

Mapping Science in Support of Knowledge Access, Navigation, and Utilization

Katy Börner

Visiting Scientist in Dirk Helbing's Group, SOMS, ETHZ
Cyberinfrastructure for Network Science Center, Director
Information Visualization Laboratory, Director
School of Library and Information Science
Indiana University, Bloomington, IN

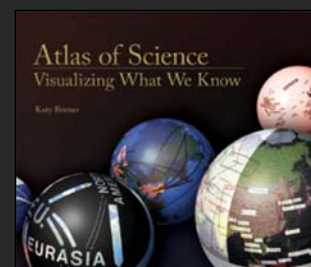
katy@indiana.edu



With special thanks to the members at the Cyberinfrastructure for Network Science Center, the NWB team, the Sci2 team, the EpiC team, and the VIVO Collaboration

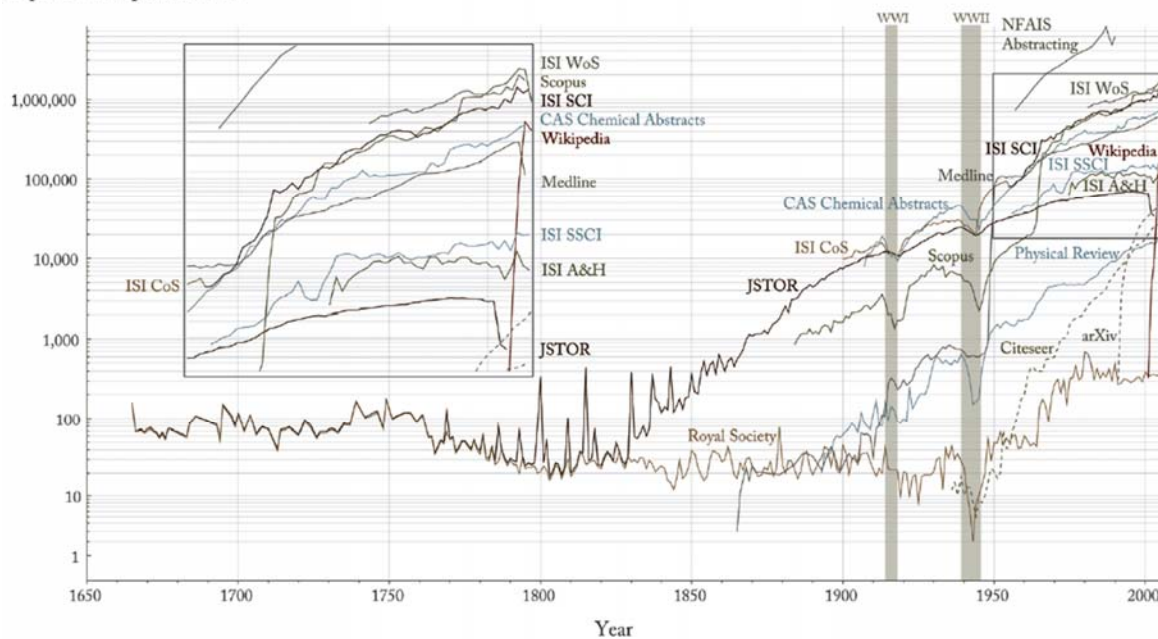
FuturICT's Meeting on the Innovation Accelerator
<http://www.futurict.ethz.ch/Innov.AccDefneMeeting>

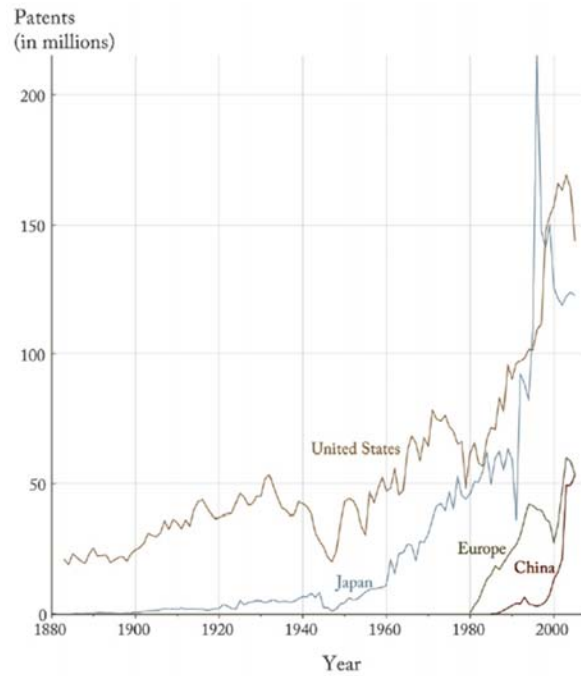
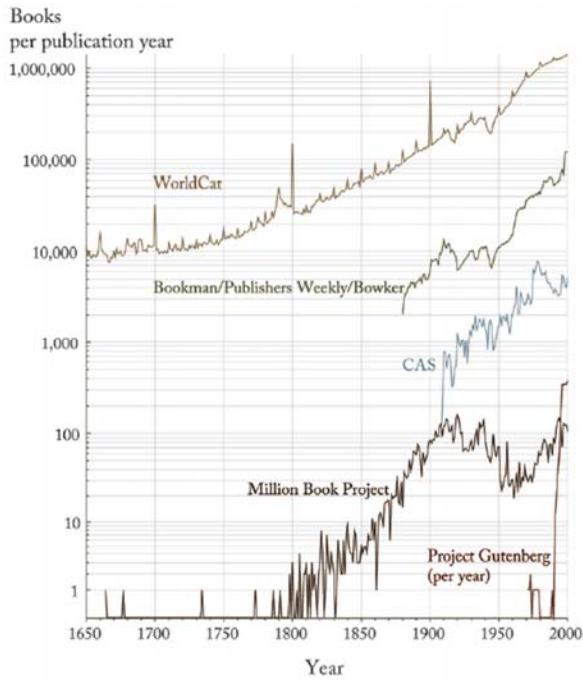
*Eidgenössische Technische Hochschule
Zürich, June 30, 2011*



