

# Mining, Mapping, and Accelerating Science and Technology

Katy Börner

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Information Visualization Laboratory, Director  
School of Library and Information Science  
Indiana University, Bloomington, IN

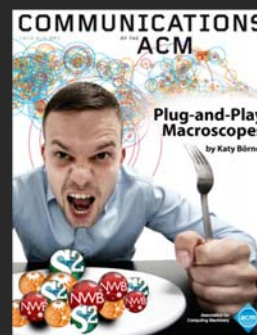
[katy@indiana.edu](mailto:katy@indiana.edu)



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

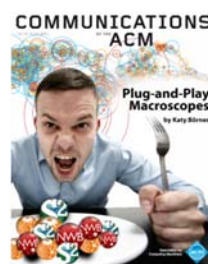
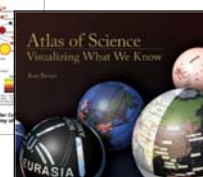
CWTS, Leiden  
The Netherlands

March 23, 2012



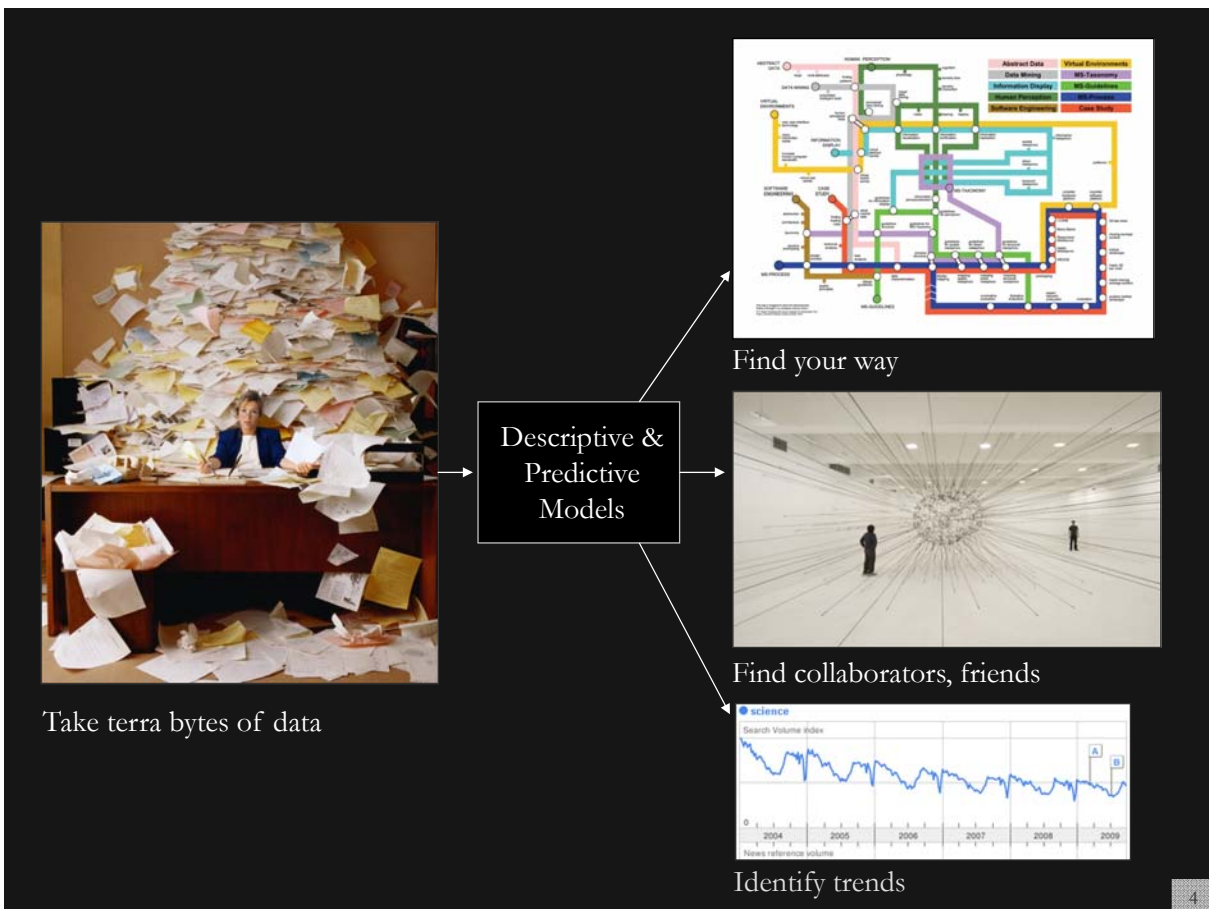
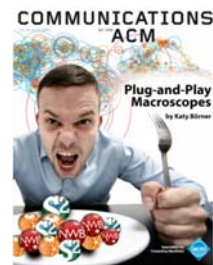
## Overview

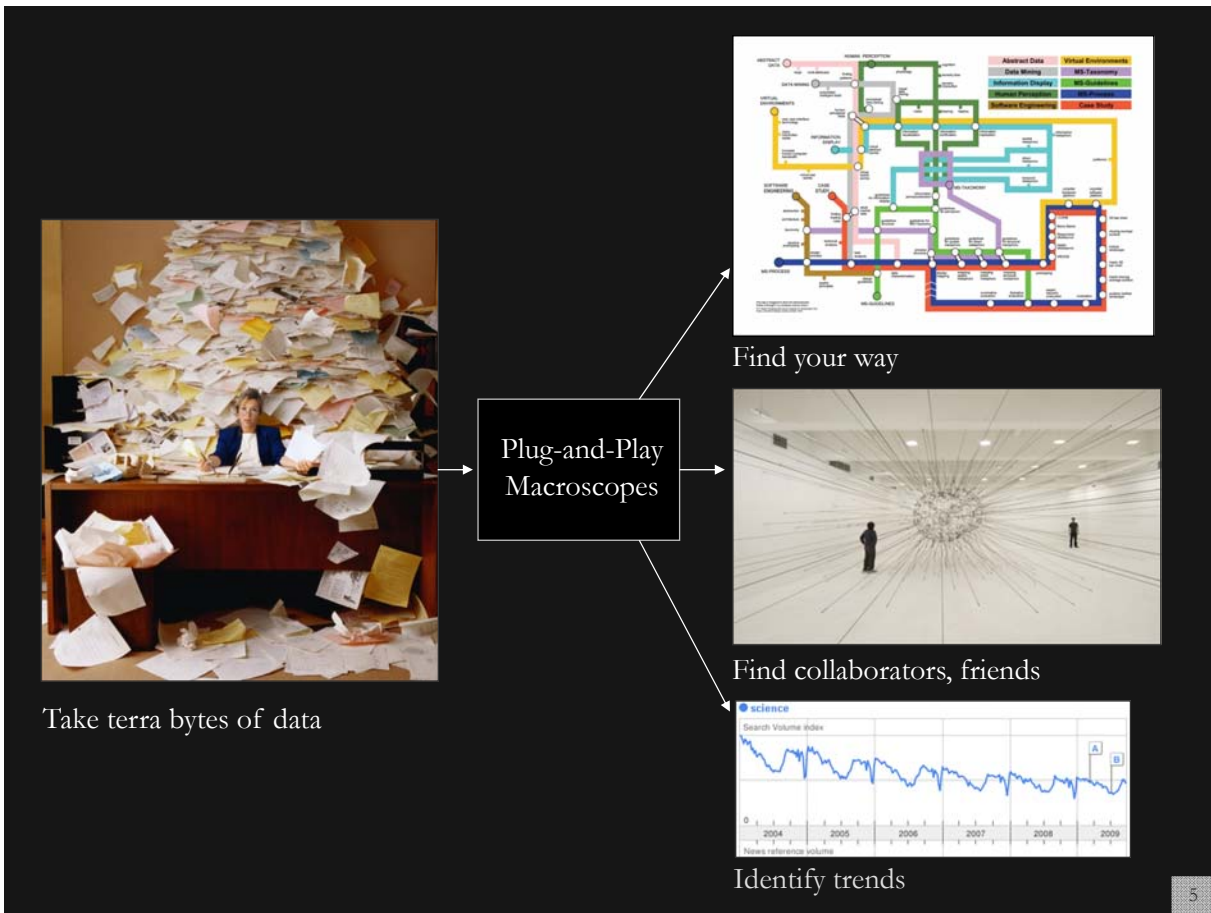
1. **Data mining and visualization research** that aims to increase our scientific understanding of the structure and dynamics of science and technology.
2. **Novel approaches and services** that improve information access, researcher networking, and research management.
3. **Data services and plug-and-play macroscope tools** that commoditize data mining and visualization.



