

# The Use of Knowledge Mapping in International STI Horizon Scanning

Katy Börner, Indiana University, USA

U.S. Looks to the Global Science, Technology, and Innovation Horizon  
Friday, 14 February 2014: 8:30 AM-11:30 AM  
Grand Ballroom C North (Hyatt Regency Chicago)

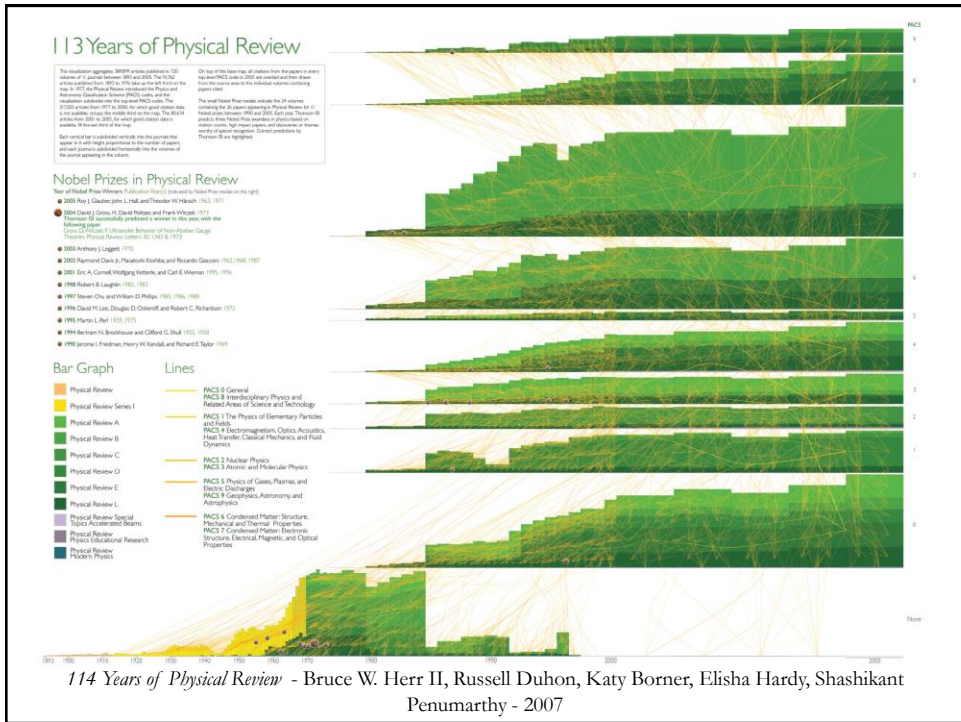
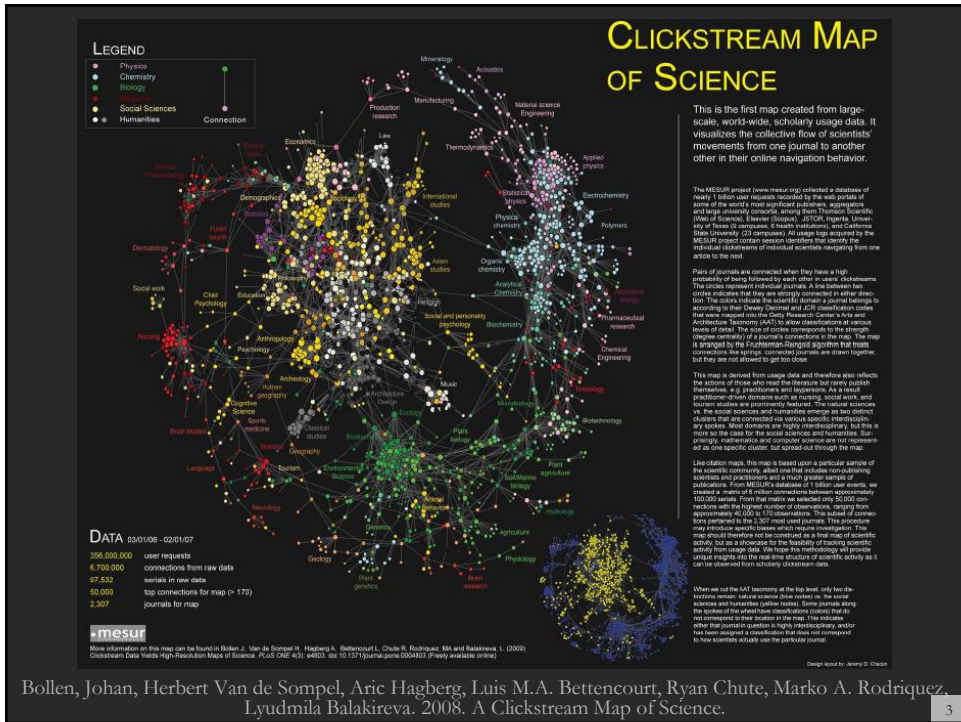