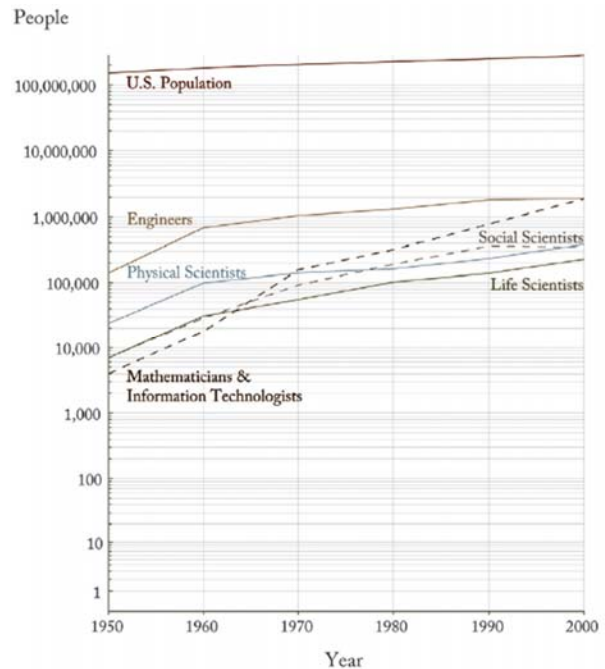
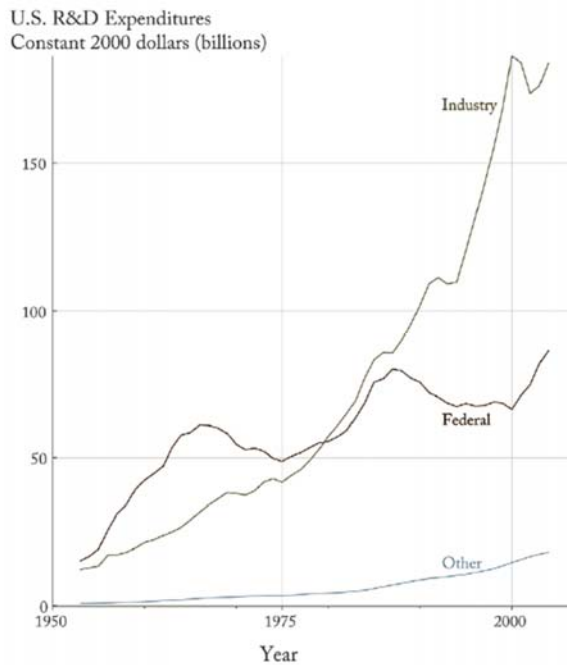
The Rise of Science and Technology

Papers & Wikipedia Entries





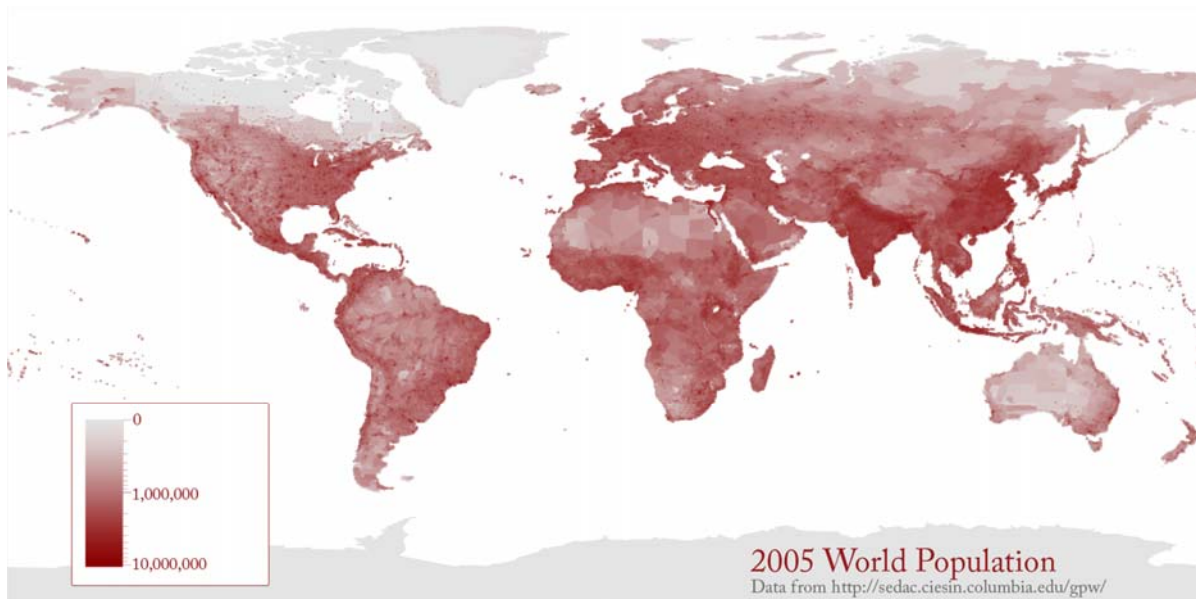
3



4

2005 World Population

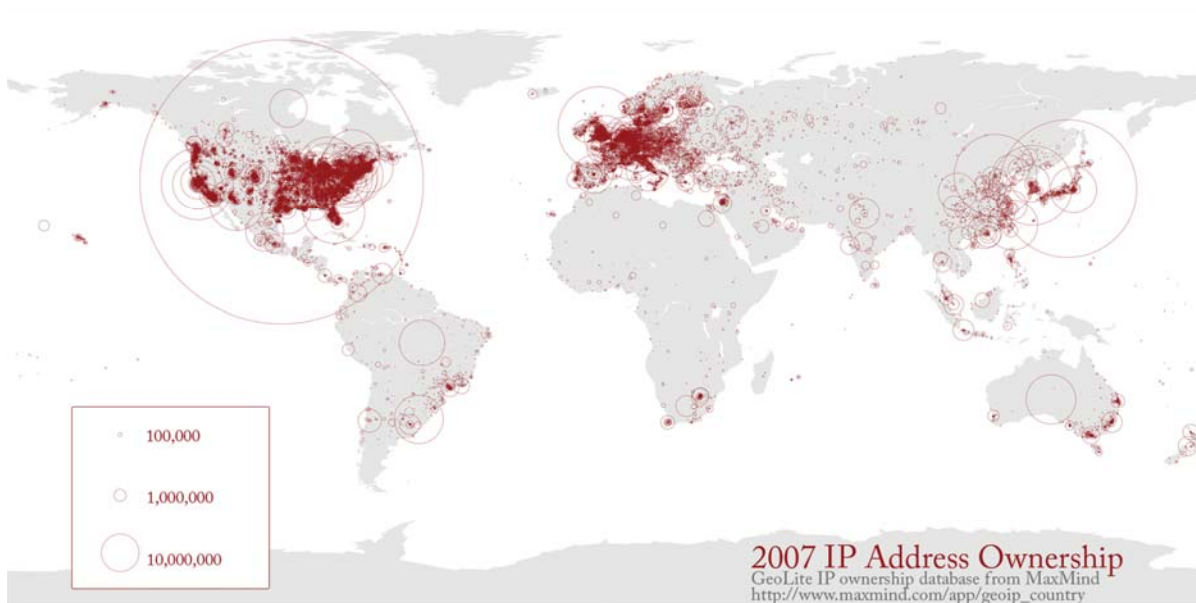
The population map uses a quarter degree box resolution. Boxes with zero people are given in white. Darker shades of red indicate higher population counts per box using a logarithmic interpolation. The highest density boxes appear in Mumbai, with 11,687,850 people in the quarter degree block, Calcutta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



