

Modeling and Mapping Science ~ Possible Futures

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*Workshop on Modeling Science
Amsterdam, The Netherlands
October 6-9, 2009*



Computational Scientometrics: Studying Science by Scientific Means

- 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>
- Börner, Katy, Ma, Nianli, Dubon, Russell Jackson & Zoss, Angela. (2009). **Science & Technology Assessment Using Open Data and Open Code**. *IEEE Intelligent Systems*. Vol. 24(4), 78-81, *IEEE Computer Systems*..
- **Places & Spaces: Mapping Science** exhibit, see also <http://scimaps.org>.

Modeling & Mapping Science – Opportunities and Challenges

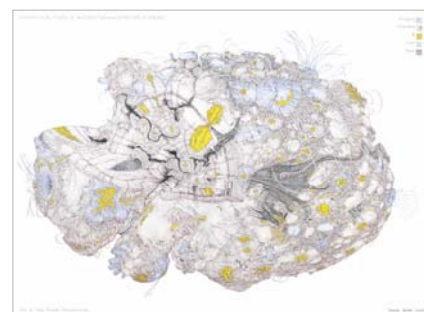
- Dynamic science and technology indicators (emerging research frontiers, evolving networks, trends, feedback loops).
- Evolution of scientific communities/fields. Capacity limit to knowledge/skills knowable by individual researchers.
- Interplay of competition and collaboration.
- Evolution of fields – birth, growth, mature, decline.
- Interactions among fields. Optimal interdisciplinary collaborations?
- Comparison of different funding models, e.g., few large vs. many small grants, teach the field how to fish or give them fish?
- Impact of publishing/collaboration/funding mechanisms on the dynamics of fields.
- Diffusion of people, ideas, skills, etc.
- How to best communicate science modeling results/insights?

Ultimate goal:

Learn how to best increase, diffuse, and utilize our collective scholarly knowledge.

Overview

- Science of Science Conceptualization(s) & Inventories
- **Modeling Science Futures (ANALYSIS AND SIMULATION)**
- Mapping Science Futures (COMMUNICATION)
- Scalable Cyberinfrastructures – Open Data and Open Code



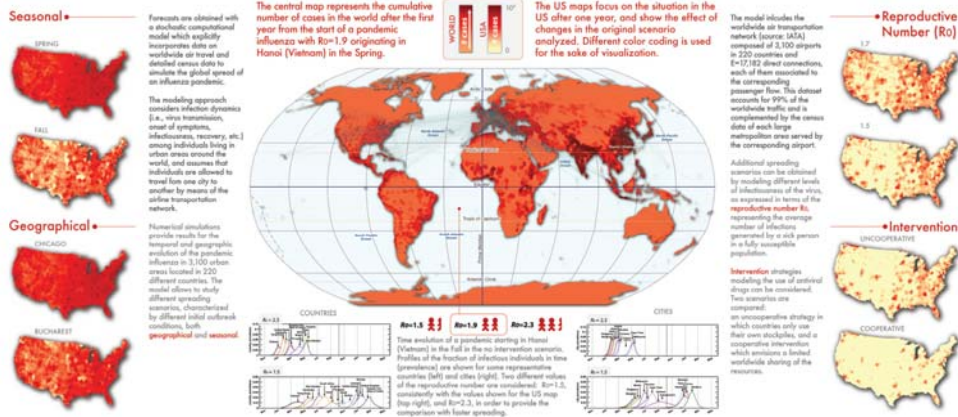
Modeling of Science

Learning from Epidemiology

Impact of Air Travel on Global Spread of Infectious Diseases



Forecasts of the Next Pandemic Influenza



Impact of Air Travel on Global Spread of Infectious Diseases - Vittoria Colizza, Alessandro Vespignani - 2007

Modeling Science

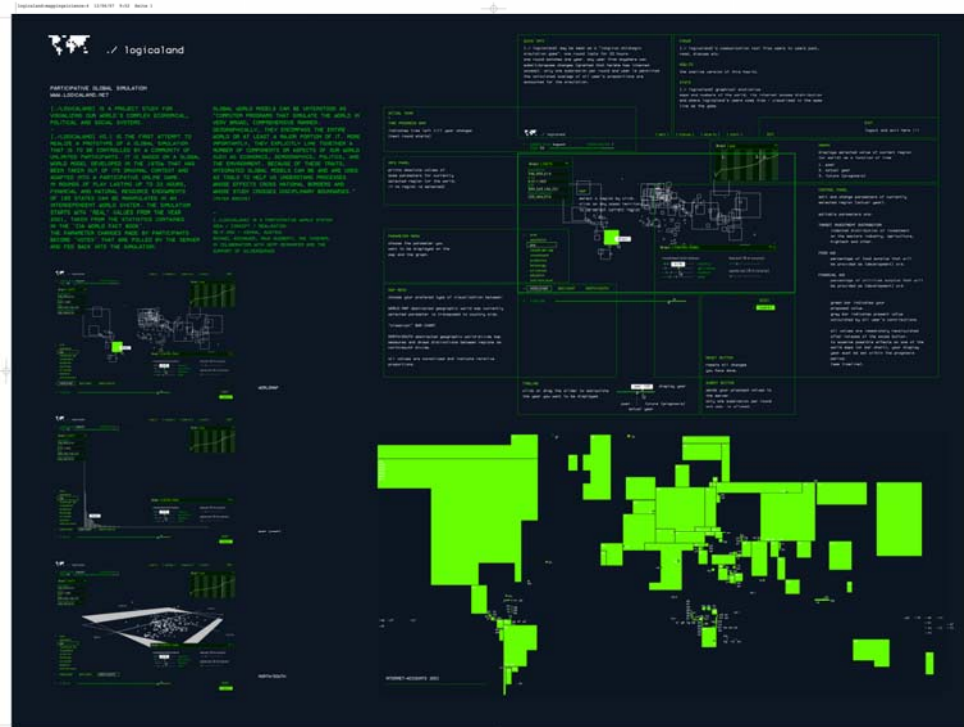
Learning from Economics



Self amplifying downward spiral | 'systemic' meltdown with intertwined breakdowns | 'war room' analyses | market wind tunnel | power market test bed | Regulators feel duty-bound to adhere to generally accepted and well-vetted techniques