## Map of Scientific Collaborations from 2005-2009



Computed Using Data from Elsevier's Scopus

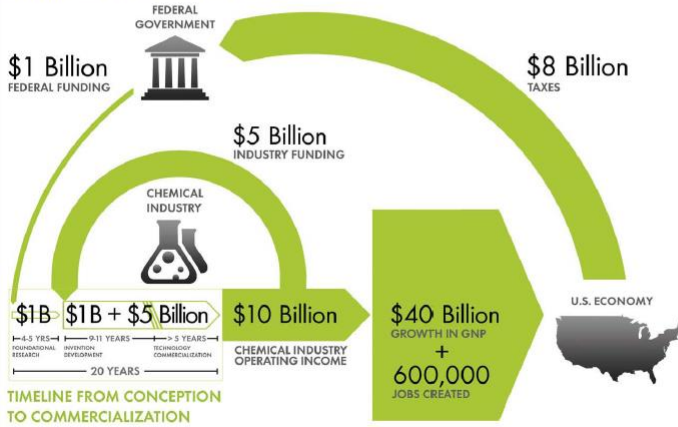
Olivier H. Beauchesne, 2011. Map of Scientific Collaborations from 2005-2009.



# Chemical Research & Development Powers the U.S. Innovation Engine

Macroeconomic Implications of Public and Private R&D Investments in Chemical Sciences

## INVESTMENT IN CHEMICAL SCIENCE R&D



## The Council for Chemical Research (CCR)

has provided the U.S. Congress and government policy makers with important results regarding the impact of Federal Research & Development (R&D) investments on U.S. innovation and global competitiveness through its commissioned 5-year two phase study. To take full advantage of typically brief access to policy makers, CCR developed the graphic below as a communication tool that details the complex data produced by these studies in clear, concise and clear terms.



The design shows that an input of \$1B in federal funding, leveraged by \$5B industry investment, brings new technologies to market and results in \$10B of operating income for the chemical industry, \$40B growth in the Gross National Product (GNP) and further impacts the US economy by generating approximately 600,000 jobs, along with a return of \$8B in taxes. Additional details, also reported in this CCR studies, are depicted in this map to the left. This map clearly shows the two R&D investment cycles; the shorter industry investment cycle and the longer federal investment cycle which begins in basic research and culminates in national economic and job growth along with the increase tax base that in turn is available for investment in basic research.

Council for Chemical Research. 2009. Chemical R&D Powers the U.S. Innovation Engine. Washington, DC. Courtesy of the Council for Chemical Research.

## 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  
415.554.2022 | 415.554.7099 | [www.iftf.org](http://www.iftf.org)



**Energy**  
A need is felt for meeting our future energy needs. The world's energy supply is expected to be exhausted by the end of the 21st century. However, the map of the future is a look for production, or for the matter, the product of production. Here it is important to explore emerging techniques in which we see an exciting number of alternative energy sources, as well as the need for energy. Rather, it's more about how to use these technologies in a way that doesn't deplete the stock and the rest of the world, and the need for energy. These energy sources are not just about the energy itself, but also about the energy. These energy sources are not just about the energy itself, but also about the energy.

**Information**  
The 21st century is a time of rapid technological change. The pace of innovation is accelerating, and the impact of technology is being felt in every aspect of our lives. This is a time of great opportunity, but also of great challenge. We must ensure that the benefits of technology are shared by all, and that the risks are managed. This is a time of great opportunity, but also of great challenge.