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## Type of Analysis vs. Level of Analysis

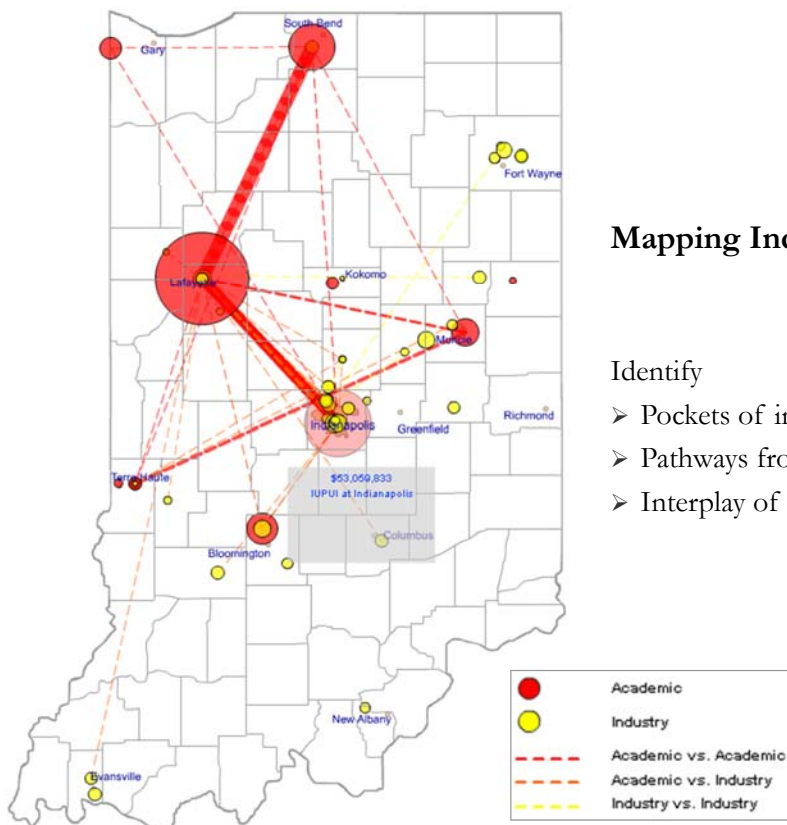
	<i>Micro/Individual (1-100 records)</i>	<i>Meso/Local (101-10,000 records)</i>	<i>Macro/Global (10,000 &lt; records)</i>
<b>Statistical Analysis/Profiling</b>	Individual person and their expertise profiles	Larger labs, centers, universities, research domains, or states	All of NSF, all of USA, all of science.
<b>Temporal Analysis (When)</b>	Funding portfolio of one individual	Mapping topic bursts in 20-years of PNAS	113 Years of Physics Research
<b>Geospatial Analysis (Where)</b>	Career trajectory of one individual	Mapping a states intellectual landscape	PNAS publications
<b>Topical Analysis (What)</b>	Base knowledge from which one grant draws.	Knowledge flows in Chemistry research	VxOrd/Topic maps of NIH funding
<b>Network Analysis (With Whom?)</b>	NSF Co-PI network of one individual	Co-author network	NIH's core competency

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## Mapping Indiana's Intellectual Space

Identify

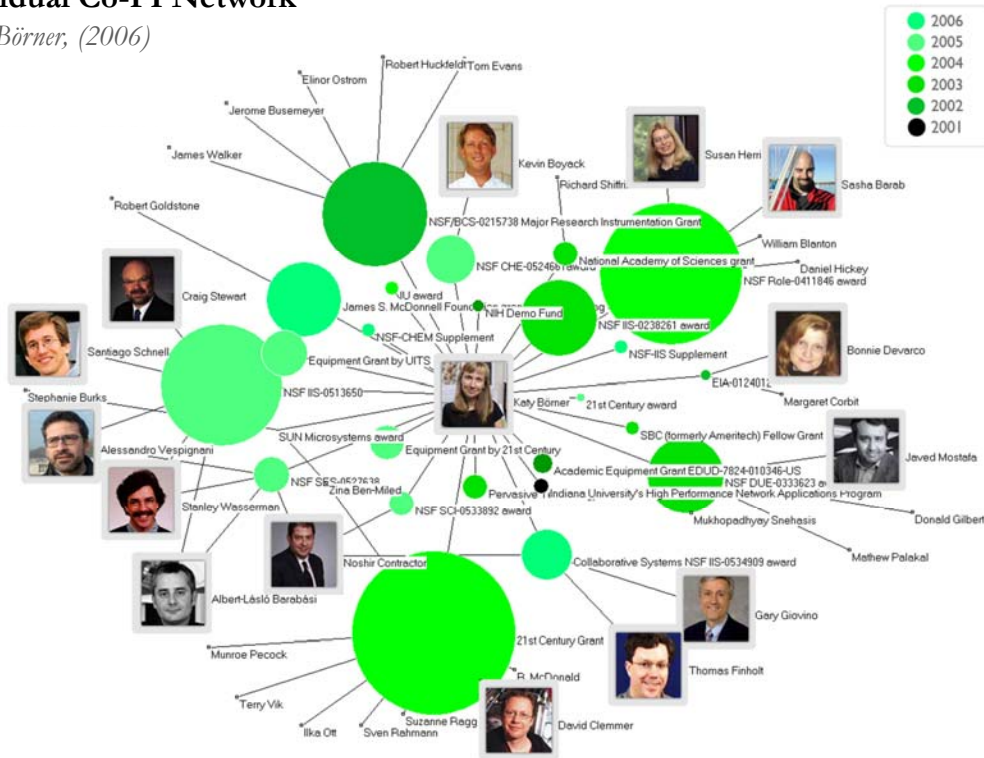
- Pockets of innovation
- Pathways from ideas to products
- Interplay of industry and academia

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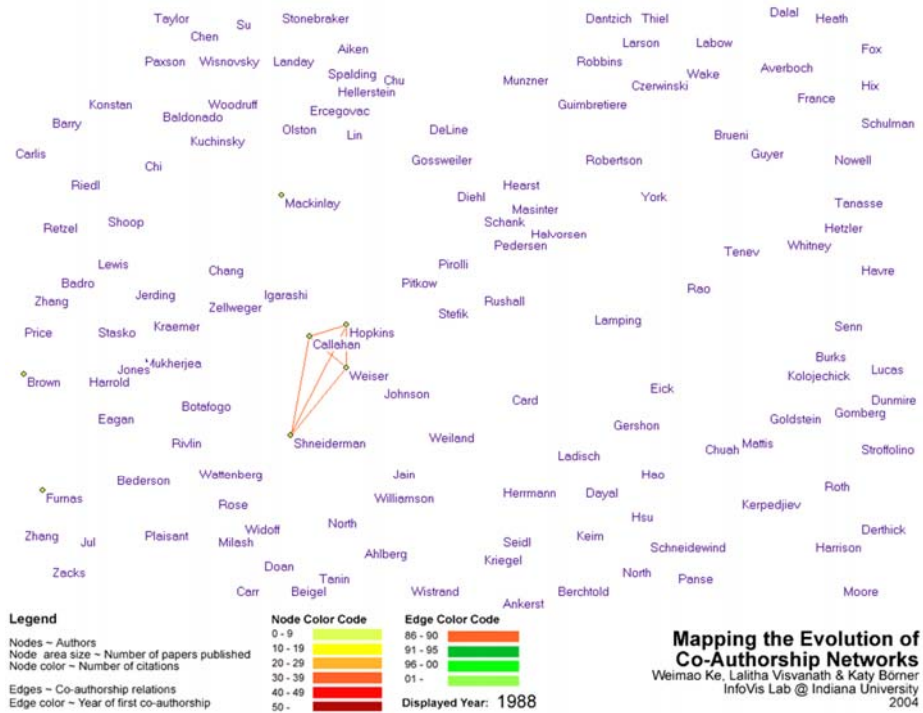
# Individual Co-PI Network

Ke & Börner, (2006)



# Mapping the Evolution of Co-Authorship Networks

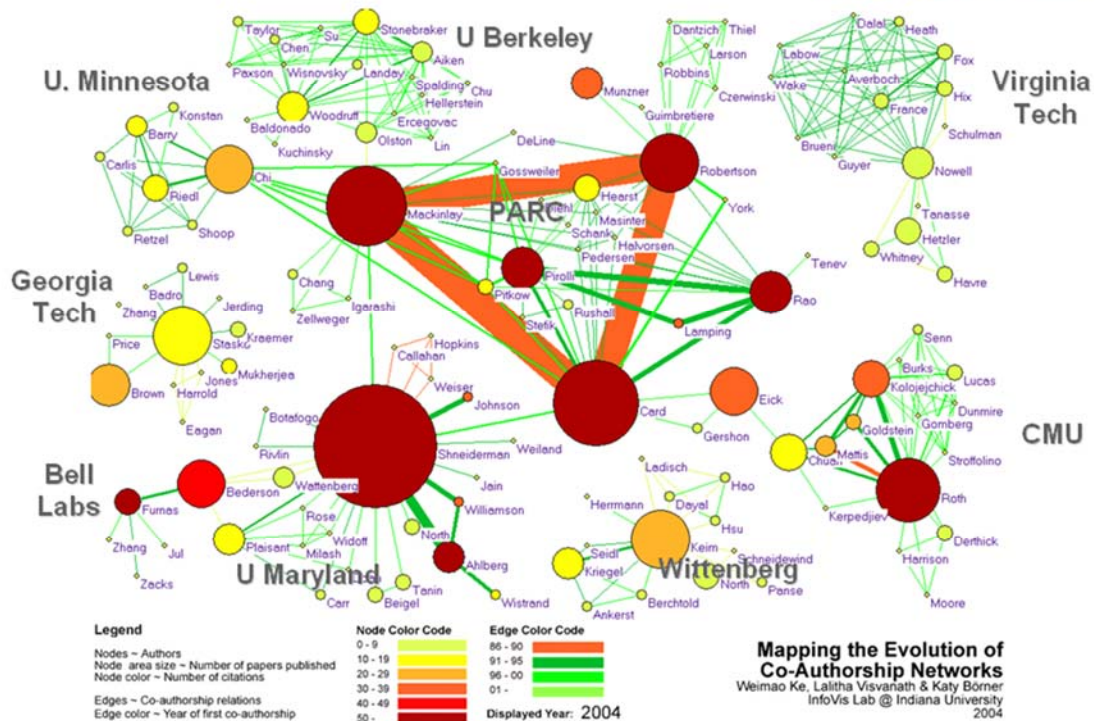
Ke, Visvanath & Börner, (2004) Won 1st price at the IEEE InfoVis Contest.



