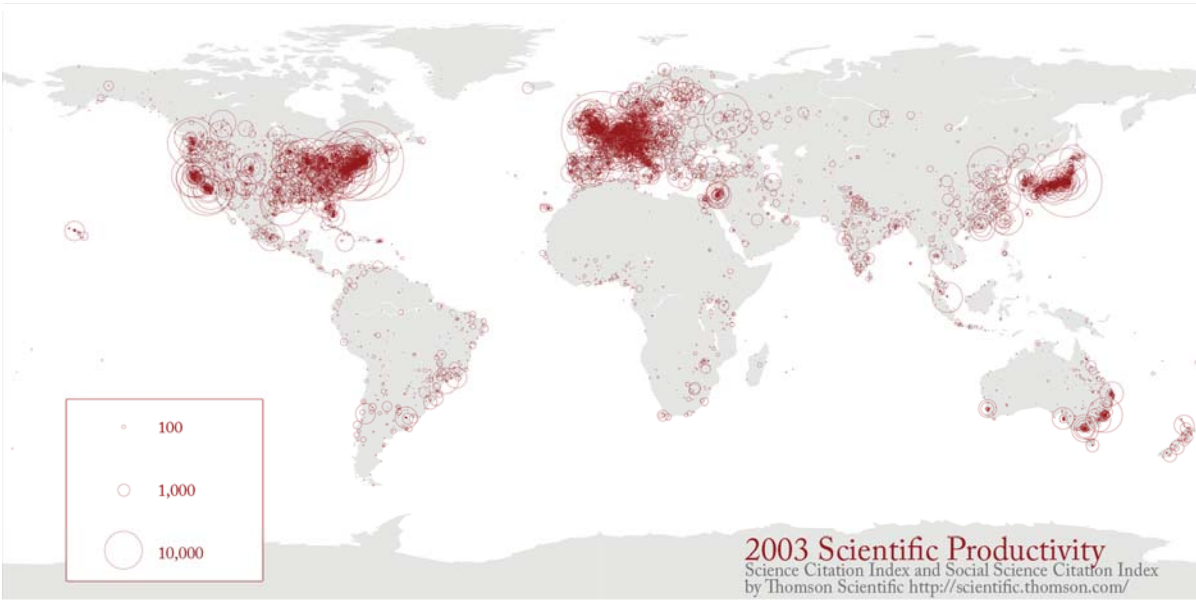
2005 World Population

The population map uses a quarter degree box resolution. Boxes with zero people are given in white. Darker shades of red indicate higher population counts per box using a logarithmic interpolation. The highest density boxes appear in Mumbai, with 11,687,850 people in the quarter degree block, Calcutta (10,816,010), and Shanghai (8,628,088).



2003 Scientific Productivity

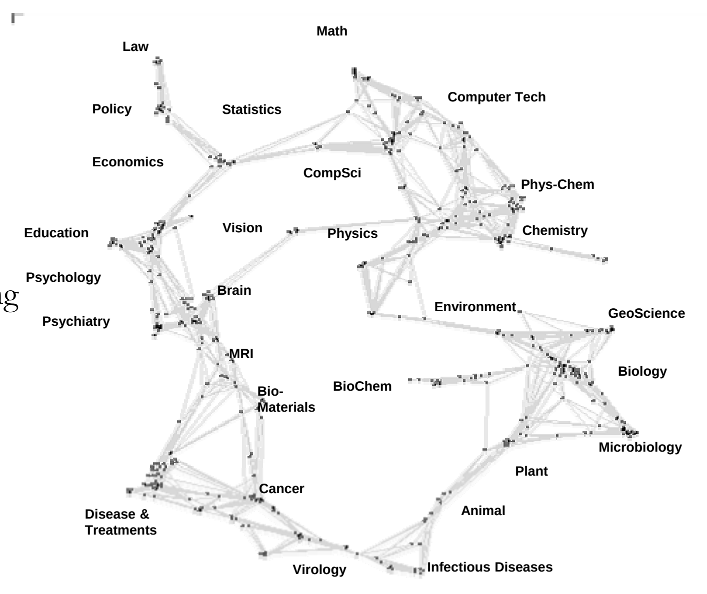
Shown is where science is performed today. Each circle indicates a geographic location at which scholarly papers are published. The larger the circle the more papers are produced. Boston, MA, London, England, and New York, NY are the top three paper production areas. Note the strong resemblance with the Night on Earth and the IP Ownership maps and the striking differences to the world population map.



Latest 'Base Map' of Science

Kevin W. Boyack, Katy Börner, & Richard Klavans (2007). Mapping the Structure and Evolution of Chemistry Research. 11th International Conference on Scientometrics and Informetrics. pp. 112-123.

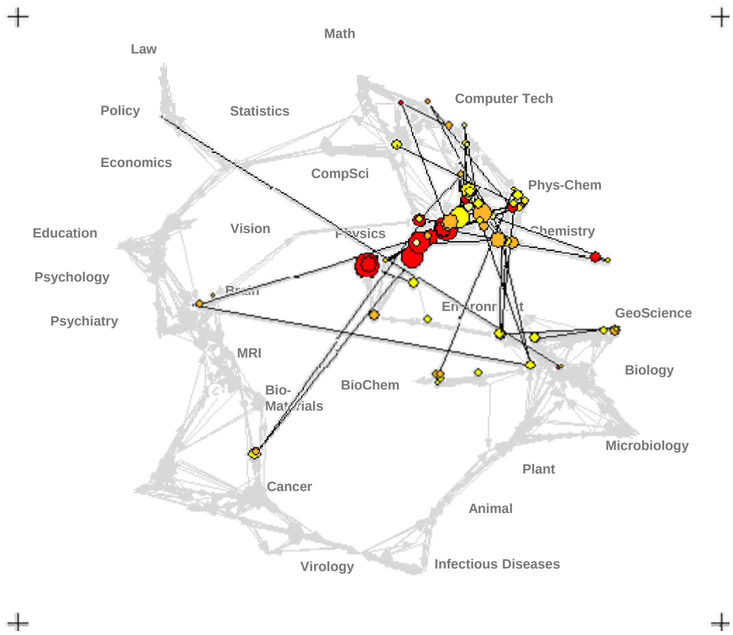
- Uses combined SCI/SSCI from 2002
  - 1.07M papers, 24.5M references, 7,300 journals
  - Bibliographic coupling of papers, aggregated to journals
- Initial ordination and clustering of journals gave 671 clusters
- Coupling counts were reaggregated at the journal cluster level to calculate the
  - (x,y) positions for each journal cluster
  - by association, (x,y) positions for each journal



Science map applications: Identifying core competency

Kevin W. Boyack, Katy Börner, & Richard Klavans (2007).

Funding patterns of the US Department of Energy (DOE)



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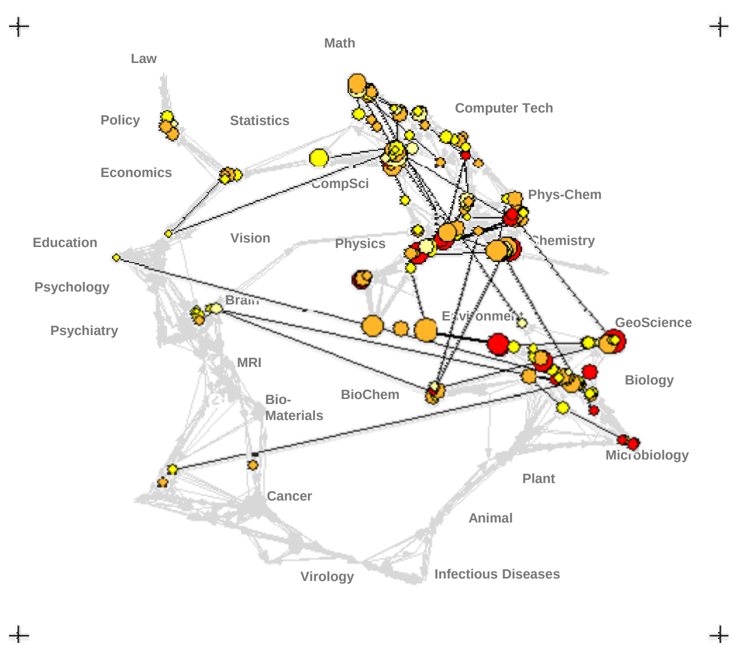

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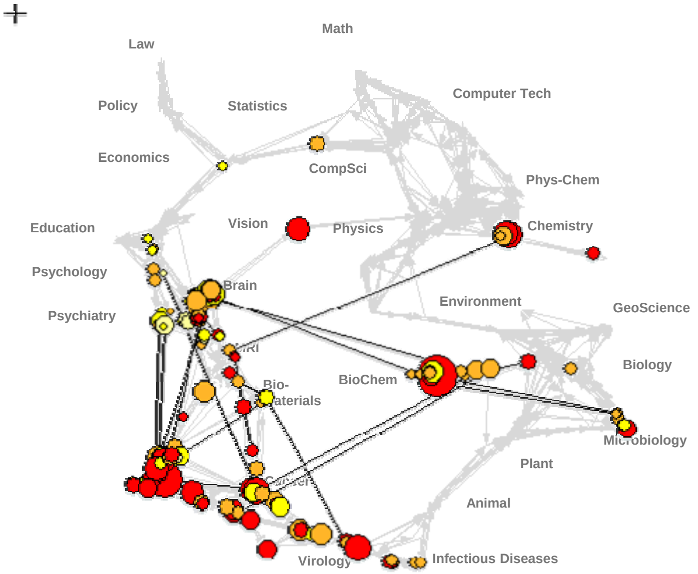


Opportunities

Advantages for Funding Agencies

- Supports monitoring of (long-term) money flow and research developments, evaluation of funding strategies for different programs, decisions on project durations, funding patterns.
- Staff resources can be used for scientific program development, to identify areas for future development, and the stimulation of new research areas.

Advantages for Researchers

- Easy access to research results, relevant funding programs and their success rates, potential collaborators, competitors, related projects/publications **(research push).**
- More time for research and teaching.

Advantages for Industry

- Fast and easy access to major results, experts, etc.
- Can influence the direction of research by entering information on needed technologies **(industry-pull)**.

Advantages for Publishers

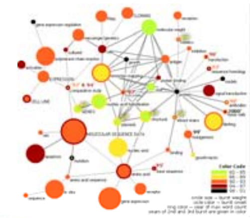
- Unique interface to their data.
- Publicly funded development of databases and their interlinkage.

For Society

- Dramatically improved access to scientific knowledge and expertise.

Overview

Computational Scientometrics



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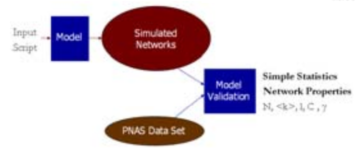

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- ➢ Scholarly Database
- ➢ Network Workbench Tool
- ➢ Mapping Science Exhibit

SDB | SCHOLARLY DATABASE

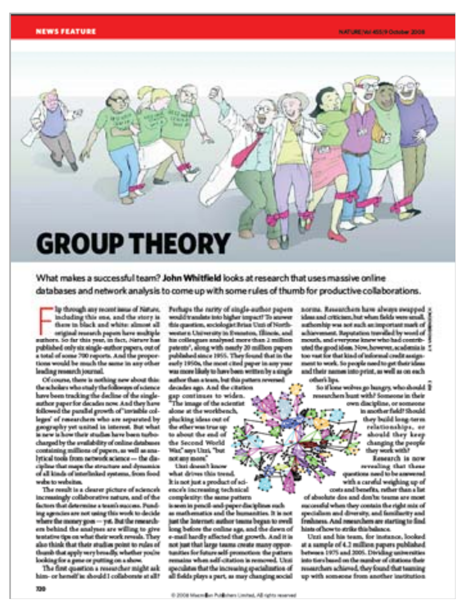
NetworkWorkbench

Information Diffusion Among Major U.S. Research Institutions

Börner, Katy, Penumarthy, Shashikant, Meiss, Mark & Ke, Weimao. (2006). Mapping the Diffusion of Information among Major U.S. Research Institutions. Scientometrics. Vol. 68(3), 415 - 426.

Questions:

1. Does space still matter in the Internet age, i.e., does one still have to study and work at major research institutions in order to have access to high quality data and expertise and to produce high quality research?
2. Does the Internet lead to more global citation patterns, i.e., more citation links between papers produced at geographically distant research instructions?



NEWS FEATURE

GROUP THEORY

What makes a successful team? John Whitfield looks at research that uses massive online databases and network analysis to come up with some rules of thumb for productive collaborations.

Contributions:

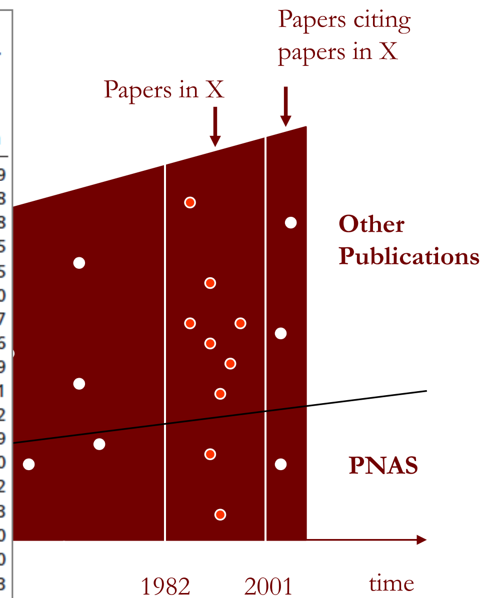
- ➢ Answer to Q1 is YES.
- ➢ Answer to Q2 is NO.
- ➢ Novel approach to analyzing the dual role of institutions as information producers and consumers and to study and visualize the diffusion of information among them.

20-Year PNAS Dataset (1982-2001)

45,120 regular articles written by 105,915 unique authors.
114,000 citation references within the set and 472,000 co-author links.

