

# Envisioning Big S&T Data

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[katy@indiana.edu](mailto:katy@indiana.edu) | <http://cns.iu.edu>

November 16, 2012



Terra bytes of data

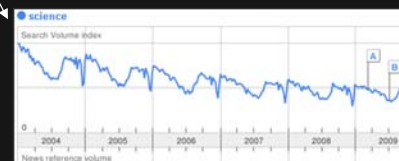
Descriptive & Predictive Models



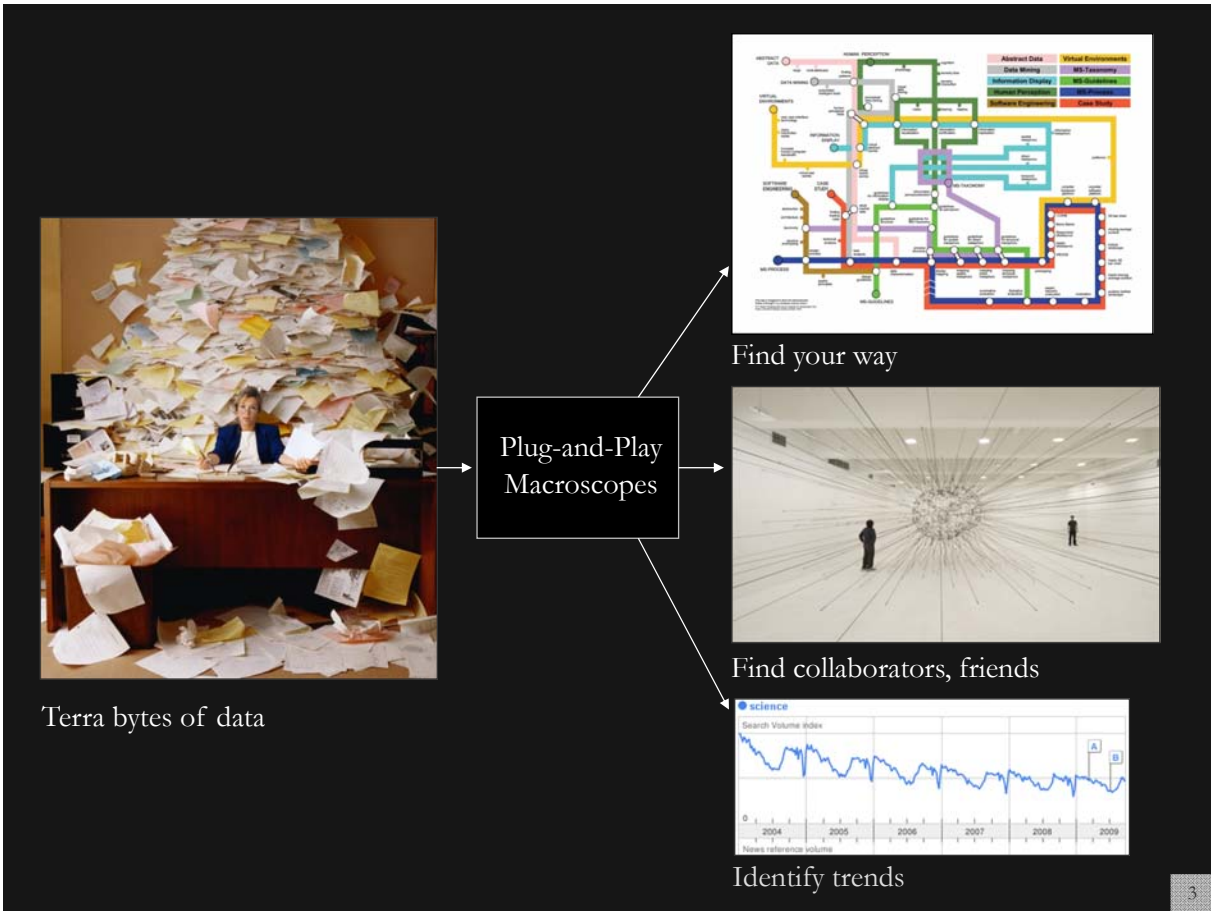
Find your way



Find collaborators, friends

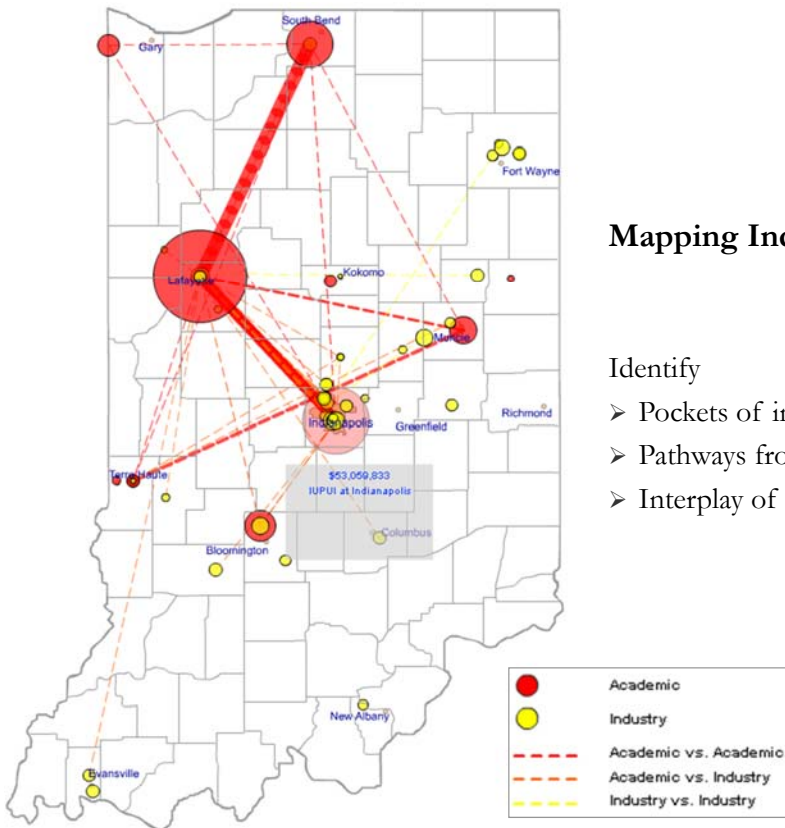


Identify trends



### Type of Analysis vs. Level of Analysis

|                                       | <i>Micro/Individual</i><br>(1-100 records)     | <i>Meso/Local</i><br>(101-10,000 records)                       | <i>Macro/Global</i><br>(10,000 < records) |
|---------------------------------------|--|---|---|
| <b>Statistical Analysis/Profiling</b> | Individual person and their expertise profiles | Larger labs, centers, universities, research domains, or states | All of NSF, SA, all of sci                |
| <b>Temporal Analysis (When)</b>       | Funding portfolio of one individual            | Topic bursts of PNAS  | 113 Years of P Research                   |
| <b>Geospatial Analysis (Where)</b>    | Career trajectory of one individual            | Wrapping a intellectual l                                       | PNAS                                      |
| <b>Topical Analysis (What)</b>        |  | research  | VxOrd/Topic r NIH funding                 |
| <b>Network Analysis (With Whom?)</b>  | NSI one  | Network of  | NIH's cy                                  |