**Mapping the Evolution of Co-Authorship Networks**  
 Weimao Ke, Lalitha Visvanath & Katy Börner  
 InfoVis Lab @ Indiana University  
 2004

## Mapping the Evolution of Co-Authorship Networks

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



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

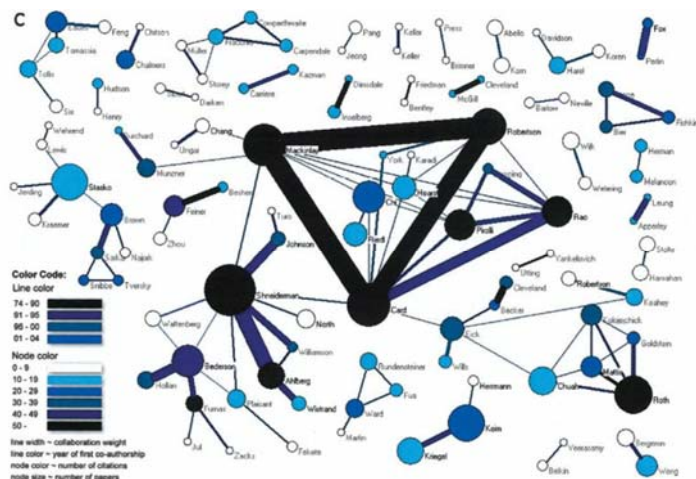
Börner, Dall'Asta, Ke & Vespignani (2005)  
*Complexity*, 10(4):58-67.

### 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.



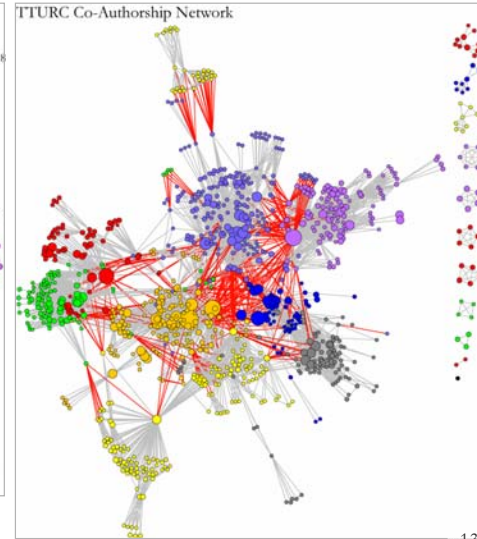
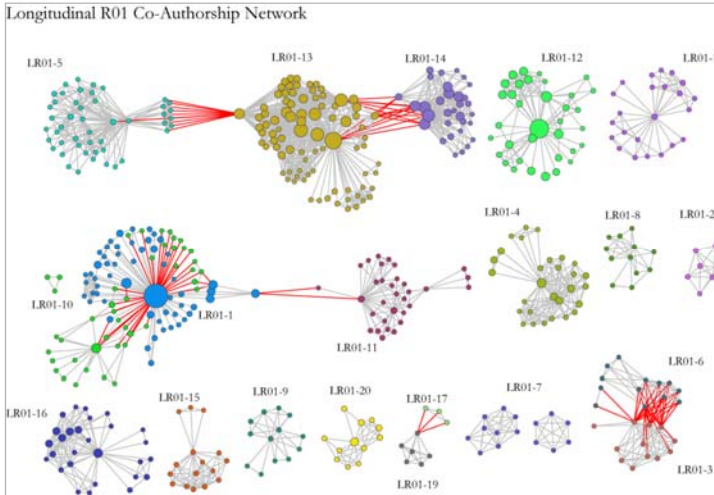
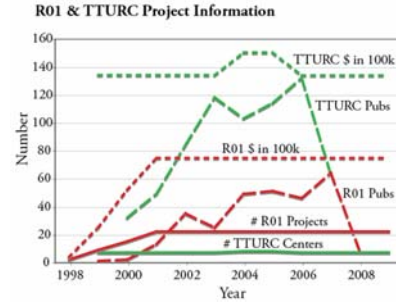
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## Mapping Transdisciplinary Tobacco Use Research Centers Publications

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

Zoss & Börner, *forthcoming*.

Supported by NIH/NCI Contract HHSN261200800812

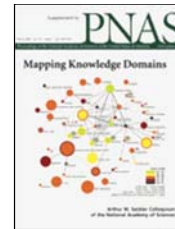
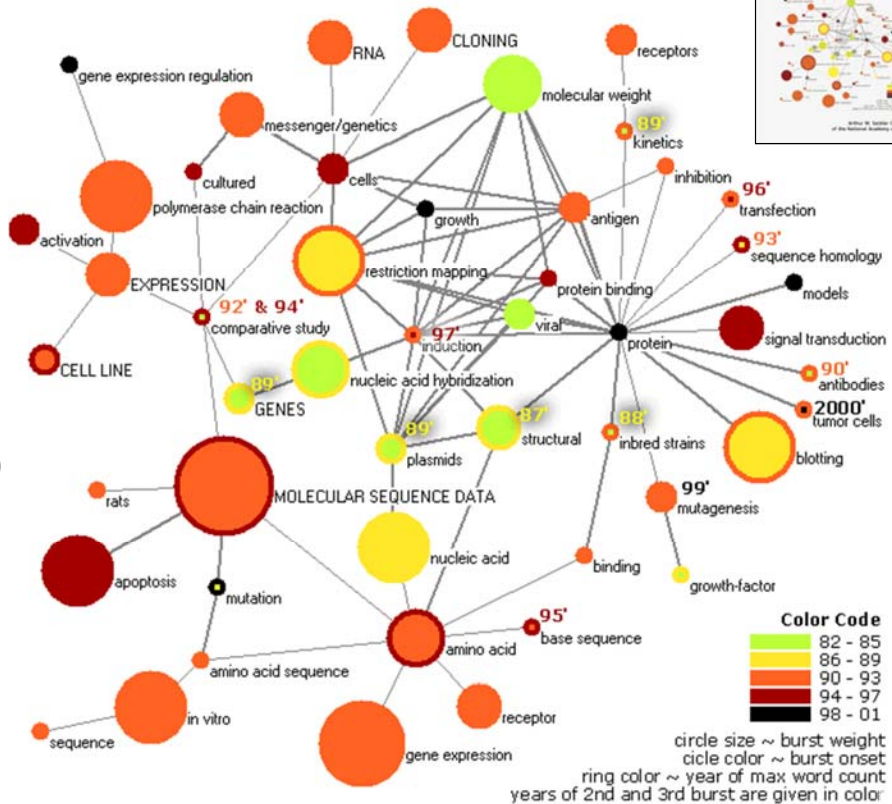


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## Mapping Topic Bursts

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

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



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## Mapping Science Exhibit at NEU



From left to right: Thomas Urell  
Communications Officer, NEU Libraries),  
David Lazer (Associate Professor of Political  
Science and Computer Science), Katy Börner,  
William Wakeling (Dean, University Libraries).

Exhibit has been on display at more than 200 venues in 19 countries on 6 continents.

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## References

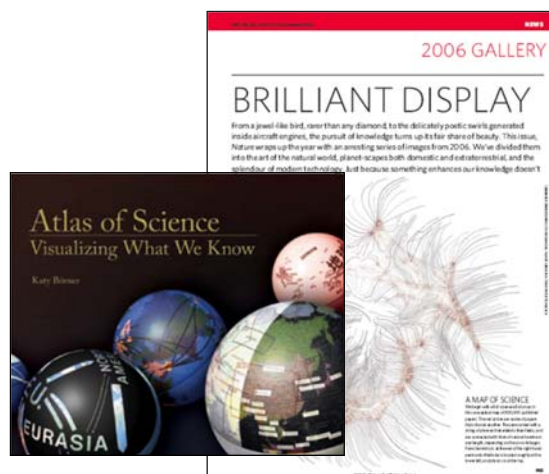
Börner, Katy, Chen, Chaomei, and Boyack, Kevin. (2003).  
**Visualizing Knowledge Domains.** In Blaise Cronin  
(Ed.), *ARIST*, Medford, NJ: Information Today, Volume  
37, Chapter 5, pp. 179-255.  
<http://ivl.slis.indiana.edu/km/pub/2003-borner-arist.pdf>

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>

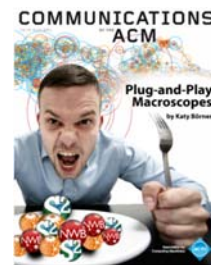
Scharnhorst, Andrea, Börner, Katy, van den Besselaar,  
Peter (2012) **Models of Science Dynamics.**  
Springer Verlag.