**Life Sciences**  
The 21st century is a time of rapid technological change. The pace of innovation is accelerating, and the impact of technology is being felt in every aspect of our lives. This is a time of great opportunity, but also of great challenge. We must ensure that the benefits of technology are shared by all, and that the risks are managed. This is a time of great opportunity, but also of great challenge.

**Space**  
The 21st century is a time of rapid technological change. The pace of innovation is accelerating, and the impact of technology is being felt in every aspect of our lives. This is a time of great opportunity, but also of great challenge. We must ensure that the benefits of technology are shared by all, and that the risks are managed. This is a time of great opportunity, but also of great challenge.

**Energy**  
A need is felt for meeting our future energy needs. The world's energy supply is expected to be exhausted by the end of the 21st century. However, the map of the future is a look for production, or for the matter, the product of production. Here it is important to explore emerging techniques in which we see an exciting number of alternative energy sources, as well as the need for energy. Rather, it's more about how to use these technologies in a way that doesn't deplete the stock and the rest of the world, and the need for energy. These energy sources are not just about the energy itself, but also about the energy. These energy sources are not just about the energy itself, but also about the energy.

**Information**  
The 21st century is a time of rapid technological change. The pace of innovation is accelerating, and the impact of technology is being felt in every aspect of our lives. This is a time of great opportunity, but also of great challenge. We must ensure that the benefits of technology are shared by all, and that the risks are managed. This is a time of great opportunity, but also of great challenge.

**Life Sciences**  
The 21st century is a time of rapid technological change. The pace of innovation is accelerating, and the impact of technology is being felt in every aspect of our lives. This is a time of great opportunity, but also of great challenge. We must ensure that the benefits of technology are shared by all, and that the risks are managed. This is a time of great opportunity, but also of great challenge.

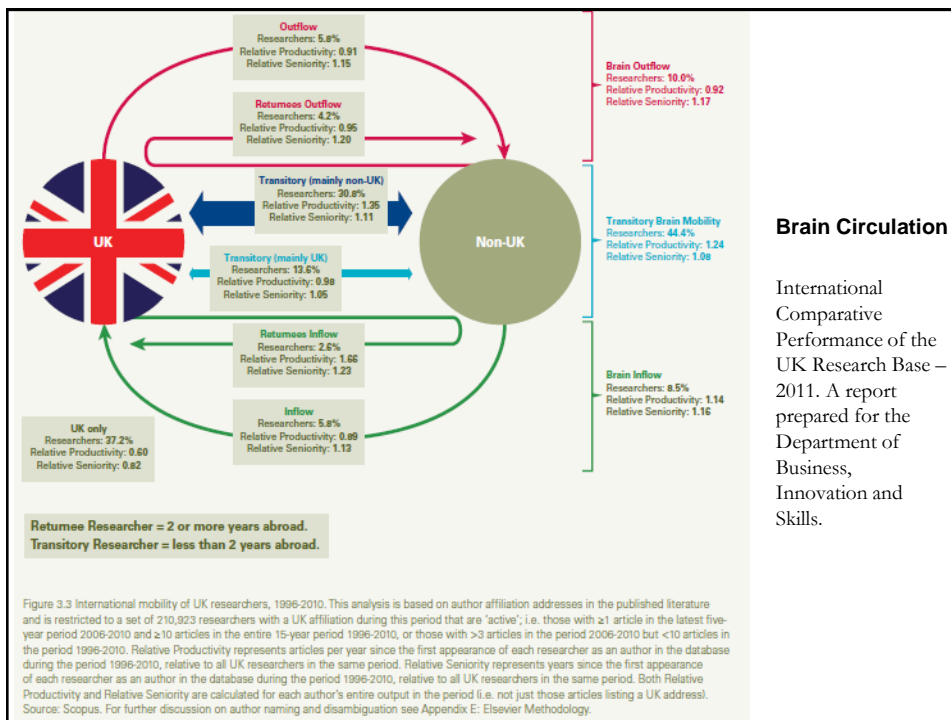
**Space**  
The 21st century is a time of rapid technological change. The pace of innovation is accelerating, and the impact of technology is being felt in every aspect of our lives. This is a time of great opportunity, but also of great challenge. We must ensure that the benefits of technology are shared by all, and that the risks are managed. This is a time of great opportunity, but also of great challenge.