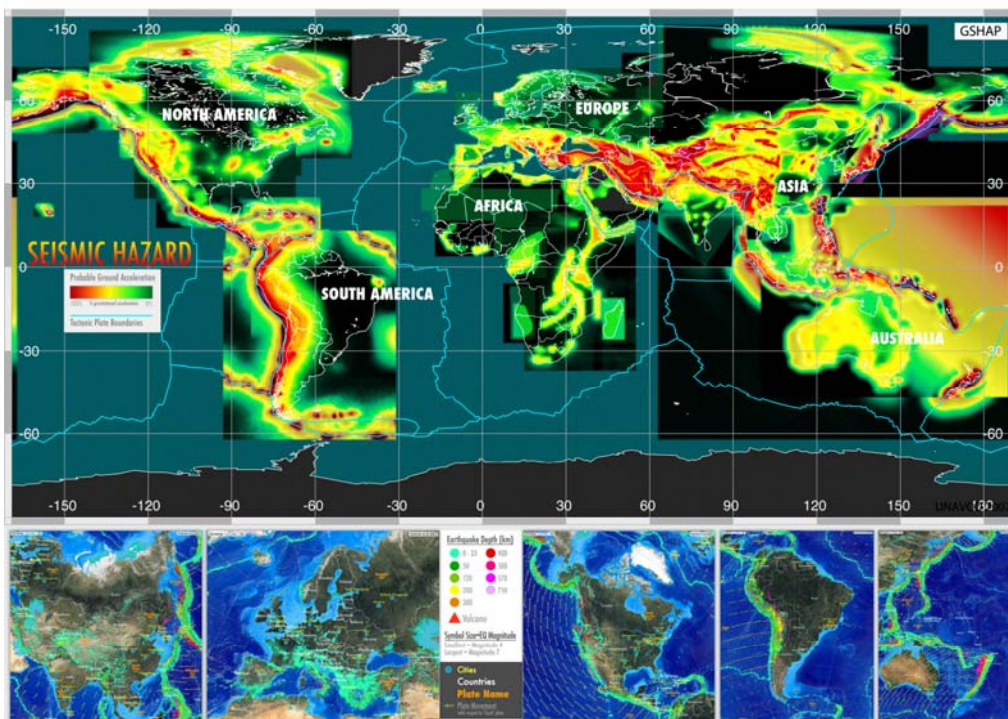
"... while any new technical device or medical drug has extensive testing for efficiency, reliability and safety before it ever hits the market, we still implement new economic measures without any prior testing." Dirk Helbing

Modeling Science *Learning from Economics*



Logicland Participative Global Simulation - Michael Ashauer, Maia Gusberti, Nik Thoenen - 2002

Patch-working Models/Studies/Maps of Science *Learning from Seismology*



Tectonic Movements and Earthquake Hazard Predictions - Martin W. Hamburger, Lou Estey, Chuck Meertens, Elisha Hardy - 2005

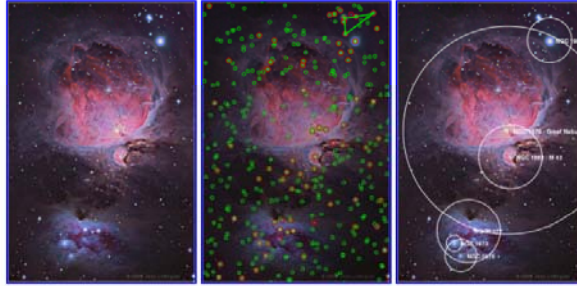


[home](#) | [project summary](#) | [people](#) | [gallery](#) | [news](#) | [related links](#) | [bibliography](#) | [data](#) | [use](#)

Gallery of Solved Images

In the images below, the red circles are stars our algorithm automatically detects in the image, and the green circles are stars from our master index which appear in the query image. Nebulae, constellations and other objects can be automatically overlayed on the image after it has been solved.

A shot of the Great Nebula, by Jerry Lodnguss (c.2006), from [astropix.com](#)



<http://www.astrometry.net/gallery.html>

http://cosmo.nyu.edu/hogg/research/2006/09/28/astrometry_google.pdf

A role for self-gravity at multiple stages of the process of star formation

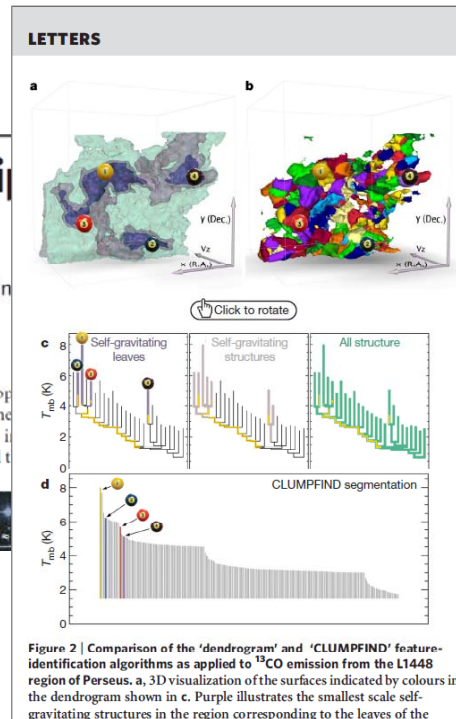
Alyssa A. Goodman^{1,2}, Erik W. Rosolowsky^{2,3}, Michelle A. Borkin¹, Jens Kauffmann^{1,2} & Jaime E. Pineda²