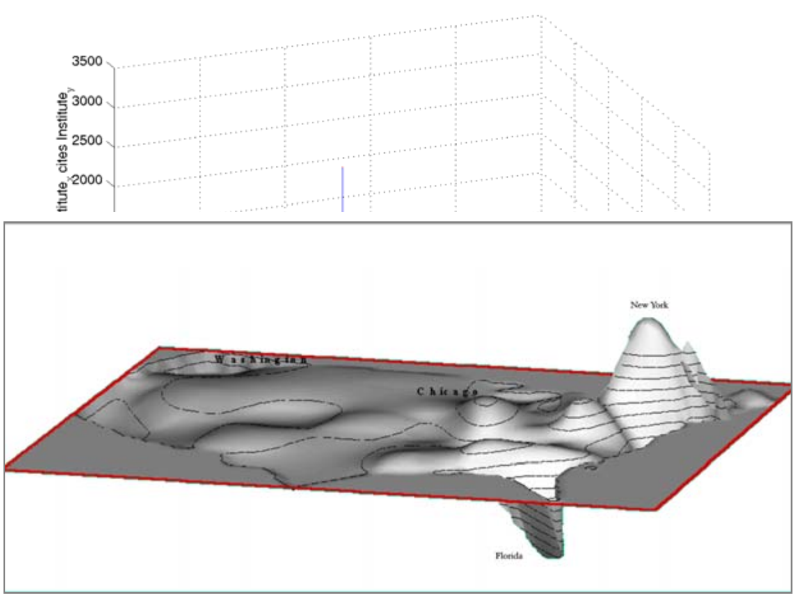
Table 1. PNAS statistics in terms of total number of papers (#p), unique authors (#a), references (#r), citations received per paper (#c), number of coauthors per paper (a#ca), and the number of citations (#c_win) within the PNAS data set for each year

Year	#p	#a	#r	#c	a#ca	#c_win
1982	1,669	5,201	46,665	56,690	3.92	6,749
1983	1,611	5,142	46,685	161,437	3.98	7,188
1984	1,695	5,583	49,834	174,161	4.22	6,928
1985	1,846	6,325	55,662	191,750	4.38	7,425
1986	2,042	7,209	64,379	218,229	4.76	7,985
1987	1,924	7,061	59,110	207,729	4.88	7,340
1988	2,035	7,471	63,116	215,227	4.8	7,547
1989	2,088	7,959	65,883	215,437	5.01	7,386
1990	2,066	8,031	66,019	207,138	5.15	7,089
1991	2,382	9,559	77,740	223,102	5.25	7,511
1992	2,500	9,812	80,949	211,238	5.29	6,932
1993	2,413	9,770	79,848	193,867	5.55	5,979
1994	2,600	10,656	86,176	187,353	5.56	5,910
1995	2,476	10,429	82,021	151,249	5.66	4,922
1996	2,765	11,803	99,061	148,622	5.96	5,013
1997	2,618	11,255	96,788	122,908	6.12	4,290
1998	2,711	12,328	100,973	107,764	6.48	3,580
1999	2,603	12,182	97,018	76,080	6.69	2,453
2000	2,501	12,201	94,181	44,131	7.6	1,354
2001	2,575	13,038	97,450	16,357	8.4	422
Total	45,120		1,509,558	3,230,469		114,003



Citation Matrix

Unsymmetrical direct citation linkage patterns among the top 500 institutions in US. High peak values in the diagonal reflect the high amount of self-citations for all institutions. Medium peak horizontal and vertical lines denote references from and citations to papers written at Harvard University.



Information Sources (Export) and Sinks (Import)

Calculate ratio of the number of references made by an institution divided by the sum of received citations and references made, multiplied by 100.

131 have a value between 0-40% acting mostly as information producers = information sources.

71 have a value between 60-100% and act mostly as information consumers – they reference a large number of papers but the number of citations they receive is comparably low = information sinks.

(Tobler, 1995)

Geographic Location of Received Citations

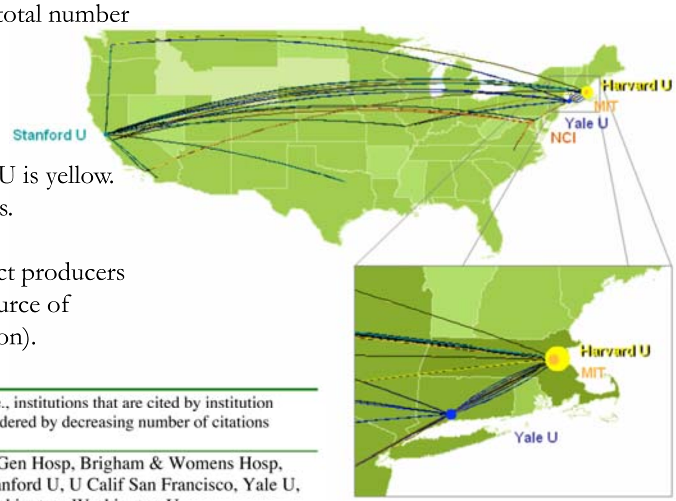
ESRI's ArcGIS program was used to show the geographic distribution of the top 500 institutions using the Albers equal area projection.
U.S. states are color coded based on the population size in the year 2000. Lighter shades of green represent lower populations.
Overlaid are the top 500 institutions, each represented by a 'citation stick'. The color and height of the stick corresponds to the number of received citations (excluding self citations).
Five institutions produced papers that attracted more than 5,000 citations and are labeled.
Harvard leads with 16,531 citations.

Information Flow Among the Top-5 Consumers and Their Top-10 Producers

U.S. states are color coded based on the total number of citations received by their institutions (excluding self citations).

Dots indicate the five producers.
Each has a different color, e.g., Harvard U is yellow.
Dot area size depicts number of citations.

Lines represent citations that interconnect producers and consumers shaded from colored (source of information) to white (sink of information).

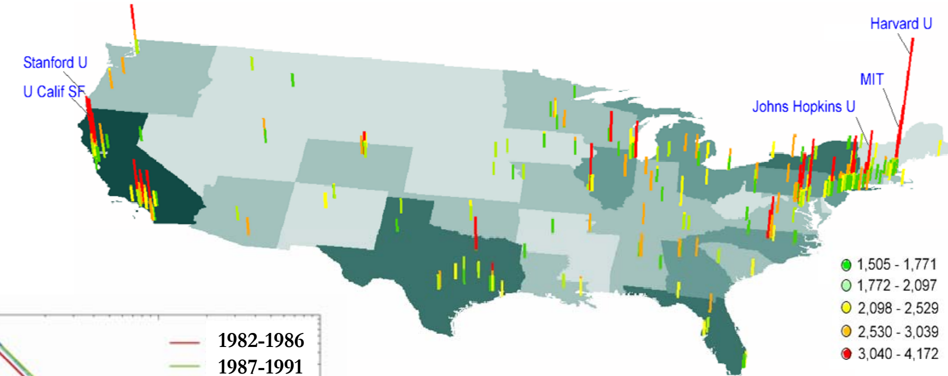


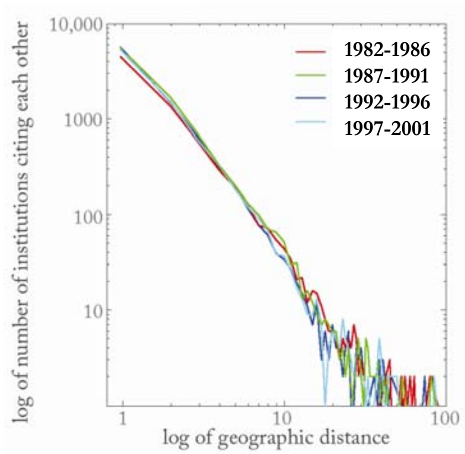
Consumers, i.e., citing institutions	# citations made	Top ten producers, i.e., institutions that are cited by institution listed in first column ordered by decreasing number of citations received.
Harvard U	13,552	MIT, Massachusetts Gen Hosp, Brigham & Womens Hosp, Johns Hopkins U, Stanford U, U Calif San Francisco, Yale U, Rockefeller U, U Washington, Washington U
U Calif SF	4,682	Harvard U, MIT, Stanford U, Johns Hopkins U, U Washington, Washington U, U Calif Berkeley, U Texas, U Calif SD, U Calif LA
MIT	4,655	Harvard U, Whitehead Inst Biomed Res, Johns Hopkins U, Stanford U, U Calif SF, Yale U, Rockefeller U, U Calif LA, Massachusetts Gen Hosp, U Calif Berkeley
NCI (zip: 20814)	4,519	Harvard U, NCI (zip: 20205), NCI (zip: 21701), MIT, Duke U, Johns Hopkins U, NIAID NICHHD, Stanford U, U Calif SF
Yale U	4,464	Harvard U, MIT, Stanford U, Rockefeller U, Johns Hopkins U, Washington U, U Calif SF, U Washington, NCI, Massachusetts Gen Hosp

Paper also shows top-5 producers and their top-10 consumers.

Changes in Citation Behavior Over Time

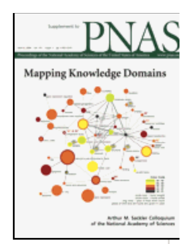
As time progresses and the amount of produced papers increases, space seems to matter more. Authors are more likely to cite papers generated by authors at close-by institutions.





1982-1986: **1.94** (R^2=91.5%)
1987-1991: **2.11** (R^2=93.5%)
1992-1996: **2.01** (R^2=90.8%)
1997-2001: **2.01** (R^2=90.7%)

Identifying Research Topics and Trends

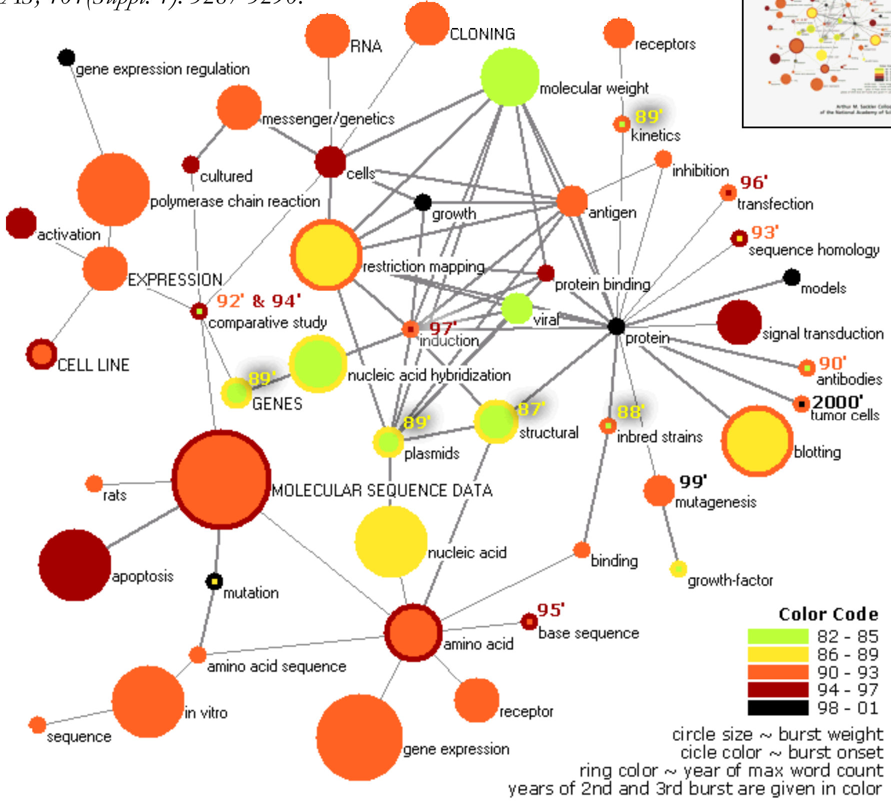


Mane & Börner. (2004) PNAS, 101(Suppl. 1): 5287-5290.

Co-word space of the top 50 highly frequent and bursty words used in the top 10% most highly cited PNAS papers 1982-2001.

Words burst first before experiencing major usage.

'Protein' and 'model' are among the highly bursty terms in 98-01 and became major research topics since then.



Modeling the Co-Evolving Author-Paper Networks

Börner, Katy, Maru, Jeegar & Goldstone, Robert. (2004). The Simultaneous Evolution of Author and Paper Networks. PNAS. Vol. 101(Suppl. 1), 5266-5273.

The TARL Model (Topics, Aging, and Recursive Linking) incorporates

- A partitioning of authors and papers into topics,
- Aging, i.e., a bias for authors to cite recent papers, and
- A tendency for authors to cite papers cited by papers that they have read resulting in a rich get richer effect.

The model attempts to capture the roles of authors and papers in the production, storage, and dissemination of knowledge.

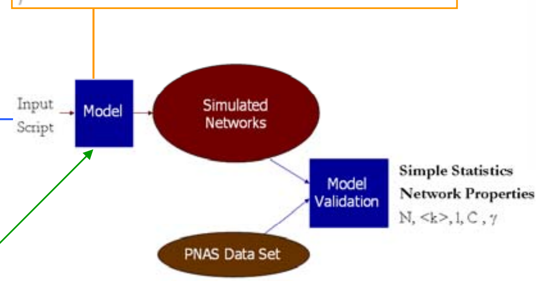
Model Assumptions

- Co-author and paper-citation networks co-evolve.
- Authors come and go.
- Papers are forever.
- Only authors that are 'alive' are able to co-author.
- All existing (but no future) papers can be cited.
- Information diffusion occurs directly via co-authorships and indirectly via the consumption of other authors' papers.