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## Overview

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## Different Stakeholder Groups and Their Needs

### Funding Agencies

- Need to monitor (long-term) money flow and research developments, identify areas for future development, stimulate new research areas, evaluate funding strategies for different programs, decide on project durations, funding patterns.

### Scholars

- Want easy access to research results, relevant funding programs and their success rates, potential collaborators, competitors, related projects/publications (*research push*).

### Industry

- Is interested in fast and easy access to major results, experts, etc. Influences the direction of research by entering information on needed technologies (*industry-pull*).

### Advantages for Publishers

- Need easy to use interfaces to massive amounts of interlinked data. Need to communicate data provenance, quality, and context.

### Society

- Needs easy access to scientific knowledge and expertise.

## Scholars Have Different Roles/Needs

**Researchers and Authors**—need to select promising research topics, students, collaborators, and publication venues to increase their reputation. They benefit from a global view of competencies, reputation and connectivity of scholars; hot and cold research topics and bursts of activity, and funding available per research area.

**Editors**—have to determine editorial board members, assign papers to reviewers, and ultimately accept or reject papers. Editors need to know the position of their journals in the evolving world of science. They need to advertise their journals appropriately and attract high-quality submissions, which will in turn increase the journal's reputation.

**Reviewers**—read, critique, and suggest changes to help improve the quality of papers and funding proposals. They need to identify related works that should be cited or complementary skills that authors might consider when selecting project collaborators.

**Teachers/Mentors**—teach classes, train doctoral students, and supervise postdoctoral researchers. They need to identify key works, experts, and examples relevant to a topic area and teach them in the context of global science.

**Inventors**—create intellectual property and obtain patents, thus needing to navigate and make sense of research spaces as well as intellectual property spaces.

**Investigators**—scholars need funding to support students, hire staff, purchase equipment, or attend conferences. Here, research interests and proposals have to be matched with existing federal and commercial funding opportunities, possible industry collaborators and sponsors.

**Team Leads and Science Administrators**—many scholars direct multiple research projects simultaneously. Some have full-time staff, research scientists, and technicians in their laboratories and centers. Leaders need to evaluate performance and provide references for current or previous members; report the progress of different projects to funding agencies.

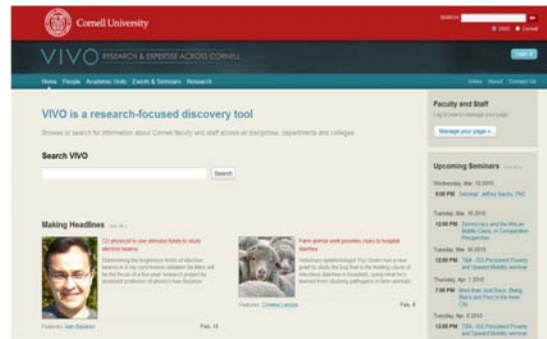


VIVO International Researcher  
Network



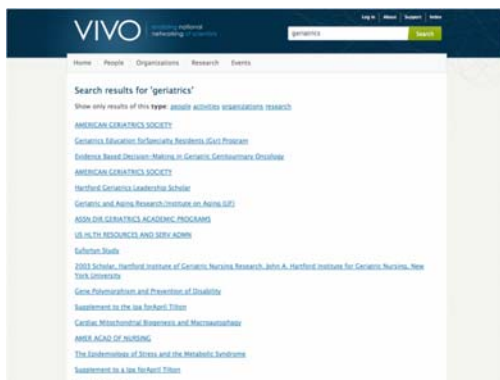
## VIVO: A Semantic Approach to Creating a National Network of Researchers (<http://vivoweb.org>)

- Semantic web application and ontology editor originally developed at Cornell U.
- Integrates research and scholarship info from systems of record across institution(s).
- Facilitates research discovery and cross-disciplinary collaboration.
- Simplify reporting tasks, e.g., generate biosketch, department report.



Funded by \$12 million NIH award.

**Cornell University:** Dean Krafft (Cornell PI), Manolo Bevia, Jim Blake, Nick Cappadona, Brian Caruso, Jon Corson-Rikert, Elly Cramer, Medha Devare, John Ferreira, Brian Lowe, Stella Mitchell, Holly Mistlebauer, Anup Sawant, Christopher Westling, Rebecca Younes. **University of Florida:** Mike Conlon (VIVO and UF PI), Cecilia Botero, Kerry Britt, Erin Brooks, Amy Buhler, Ellie Bushhousen, Chris Case, Valrie Davis, Nita Ferree, Chris Haines, Rae Jesano, Margeaux Johnson, Sara Kreinest, Yang Li, Paula Markes, Sara Russell Gonzalez, Alexander Rockwell, Nancy Schaefer, Michele R. Tennant, George Hack, Chris Barnes, Narayan Raum, Brenda Stevens, Alicia Turner, Stephen Williams. **Indiana University:** Katy Borner (IU PI), William Barnett, Shanshan Chen, Ying Ding, Russell Duhon, Jon Dunn, Micah Linnemeier, Nianli Ma, Robert McDonald, Barbara Ann O'Leary, Mark Ping, Yuyin Sun, Alan Walsh, Brian Wheeler, Angela Zoss. **Ponce School of Medicine:** Richard Noel (Ponce PI), Ricardo Espada, Damaris Torres. **The Scripps Research Institute:** Gerald Joyce (Scripps PI), Greg Dunlap, Catherine Dunn, Brant Kelley, Paula King, Angela Murrell, Barbara Noble, Cary Thomas, Michaelen Trimarchi. **Washington University, St. Louis:** Rakesh Nagarajan (WUSTL PI), Kristi L. Holmes, Sunita B. Koul, Leslie D. McIntosh. **Weill Cornell Medical College:** Curtis Cole (Weill PI), Paul Albert, Victor Brodsky, Adam Cheriff, Oscar Cruz, Dan Dickinson, Chris Huang, Itay Klaz, Peter Michelini, Grace Migliorisi, John Ruffing, Jason Specland, Tru Tran, Jesse Turner, Vinay Varughese.



**University of Florida**

How do you want to compare?  
by Grants

Who do you want to compare?  
Search: X

Records 1 - 10 of 30

Entity Label	Grant Count	Entity Type
<input checked="" type="checkbox"/> Continuing Education	562	UF Department, Agent, Non-Academic Department, Department
<input checked="" type="checkbox"/> Florida Museum of Natural History	203	Museum, Agent
<input checked="" type="checkbox"/> College of Agricultural and Life Sciences	166	Agent, UF College, College
<input checked="" type="checkbox"/> College of Engineering	103	Agent, UF College, College
<input checked="" type="checkbox"/> Evelyn F. and William L. McKnight Brain Institute of the University of Florida	64	UF Center, Agent, Center
<input checked="" type="checkbox"/> International Center	54	UF Department, Agent, Non-Academic Department, Department
<input checked="" type="checkbox"/> Florida Sea Grant	44	UF Center, Agent, Center
<input type="checkbox"/> Whitney Laboratory for Marine Bioscience	42	UF Research Laboratory, Agent, Laboratory, Research Laboratory
<input type="checkbox"/> Water Institute	38	UF Center, Agent, Center
<input type="checkbox"/> College of Dentistry	35	Agent, UF College, College

Save as CSV Clear

**Comparing Grants of Organizations in University of Florida**

**Total Number of Grants**  
You have selected 7 of a maximum 10 organizations to compare. Clear

- Florida Sea Grant 44
- International Center 54
- Evelyn F. and William L. McKnight Brain Institute of the University of Florida 64
- College of Engineering 103
- College of Agricultural and Life Sciences 166
- Florida Museum of Natural History 203
- Continuing Education 562

**Temporal Analysis (When)** Temporal visualizations of the number of papers/funding award at the institution, school, department, and people level