Science & Technology Outlook: 2005-2055 - Alex Soojung-Kim Pang, David Pescovitz, Marina Gorbis, Jean Hagan - 2006

## Places & Spaces: Mapping Science Exhibit scimaps.org



7



## Spatio-Temporal Information Production and Consumption of Major U.S. Research Institutions

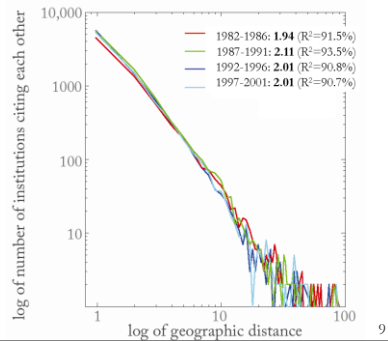
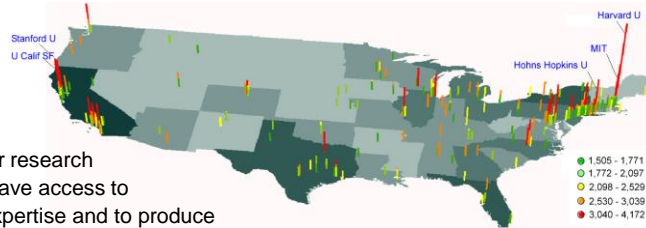
Börner, Katy, Penumarthy, Shashikant, Meiss, Mark and Ke, Weimao. (2006) *Mapping the Diffusion of Scholarly Knowledge Among Major U.S. Research Institutions. Scientometrics. 68(3), pp. 415-426.*

### Research questions:

1. Does space still matter in the Internet age?
2. 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?
3. Does the Internet lead to more global citation patterns, i.e., more citation links between papers produced at geographically distant research institutions?

### Contributions:

- Answer to Qs 1 + 2 is YES.
- Answer to Qs 3 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.



## The Global 'Scientific Food Web'

Mazloumian, Amin, Dirk Helbing, Sergi Lozano, Robert Light, and Katy Börner. 2013. "Global Multi-Level Analysis of the 'Scientific Food Web'". *Scientific Reports* 3, 1167.

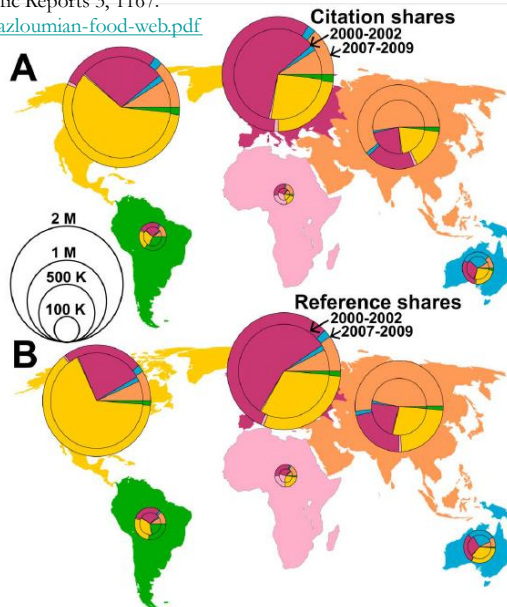
<http://cns.iu.edu/docs/publications/2013-mazloumian-food-web.pdf>