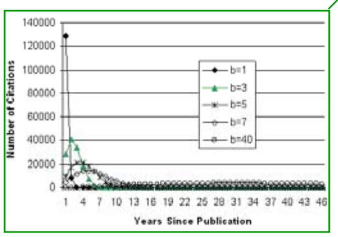
- Preferential attachment is modeled as an *emergent property* of the elementary, local networking activity of authors reading and citing papers, but also the references listed in papers.

```
----------------------------------------------
Model Parameters (0=without, 1=with)
----------------------------------------------
0/1  Topics
0/1  Co-Authors
0/1  Consider References
0    Aging Function
----------------------------------------------
Model Initialization Values
----------------------------------------------
2  # Years
5  # Authors in Start Year
5  # Papers in Start Year
2  # Papers Consumed (Referenced) per Paper
1  # Papers Produced per Author each Year
5  # Topics
1  # Co-Author(s) per Author
1  # Levels References are Considered
```

```
// Initialization
generate #_papers papers and assign a random topic to each paper;
generate #_authors authors and assign a random topic to each author;
randomly assign #_co-authors+1 authors to papers of the same topic;
// Simulation
for each year do {
    add #_new_authors new authors, deactivate authors older than #_author_age;
    for each topic do {
        randomly partition set of authors into author_groups of size #_co-authors+1;
        for each author_group do {
            for each new_paper to be produced, do {
                generate new_paper;
                randomly select #_read_ papers from existing papers;
                get all references of read_ papers up to #_reference_path_length;
                for each new_paper_reference do {
                    select a time_slice from (start year to curr_year-1) with probability given in aging_function;
                    randomly select a paper published or cited in this time_slice; as a new_paper_reference;
                    add the new_paper_reference to new_paper;
                }
            }
        }
    }
    add all new papers to the set of existing papers;
    add new links to author and paper information;
}
```



Aging function



Model Validation
The properties of the networks generated by this model are validated against the 20-year PNAS data set (1982-2001).

Table 3 Statistics for SIM data

Year	#p	#a	#r	#c	a#ca
1981	1624	3953	0	756	8.21
1982	1040	5200	31200	112161	4
1983	1118	5590	33540	21397	4
1984	1197	5985	35910	10224	4
1985	1275	6375	38250	6184	4
1986	1353	6765	40590	4687	4
1987	1432	7160	42960	3573	4
1988	1510	7550	45300	2816	4
1989	1589	7945	47670	2219	4
1990	1667	8335	50010	1853	4
1991	1745	8725	52350	1634	4
1992	1824	9120	54720	1431	4
1993	1902	9510	57060	1167	4
1994	1981	9905	59430	1040	4
1995	2059	10295	61770	767	4
1996	2137	10685	64110	632	4
1997	2216	11080	66480	522	4
1998	2294	11470	68820	400	4
1999	2373	11865	71190	265	4
2000	2451	12255	73530	125	4
2001	2529	12645	75870	0	4
Total	**37316**		**1070760**	**173853**	

Table 2. PNAS Statistics

Year	#p	#a	#r	#c	a#ca
1982	1669	5201	46665	156690	3.92
1983	1611	5142	46685	161437	3.98
1984	1695	5583	49834	174161	4.22
1985	1846	6325	55662	191750	4.38
1986	2042	7209	64379	218229	4.76
1987	1924	7061	59110	207729	4.88
1988	2035	7471	63116	215227	4.8
1989	2088	7959	65883	215437	5.01
1990	2066	8031	66019	207138	5.15
1991	2382	9559	77740	223102	5.25
1992	2500	9812	80949	211238	5.29
1993	2413	9770	79848	193867	5.55
1994	2600	10656	86176	187353	5.56
1995	2476	10429	82021	151249	5.66
1996	2765	11803	99061	148622	5.96
1997	2618	11255	96788	122908	6.12
1998	2711	12328	100973	107764	6.48
1999	2603	12182	97018	76080	6.69
2000	2501	12201	94181	44131	7.6
2001	2575	13038	97450	16357	8.4
Total	**45120**		**1509558**	**3230469**	

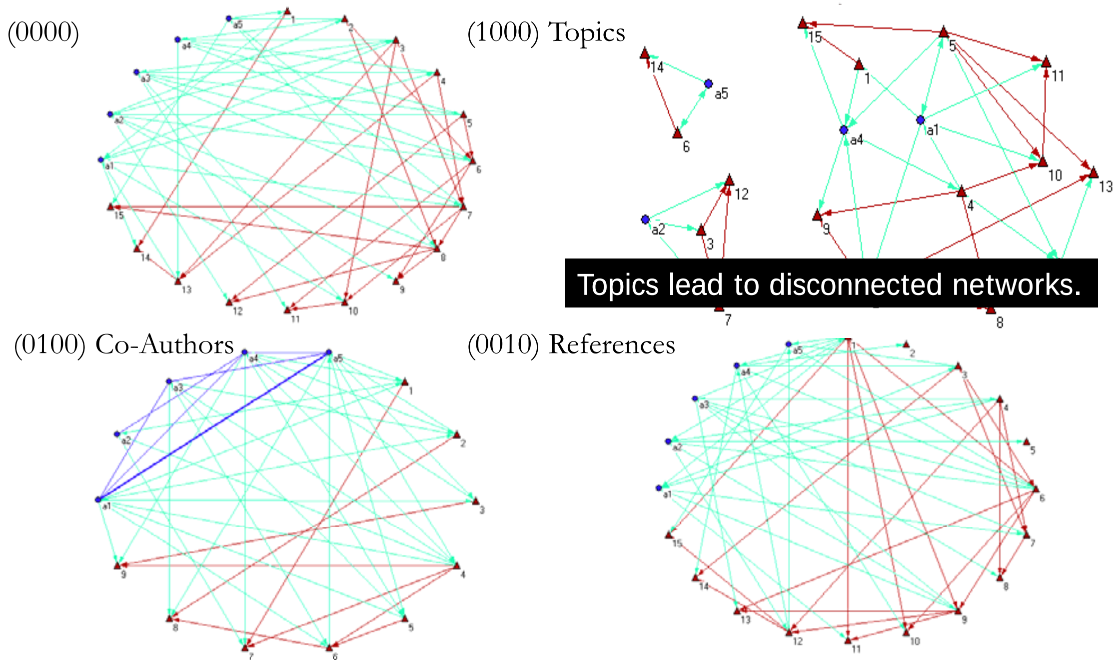
Process Model in Pseudocode & Input Parameters

If no topics are considered then the number of topics is one, i.e., all papers and authors have the same topic. If no coauthors are considered then each paper has exactly one author. If the reference path length is 0 then no references are considered for citation.


```
----------------------------------------------
Model Parameters (0=without, 1=with)
----------------------------------------------
0/1  Topics
0/1  Co-Authors
0/1  Consider References
0    Aging Function
----------------------------------------------
Model Initialization Values
----------------------------------------------
2  # Years
5  # Authors in Start Year
5  # Papers in Start Year
2  # Papers Consumed (Referenced) per Paper
1  # Papers Produced per Author each Year
5  # Topics
1  # Co-Author(s) per Author
1  # Levels References are Considered
```

```
// Initialization
generate #_papers papers and assign a random topic to each paper;
generate #_authors authors and assign a random topic to each author;
randomly assign #_co-authors+1 authors to papers of the same topic;
// Simulation
for each year do {
    add #_new_authors new authors, deactivate authors older than #_author_age;
    for each topic do {
        randomly partition set of authors into author_groups of size #_co-authors+1;
        for each author_group do {
            for each new_paper to be produced, do {
                generate new_paper;
                randomly select #_read_ papers from existing papers;
                get all references of read_ papers up to #_reference_path_length;
                for each new_paper_reference do {
                    select a time_slice from (start year to curr_year-1) with probability given in aging_function;
                    randomly select a paper published or cited in this time_slice; as a new_paper_reference;
                    add the new_paper_reference to new_paper;
                }
            }
        }
    }
    add all new papers to the set of existing papers;
    add new links to author and paper information;
}
```

The TARL Model: The Effect of Parameters

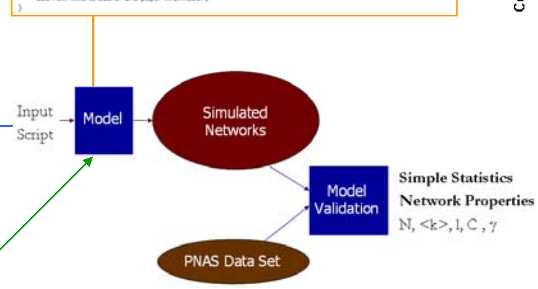


Topics lead to disconnected networks.

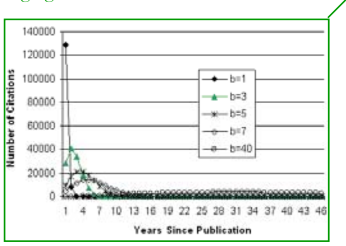
Co-authoring leads to fewer papers.

```
-----------------------------------------
Model Parameters (0=without, 1=with)
-----------------------------------------
0/1  Topics
0/1  Co-Authors
0/1  Consider References
0    Aging Function
-----------------------------------------
Model Initialization Values
-----------------------------------------
2  # Years
5  # Authors in Start Year
5  # Papers in Start Year
2  # Papers Consumed (Referenced) per Paper
1  # Papers Produced per Author each Year
5  # Topics
1  # Co-Author(s) per Author
1   # Levels References are Considered
```

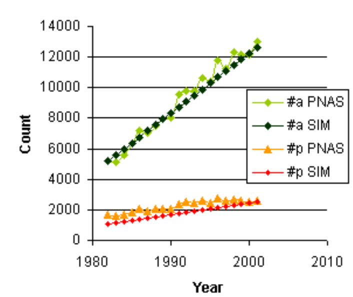
```
// Initialization
generate #_papers papers and assign a random topic to each paper;
generate #_authors authors and assign a random topic to each author;
randomly assign #_co-authors+1 authors to papers of the same topic;
// Simulation
for each year do {
    add #_new_authors new authors, deactivate authors older than #_author_age;
    for each topic do {
        randomly partition set of authors into author_groups of size #_co-authors+1;
        for each author_group do {
            for each new_paper to be produced, do {
                generate new_paper;
                randomly select #_read_ papers from existing papers;
                get all references of read_ papers up to #_reference_path_length;
                for each new_paper_reference do {
                    select a time_slice from (start year to curr_year-1) with probability given in aging_function;
                    randomly select a paper published or cited in this time_slice; as a new_paper_reference;
                    add the new_paper_reference to new_paper;
                }
            }
        }
    }
    add all new papers to the set of existing papers;
    add new links to author and paper information;
}
```



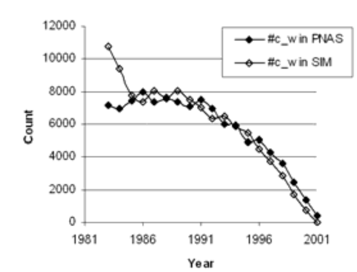
Aging function



Counts for Papers and Authors



Counts for Citations



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----------------------------------------------
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0/1  Consider References
0    Aging Function
----------------------------------------------
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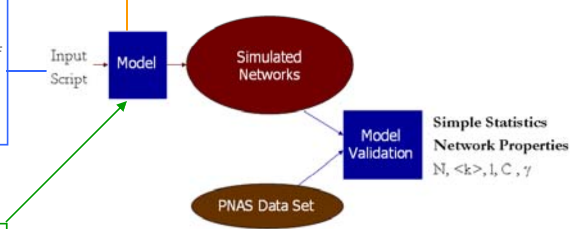
randomly assign #_co-authors+1 authors to papers o
// Simulation
for each year do {
    add #_new_authors new authors, deactivate au
    for each topic do {
        randomly partition set of authors into autho
        for each author_group do {
            for each new_paper to be produced,
                generate new_paper;
                randomly select #_read_ paper
                get all references of read_ pap
                for each new_paper_reference
                    select a time_slice from (
                    randomly select a paper p
                    add the new_paper_refere
                }
            }
        }
    }
    add all new papers to the set of existing papers;
    add new links to author and paper information;
}
```

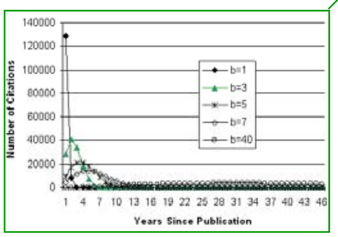
Table 2. Properties of co-author & paper citation networks comprising number of nodes n, average node degree <k>, path length l, cluster coefficient C, and power law exponent γ. Source references are given in the left column.

Network	n	<k>	l	C	γ	Reference
Co-authorship networks						
LANL	52,909	9.7	5.9	0.43	--	Newman, (2001a; 2001b; 2001c)
MEDLINE	1,520,251	18.1	4.6	0.066	--	
SPIRES	56,627	1.73	4.0	0.726	1.2	
NCSTRL	11,994	3.59	9.7	0.496	--	
Math.	70,975	3.9	9.5	0.59	2.5	Barabasi et al., (2002)
Neurosci.	209,293	11.5	6	0.76	2.1	
PNAS	105,915	8.97	5.89	0.399	2.54	
Paper-citation networks						
ISI	783,339	8.57	--	--	3	Redner, (1998)
PhysRev	24,296	14.5	--	--	3	
PNAS	45,120	3.53	--	0.081	2.29	
SIM	37,114	2.13	--	0.074	2.05	

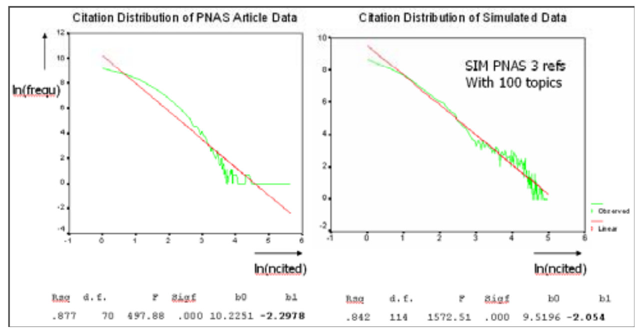


Co-Author and Paper-Citation Network Properties

Aging function



Power Law Distributions