Self-gravity plays a decisive role in the final stages of star formation, where dense cores (size ~ 0.1 parsecs) inside molecular clouds collapse to form star-plus-disk systems¹. But self-gravity's role at earlier times (and on larger length scales, such as ~ 1 parsec) is unclear; some molecular cloud simulations that do not include self-gravity suggest that 'turbulent fragmentation' alone is sufficient to create a mass distribution of dense cores that resembles, and sets, the stellar initial mass function². Here we report a 'den-

overlap
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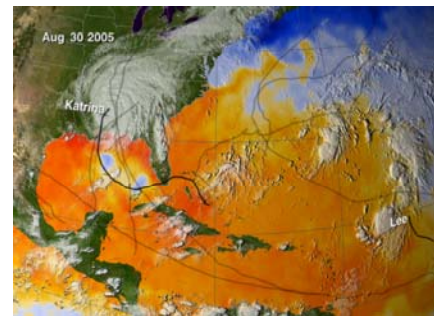


http://www.cfa.harvard.edu/~agoodman/3D/threeDpdf_small.mov



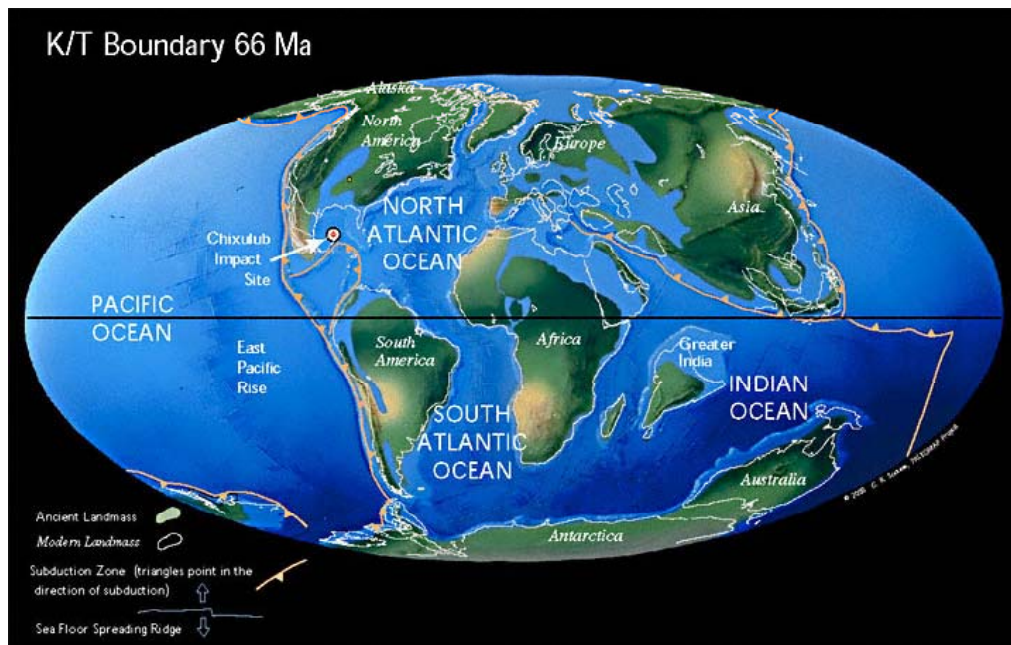
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- Modeling Science Futures (ANALYSIS AND SIMULATION)
- **Mapping Science Futures (COMMUNICATION)**
- Scalable Cyberinfrastructures – Open Data and Open Code