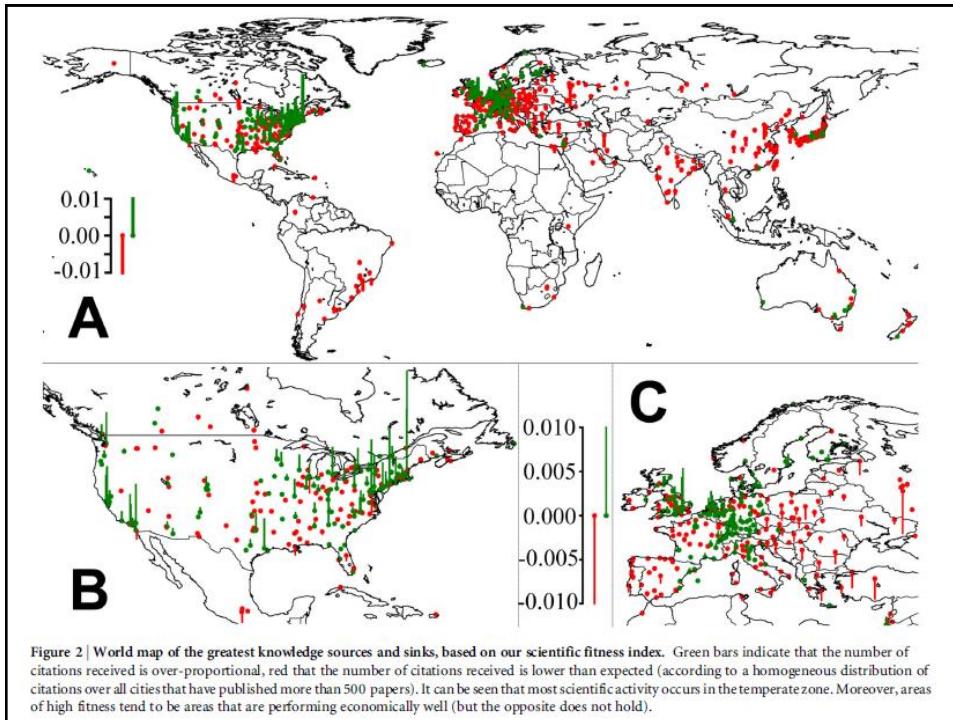
### Contributions:

Comprehensive global analysis of scholarly knowledge production and diffusion on the level of continents, countries, and cities.

Quantifying knowledge flows between 2000 and 2009, we identify global sources and sinks of knowledge production. Our knowledge flow index reveals, where ideas are born and consumed, thereby defining a global 'scientific food web'.

While Asia is quickly catching up in terms of publications and citation rates, we find that its dependence on knowledge consumption has further increased.





### Collective Allocation of Science Funding as an Alternative to Peer Review

Bollen, Johan, David Crandall, Damion Junk, Ying Ding, and Katy Börner. 2014. "From funding agencies to scientific agency: Collective allocation of science funding as an alternative to peer review". *EMBO Reports* 15 (1): 1-121.

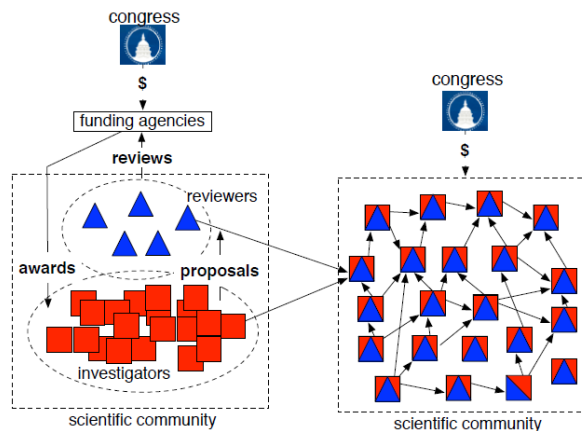
<http://embor.embopress.org/content/early/2014/01/07/embr.201338068>

#### Contribution:

We propose and validate a highly decentralized funding system.

The system operates by giving all scientists an unconditional, equal amount of funding each year; scientists are required to donate a given percentage of their total funding to other scientists whom they feel would make best use of the money.

The proposed system requires a fraction of the costs associated with peer review, but has been shown to yield comparable results.



NEWSFOCUS

### Making Every Scientist a Research Funder

When it comes to using peer review to distribute research dollars, Johan Bollen favors radical simplicity.

Over the years, many scientists have suggested that the current system could be improved by changing the composition of the review panels, tweaking the interactions among reviewers, or revising how the proposals are scored. But Bollen, a computer scientist at Indiana University, Bloomington, would simply award all eligible researchers a block grant—and then require them to give some of it away to colleagues they judge most deserving.