```
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Model Parameters (0=without, 1=with)
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1  # Co-Author(s) per Author
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        for each author_group do {
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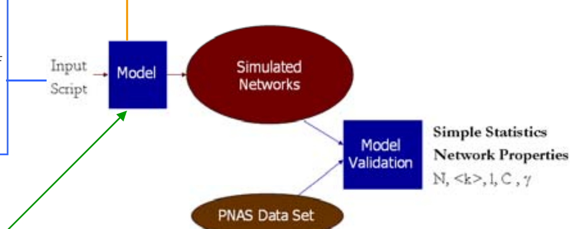
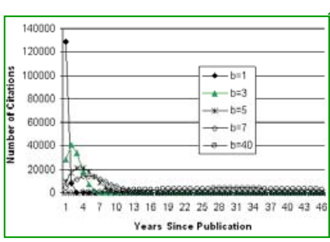
                generate new_paper;
                randomly select #_read_ papers from existing papers;
                get all references of read_ papers up to #_reference_path_length;
                for each new_paper_reference do {
                    select a time_slice from (start year to curr_year-1) with probability given in aging_function;
                    randomly select a paper published or cited in this time_slice; as a new_paper_reference;
                    add the new_paper_reference to new_paper;
                }
            }
        }
    }
    add all new papers to the set of existing papers;
    add new links to author and paper information;
}
```



Aging function

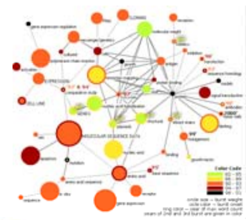


Topics: The number of topics is linearly correlated with the clustering coefficient of the resulting network: C= 0.000073 * #topics. Increasing the number of topics increases the power law exponent as authors are now restricted to cite papers in their own topics area.

Aging: With increasing b, and hence increasing the number of older papers cited as references, the clustering coefficient decreases. Papers are not only clustered by topic, but also in time, and as a community becomes increasingly nearsighted in terms of their citation practices, the degree of temporal clustering increases.

References/Recursive Linking: The length of the chain of paper citation links that is followed to select references for a new paper also influences the clustering coefficient. Temporal clustering is ameliorated by the practice of citing (and hopefully reading!) the papers that were the earlier inspirations for read papers.

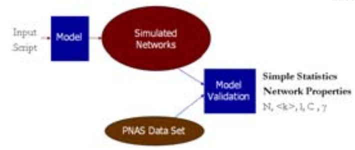
Overview



Computational Scientometrics

Case Studies:

- Information Diffusion Among Major U.S. Research Institutions
- Identifying Research Topics and Trends
- Modeling the Co-Evolving Author-Paper Networks



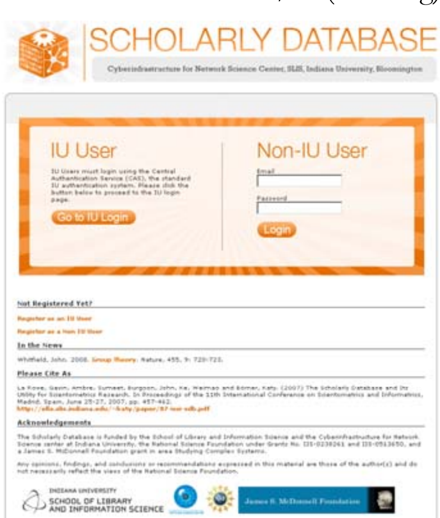
Science of Science Cyberinfrastructures

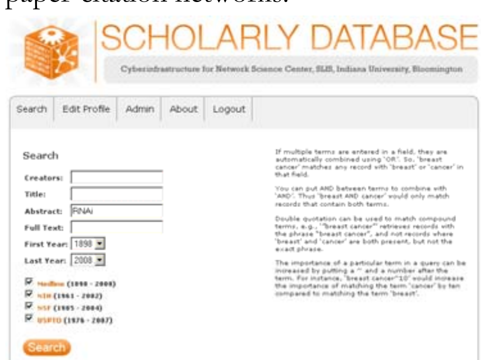
- Scholarly Database
- Network Workbench Tool

- Mapping Science Exhibit

Scholarly Database: Web Interface

Search across publications, patents, grants.
Download records and/or (evolving) co-author, paper-citation networks.





Register for free access at http://sdb.slis.indiana.edu

Scholarly Database: # Records & Years Covered

Datasets available via the Scholarly Database

Dataset	#Records	Years Coverage	updated	Restricted Access
Medline	16,053,495	1898-2008	Yes	
PhysRev	398,005	1893-2006		Yes
PNAS	16,167	1997-2002		Yes
JCR	59,078	1974,1979,1984,1989,1994-2004		Yes
USPTO	3,710,952	1976-2007	Yes	
NSF	174,835	1985-2003	Yes	
NIH	1,043,804	1972-2002	Yes	
Total	**21,456,336**	**1893-2008**	**4**	**3**

Aim for comprehensive temporal, geospatial, and topic coverage.

Network Workbench (NWB) Project

Investigators: Katy Börner, Albert-Laszlo Barabasi, Santiago Schnell, Alessandro Vespignani & Stanley Wasserman, Eric Wernert