5

2007 IP Address Ownership

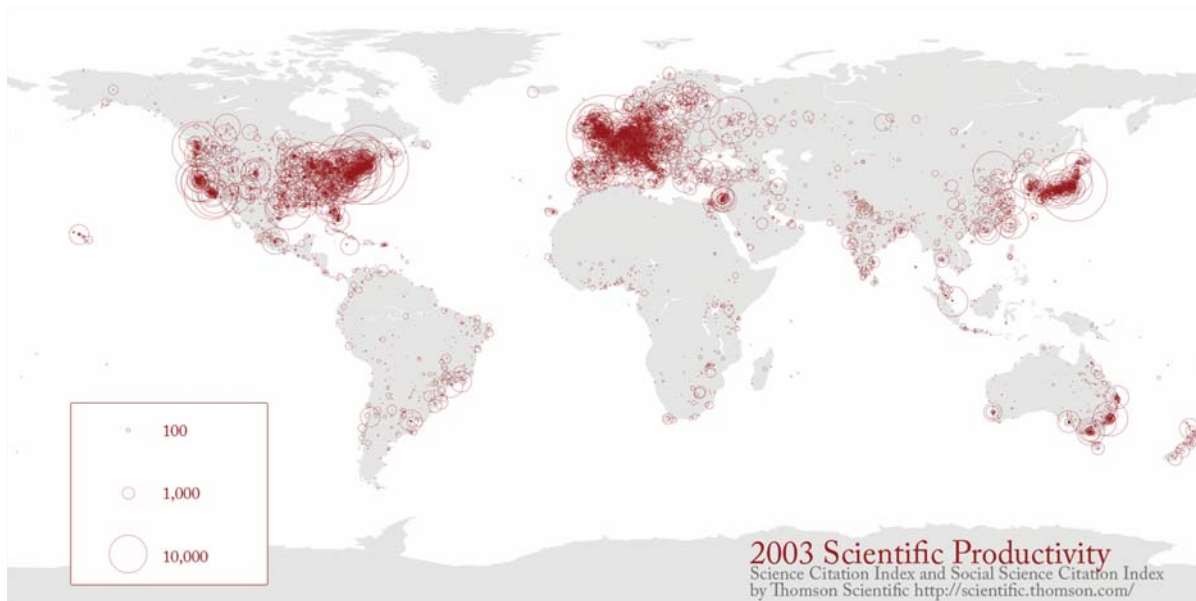
This map shows IP address ownership by location. Each owner is represented by a circle and the area size of the circle corresponds to the number of IP addresses owned. The largest circle denotes MIT's holdings of an entire class A subnet, which equates to 16,581,375 IP addresses. The countries that own the most IP addresses are US (560 million), Japan (130 million), Great Britain (47 million).



6

2003 Scientific Productivity

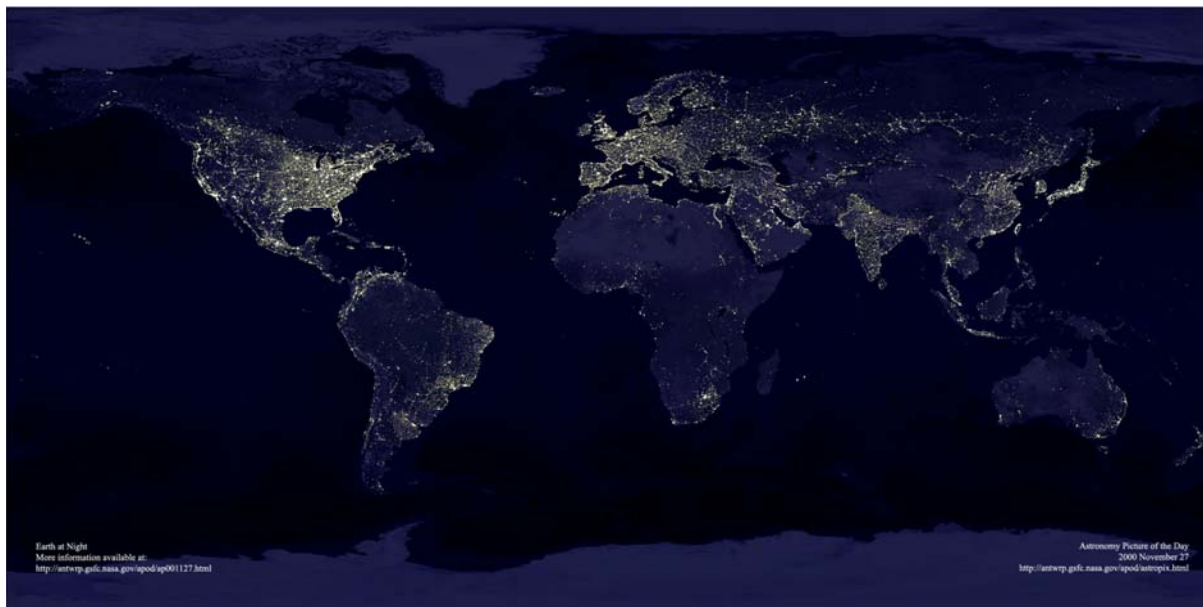
Shown is where science is performed today. Each circle indicates a geographic location at which scholarly papers are published. The larger the circle the more papers are produced. Boston, MA, London, England, and New York, NY are the top three paper production areas. Note the strong resemblance with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