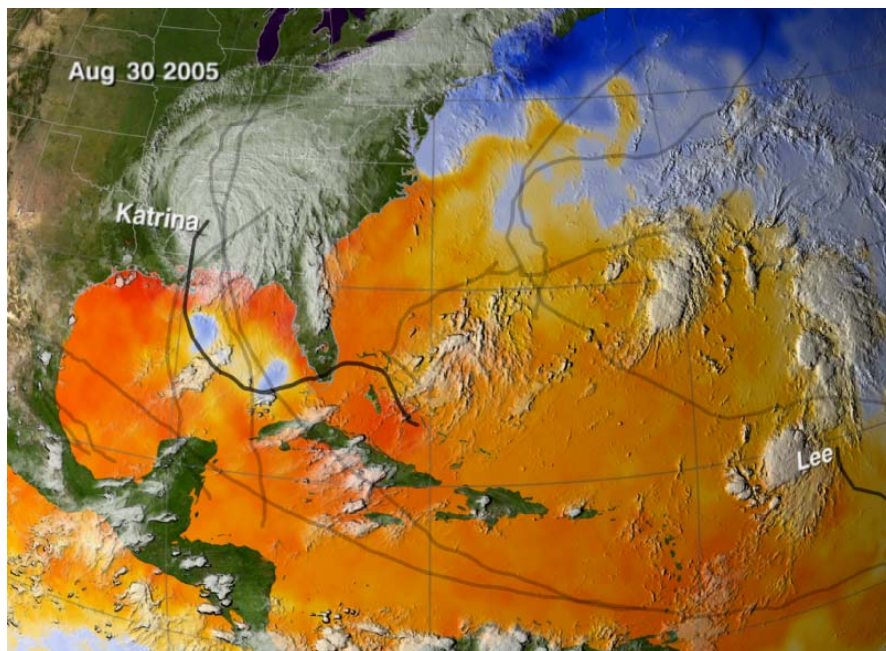
Mapping Science

Learning from Geology/Geography



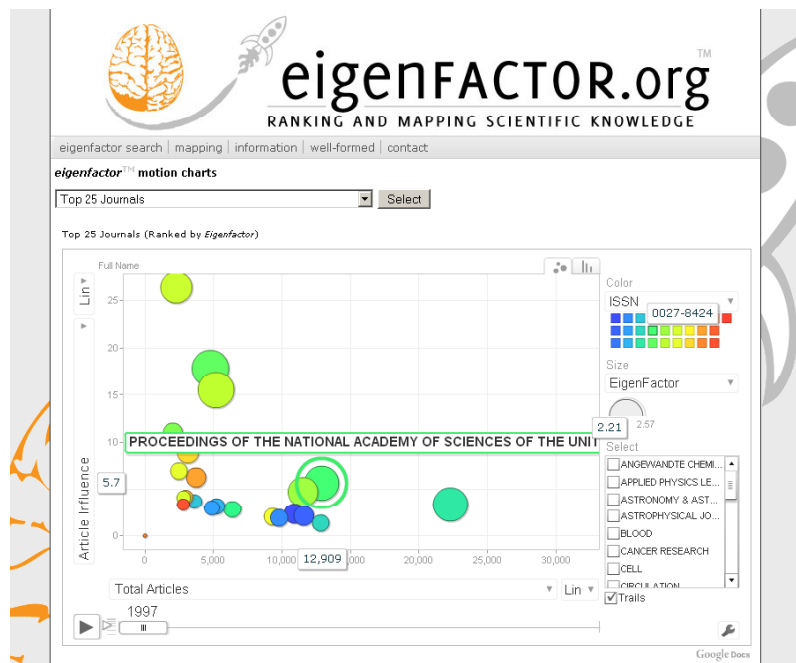
<http://www.scotese.com/>

Mapping Science *Learning from Meteorology*



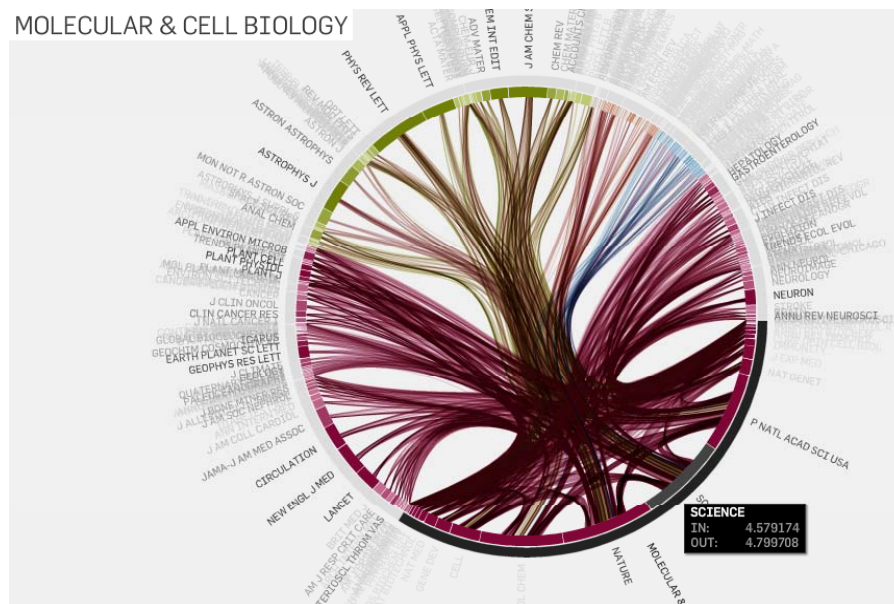
Named Storms, available online at <http://svs.gsfc.nasa.gov/vis/a000000/a003200/a003279>

Interactive Maps of Science – Journal-Level *People can read Gapminder maps*



<http://www.eigenfactor.org>

Interactive Maps of Science – Journal-Level Circular Hierarchy Maps



<http://well-formed.eigenfactor.org/radial.html>

Interactive Maps of Science – Paper-Level

MAPS OF SCIENCE

Overview
Detail
Disciplinary Maps
Competency Maps
Paradigm Maps
Posters
Education

Institutional Strategy: The following color coding is used for the disciplinary map:

NIH

■ Math & Physics	■ Biotechnology	■ Medical Specialties	<input type="checkbox"/> Humanities
■ Chemistry	■ Earth Sciences	■ Brain Research	
■ Computer Science & EE	■ Biology	■ Health Professionals	
■ Other Engineering	■ Infectious Diseases	■ Social Sciences	

[View all](#)

- [National Institute of General Med Science](#)
- [National Institute of Allergy & Inf Disease](#)
- [Nat. Cancer Institute](#)
- [Nat. Heart, Lung & Blood Institute](#)
- [Nat. Inst Diabetes, Dig & Kidney Disease](#)
- [Nat. Inst of Neuro Disorders & Stroke](#)
- [National Institute of Mental Health](#)
- [Nat. Inst of Child Health & Hum Dev](#)

National Institute of Allergy & Infectious Diseases. NIAID has a very tight core that centers on infectious diseases, virology, immunology, endocrinology, and cytogenetics. They also incorporate some plant and protein sciences.

<http://www.mapsofscience.com>

Interactive Maps of Science – Paper-Level in Real Time

Living Science - Mozilla Firefox
 http://www.livingscience.ethz.ch

Living Science: Where Science is Happening

Search by Submitting author Search for a city/country Search by keyword (Title and Abstract)

Aggregated by:
 Paper
 City
 Country

From: 09/29/2009
 To: 10/06/2009
 Today
 Last 7 days
 Last 30 days

Update View

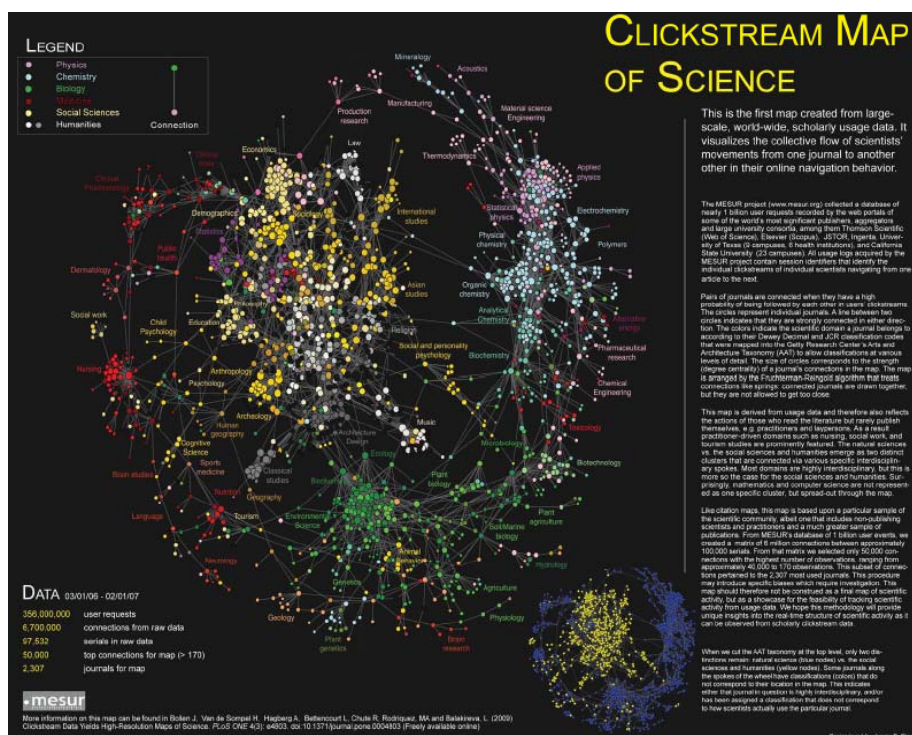
arXiv categories
 Collapse All | Expand All
 Physics
 Mathematics
 Nonlinear Sciences
 Computer Science
 Biology
 Quantitative Finance
 Statistics