**VIVO** enabling national networking of scientists

Index Log in

Home People Organizations Research Events

**University of Florida**

Explore 487 publications activity across 554 scientific sub-disciplines

13 Disciplines | 554 Sub-Disciplines

Search: X

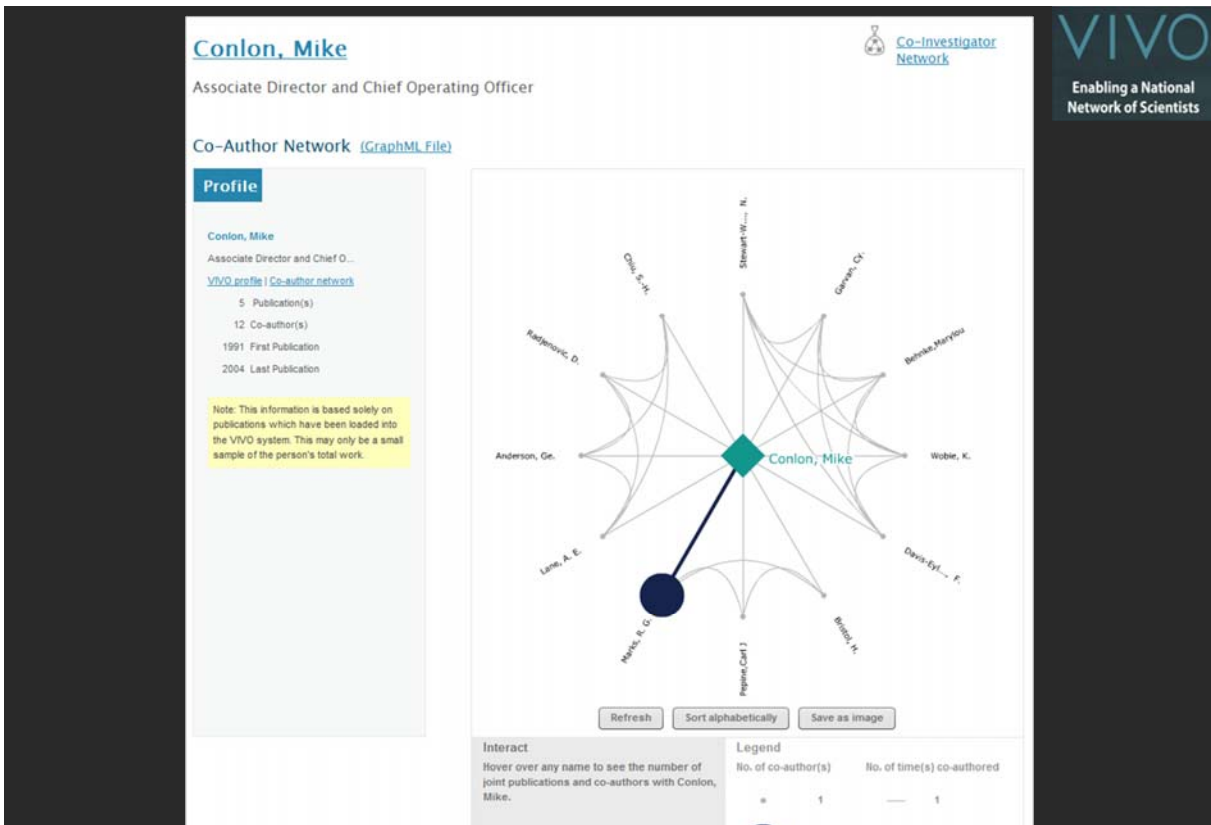
1 - 13 of 554

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

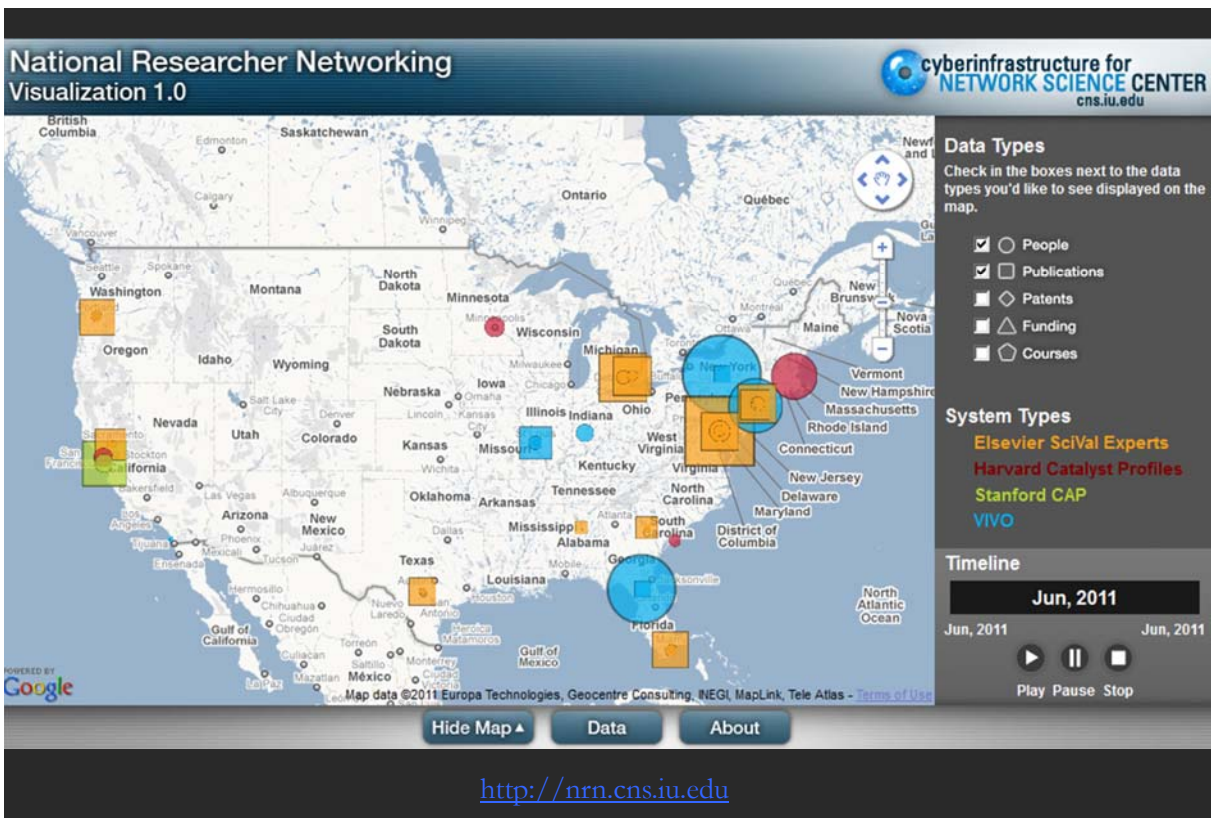
Top 290 disciplines shown

mapped 14.55% of 3,346 publications

**Topical Analysis (What)** Science map overlays will show where a person, department, or university publishes most in the world of science. (in work)



**Network Analysis (With Whom?)** Who is co-authoring, co-investigating, co-inventing with whom? What teams are most productive in what projects? 27



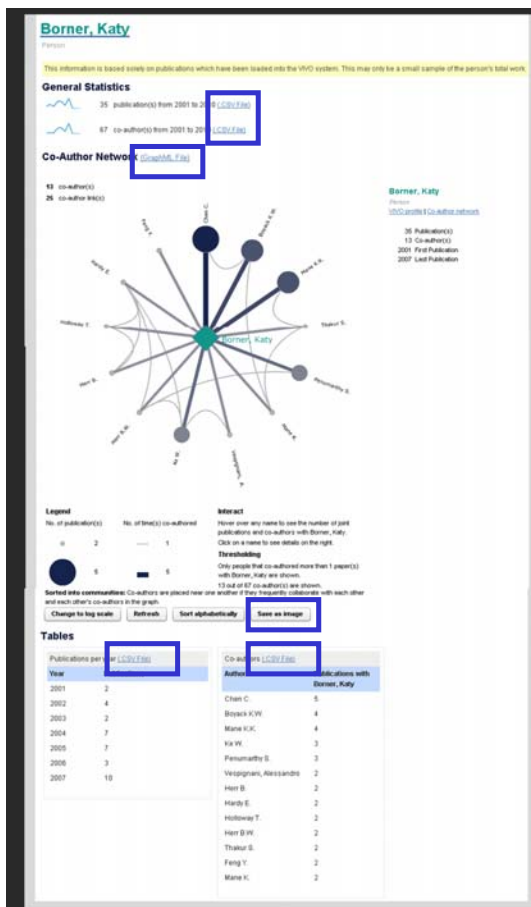
**Geospatial Analysis (Where)** Where is what science performed by whom? Science is global and needs to be studied globally. 28



## VIVO On-The-Go

## Overview, Interactivity, Details on Demand

come to  
commonly  
used devices  
and environments



## Download Data

### General Statistics

- 36 publication(s) from 2001 to 2010 [\(.CSV File\)](#)
- 80 co-author(s) from 2001 to 2010 [\(.CSV File\)](#)

### Co-Author Network

[\(GraphML File\)](#)

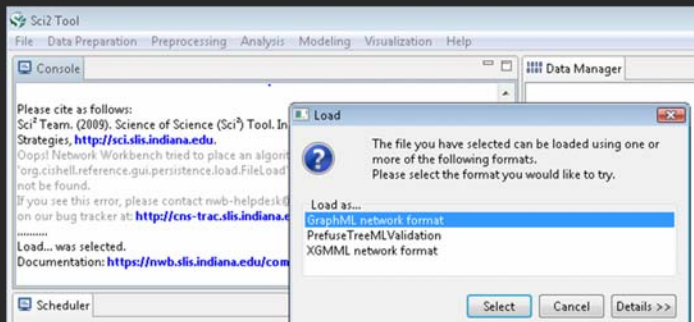
Save as Image (.PNG file)

### Tables

- Publications per year [\(.CSV File\)](#)
- Co-authors [\(.CSV File\)](#)

<http://vivo.iu.edu/vis/author-network/person25557>

## Run Sci2 Tool and Load Co-Author Network ([GraphML File](#))



Network Analysis Toolkit

Nodes: 81

Edges: 390

Visualize the file using Radial Graph layout.



Click on node to focus on it.

Hover over a node to highlight its co-authors.