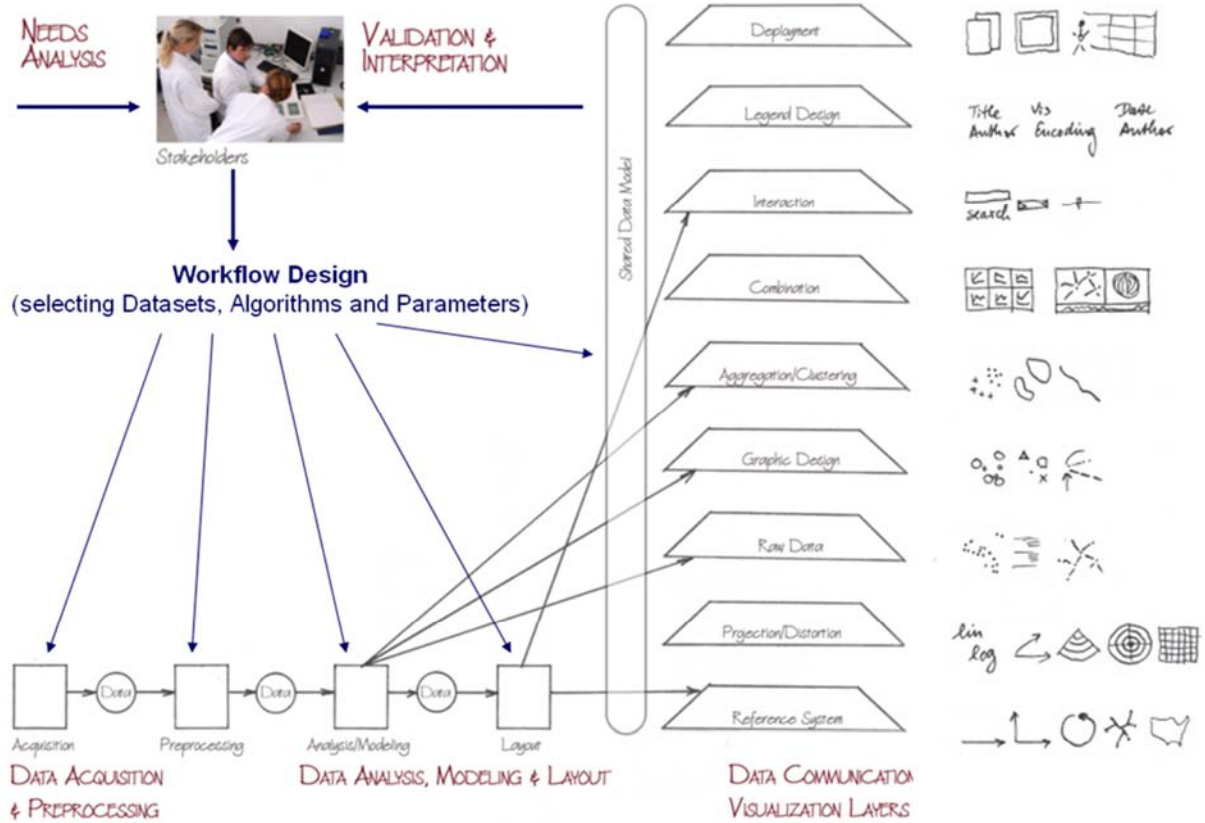
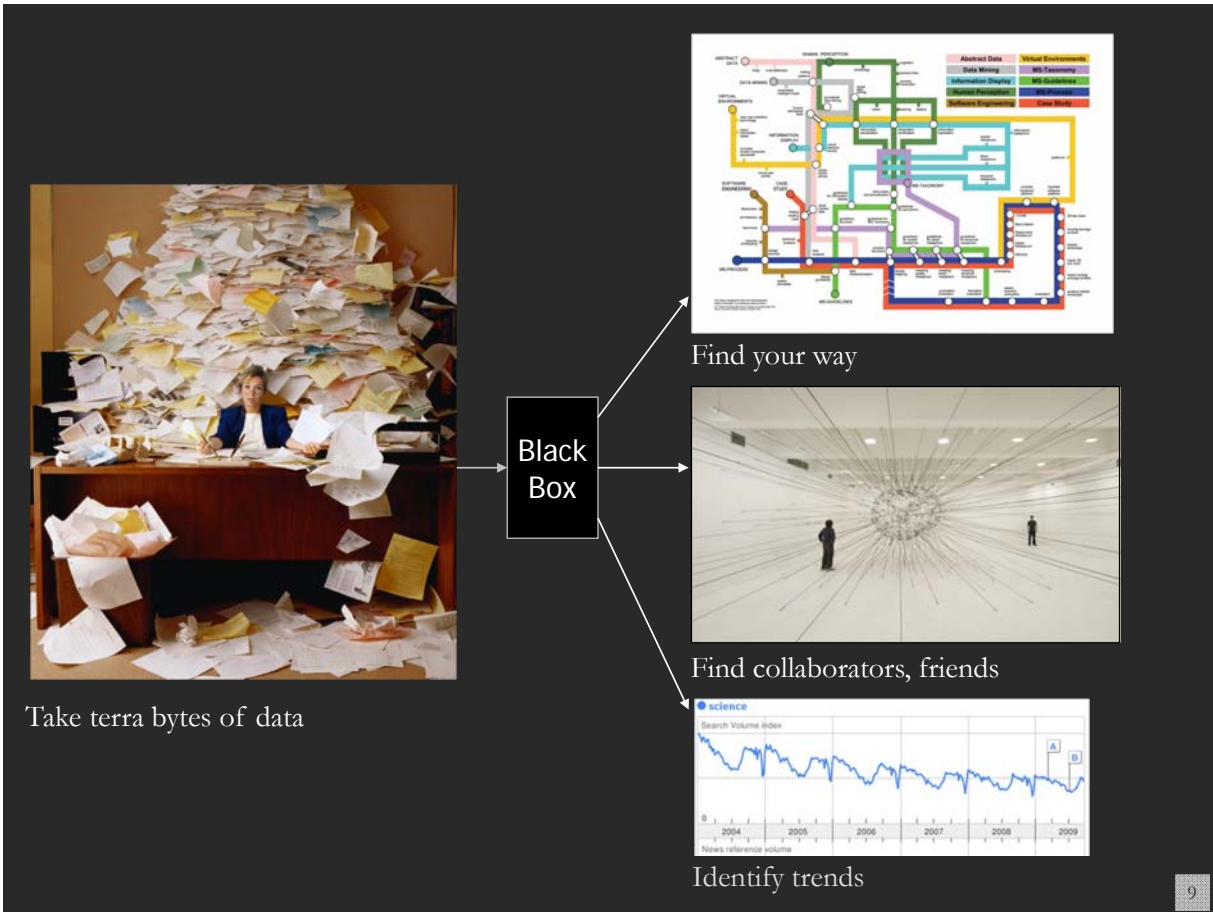
7

2000 Night on Earth

This image shows city lights at night. It was composed from hundreds of pictures made by orbiting satellites. The seaboard of Europe, the eastern United States, and Japan are particularly well lit. Many cities exist near rivers or oceans so that goods can be exchanged cheaply by boat. The central parts of South America, Africa, and Australia are rather dark despite their high population density, see map to the left.



8



Third Iteration of Exhibit (2007): The Power of Forecasts

Four Existing Forecasts Versus Six Science Forecasts

The third iteration of the exhibit compares and contrasts seismic hazard, economic, resource depletion, and epidemic forecast maps with maps forecasting the structure and evolution of science.

Real-time weather forecasts are served by the National Oceanic and Atmospheric Administration (NOAA) or the National Aeronautics and Space Administration (NASA). Computational models of the movements of tectonic plates help reduce losses due to earthquake tsunamis. Epidemic models make us understand and how actions far away affect us right here. Eco-catastrophic and sustainable futures for mankind.

Daily science and technology forecasts would sift of top experts/institutions/countries, major activities frontiers, augmenting our knowledge and decisions available on TV, in the press, and online?