How to use LivingScience:
 • Choose a number of categories from the arxiv classification on the right
 • Choose a time window
 • Choose an aggregation level
 • Zoom the map to greater detail
 • Click on the icons on the map for further information
 • Each time you select a new time window, click "Update View" to let the changes take effect

Notice: No warranty or liability for this service. By using it, users accept responsibility for their actions and implications that they may have. Comments and suggestions are most welcome.

http://www.livingscience.ethz.ch

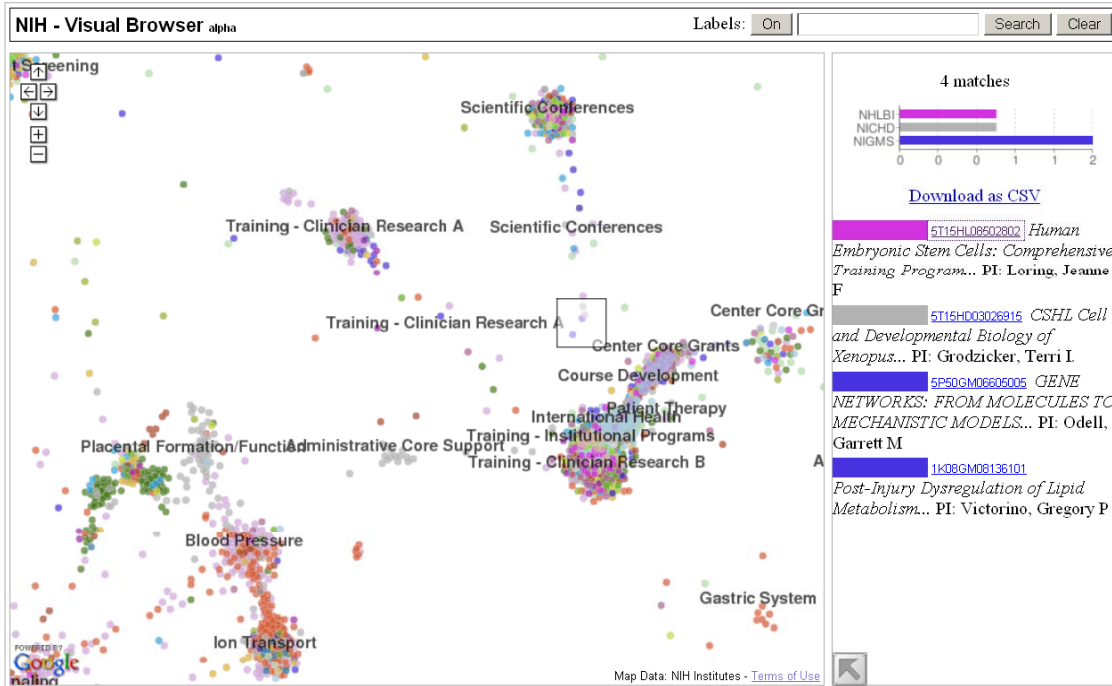
Interactive Maps of Science – Paper-Level Downloads



A Clickstream Map of Science – Bollen, Johan, Herbert Van de Sompel, Aric Hagberg, Luis M.A. Bettencourt, Ryan Chute, Marko A. Rodriguez, Lyudmila Balakireva - 2008

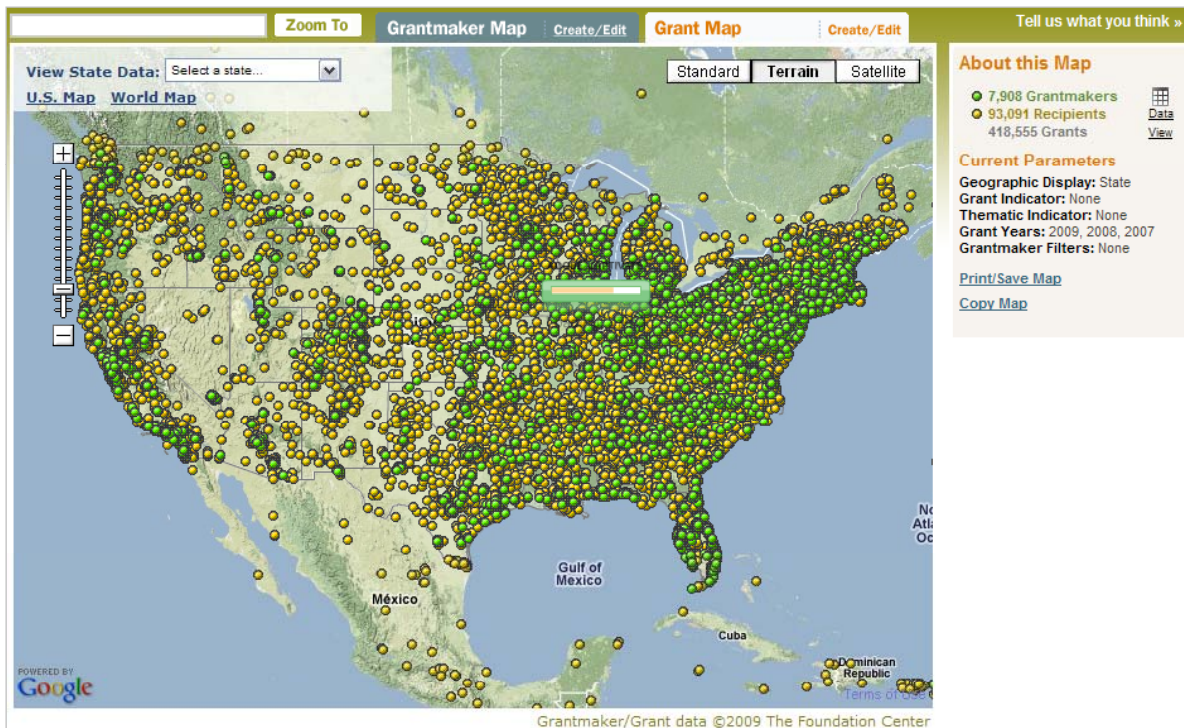
Interactive Maps of Science – NIH Funding

Google maps with charts and tables



<http://scimaps.org/maps/nih/2007>

Interactive Maps of Science – Philanthropy



<http://www.philanthropyinsight.org>

Custom Maps of Science – Institution Level

SciVal SPOTLIGHT FUNDING

Home The challenge The solution How it works Evaluate & subscribe

Welcome to the support site for SciVal Spotlight.