Code and tutorials are linked from <http://sci2.wiki.cns.edu>

## Develop VIVO Visualizations

See also *Visualization in VIVO Workshop on Aug 24, 2011*

<http://wiki.cns.in.edu/display/PRES/VIVO+Presentation>



### VIVO Presentation

4 Added by Chin Hua Kong, last edited by Chintan Tank on Aug 24, 2011 (view change)

#### August, 2011 Workshop

##### Material

- [Java 1.5 or higher](#) - A programming language and computing platform for developing cross OS softwares.
- [Science of Science tool \(Sci2\)](#) - An desktop application for information analysis and visualization.
- [Gephi](#) - An interactive visualization tool for networks and complex systems, dynamic and hierarchical graphs.
- [VIVO August 2011 workshop data.zip](#) - Hands on workshop data package

##### Slides

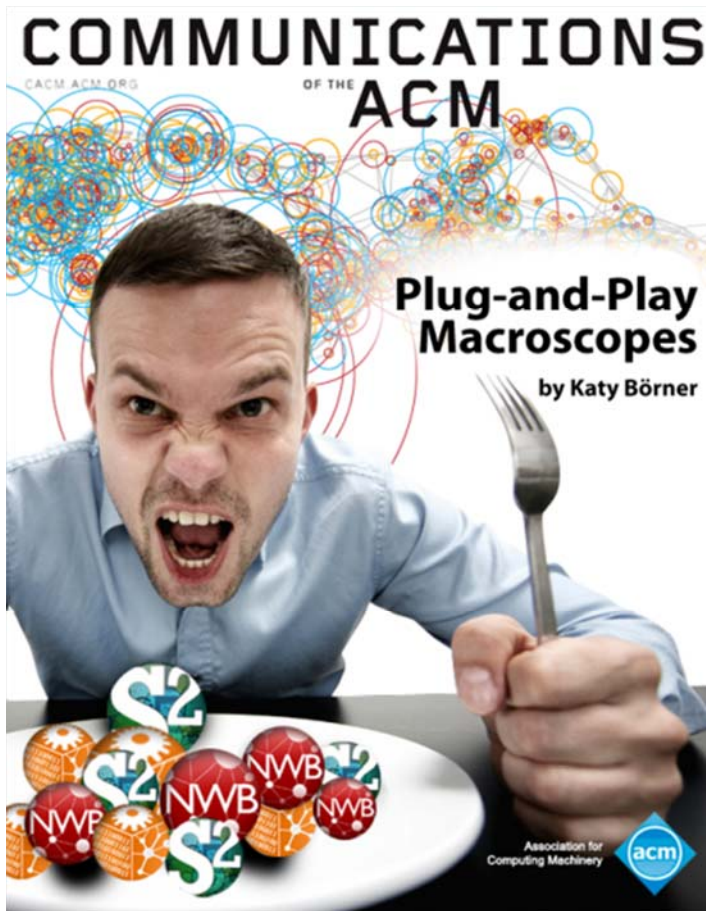
- [Tutorial Slides](#) presented at the VIVO Conference 2011
- [Pre-Questionnaire](#) and [Post-Questionnaire](#)

##### Demo Links

- [Map of Science Visualization \(dev link\)](#)
- [Temporal Graph Visualization \(dev link\)](#)
- [National Researcher Networking Visualization](#)
- [Word Cloud Visualization dev link](#)



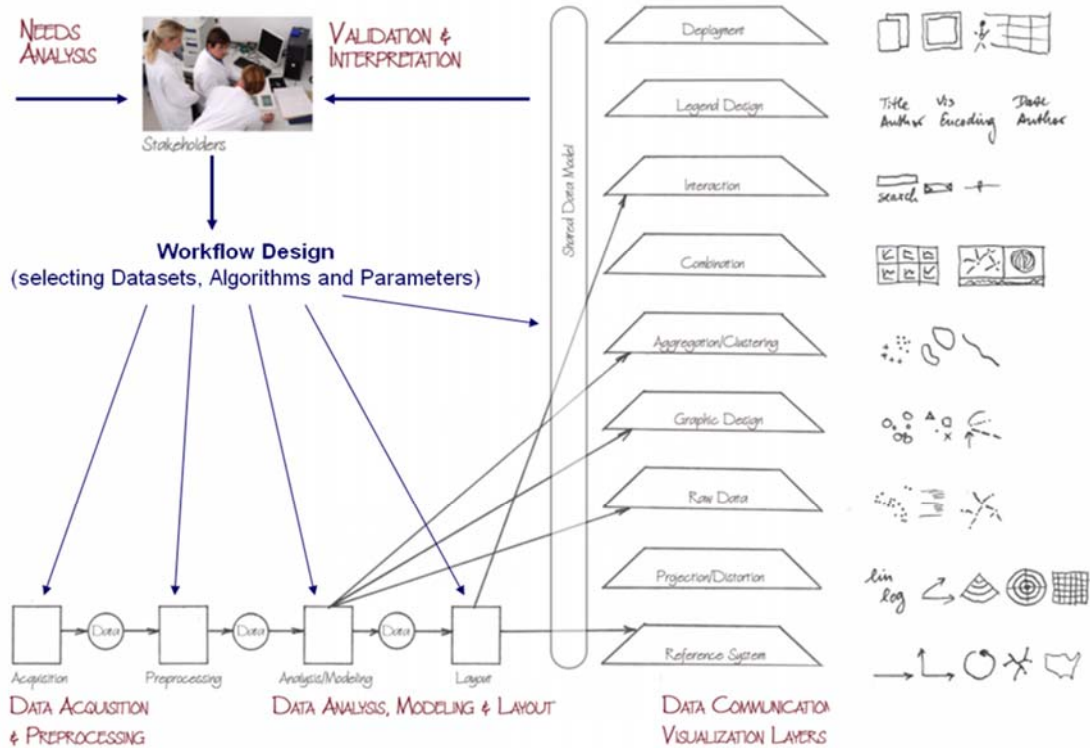




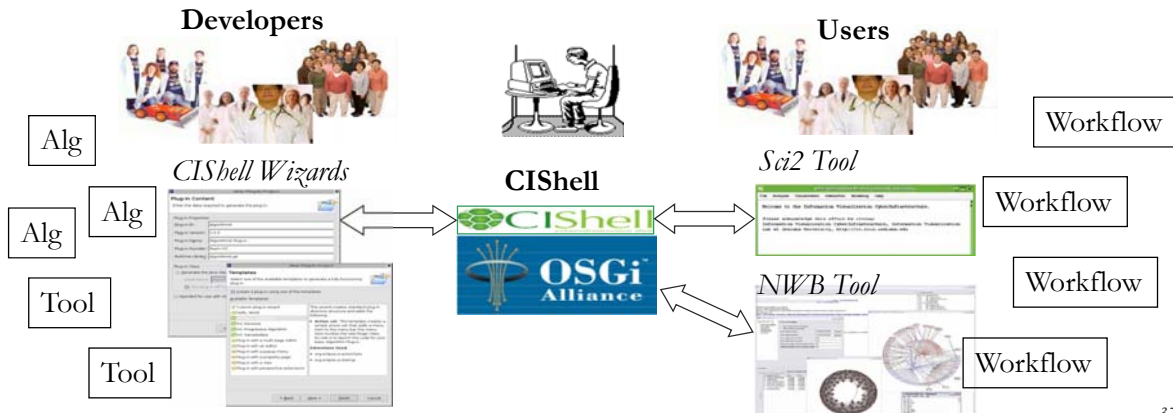
Börner, Katy. (March 2011).  
 Plug-and-Play Macroscopes.  
*Communications of the ACM*,  
 54(3), 60-69.

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


**Needs-Driven Workflow Design** using a modular data acquisition/analysis/  
 modeling/ visualization pipeline as well as modular visualization layers.



- CIShell (<http://cishell.org>) is an open source software specification for the integration and utilization of datasets, algorithms, and tools.
- It extends the Open Services Gateway Initiative (OSGi) (<http://osgi.org>), a standardized, component oriented, computing environment for networked services widely used in industry since more than 10 years.
- Specifically, CIShell provides “sockets” into which existing and new datasets, algorithms, and tools can be plugged using a wizard-driven process.



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Edit Add

1 Added by [Micah Linnemeier](#), last edited by [Micah Linnemeier](#) on Mar 16, 2011 ([view change](#))

## About the Cyberinfrastructure Shell

The Cyberinfrastructure Shell (CIShell) is an open source, community-driven platform for the integration and utilization of datasets, algorithms, tools, and computing resources. Algorithm integration support is built in for Java and most other programming languages. Being Java based, it will run on almost all platforms. The software and specification is released under an Apache 2.0 License.

CIShell is the basis of [Network Workbench](#), [TextTrend](#), [Sci2](#) and the upcoming [EpiC](#) tool.

CIShell supports remote execution of algorithms. A standard web service definition is in development that will allow pools of algorithms to transparently be used in a peer-to-peer, client-server, or web front-end fashion.