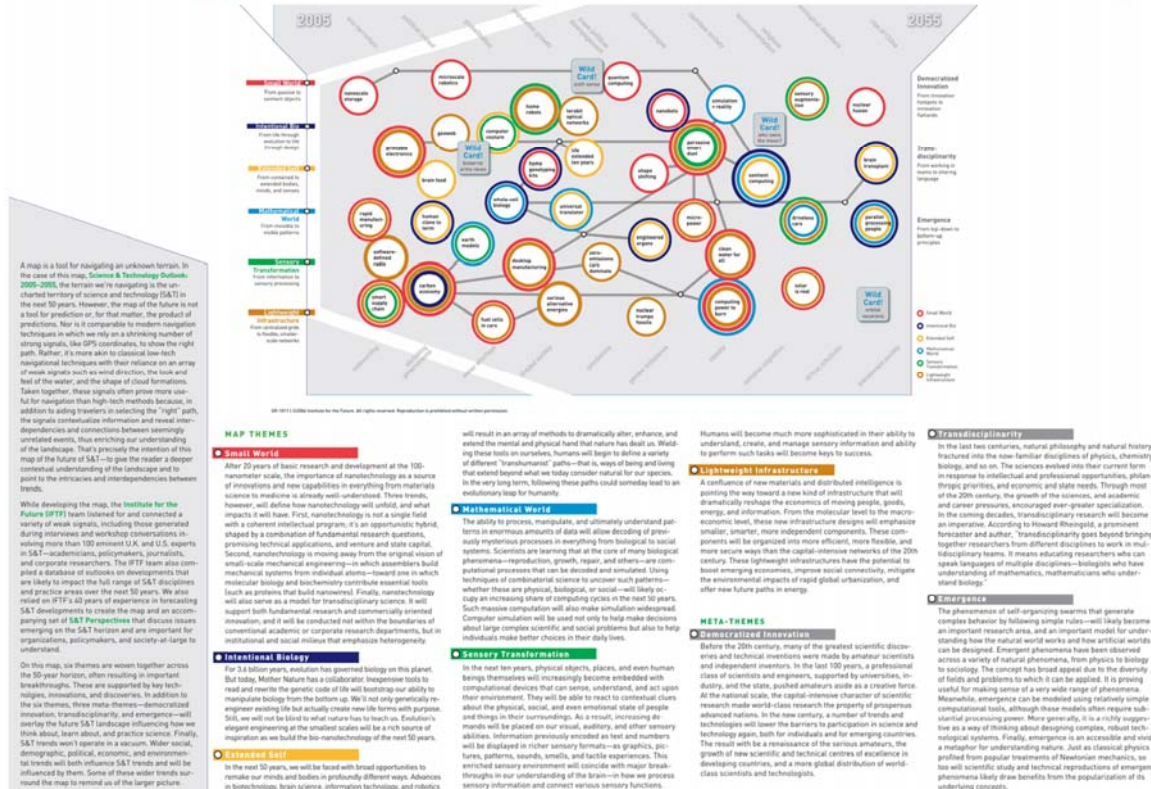
A total of 60 maps can be explored at <http://scimaps.org>



11

INSTITUTE FOR THE FUTURE Science & Technology Outlook: 2005-2055

Technology Horizons Program
Institute for the Future
124 University Avenue, 2nd Floor, Palo Alto, CA 94301
1.650.854.4322 1.450.854.7855 www.iftf.org

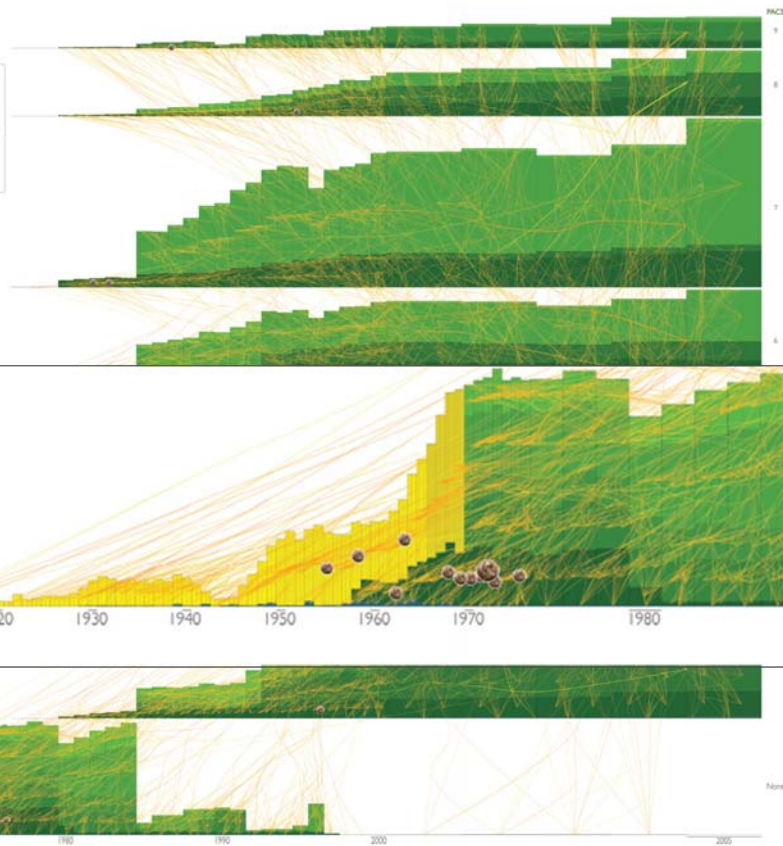


12

113 Years of Physical Review

The visualization aggregates 381,899 articles published in 720 volumes of 13 journals between 1893 and 2005. The 14,352 articles published from 1893 to 1975 are on the left side of the map. In 1975, the Physical Review established the Physics and Astronomy Classification Scheme (PACS) codes, and the visualization includes one for the updated PACS codes. The 213,023 articles from 1975 to 2005, for which good citation data is not available, include the results from the map. The 68,616 articles from 2001 to 2005, for which good citation data is available, are on the right side of the map.

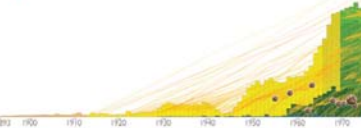
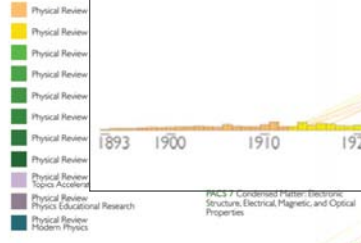
Each article is represented by a dot on the map, and the size of the dot is proportional to the number of papers that journal is cited by. The color of the dot represents the journal in which the article appeared in the color.



Nobel Prizes in Physical Review

- Year of Nobel Prize Winner (Publication Year) (indicated by Nobel Prize medals on the right)
- 2005 Roy J. Glauber, John L. Hall, and Theodor W. Hänsch (1962, 1971)
 - 2004 David J. Gross, H. David Politzer, and Frank Wilczek (1973)
 - Thomson IS successfully predicted a winner in this year, with the following paper:
 - Gross, D.J., Politzer, H. Ultraviolet Behavior of Non-Abelian Gauge Theories. Physical Review Letters, 26, 1643 & 1973
 - 2003 Anthony J. Leggett (1970)
 - 2002 Raymond Davis Jr., Masatoshi Koshiba, and Riccardo Giacconi (1962, 1968, 1987)
 - 2001 Eric A. Cornell, Wolfgang Ketterle, and Carl E. Wieman (1995, 1996)
 - 1998 Robert B. Laughlin (1982, 1983)
 - 1997 Steven Chu and Claude Cohen-Tannoudji (1983, 1997)
 - 1986 David H. Lee, D.
 - 1985 Martin L. Perl (1975)
 - 1984 Bertalan N. Br.
 - 1980 Jerome I. Friedman