That radical step, described in a paper Bollen and four Indiana colleagues recently posted on *EMBO Reports*, retains peer review's core concept of tapping into the views of the most knowledgeable researchers. But it would eliminate the huge investment in time and money required to submit proposals and assemble panels to judge them.

Bollen's process would be almost instantaneous: In a version of expert-directed crowdsourcing, scientists would fill out a form once a year listing their favored researchers, and a predetermined portion of their annual grant money—a total of, say, 50%—would then be transferred to their choices.

"So many scientists spend so much time on peer review, and there's a high level of frustration," Bollen explains. "We already know who the best people are. And if you're doing good work, then you deserve to receive support."

Others are skeptical. "I've known Johan for a long time and have the highest regard for his ability as an out-of-the-box thinker," says Stephen Griffin, a retired National Science Foundation (NSF) program manager who's now a visiting professor of information sciences at the University of Pittsburgh in Pennsylvania. "But there are a number of issues he doesn't address."

Those sticking points include the likely mismatch between what researchers need and what their colleagues give them; the absence of any replacement for the overhead payments in today's grants, which support infrastructure at host institutions; and the dearth of public accountability for the billions of dollars that would flow from public coffers to individuals. "Scientists aren't really equipped to be a funding agency," Griffin notes.

Bollen acknowledges that the process would need safeguards to ensure that scientists don't reward their friends or punish their enemies. But his analysis suggests that the U.S. research landscape would not look all that different if his radical proposal were adopted.

Drawing upon citation data in 37 million papers over 20 years, the Indiana researchers conducted a simulation premised on the idea that scientists would reallocate their federal dollars according to how often they cited their peers. The simulation, he says, yielded a funding pattern "similar in shape to the actual distribution" at NSF and the National Institutes of Health for the past decade—at a fraction of the overhead required by the current system.

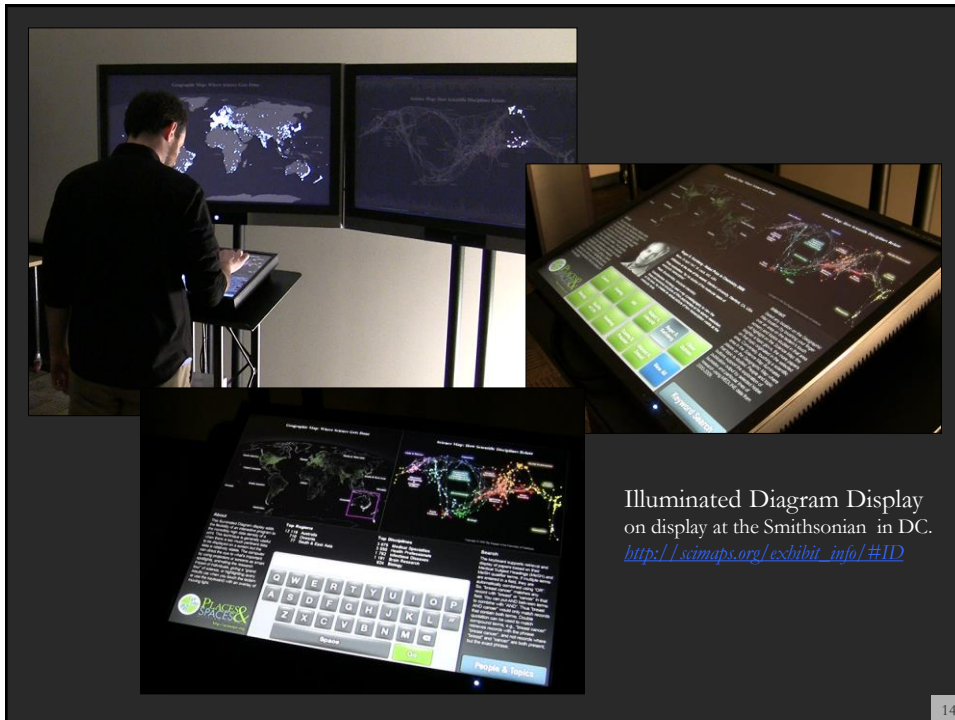
—JDM

February 7, 2014

Science 7 February 2014: Vol. 343 no. 6171 p. 598

DOI: 10.1126/science.343.6171.598

<http://www.sciencemag.org/content/343/6171/598.full?sid=4f40a7f0-6ba2-4ad8-a181-7ab394fe2178>



### Geographic Map: Where Science Gets Done

North America, Central America, South America, Europe, Africa, Asia, Oceania, North & East Asia, South & East Asia, Antarctica.