The Most Innovative Solution for Establishing, Evaluating and Executing Informed Research Strategies

The challenge
Learn about the challenges behind measuring interdisciplinary research performance and allocating resources.
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The solution
Learn about how SciVal Spotlight provides the data needed to make strategic research decisions.
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How it works
View the elements of SciVal Spotlight and see how they identify research strengths.
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Request a demonstration of SciVal Spotlight or contact an Elsevier representative.
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Webcast
Measuring Research Performance
[Click here to view >>](#)

"This will be highly useful in identifying collaborators for multi-institutional grants initiatives, which continue to increase in number"
- Vice Chancellor for research

Resources

- Resource Library
- SciVal Spotlight Factsheet (PDF)
- White Paper (PDF)
- Research Events (sign up)
- SciVal Funding InfoKit

News and updates
Elsevier introduces SciVal Performance planning and funding solutions
These new tools will give institutional leaders, researchers...
[More](#)

SciVal Spotlight Demo
Watch this video to learn how SciVal Spotlight helps you evaluate, establish and execute informed research strategies.
Note: Shockwave is required to view this demo.

Download Prospectus
The Most Innovative Web-Based Solution for Establishing, Evaluating and Executing Your Research Strategies
[click here](#)

Download White Paper
Co-Citation Analysis: The Methodology of SciVal Spotlight
[click here](#)

<http://www.info.spotlight.scival.com>

Custom Maps of Science – People Level

biomedexperts your scientific match point

200,000 Experts active in the community

Home About Privacy Register Free FAQ Contact Terms of Use

Sign Up Free

Username

Password

LOGIN

[Forgot Password?](#)

News

Collexis BiomedExperts Hits 80,000 Registered Users Within the First Year!
BiomedExperts.com chosen by Outsell, Inc. as a Community to Watch in 2009.

Collexis Unveils Enhanced Services for Premier Online Scientific Social Network Community, BioMedExperts
Collexis Holdings Inc. announced today website enhancements to BioMedExperts.com, the first online social network of its kind that promotes global collaborative medical research and development.

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Connect with global Collaborators **Browse over 1.5 million expert profiles** **Explore scientific expert networks**

BiomedExperts - the first literature-based scientific social network - brings the right researchers together and allows them to collaborate online. Collexis provides the BiomedExperts social network free of charge to researchers worldwide in an effort to increase collaborative biomedical research for the common good.
[Learn more >](#)

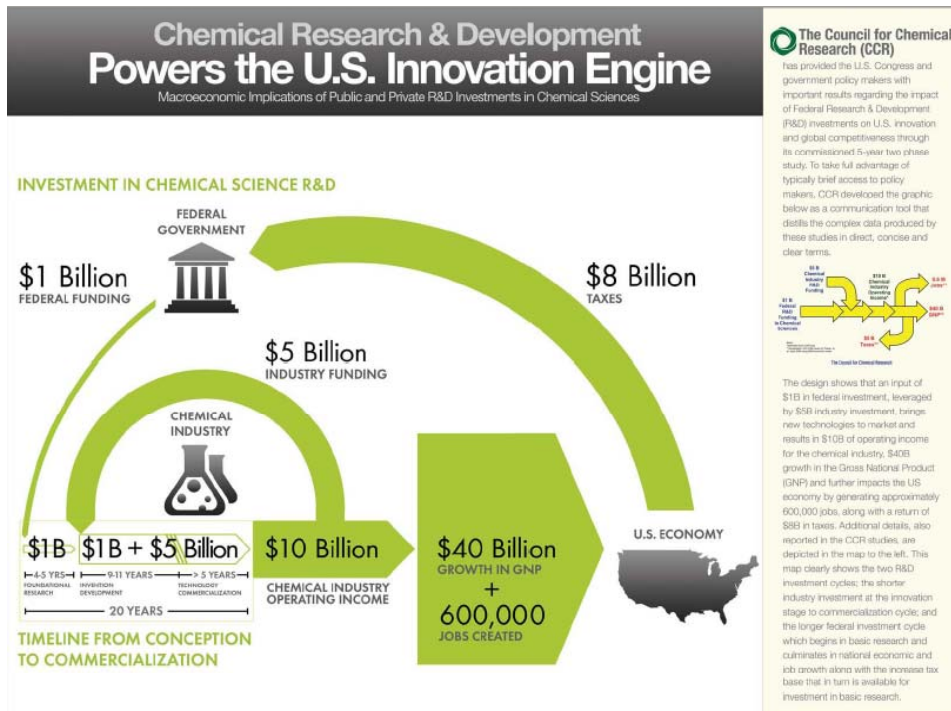
BME for research institutions
Pinpoint institutional expertise for big-science and translation-research initiatives
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BME for governmental institutions
Interlink biomedical experts in your area and unveil their combined regional expertise to the world
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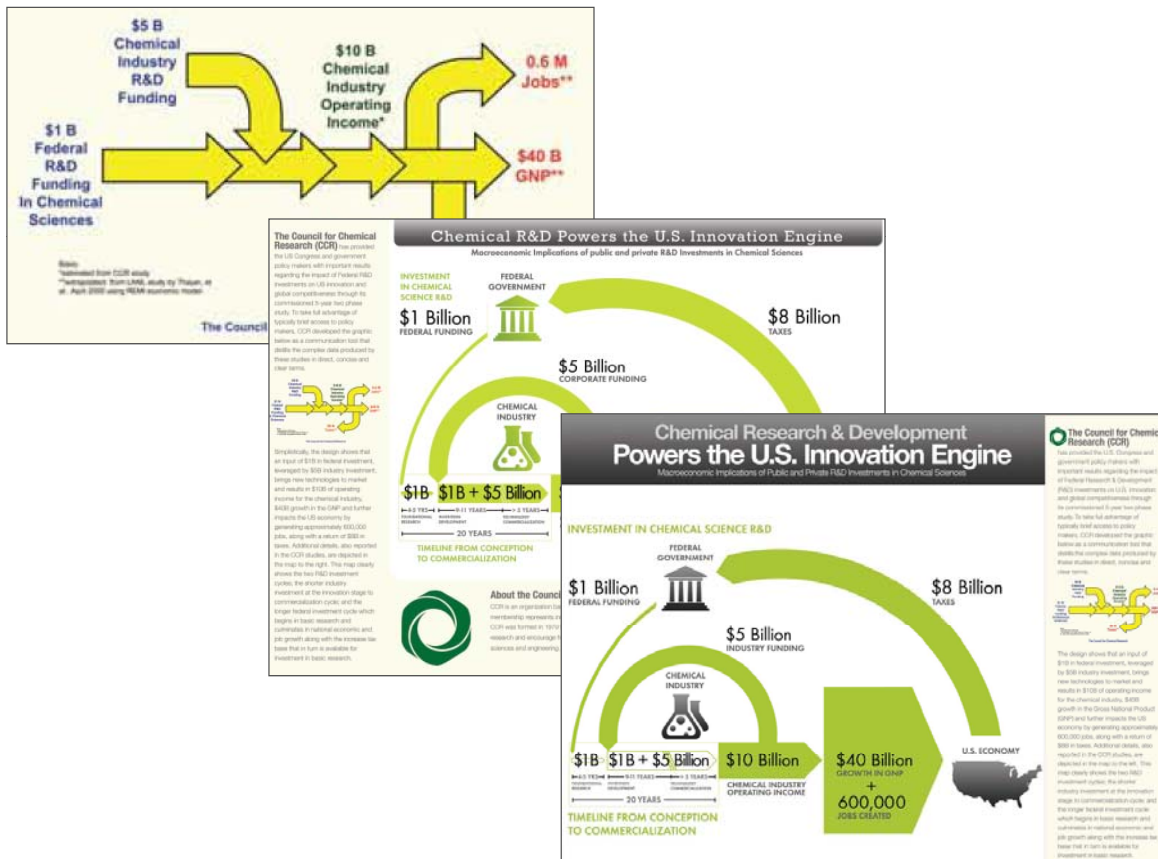
BME for biomed associations
Connect association members and stimulate research cooperation
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<http://www.biomedexperts.com>