Bar Graph



MAPS OF SCIENCE

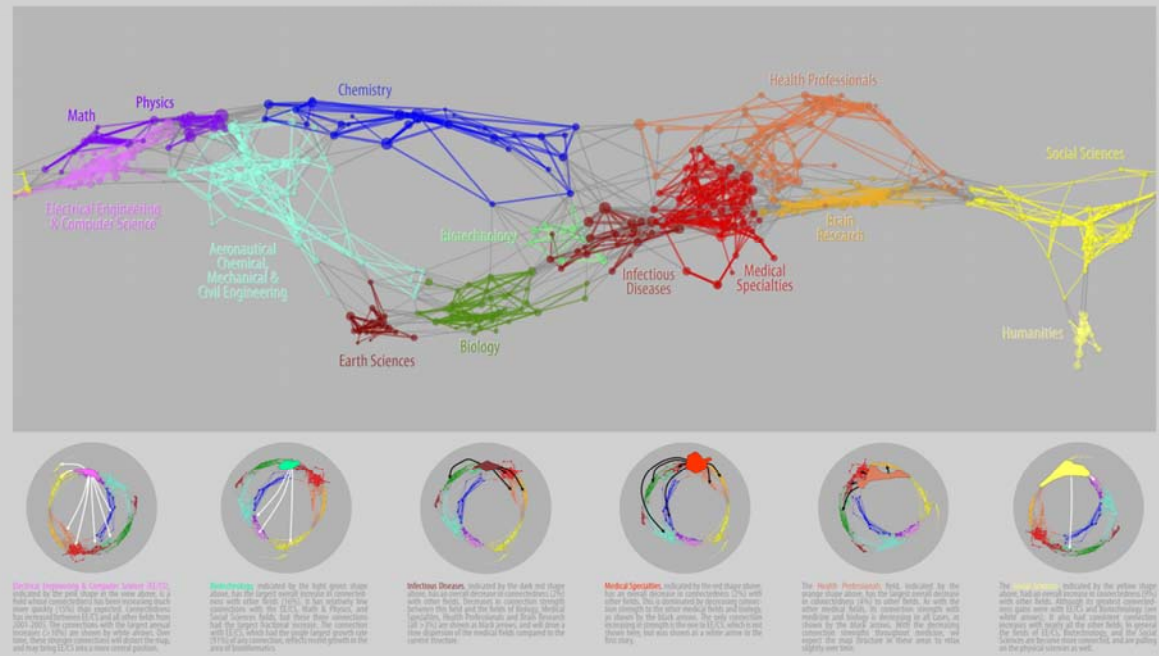
A visualization of 7.2 million scholarly documents appearing in over 16,000 journals, proceedings or symposia between Jan, 2001 and Dec, 2005

Forecasting Large Trends in Science

Calculations were performed using the large colored groupings of disciplines (fields) to determine a list of items which could be used to predict change in the structure of journal data. Correlation coefficients between fields were calculated for each individual year (2001-2005). A simple regression analysis was conducted to see if there were significant changes in these correlation coefficients year to year.

If the structure of science shows signs of moving toward stability, we would expect connections between neighboring fields to increase, and connections between distant fields to decrease. We found the opposite, suggesting that the underlying structure is unstable and likely to change dramatically over the next decade.

So, science, representing how the structure is likely to change, are provided below. Maps with white arrows represent increases of science fields that are likely to be pulled closer to each other in the future. Maps with dark arrows represent fields that are currently close but that are likely to become more dispersed. We expect that large maps of science will show changes in structure corresponding to these observations. Medicine will disperse slightly, while the physical sciences will tighten and draw closer to the medical fields.



Physics (indicated by the purple stage above) has the largest central clusters in connections (74%) with other fields. Secondary in connection strength between this field and the fields of Biology, Medical Specialties, Health Professionals and Brain Research (33.7%) are shown in dark purple, and will show a slow dispersion of the medical field compared to the current structure.

Medicine (indicated by the dark red stage above) has the largest central clusters in connections (74%) with other fields. Secondary in connection strength between this field and the fields of Biology, Medical Specialties, Health Professionals and Brain Research (33.7%) are shown in dark purple, and will show a slow dispersion of the medical field compared to the current structure.

Infectious Diseases, indicated by the dark red stage above, has the largest central clusters in connections (74%) with other fields. Secondary in connection strength between this field and the fields of Biology, Medical Specialties, Health Professionals and Brain Research (33.7%) are shown in dark purple, and will show a slow dispersion of the medical field compared to the current structure.

Medical Specialties, indicated by the dark red stage above, has the largest central clusters in connections (74%) with other fields. Secondary in connection strength between this field and the fields of Biology, Medical Specialties, Health Professionals and Brain Research (33.7%) are shown in dark purple, and will show a slow dispersion of the medical field compared to the current structure.

Health Professionals (indicated by the orange stage above) has the largest central clusters in connections (74%) with other fields. Secondary in connection strength between this field and the fields of Biology, Medical Specialties, Health Professionals and Brain Research (33.7%) are shown in dark purple, and will show a slow dispersion of the medical field compared to the current structure.

Social Sciences (indicated by the yellow stage above) has the largest central clusters in connections (74%) with other fields. Secondary in connection strength between this field and the fields of Biology, Medical Specialties, Health Professionals and Brain Research (33.7%) are shown in dark purple, and will show a slow dispersion of the medical field compared to the current structure.

VIVO enabling national networking of scientists

Index Log in

Search

Home People Organizations Research Events

University of Florida **i**

Explore 487 publications activity across 554 scientific sub-disciplines **i**

13 Disciplines | 554 Sub-Disciplines **i**

Search: X

1 - 13 of 554 [« First](#) [« Prev](#) [Next](#) [» Last](#) »

Sub-Disciplines	# of pubs.	% activity
Pest Management Science	24.2	5.0
Wildlife Research	19.1	3.9
Protein Science	13.1	2.7
Clinical Cancer Research	12.6	2.6
Pain	12.0	2.5
Environmental Contamination	11.2	2.3
Insect Physiology	11.1	2.3
Organic Chemistry	10.9	2.2
Marine Biology	10.3	2.1
Computer Aided Molecular Design	10.2	2.1
BioStatistics	9.0	1.9

✓ Show discipline labels

Top 290 disciplines shown

Terms of Use

mapped 14.55% of 3,346 publications **i**

Topical Analysis Science map overlays show where a person, department, or university publishes most in the world of science.

Interactive World and Science Map of S&T Jobs

Angela Zoss, Michael Conover, Katy Börner (2010)

Visualization of Job Postings

Map of Science | Geographic

Visualization of Job Postings

Map of Science | Geographic

Postdoc at Harvard Medical School [Link to Post](#)

Visualization of Job Postings

Map of Science | Geographic

Map of Science

Scientific domains are highly interconnected. The boundaries between different domains are often fuzzy. One way of thinking about the relationships between domains is to conceptualize all scientific domains as existing within a large network of research.

Creating a network of scientific research can be accomplished by looking at scientific journals and their articles. The UCSD Map of Science used here is the product of a large study by researchers at the University of California San Diego using 7.2 million papers and over 16,000 separate journals, proceedings, and series from Thomson Scientific and Scopus over the five year period from 2001 to 2005. The researchers used citations between the papers and journals to cluster journals into small groups of highly related journals.