### Science Map: How Scientific Disciplines Relate

Math & Physics, Chemistry, Health Professionals, Social Sciences, Medicine, Biotechnology, Earth Sciences, Biology, Humanities, Environmental, Chemical, Mechanical & Civil Engineering, Robotics, Biomedical Sciences.

Copyright © 2008 The Regents of the University of California

**About**

This Illuminated Diagram display adds the flexibility of an interactive program to the incredibly high data density of a print. This technique is generally useful when there is too much pertinent data to be displayed on a screen but the data is relatively stable. The computer can direct the eye to what's important by using projectors or screens as smart spotlights, animating the research impact of individuals, giving a "grand tour" of science, or highlighting query results (as when you touch the ledism or use the keyboard) with an overlay of moving light.

**Top Five Continents**

North America - 4,000 records  
 South & East Asia - 3,589  
 Australia - 2,431  
 Africa - 2,206  
 South America - 1,362

**Top Five Scientific Disciplines**

Math & Physics - 4,000 records  
 Health Professionals - 3,589  
 Social Sciences - 2,431  
 Aeronautical, Chemical, Mechanical & Civil Engineering - 2,206  
 Humanities - 1,362

**Search**

The keyboard supports retrieval and display of papers based on their Medical Subject Headings (MeSH) and MeSH qualifier terms. If multiple terms are entered in a field, they are automatically combined using "OR". So, "breast cancer" matches any record with "breast" or "cancer" in that field. You can put AND between terms to combine with "AND". Thus "breast AND cancer" would only match records that contain both terms. Double quotation can be used to match compound terms, e.g. "breast cancer" retrieves records with the phrase "breast cancer", and not records where "breast" and "cancer" are both present, but the exact phrase.

Input your search query here.

Q	W	E	R	T	Y	U	I	O	P
A	S	D	F	G	H	J	K	L	"
Z	X	C	V	B	N	M			
Space									Go

People & Topics

15

Science Maps in "Expedition Zukunft" science train visiting 62 cities in 7 months 12 coaches, 300 m long Opening was on April 23<sup>rd</sup>, 2009 by German Chancellor Merkel

<http://www.expedition-zukunft.de>

16



Terra bytes of data

Information Technology

Find your way

Find collaborators, friends

Identify trends

17

COMMUNICATIONS OF THE ACM

Plug-and-Play Macroscopes

by Katy Börner

Association for Computing Machinery

18

Börner, Katy. (March 2011).  
 Plug-and-Play Macroscopes.  
*Communications of the ACM*,  
 54(3), 60-69.

Video and paper are at  
<http://www.scivee.tv/node/27704>

**Overview**

This course provides an overview about the state of the art in information visualization. It teaches the process of producing effective visualizations that take the needs of users into account.

Among other topics, the course covers:

- Data analysis algorithms that enable extraction of relationships in data
- Major visualization and interaction techniques
- Discussions of systems that drive research and development.

A certificate will be issued upon successful completion. Please watch the introduction video to get better acquainted with the course.

Katy Börner, Ph.D.  
Indiana University



Sign Up For The Course

Register for free at <http://ivmoooc.cns.iu.edu>. Class restarted on Jan 28, 2014.

**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/](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 (2012) **Models of Science Dynamics**. Springer Verlag.

Katy Börner, Michael Conlon, Jon Corson-Rikert, Cornell, Ying Ding (2012) **VIVO: A Semantic Approach to Scholarly Networking and Discovery**. Morgan & Claypool.

Katy Börner and David E Polley (2014) **Visual Insights: A Practical Guide to Making Sense of Data**. MIT Press.



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>