Software Team: Lead: Micah Linnemeier

Members: Patrick Phillips, Russell Duhon, Tim Kelley & Ann McCranie

Previous Developers: Weixia (Bonnie) Huang, Bruce Herr, Heng Zhang, Duygu Balcan, Bryan Hook, Ben Markines, Santo Fortunato, Felix Terkhorn, Ramya Sabbineni, Vivek S. Thakre & Cesar Hidalgo

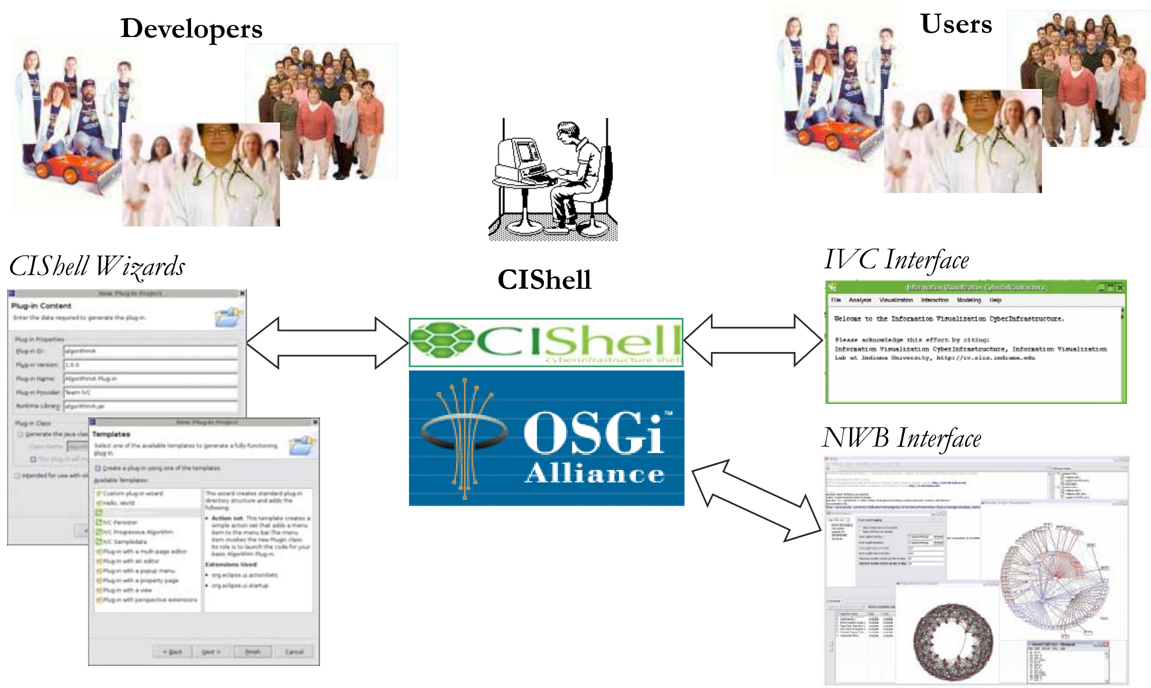
Goal: Develop a large-scale network analysis, modeling and visualization toolkit for physics, biomedical, and social science research.

Amount: $1,120,926, NSF IIS-0513650 award

Duration: Sept. 2005 - Aug. 2009

Website: http://nwb.slis.indiana.edu

Serving Non-CS Algorithm Developers & Users



See https://nwb.slis.indiana.edu/community July 1st, 2008

Algorithms Currently Available

Preprocessing Edit

- **Remove Nodes**
  - Extract Top Nodes
  - Extract Nodes Above or Below Val
  - Delete High Degree Nodes
  - Delete Random Nodes
  - Delete Isolates
- **Remove Edges**
  - Extract Top Edges
  - Extract Edges Above or Below Vali
  - Remove Self Loops
  - Trim By Degree[?]
  - Pathfinder Network Scaling
- **Sampling**
  - Snowball Sampling (n nodes)
  - Node Sampling
  - Edge Sampling
- **Transformations**
  - Symmetrize
  - Dichotomize
  - Multipartite Joining

Modeling Edit

- **General**
  - Random Graph
  - Watts-Strogatz Small World
  - Barabási-Albert Scale-Free
- **Structured**
  - CAN
  - Chord
- **Unstructured**
  - Hypergrid
  - PRU
- **Other**
  - TARL
  - Discrete Network Dynamics

Analysis Edit

- **General Purpose**
  - Network Analysis Toolkit[?]
- **Unweighted & Undirected**
  - **Based on degree/**
    - Node Degree
    - Node Distribution
  - **Based on clustering**
    - k-Nearest Neighbor
    - Watts Strogatz Clustering Coefficie
    - Watts Strogatz Clustering Coefficie
  - **Based on path**
    - Diameter
    - Average Shortest Path
    - Shortest Path Distribution
    - Node Betweenness Centrality
  - **Based on components**
    - Connected Components
    - Weak Component Clustering
  - **K-Core**
    - Extract K-Core[?]
    - Annotate K-Coreness[?]
- **Unweighted & Directed**
  - **Based on degree**
    - Node Indegree
    - Node Outdegree
    - Indegree Distribution
    - Outdegree Distribution
  - **Based on local graph structure**
    - k-Nearest Neighbor
    - Single Node In-Out Degree Correla
  - **Unnamed Category?**
    - Page Rank
  - **Based on local graph structure :**
    - Dyad Reciprocity[?]
    - Arc Reciprocity[?]
    - Adjacency Transitivity[?]
  - **Based on components**
    - Weak Component Clustering
    - Extract Attractors[?]

Visualization Edit

- **Tools**
  - GUESS
  - GnuPlot[?]
- **Predefined Positions Layout**
  - DrL (VxOrd)
  - Pre-defined Positions (prefuse beta)[?]
- **Move**
  - Circular
- **Tree Layouts**
  - Radial Tree (prefuse alpha)
  - Radial Tree with Annotations (prefuse beta)[?]
  - Tree Map
  - Tree View
  - Balloon Graph (prefuse alpha)[?]
- **Network Layouts**
  - Force Directed with Annotation (prefuse beta)
  - Kamada-Kawai (JUNG)
  - Fruchterman-Reingold (JUNG)
  - Fruchterman-Reingold with Annotation (prefuse beta)
  - Spring (JUNG)
  - Small World (prefuse alpha)
- **Other Layouts**
  - Parallel Coordinates (demo)[?]
  - LaNet (k-Core Decomposition)

Scientometrics Edit

- **Extract Network From Table**