Those clusters are represented by 554 individual nodes in the network. The links between the clusters show that some clusters are related to other clusters but are not as tightly connected as the journals that make up each cluster. Then the clusters are labeled both by the content area shared by the journals in the cluster and by the overarching scientific domain for that cluster (represented by one of 13 colors).

Maps of science like this one can be used to understand many different data sets and how they can be represented by topic. Here we are looking at the topics that appear in job postings from some inst.

Copyright © 2008 The Regents of the University of California - [Terms of Use](#)

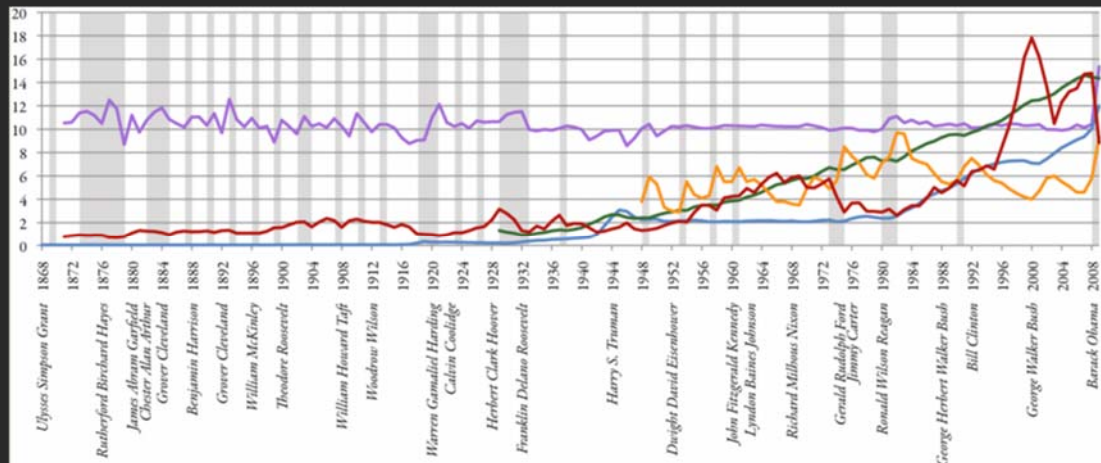
Search for Jobs

Search for Jobs

Search for Jobs

Interactive World and Science Map of S&T Jobs

Angela Zoss, Michael Connover, Katy Börner (2010)



Geographic Map Science Map

Map data ©2010 Europa Technologies, NEA

Maps Detail **Data** About

Datasets

The dataset covers 13,528 records on "biomass" and "biofuel" research and technology from seven different publication, patent, funding datasets for the years 1901 to 2010.

Funding

National Institutes of Health (NIH) awards retrieved from the Scholarly Database (<http://sdb.slis.indiana.edu>) at Indiana University on 11/20/2010. Search query used was biomass OR biofuel OR "bio mass" OR "bio fuel" in the 'All Text' field.

National Science Foundation (NSF) awards retrieved from the Scholarly Database (<http://sdb.slis.indiana.edu>) at Indiana University on 11/20/2010. Search query used was biomass OR biofuel OR "bio mass" OR "bio fuel" in the 'All Text' field.

Publications

MEDLINE papers by the National Library of Medicine retrieved from the Scholarly Database (<http://sdb.slis.indiana.edu>) at Indiana University on 11/20/2010. Search query used was biomass OR biofuel OR "bio mass" OR "bio fuel" in the 'All Text' field.

<http://mapsustain.cns.iu.edu>

The geographic map at state level.

Geographic Map Science Map

Color B & W

USPTO
2009

- Automated Accelerated Extraction Of Trace Elements From Biomass
- Biomass Based Michael Addition Compositions

2008

- Thermal Tolerant Avicelase From Chitosan And Method Of Preparing Chitosan
- Process For Pyrolytic Heat Recovery Enhanced With Gasification Of Organic Material
- Chitosan And Method Of Preparing Chitosan
- Self-Contained Microelectrochemical Bioassay Platforms And Methods
- Highly Active Xylose Reductase From Process For The Solvent-Based Extraction Of Polyhydroxyalkanoates From Biomass
- Process For The Solvent-Based Extraction Of Polyhydroxyalkanoates From Biomass
- Process For The Solvent-Based Extraction Of Polyhydroxyalkanoates From Biomass
- Light Sensing Instrument With Modulated Polychromatic Source
- Method For Purifying Water
- Synthesis Of Caprolactam From Lysine

<http://mapsustain.cns.uu.edu>

POWERED BY Google

Copyright © 2008 The Regents of the University of California - [Terms of Use](#)

0.366 to 3,300
0.867 to 7,853
16 to 671

Math & Physics	Biotechnology	Medical Specialties
Chemistry	Earth Sciences	Brain Research
Computer Science & EE	Biology	Health Professionals
Other Engineering	Infectious Diseases	Social Sciences
		Humanities

19



Science Maps in "Expedition Zukunft" science train visiting 62 cities in 7 months 12 coaches, 300 m long
Opening was on April 23rd, 2009 by German Chancellor Merkel
<http://www.expedition-zukunft.de>



Chin Hua interacts with 6 foot diameter Wikipedia map on a tiled display, see also Gigapan map at <http://www.gigapan.org/gigapans/4277>

Computational Scientometrics Cyberinfrastructures



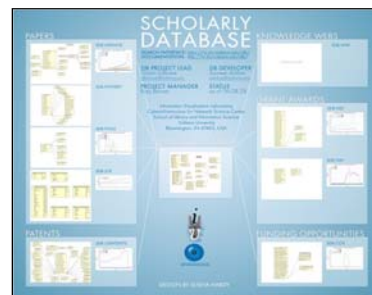
Scholarly Database: 25 million scholarly records