Depicting Dynamics, e.g., Feedback Loops

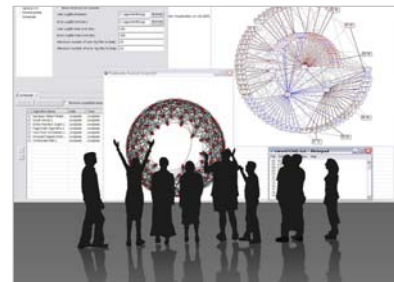


Council for Chemical Research - Chemical R&D Powers the U.S. Innovation Engine. Washington, DC. Courtesy of the Council for Chemical Research - 2009



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Scholarly Database: Web Interface

SCHOLARLY DATABASE
Cyberinfrastructure for Network Science Center, SLIS, Indiana University, Bloomington

Search Edit Profile About Logout

Search

Creators:
Title:
Abstract:
All Text: "artificial intelligence"
First Year: 1898
Last Year: 2008

Medline (1898 - 2008)
 NIH (1961 - 2002)
 NSF (1985 - 2004)
 USPTO (1976 - 2008)

Search

Browse Results

Your search returned 13,225 results in 0.162 seconds.

Total results per database: NIH: 2,103, Medline: 10,229, USPTO: 279, NSF: 614.

Results 1 through 20.
Next>>

Source	Authors/Creators	Year	Title
Medline	LaCombe	1987	Artificial intelligen
Medline	Schmitt	1989	Artificial intelligen
Medline	Schmitt	1990	[Artificial intelligen
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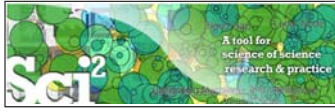
Download Results

Select All Sample File Data Dictionary

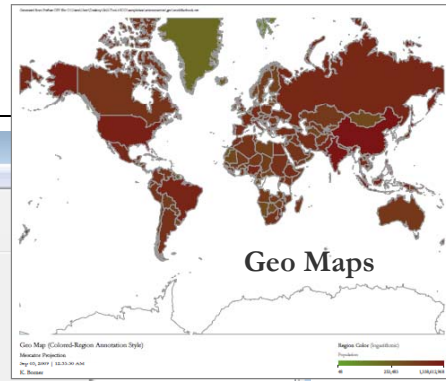
Medline Database:
 Medline master table
 Medline author table

Anybody can register for free at <http://sdb.slis.indiana.edu> records and download results as data dumps.

In May 2009, SDB has over 170 registered users from over 80 institutions and four continents.



Sci² Tool



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 Network Science center and the School of Li Indiana University, the National Science Foundation IIS-0715303, and the James S. McDonnell Cyberinfrastructure portal (<http://sci.slis.indiana.edu>)

The primary investigators are Katy Börner, In SciTech 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 Workbench (<http://nwb.slis.indiana.edu>).

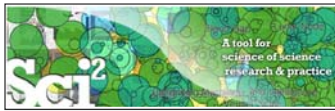
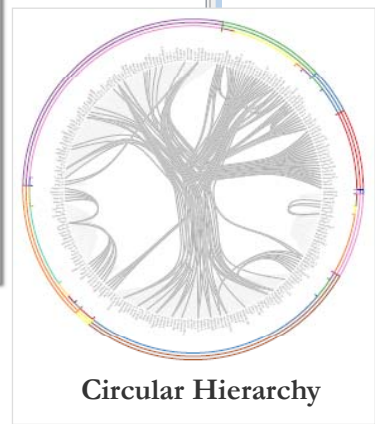
Please cite as follows:
Sci² Team. (2009). Science of Science Tool. In SciTech Strategies Inc., <http://sci.slis.indiana.edu>.