## CIShell Features

**A framework for easy integration of new and existing algorithms written in any programming language**

Using CIShell, an algorithm writer can fully concentrate on creating their own algorithm in whatever language they are comfortable with. Simple tools are provided to then take their algorithm and

## Learn More...

- [CIShell Papers](#)
- [CIShell Powered Tools](#)
- [Algorithms](#)
- [Plugins \(coming soon\)](#)
- [Misc. Tool Documentation](#)
- CIShell Web Services (coming soon)
- [Screenshots](#)

## Getting Started...

- [Documentation & Developer Resources](#)
- [Download](#)

## Getting Involved...

- [Contact Us](#)

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## Network Workbench Tool

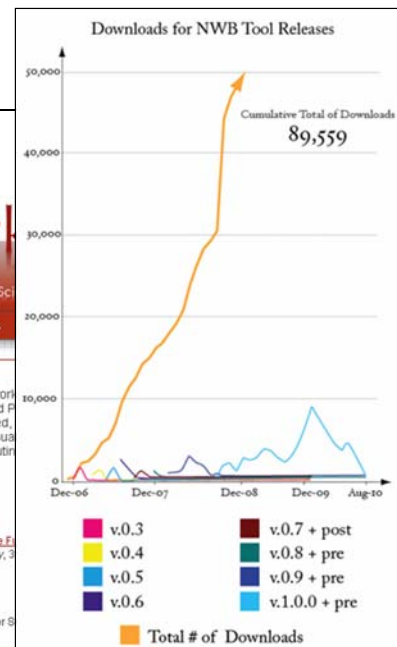
<http://nwb.cns.edu>

The Network Workbench (NWB) tool supports researchers, educators, and practitioners interested in the study of biomedical, social and behavioral science, physics, and other networks.

In February 2009, the tool provides more than 169 plugins that support the preprocessing, analysis, modeling, and visualization of networks.

**More than 50 of these plugins can be applied or were specifically designed for S&T studies.**

It has been downloaded more than 110,000 times since December 2006.





## Computational Proteomics

What relationships exist between protein targets of all drugs and all disease-gene products in the human protein–protein interaction network?

*Yildirim, Muhammed A., Kwan-II Goh, Michael E. Cusick, Albert-László Barabási, and Marc Vidal. (2007). Drug-target Network. Nature Biotechnology 25 no. 10: 1119-1126.*



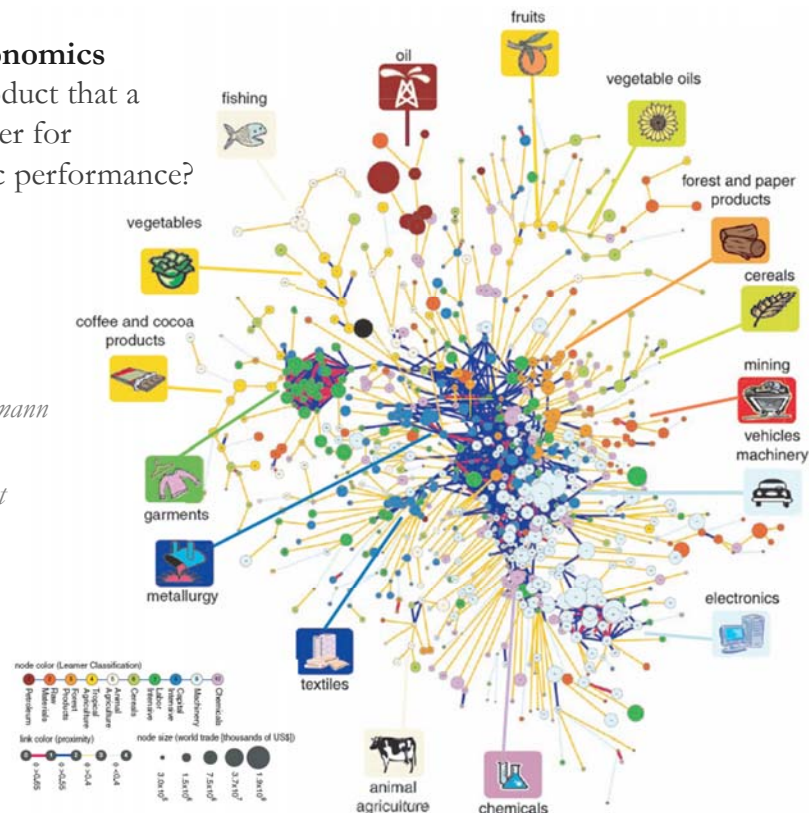
**Figure 2** Drug-target network (DT network). The DT network is generated by using the known associations between FDA-approved drugs and their target proteins. Circles and rectangles correspond to drugs and target proteins, respectively. A link is placed between a drug node and a target node if the protein is a known target of that drug. The area of the drug (protein) node is proportional to the number of targets that the drug (the number of drugs targeting the protein). Color codes are given in the legend. Drug nodes (circles) are colored according to their Anatomical Therapeutic Chemical Classification, and the target proteins (rectangular boxes) are colored according to their cellular component obtained from the Gene Ontology database.

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## Computational Economics

Does the type of product that a country exports matter for subsequent economic performance?

*C. A. Hidalgo, B. Klinger, A.-L. Barabási, R. Hausmann (2007) The Product Space Conditions the Development of Nations. Science 317, 482 (2007).*



**Fig. 1.** The product space. (A) Hierarchically clustered proximity matrix representing the 775 SITC-4 product classes exported in the 1998–2000 period. (B) Network representation of the product space. Links are color coded with their proximity value. The sizes of the nodes are proportional to world trade, and their colors are chosen according to the classification introduced by Leamer.

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## Computational Social Science

Studying large scale social networks such as Wikipedia

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

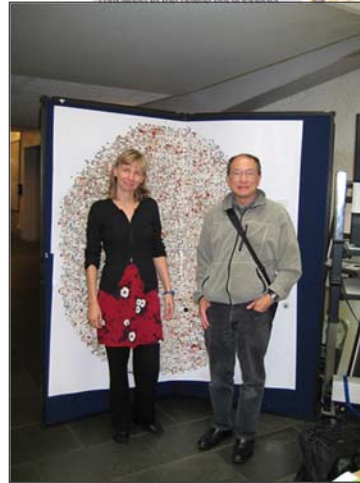


## Second sight

Image: Bruce W. Hest and Todd M. Holloway

### Power struggle

How do you keep track of the bobbling mass of information that is Wikipedia? This chaotic-looking mosaic is one attempt to show which topics are contained in the online encyclopedia.



...which were the most viewed pages at the time of writing include entries on Sheffield Wednesday football club, Mikhail Gorbachev and pigs). The mosaic has been commended in a competition for images that visualise network dynamics, coinciding with this week's International Workshop and Conference on Network Science in Bloomington.

www.newscientist.com



19 May 2007 | NewScientist | 55

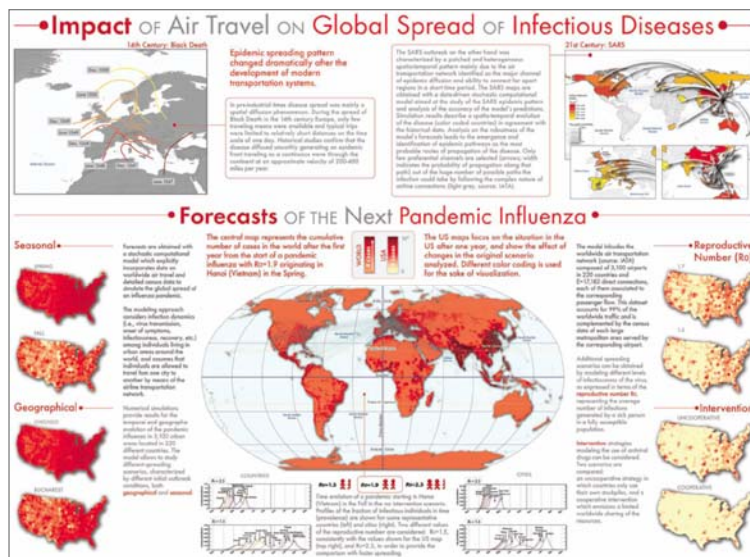
## Computational Epidemics

Forecasting (and preventing the effects of) the next pandemic.