  - Extract Co-Authorship Network
  - Extract Co-Occurrence Network From Table[?]
  - Extract Directed Network From Table[?]
- **Extract Network From Another Network**
  - Extract Bibliographic Coupling Similarity Network
  - Extract Co-Citation Similarity Network[?]
- **Cleaning**
  - Remove ISI Duplicate Records
  - Detect Duplicate Nodes
  - Remove Rows With Multitudinous Fields[?]

EpiC will Build on and Extend NWB

INDIANA UNIVERSITY

IU News Room

IU News from all eight campuses

Sunday, May 4, 2008

Browse by Campus | Services & Resources

Browse by Topic: Arts & Humanities, Athletics, Business, Education, General, Health & Medicine, Law, Public & Environmental Affairs, Science, Social Science, Technology

Multimedia News

Search GO | For Journalists | Archives | Site Index | Contact Us | Public Affairs

Newsroom Home > Indiana University Media Relations > News Release

Last modified: Tuesday, April 8, 2008

$1.2 million NIH project will help track and predict epidemics

E-mail this page | Print this page

FOR IMMEDIATE RELEASE
April 8, 2008

BLOOMINGTON, Ind. -- The National Institutes of Health has given $1.2 million to Indiana University researchers to build the ultimate international epidemic research tool.

Media Contacts
- Neal Moore ngmoore@indiana.edu 317-278-9208
- David Bricker brickerd@indiana.edu 812-856-9035

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- General News
- Graduate Studies
- Life Sciences
- Science
- Technology

More Topics >>

News by Category

Mapping Science Exhibit – 10 Iterations in 10 years

http://scimaps.org/

The Power of Maps (2005)

Science Maps for Economic Decision Makers (2008)

The Power of Reference Systems (2006)

Science Maps for Science Policy Makers (2009)
Science Maps for Scholars (2010)
Science Maps as Visual Interfaces to Digital Libraries (2011)
Science Maps for Kids (2012)
Science Forecasts (2013)

The Power of Forecasts (2007)

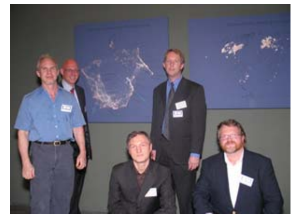
How to Lie with Science Maps (2014)

Exhibit has been shown in 49 venues on four continents. Also at
- NSF, 10th Floor, 4201 Wilson Boulevard, Arlington, VA.
- Chinese Academy of Sciences, China, May 17-Nov. 15, 2008.
- University of Alberta, Edmonton, Canada, Nov 10-Jan 31, 2009
- Center of Advanced European Studies and Research, Bonn, Germany, Dec. 11-19, 2008.

ORDER MAPS

Illuminated Diagram Display

W. Bradford Paley, Kevin W. Boyack, Richard Kalvans, and Katy Börner (2007) Mapping, Illuminating, and Interacting with Science. SIGGRAPH 2007.



Large-scale, high resolution prints illuminated via projector or screen.

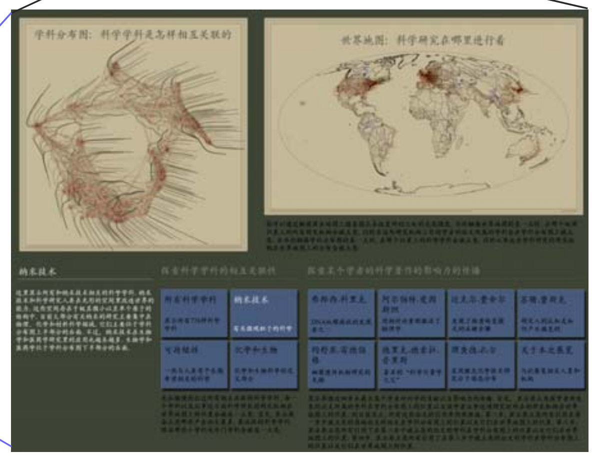
Questions:

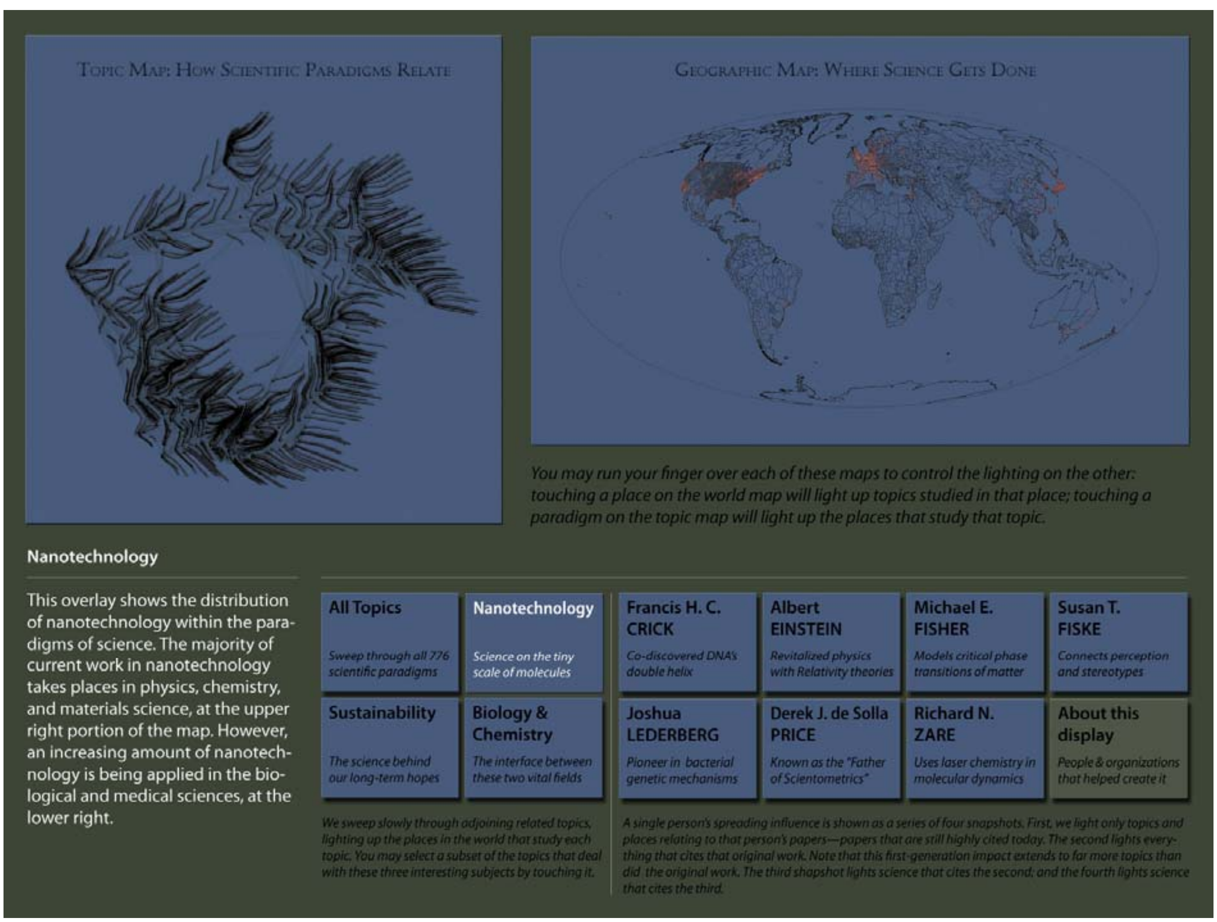
- Who is doing research on what topic and where?
- What is the 'footprint' of interdisciplinary research fields?
- What impact have scientists?

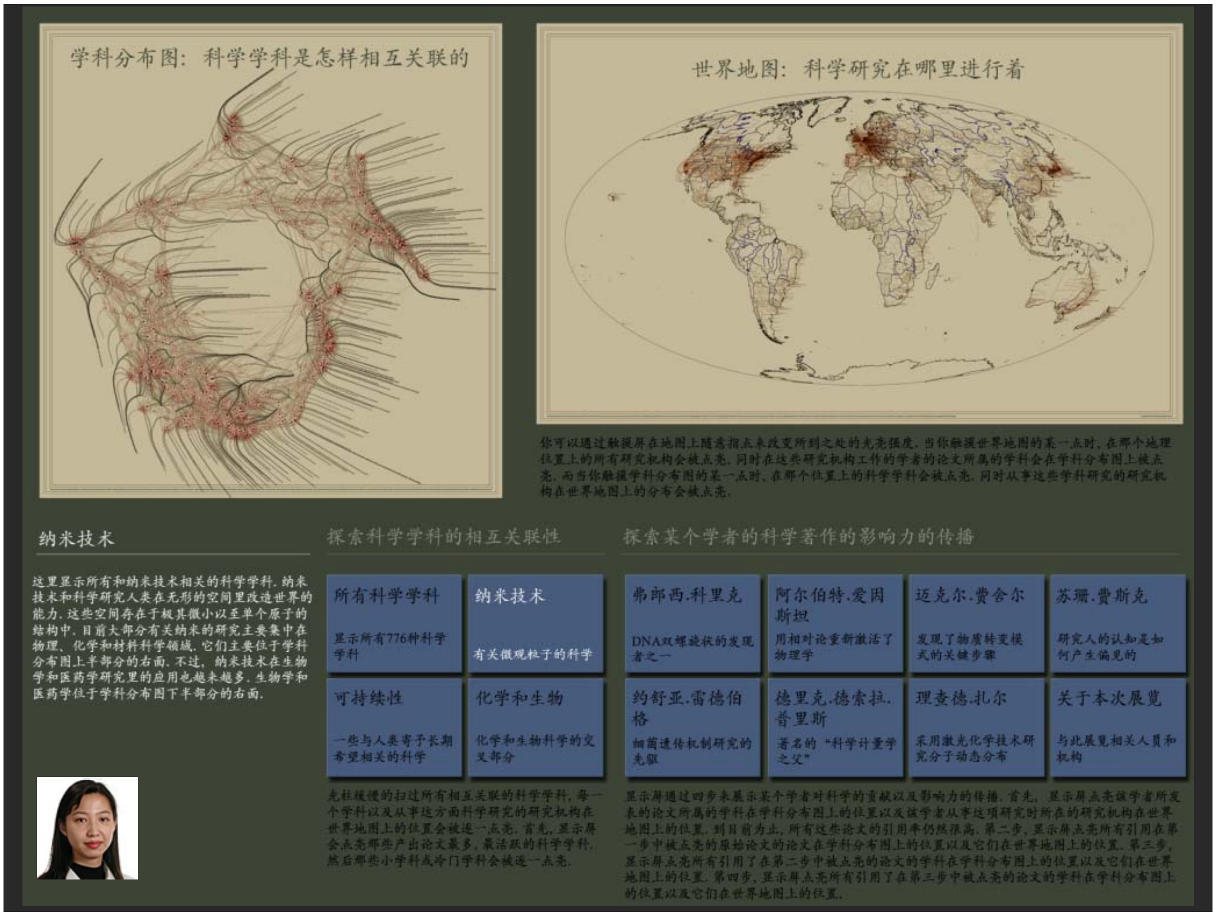
Interactive touch panel.

Contributions:

- Interactive, high resolution interface to access and make sense of data about scholarly activity.



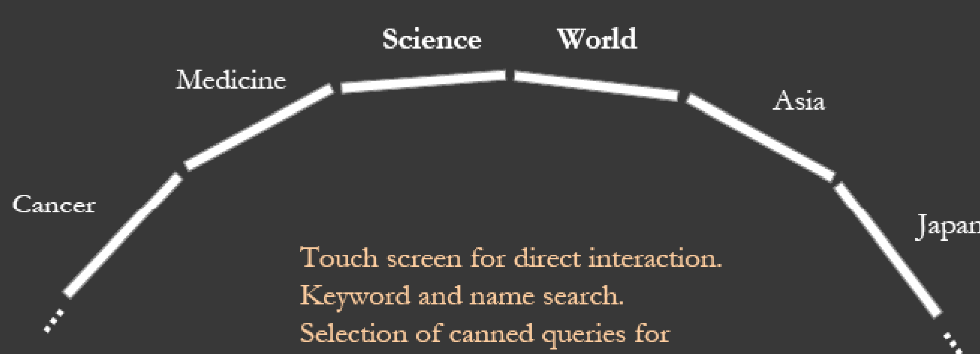




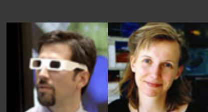
Re-implementation of Illuminated Diagram Software

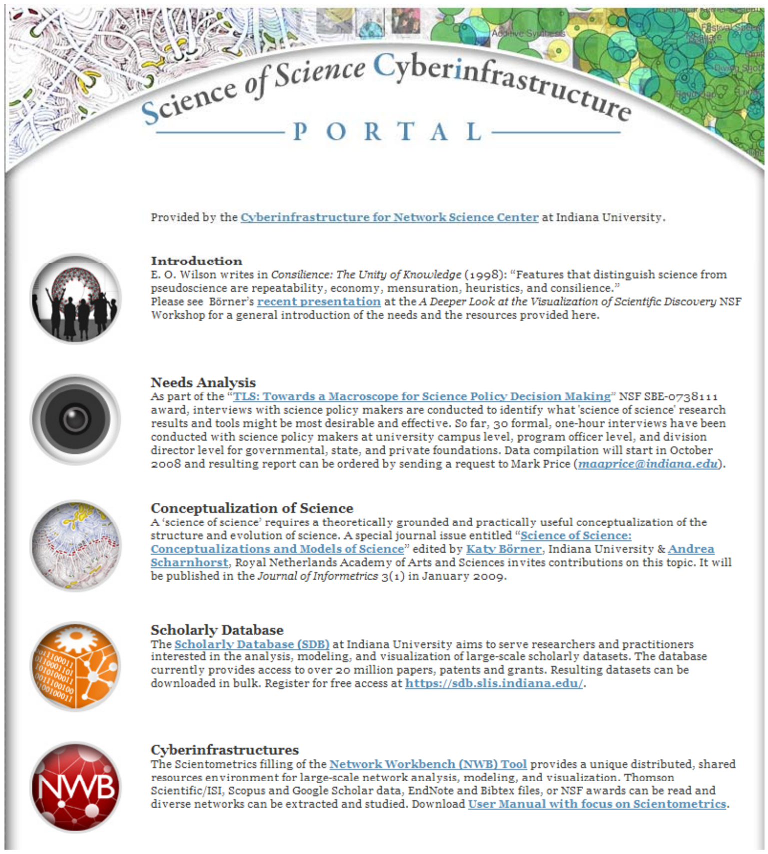
by Advanced Visualization Lab, Indiana University

Drives unlimited number of ID screens.



Touch screen for direct interaction.
Keyword and name search.