<http://sdb.cns.iu.edu>



VIVO Research Networking

<http://vivoweb.org>



Information Visualization Cyberinfrastructure

<http://iv.cns.iu.edu>



Network Workbench Tool & Community Wiki

<http://nwb.cns.iu.edu>



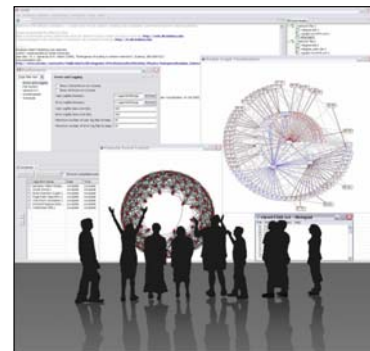
Science of Science (Sci²) Tool

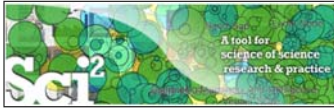
<http://sci2.cns.iu.edu>



Epidemics Tool and Marketplace

forthcoming

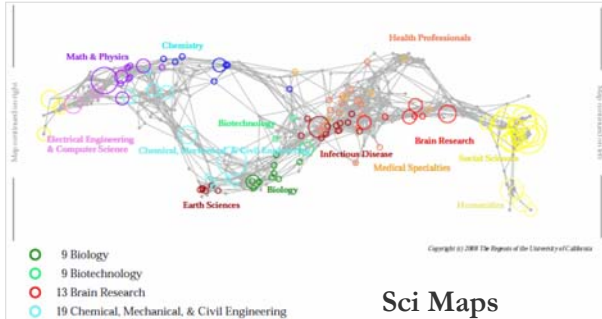




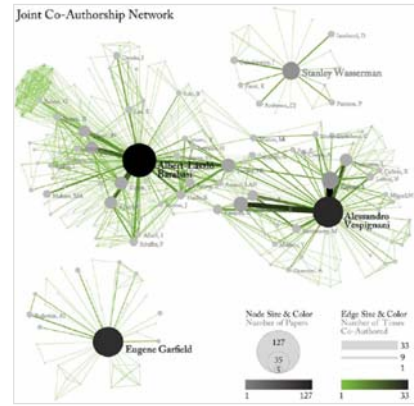
Sci² Tool – “Open Code for S&T Assessment”

<http://sci2.cns.iu.edu>

OSGi/CIShell powered tool with NWB plugins and many new scientometrics and visualizations plugins.



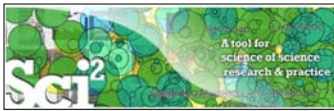
Sci Maps



GUESS Network Vis



Börner, Katy. (2011). [Plug-and-Play Macroscopes](#). *Communications of the ACM*. Vol. 54(3), 60-69, ACM Press



Sci² Tool—More than 200 Plugins/Algorithms

Sci² Tool

File Preprocessing Modeling Analysis Visualization Scientometrics Help

Console

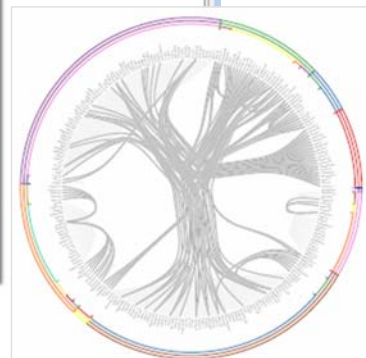
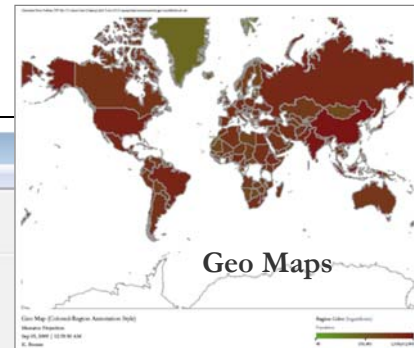
Welcome to the Science of Science Tool (Sci²). The development of this tool is supported in part by the Network Science center and the School of Li at Indiana University, the National Science Foundation (NSF) grant IRI-0715303, and the James S. McDonnell Cyberinfrastructure portal (<http://sci.slis.indiana.edu>). The primary investigators are Katy Börner, InSciTech Strategies Inc. The Sci² tool was developed by J. Duhon, Patrick A. Phillips, Chintan Tank, a Cyberinfrastructure Shell (<http://cishell.org>) for Network Science Center (<http://cns.slis.indiana.edu>). Many algorithm plugins were derived from the Network Science Center (<http://nwb.slis.indiana.edu>).

Please cite as follows:
Sci² Team. (2009). Science of Science Tool. InSciTech Strategies Inc., <http://sci.slis.indiana.edu>.

Scheduler

Remove From List Remove completed

!	Algorithm Name	Date	Time	% Con
<input checked="" type="checkbox"/>	Extract Co-Author Netw...	09/03/2009	00:15:20 AM	<div style="width: 100%; height: 10px; background-color: green;"></div>
<input checked="" type="checkbox"/>	Load and Clean ISI File	09/03/2009	00:15:05 AM	<div style="width: 100%; height: 10px; background-color: green;"></div>



Circular Hierarchy

References

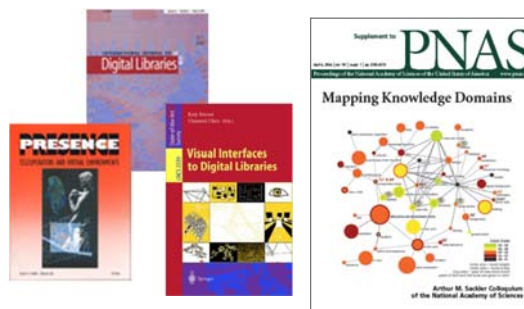
Börner, Katy, Chen, Chaomei, and Boyack, Kevin. (2003). **Visualizing Knowledge Domains**. In Blaise Cronin (Ed.), *ARIST*, Medford, NJ: Information Today, Volume 37, Chapter 5, pp. 179-255.
<http://ivl.slis.indiana.edu/km/pub/2003-borner-arist.pdf>

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/

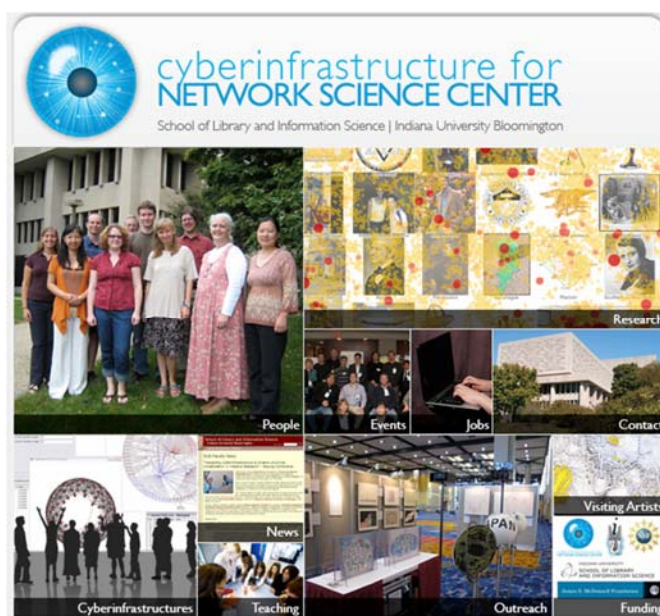
Börner, Katy, Sanyal, Soma and Vespignani, Alessandro (2007). **Network Science**. In Blaise Cronin (Ed.), *ARIST*, Information Today, Inc., Volume 41, Chapter 12, pp. 537-607.
<http://ivl.slis.indiana.edu/km/pub/2007-borner-arist.pdf>

Börner, Katy (2010) **Atlas of Science**. MIT Press.
<http://scimaps.org/atlas>

Scharnhorst, Andrea, Börner, Katy, van den Besselaar, Peter (2011) **Models of Science Dynamics**. Springer Verlag.



25



All papers, maps, tools, talks, press are linked from <http://cns.iu.edu>

CNS Facebook: <http://www.facebook.com/cnscenter>

Mapping Science Exhibit Facebook: <http://www.facebook.com/mappingscience>

26