Scheduler

Remove From List Remove completed

!	Algorithm Name	Date	Time	% Complete
<input checked="" type="checkbox"/>	Extract Co-Author Network	09/03/2009	00:15:20 AM	100%
<input checked="" type="checkbox"/>	Load and Clean ISI File	09/03/2009	00:15:05 AM	100%

- 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

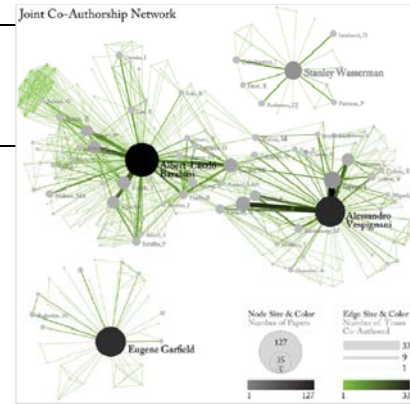
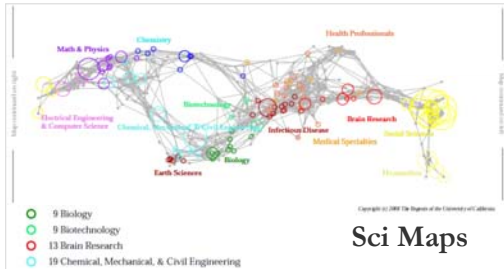


Sci² Tool

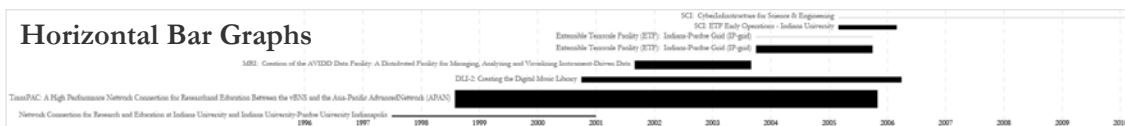
<http://sci.slis.indiana.edu>

“Open Code for S&T Assessment”

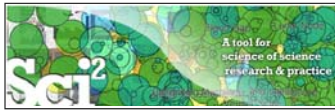
Branded OSGi/CIShell based tool with NWB plugins and many new plugins.



Horizontal Bar Graphs



Börner, Katy, Huang, Weixia (Bonnie), Linnemeier, Micah, Dubon, Russell Jackson, Phillips, Patrick, Ma, Nianli, Zoss, Angela, Guo, Hanning & Price, Mark. (2009). *Refe-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.



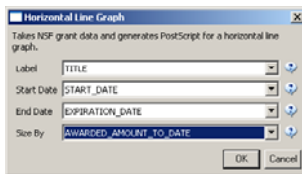
Stanford University

429 active NSF awards on 09/10/2009



Horizontal Bar Graphs

2000 2015



Context: Plug-and-Play Macroscopes

CIShell/OSGi is at the core of different CIs and a total of 169 unique plugins are used in the

- **Information Visualization** (<http://iv.slis.indiana.edu>),
- **Network Science** (<http://nwb.slis.indiana.edu>),
- **Sci2 Tool** (<http://sci.slis.indiana.edu>), and
- **Epidemics** (<http://epic.slis.indiana.edu>) research communities.

Most interestingly, a number of other projects recently adopted OSGi and one adopted CIShell:

Cytoscape (<http://www.cytoscape.org>) lead by Trey Ideker, UCSD 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).

Taverna Workbench (<http://taverna.sourceforge.net>) lead by Carol Goble, University of Manchester, UK 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.

MAEviz (<https://wiki.ncsa.uiuc.edu/display/MAE/Home>) managed by Shawn Hampton, NCSA is an open-source, extensible software platform which supports seismic risk assessment based on the Mid-America Earthquake (MAE) Center research.

TEXTrend (<http://www.textrend.org>) lead by George Kampis, Eötvös University, Hungary develops a framework for the easy and flexible integration, configuration, and extension of plugin-based components in support of natural language processing (NLP), classification/mining, and graph algorithms for the analysis of business and governmental text corpuses with an inherently temporal component.

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 or macroscopes will expand.



Exhibit Purpose and Goals

The Places & Spaces exhibit has been created to demonstrate the power of maps.

An initial theme of this exhibit is to compare and contrast first maps of our entire planet with the first maps of all of science as we know it.

Come see with your own eyes the extent to which maps can be employed to help make sense of the flood of information we are confronted with and how domain maps can be used to locate complex and beautiful information.

This online part of the exhibit provides links to a selected series of maps and their makers along with detailed explanations of why these maps work. The physical counterpart supports the close inspection of high quality reproductions for display at conferences and education centers. It is meant to inspire cross-disciplinary discussion on how to best track and communicate human activity and scientific progress on a global scale.



Places & Spaces: Mapping Science

a science exhibit that introduces people to maps of sciences, their makers and users.

Exhibit Curators:

Dr. Katy Börner & Elisha Hardy

<http://scimaps.org>

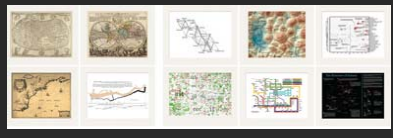


Mapping Science Exhibit – 10 Iterations in 10 years

<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 72 venues on four continents. Currently at

- NSF, 10th Floor, 4201 Wilson Boulevard, Arlington, VA
- Wallenberg Hall, Stanford University, CA
- Center of Advanced European Studies and Research, Bonn, Germany
- Science Train, Germany.





Debut of 5th Iteration of Mapping Science Exhibit at MEDIA X was on May 18, 2009 at Wallenberg Hall, Stanford University, <http://mediax.stanford.edu>, <http://scaleindependentthought.typepad.com/photos/scimaps>



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>

This is the only mockup in this slide show.

Everything else is available today.



A website mockup for the Cyberinfrastructure for Network Science Center. The header features a blue circular logo with a network pattern and the text "cyberinfrastructure for NETWORK SCIENCE CENTER" and "School of Library and Information Science | Indiana University Bloomington". Below the header is a grid of images representing different aspects of the center: "People" (a group of people), "Research" (a collage of research papers and maps), "Events" (a group of people at a meeting), "Jobs" (a person working on a laptop), "Contact" (a building), "News" (a newspaper clipping), "Teaching" (a classroom), "Outreach" (a person at a table), and "Funding" (a person at a table). The grid also includes "Cyberinfrastructures" (a network diagram) and "Visiting Artists" (a person at a table).

All papers, maps, cyberinfrastructures, talks, press are linked from <http://cns.slis.indiana.edu>