Selection of canned queries for
- interdisciplinary research areas
- famous people
- activity patterns, e.g., bursts, trends, etc.





Science of Science Cyberinfrastructure

PORTAL

Provided by the Cyberinfrastructure for Network Science Center at Indiana University.

Introduction
E. O. Wilson writes in *Consilience: The Unity of Knowledge* (1998): "Features that distinguish science from pseudoscience are repeatability, economy, mensuration, heuristics, and consilience."
Please see Börner's recent presentation at the *A Deeper Look at the Visualization of Scientific Discovery* NSF Workshop for a general introduction of the needs and the resources provided here.

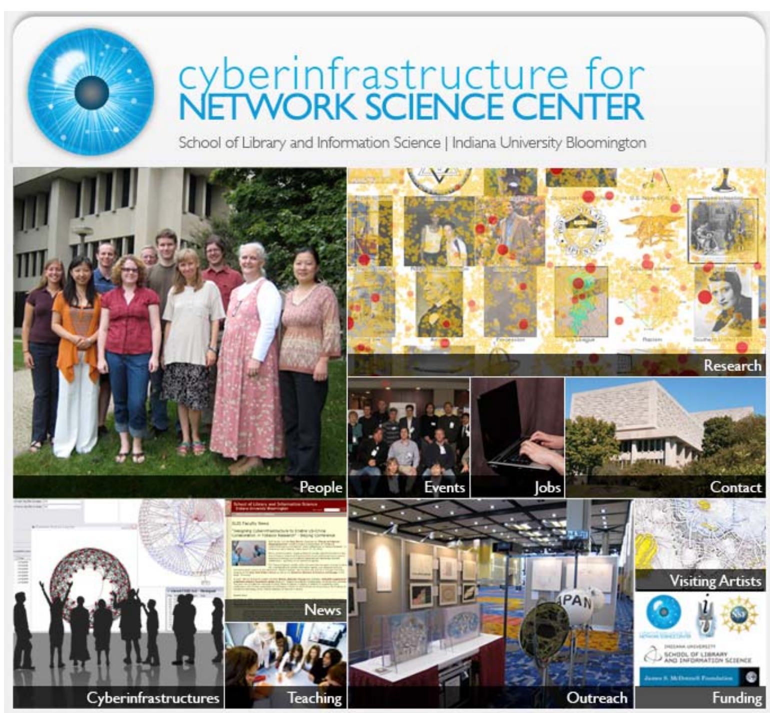
Needs Analysis
As part of the "TLS: Towards a Macroscope for Science Policy Decision Making" NSF SBE-0738111 award, interviews with science policy makers are conducted to identify what 'science of science' research results and tools might be most desirable and effective. So far, 30 formal, one-hour interviews have been conducted with science policy makers at university campus level, program officer level, and division director level for governmental, state, and private foundations. Data compilation will start in October 2008 and resulting report can be ordered by sending a request to Mark Price (maaprice@indiana.edu).

Conceptualization of Science
A 'science of science' requires a theoretically grounded and practically useful conceptualization of the structure and evolution of science. A special journal issue entitled "Science of Science: Conceptualizations and Models of Science" edited by Katy Börner, Indiana University & Andrea Scharnhorst, Royal Netherlands Academy of Arts and Sciences invites contributions on this topic. It will be published in the *Journal of Informetrics* 3(1) in January 2009.

Scholarly Database
The Scholarly Database (SDB) at Indiana University aims to serve researchers and practitioners interested in the analysis, modeling, and visualization of large-scale scholarly datasets. The database currently provides access to over 20 million papers, patents and grants. Resulting datasets can be downloaded in bulk. Register for free access at https://sdb.slis.indiana.edu/.

Cyberinfrastructures
The Scientometrics filling of the Network Workbench (NWB) Tool provides a unique distributed, shared resources environment for large-scale network analysis, modeling, and visualization. Thomson Scientific/ISI, Scopus and Google Scholar data, EndNote and Bibtex files, or NSF awards can be read and diverse networks can be extracted and studied. Download User Manual with focus on Scientometrics.

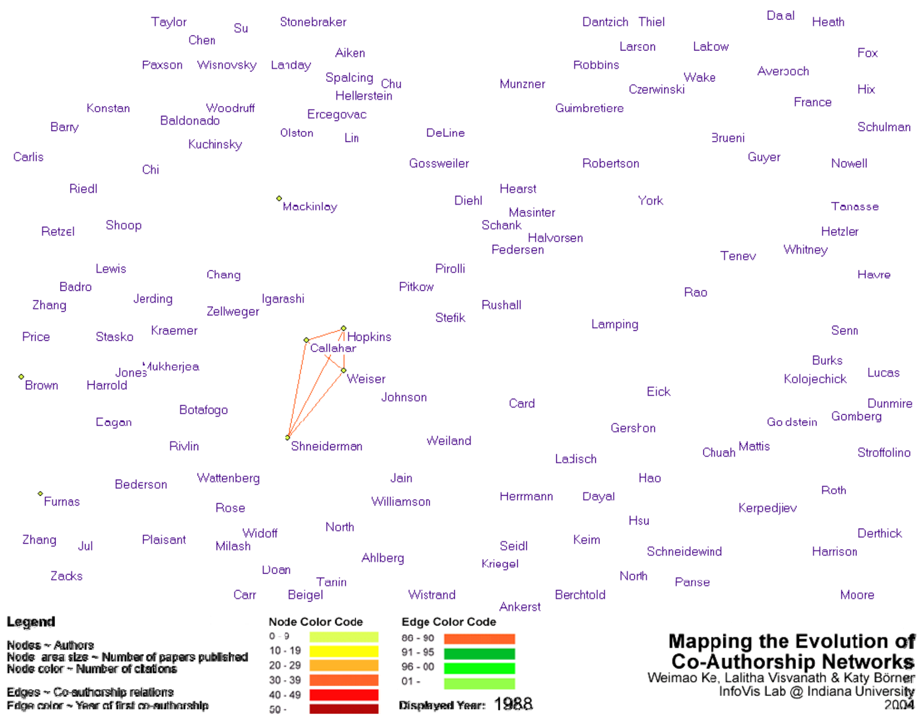
http://sci.slis.indiana.edu



http://cns.slis.indiana.edu

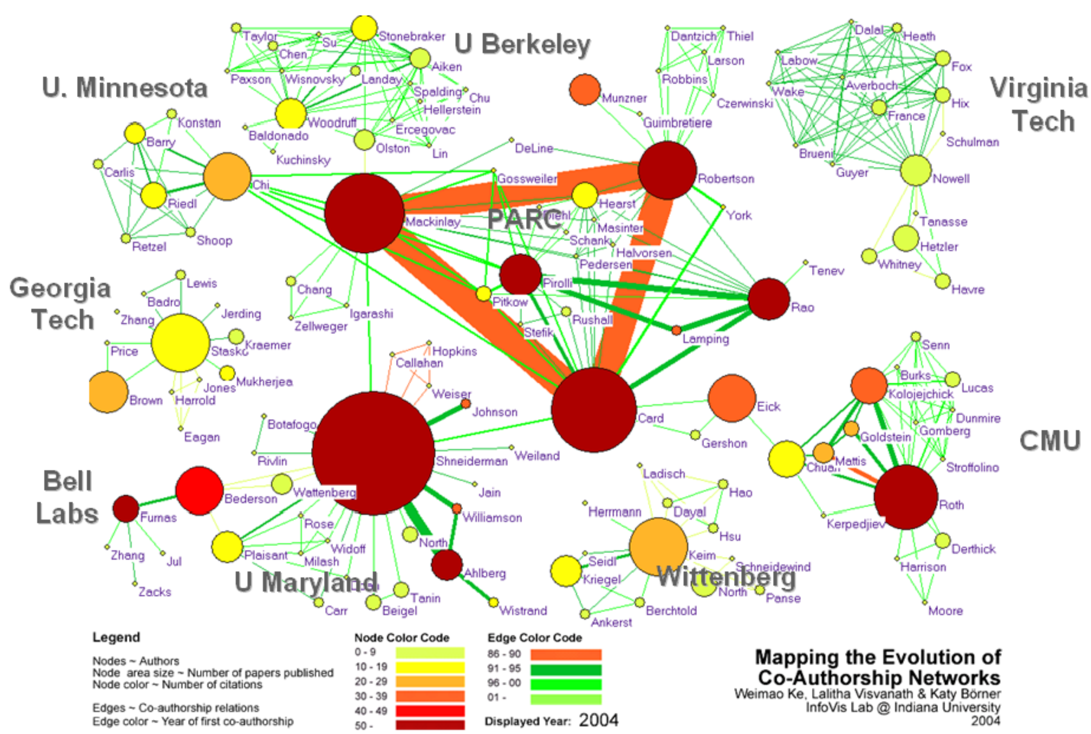
Mapping the Evolution of Co-Authorship Networks

Ke, Visvanath & Börner, (2004) Won 1st price at the IEEE InfoVis Contest.



Mapping the Evolution of Co-Authorship Networks

Ke, Visvanath & Börner, (2004) Won 1st price at the IEEE InfoVis Contest.



Studying the Emerging Global Brain: Analyzing and Visualizing the Impact of Co-Authorship Teams

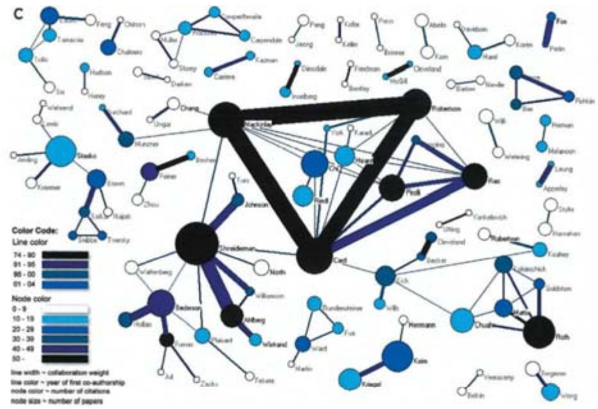
Börner, Dall'Asta, Ke & Vespignani (2005) Complexity, 10(4):58-67.

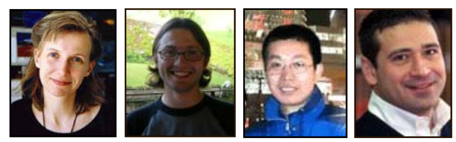
Research question:

- Is science driven by prolific single experts or by high-impact co-authorship teams?

Contributions:

- New approach to allocate citational credit.
- Novel weighted graph representation.
- Visualization of the growth of weighted co-author network.
- Centrality measures to identify author impact.
- Global statistical analysis of paper production and citations in correlation with co-authorship team size over time.
- Local, author-centered entropy measure.

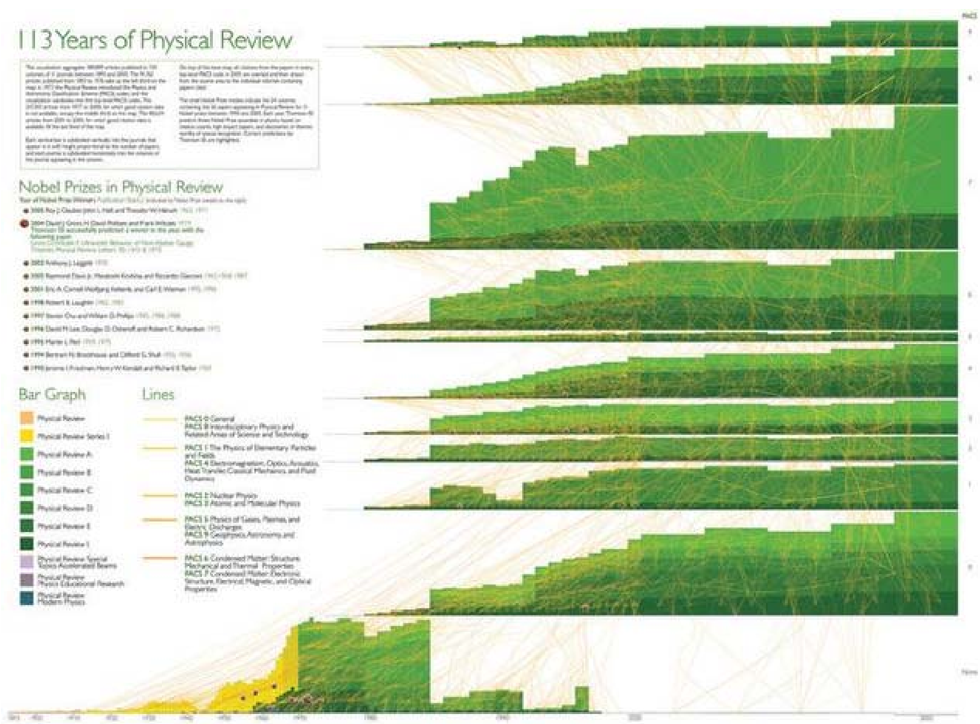




113 Years of Physical Review

http://scimaps.org/dev/map_detail.php?map_id=171

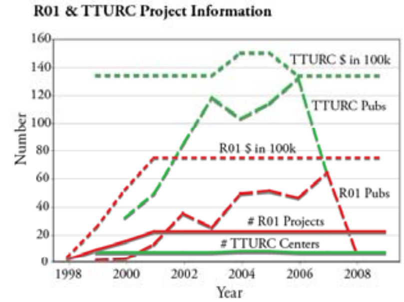
Bruce W. Herr II and Russell Duhon (Data Mining & Visualization), Elisha F. Hardy (Graphic Design), Shashikant Penumarthy (Data Preparation) and Katy Börner (Concept)

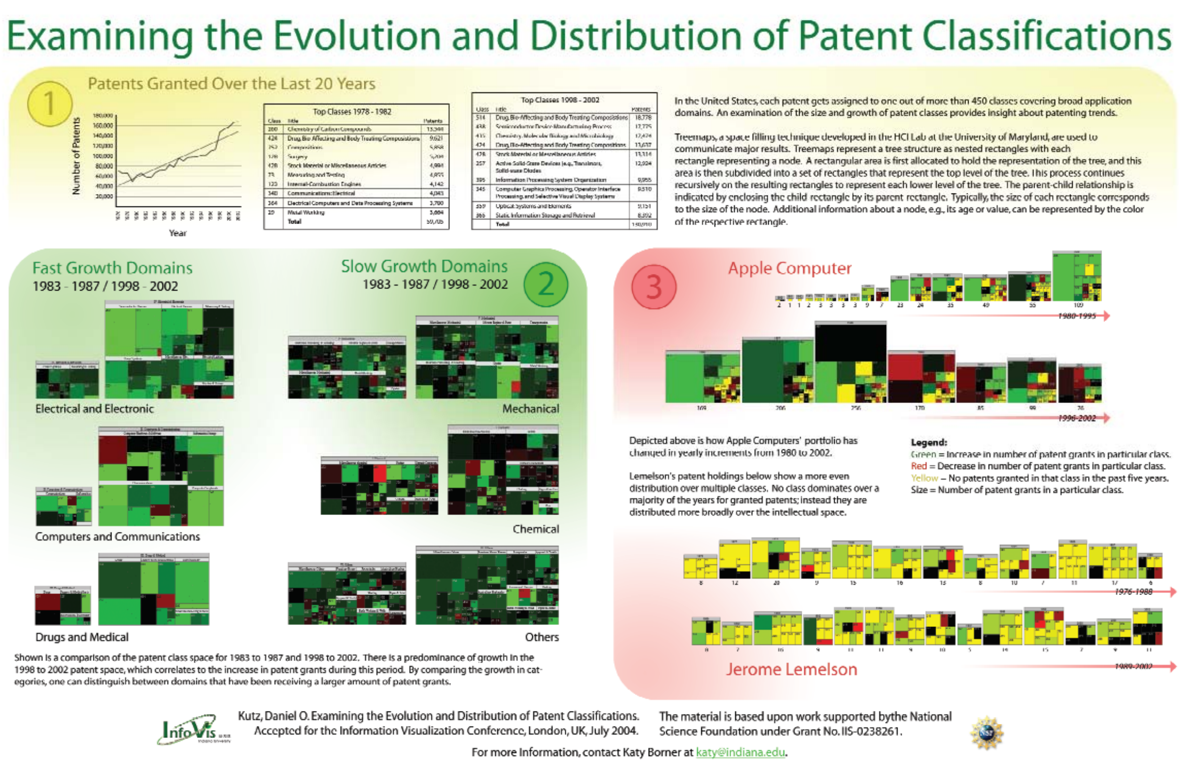


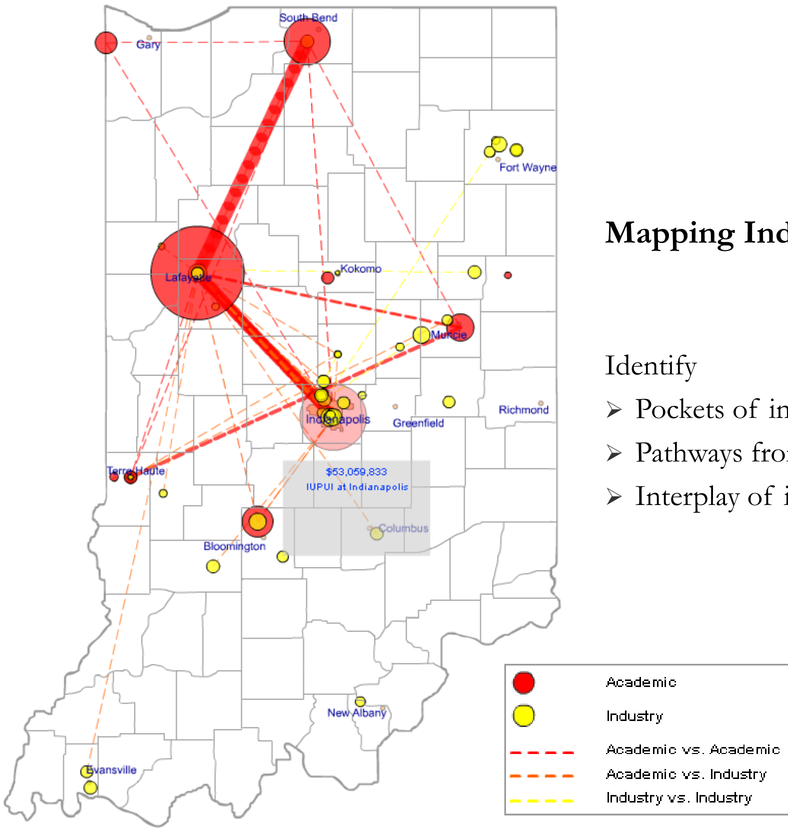
Mapping Transdisciplinary Tobacco Use Research Centers Publications

Compare R01 investigator based funding with TTURC Center awards in terms of number of publications and evolving co-author networks.

Zoss & Börner, forthcoming.







Mapping Indiana's Intellectual Space

Identify

- Pockets of innovation
- Pathways from ideas to products
- Interplay of industry and academia

Wikipedian Activity

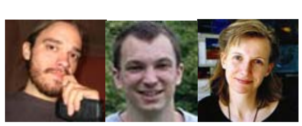
Studying large scale social networks such as Wikipedia

Vizzards 2007 Entry

Second Sight: An Emergent Mosaic of Wikipedian Activity, The NewScientist, May 19, 2007

Rendered as Google Map:
http://scimaps.org/maps/wikipedia

Jan 8th, 2008 Data Version on Gigapan:
http://gigapan.org/viewGigapan.php?id=5042



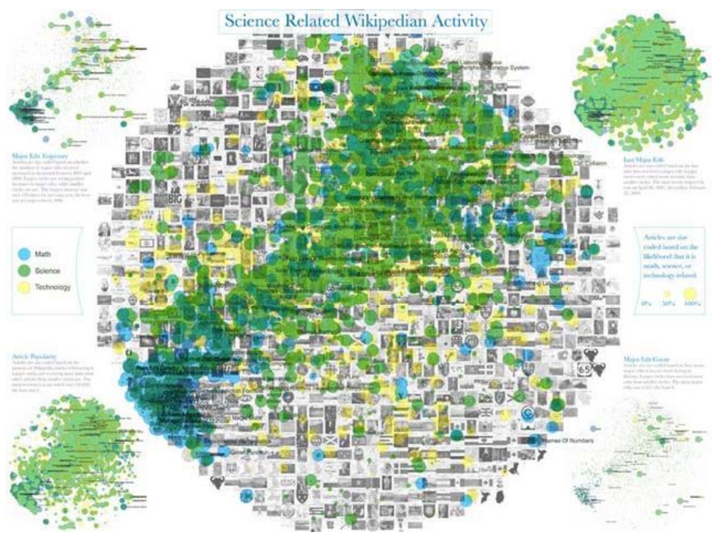
Science Related Wikipedian Activity

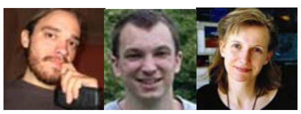
http://scimaps.org/dev/map_detail.php?map_id=165

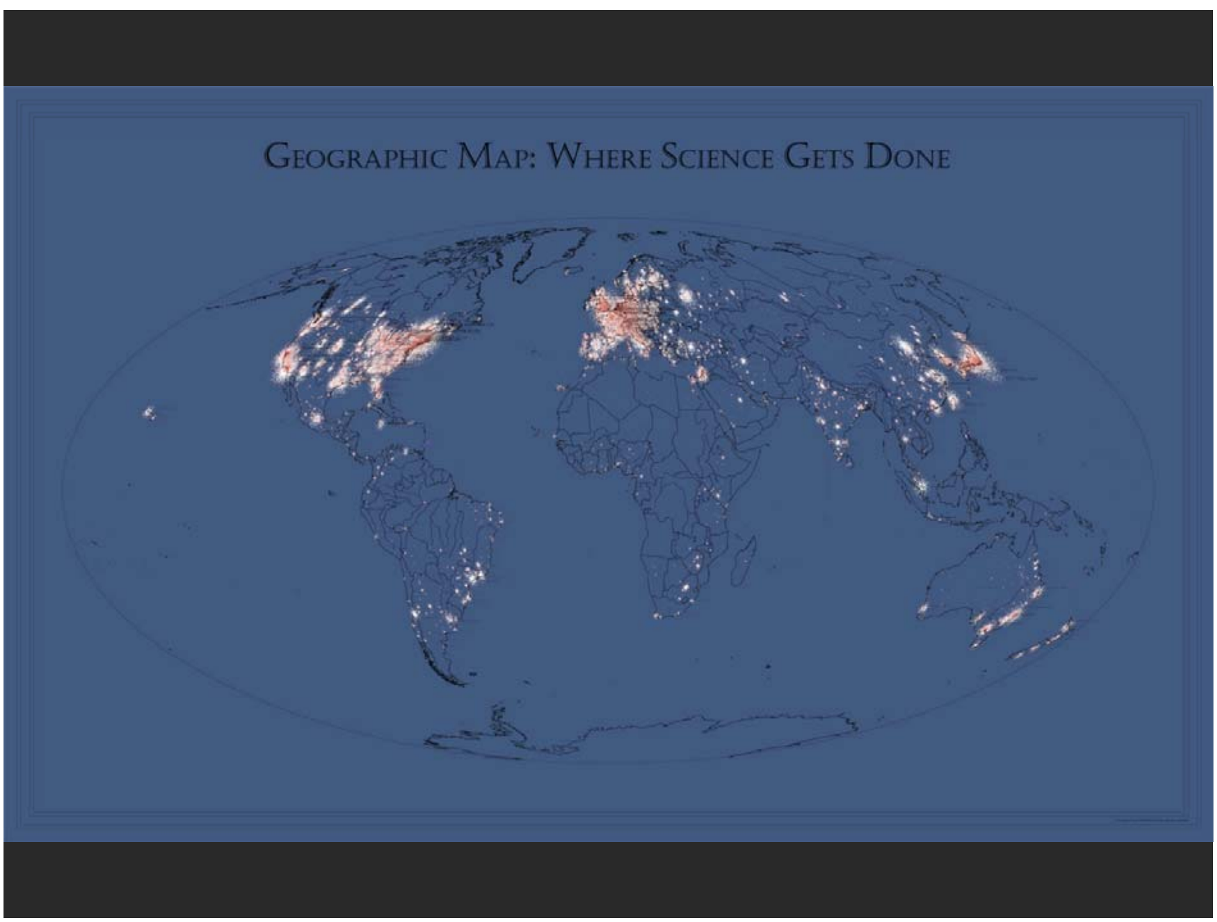
Same base map.

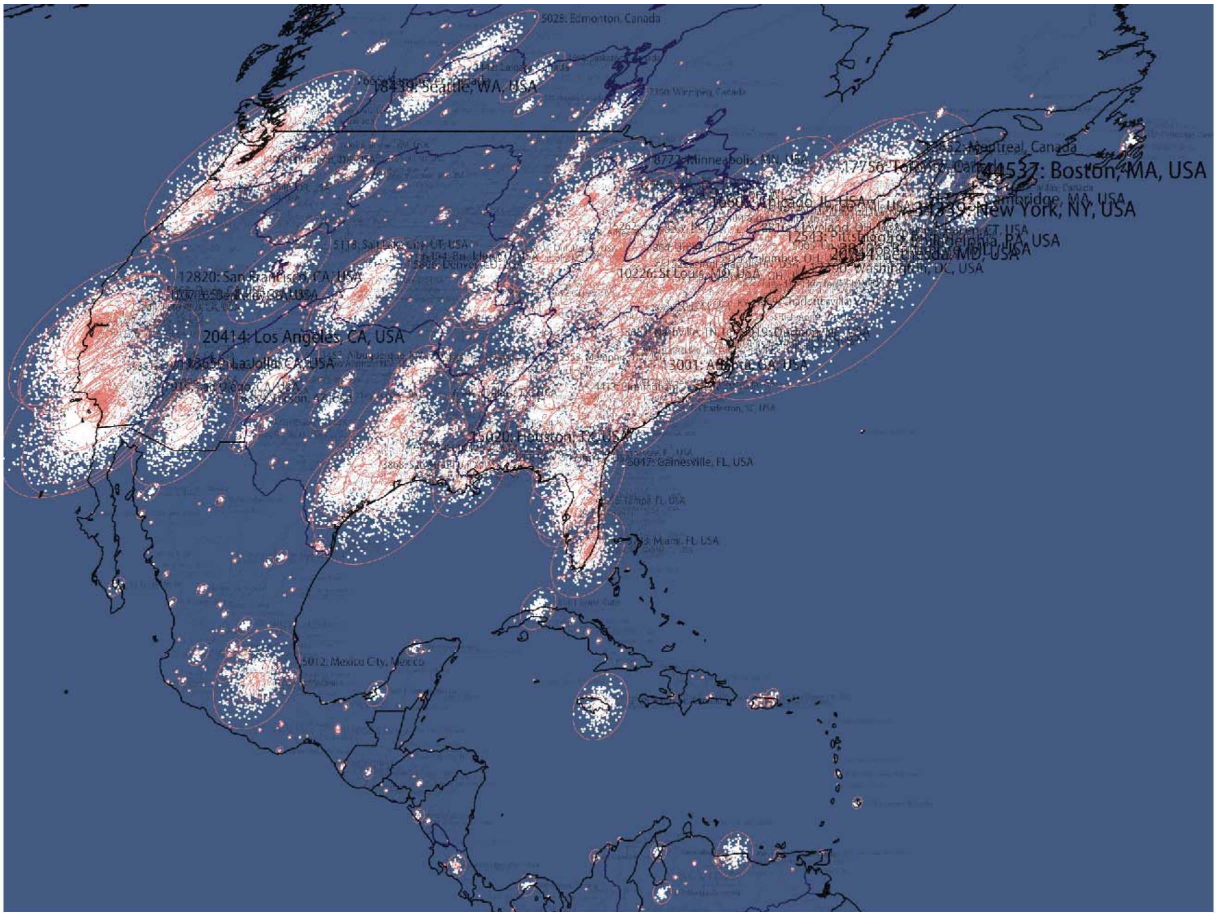
Overlaid are 3,599 math (blue), 6,474 science (green), and 3,164 technology relevant articles (yellow).
All other articles are given in grey.

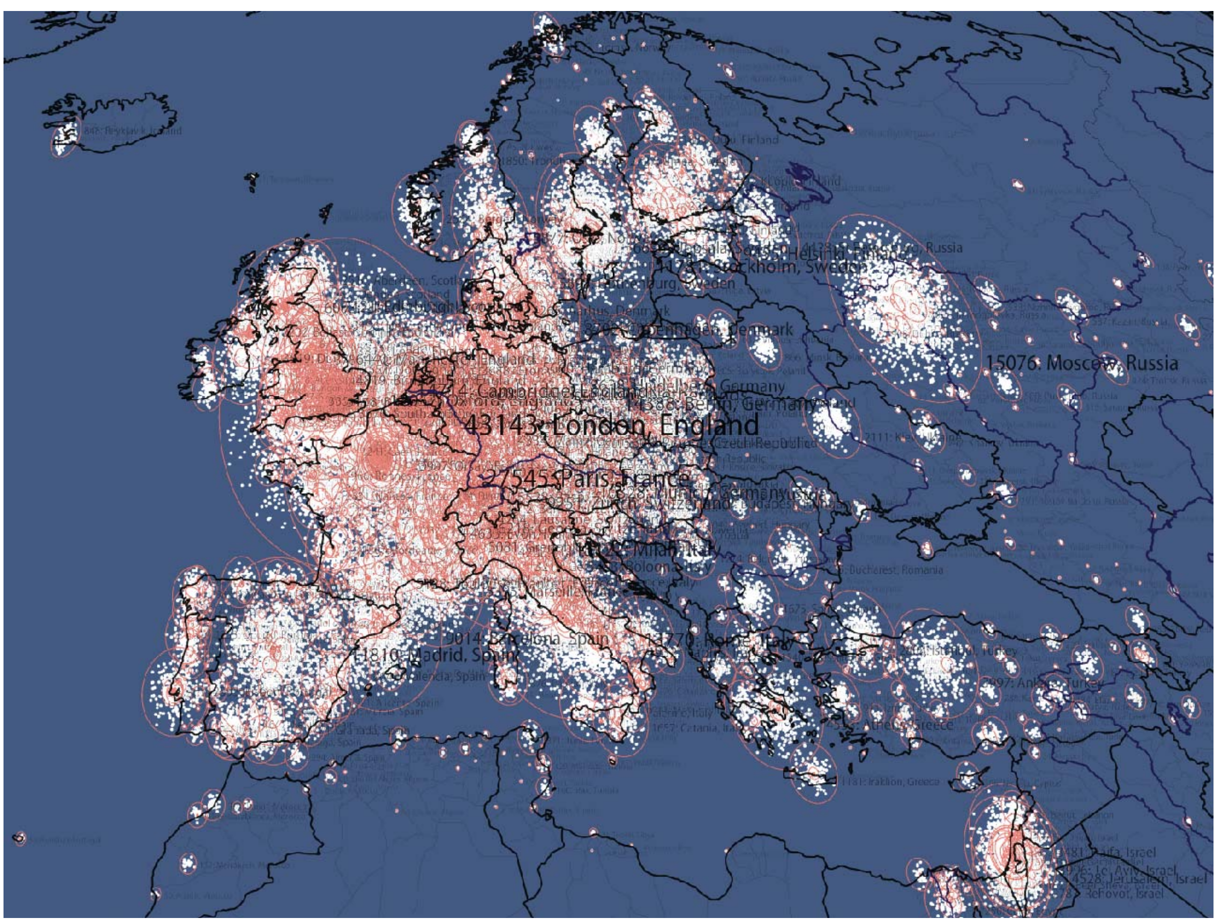
Corners show articles size coded according to
-article edit activity (top left),
- number of major edits (top right),
- number of bursts in edit activity (bottom, right)
- indegree (bottom left).

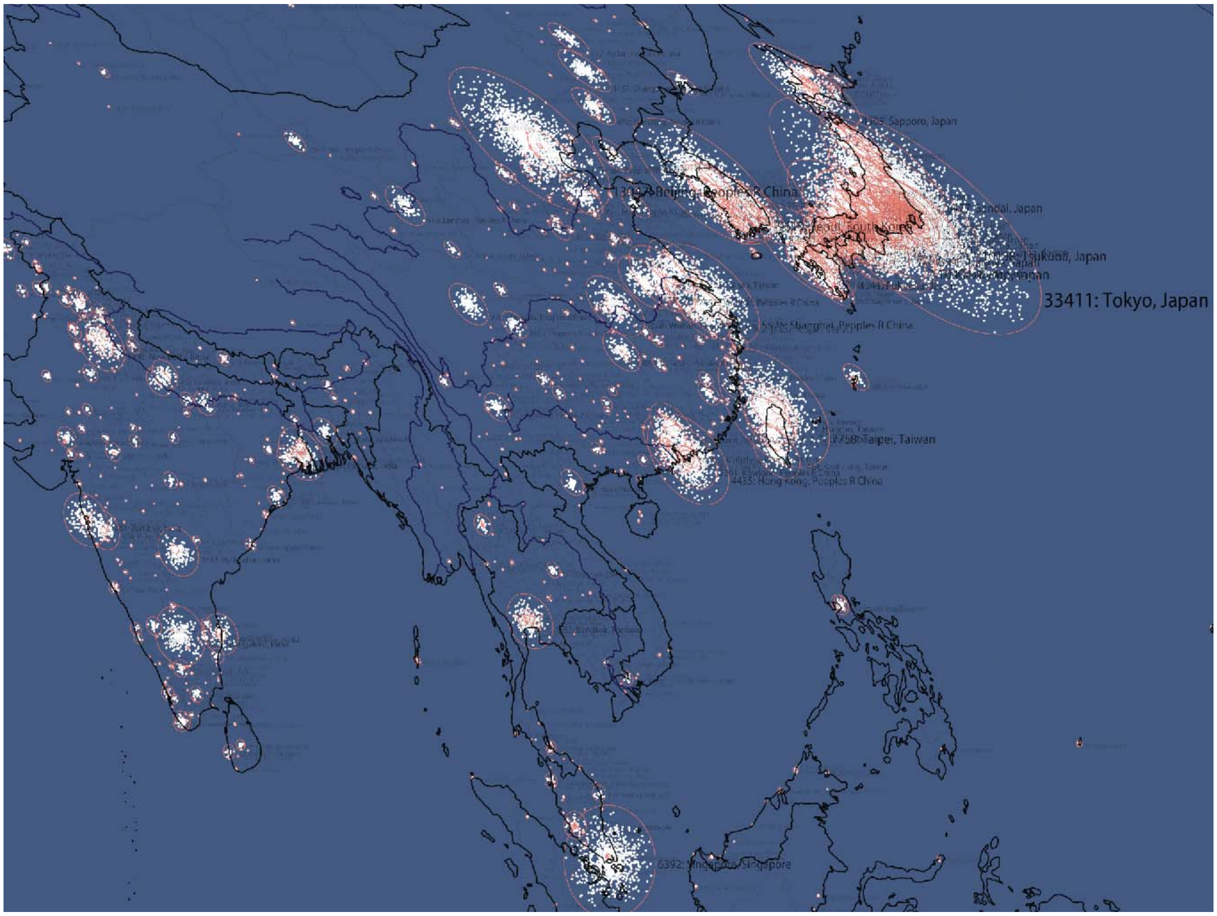


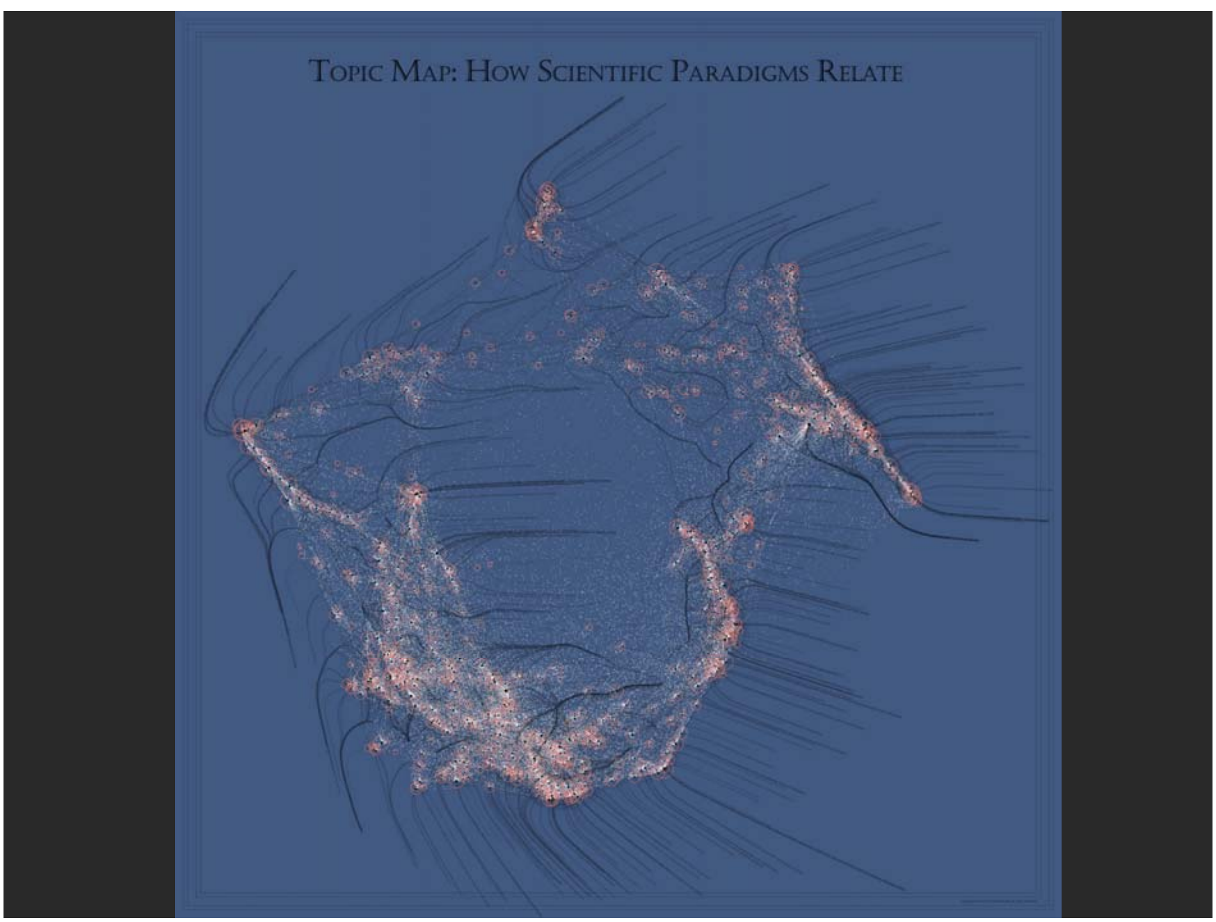


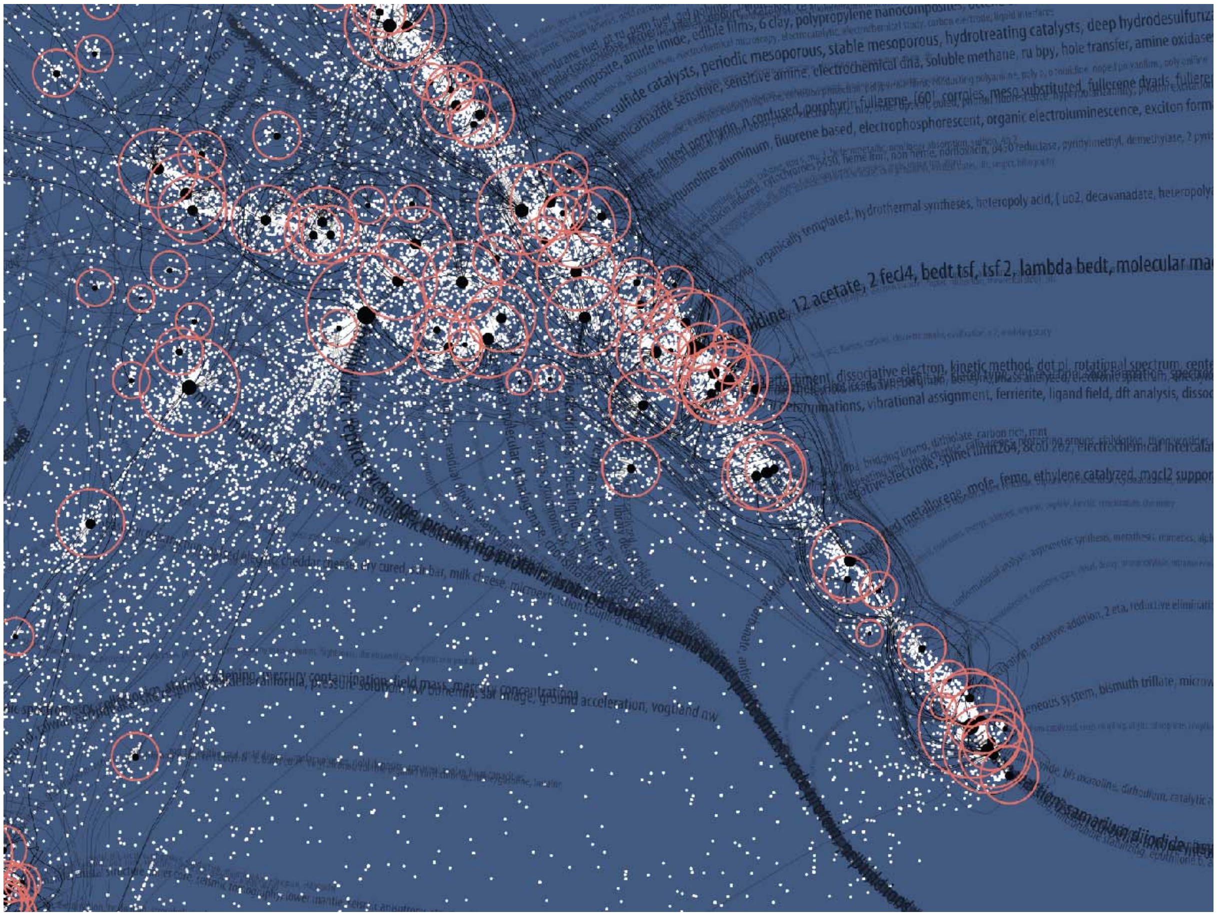



5028: Edmonton, Canada
44537: Boston, MA, USA
12820: San Francisco, CA, USA
20414: Los Angeles, CA, USA
5017: Gainesville, FL, USA
5012: Mexico City, Mexico


43143: London, England
27545: Paris, France
15076: Moscow, Russia


Sapporo, Japan
33411: Tokyo, Japan
Taipei, Taiwan
6392: Singapore, Singapore


TOPIC MAP: HOW SCIENTIFIC PARADIGMS RELATE



periodic mesoporous, stable mesoporous, hydrotreating catalysts
sulfide catalysts
soluble methane, ru bpy, hole transfer
fullerene dyads
fluorene based, electrophosphorescent, organic electroluminescence
hydrothermal syntheses, heteropoly acid
12 acetate, 2 fecl4, bedt tsf, tsf 2, lambda bedt, molecular
dissociative electron, kinetic method
vibrational assignment, ferrierite, ligand field, dft analysis
mofe, femo, ethylene catalyzed
cheddar cheese, dry cured, milk cheese
ground acceleration, vogtland nw
oxidative addition, 2 eta, reductive eliminati
bismuth triflate
samarium diiodide