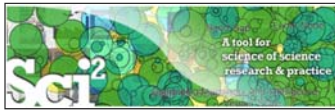
*Epidemic Modeling in Complex realities, V. Colizza, A. Barrat, M. Barthelemy, A. Vespignani, Comptes Rendus Biologie, 330, 364-374 (2007).*

*Reaction-diffusion processes and metapopulation models in heterogeneous networks, V. Colizza, R. Pastor-Satorras, A. Vespignani, Nature Physics 3, 276-282 (2007).*

*Modeling the Worldwide Spread of Pandemic Influenza: Baseline Case and Containment Interventions, V. Colizza, A. Barrat, M. Barthelemy, A.-J. Valleron, A. Vespignani, PLoS-Medicine 4, e13, 95-110 (2007).*

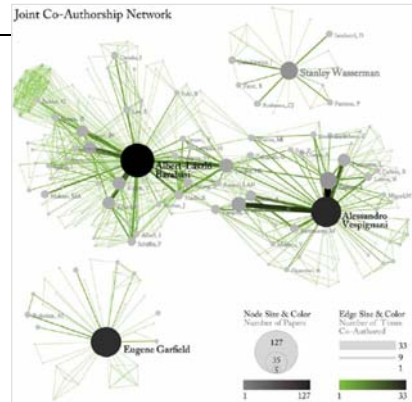
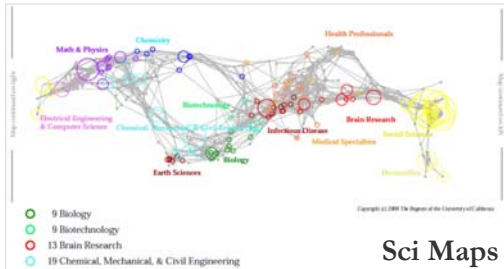






## Sci² Tool – “Open Code for S&T Assessment”

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



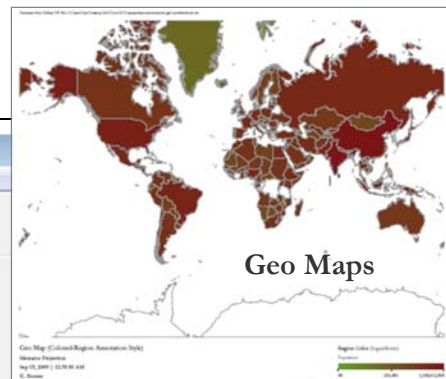
### Horizontal Time Graphs



Börner, Katy, Huang, Weixia (Bonnie), Linnemeier, Micah, Dubon, Russell Jackson, Phillips, Patrick, Ma, Nianli, Zoss, Angela, Guo, Hanning & Price, Mark. (2009). *Reti-Netzwerk-Red: Analyzing and Visualizing Scholarly Networks Using the Scholarly Database and the Network Workbench Tool*. *Proceedings of ISSI 2009: 12th International Conference on Scientometrics and Informetrics, Rio de Janeiro, Brazil, July 14-17*. Vol. 2, pp. 619-630.



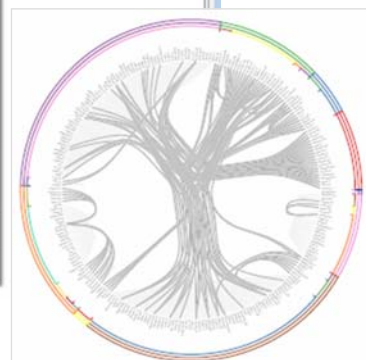
## Sci² Tool Vis cont.



**Visualization Menu:**

- GUESS
- GnuPlot
- Radial Tree/Graph (prefuse alpha)
- Radial Tree/Graph with Annotation (prefuse beta)
- Tree View (prefuse beta)
- Tree Map (prefuse beta)
- Force Directed with Annotation (prefuse beta)
- Fruchterman-Reingold with Annotation (prefuse beta)
- DrL (VxOrd)
- Specified (prefuse beta)
- Horizontal Line Graph
- Circular Hierarchy
- Geo Map (circle annotations)
- Geo Map (region coloring annotations)
- Image Viewer
- RefMapper

Algorithm Name	Date	Time	% Con
Extract Co-Author Netw...	09/03/2009	00:15:20 AM	100%
Load and Clean ISI File	09/03/2009	00:15:05 AM	100%





**Sci<sup>2</sup> Tool**  
A tool for science of science research & practice

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**Tutorials**  
Katy Börner (2010) Science of Science Research and Tools (12 Tutorials). Reporting Branch, Office of Extramural Research/Office of the Director, National Institutes of Health, Bethesda, MD.  
Scott Weingart, Biberstine (2010) Science, Indiana

- Tutorial #01: [Science of Science Research](#)
- Tutorial #02: [Network Science / Information Visualization](#)
- Tutorial #03: [CIShell Powered Tools: Network Workbench and Science of Science Tool](#)
- Tutorial #04: [Temporal Analysis—Burst Detection](#)
- Tutorial #05: [Geospatial Analysis and Mapping](#)
- Tutorial #06: [Topical Analysis & Mapping](#)
- Tutorial #07: [Tree Analysis and Visualization](#)
- Tutorial #08: [Network Analysis and Visualization](#)
- Tutorial #09: [Large Network Analysis and Visualization](#)
- Tutorial #10: [Using the Scholarly Database at IU](#)
- Tutorial #11: [VIVO National Researcher Networking](#)
- Tutorial #12: [Future Developments](#)

<http://sci2.cns.in.edu>  
<http://sci2.wiki.cns.in.edu>

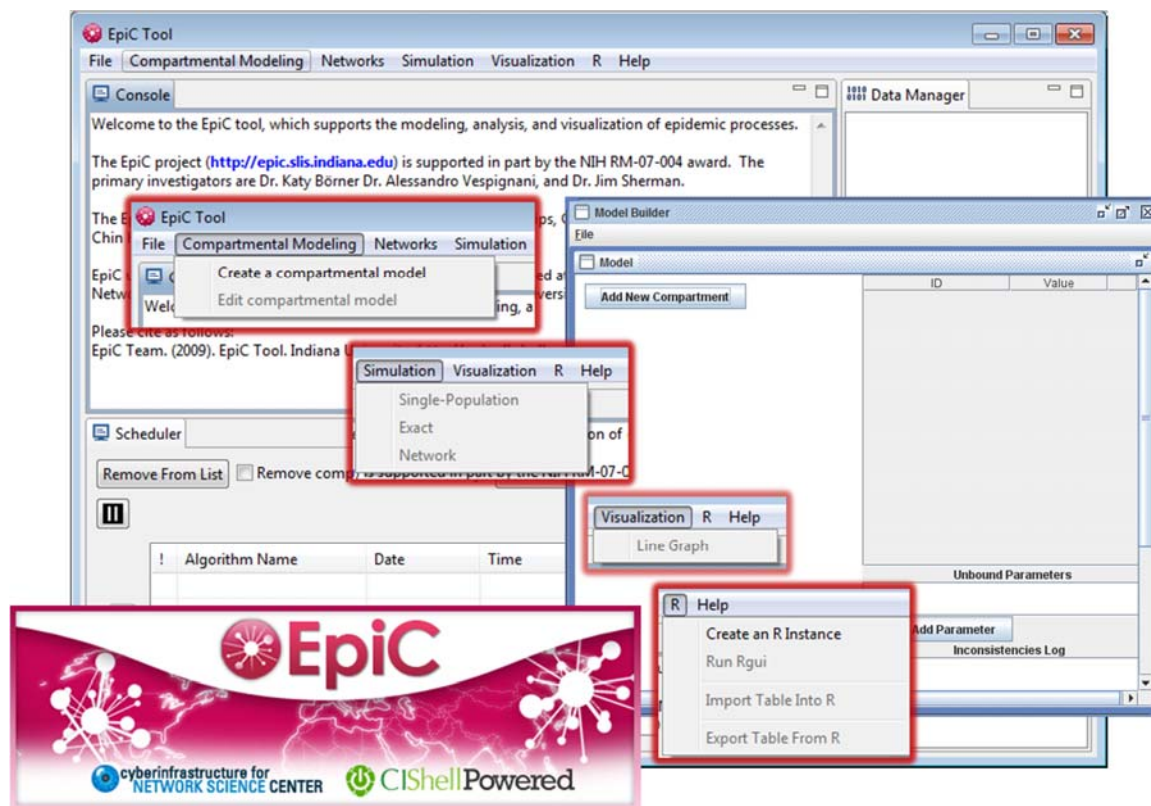
Geetha Senthil (2010) [Multidisciplinary Nature of Work With Reference to PIs and ICs Within a Portfolio](#). PA Group at NIH.

NIH Office of Extramural Research and Katy Börner (2010) [Network Visualizations Using SPIRES Data and the Sci2 Tool](#). Office of Extramural Research at NIH.



Wordle.net of “Interest to Learn” response by users from more than 40 countries





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## OSGi/CIShell Adoption

A number of other projects recently adopted OSGi and/or CIShell:

USA

- *Cytoscape* (<http://cytoscape.org>) Led by Trey Ideker at the University of California, San Diego is an open source bioinformatics software platform for visualizing molecular interaction networks and integrating these interactions with gene expression profiles and other state data (Shannon et al., 2002).
- *MAEviz* (<https://wiki.ncsa.uiuc.edu/display/MAE/Home>) Managed by Jong Lee at NCSA is an open-source, extensible software platform which supports seismic risk assessment based on the Mid-America Earthquake (MAE) Center research.

Europe

- *Taverna Workbench* (<http://taverna.org.uk>) Developed by the myGrid team (<http://mygrid.org.uk>) led by Carol Goble at the University of Manchester, U.K. is a free software tool for designing and executing workflows (Hull et al., 2006). Taverna allows users to integrate many different software tools, including over 30,000 web services.
- *TEXTrend* (<http://textrend.org>) Led by George Kampis at Eötvös Loránd University, Budapest, Hungary supports natural language processing (NLP), classification/mining, and graph algorithms for the analysis of business and governmental text corpuses with an inherently temporal component.
- *DynaNets* (<http://www.dynanets.org>) Coordinated by Peter M.A. Sloot at the University of Amsterdam, The Netherlands develops algorithms to study evolving networks.
- *SISOB* (<http://sisob.lcc.uma.es>) An Observatory for Science in Society Based in Social Models.

As the functionality of OSGi-based software frameworks improves and the number and diversity of dataset and algorithm plugins increases, the capabilities of custom tools will expand.

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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>