## Mapping Indiana's Intellectual Space

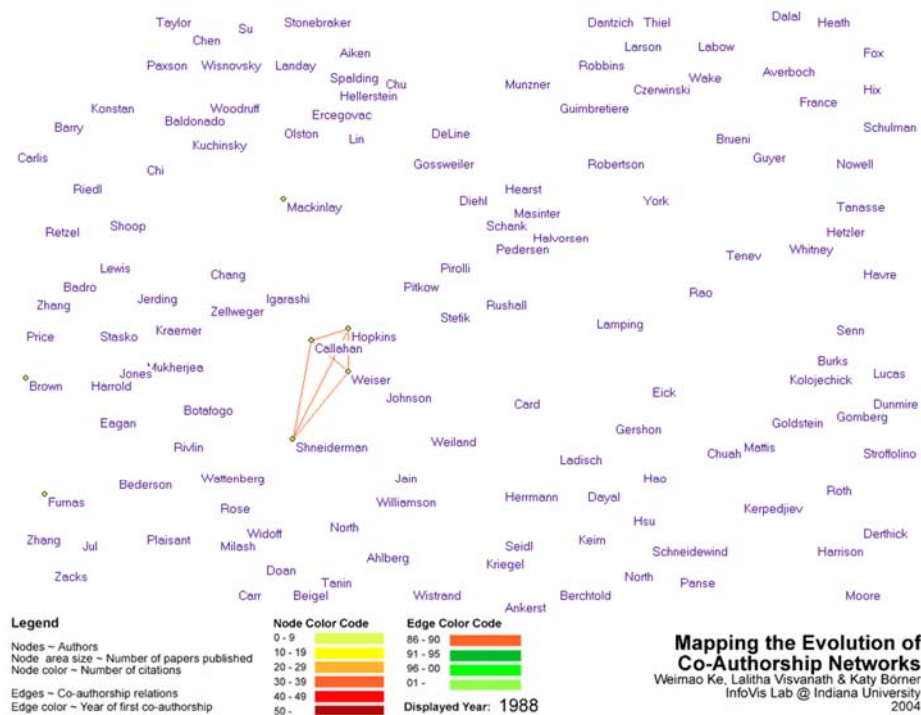
Identify

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

5

## Mapping the Evolution of Co-Authorship Networks

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

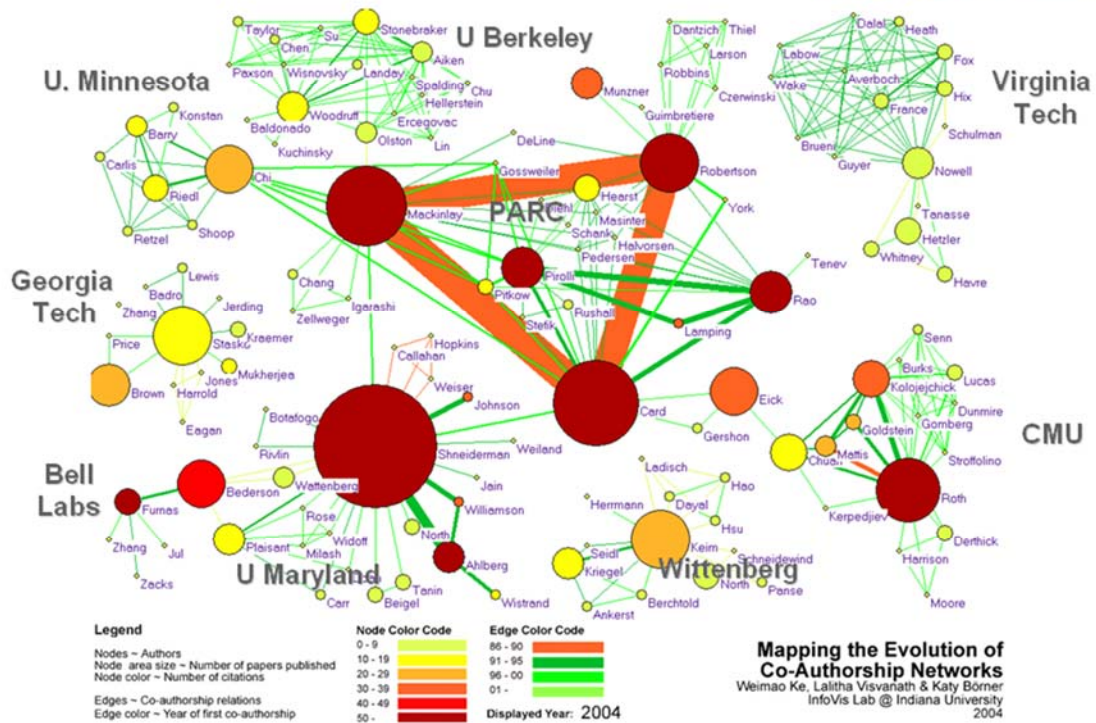


6



# Mapping the Evolution of Co-Authorship Networks

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



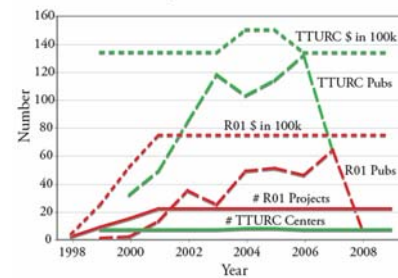
# Mapping Transdisciplinary Tobacco Use Research Centers Publications

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

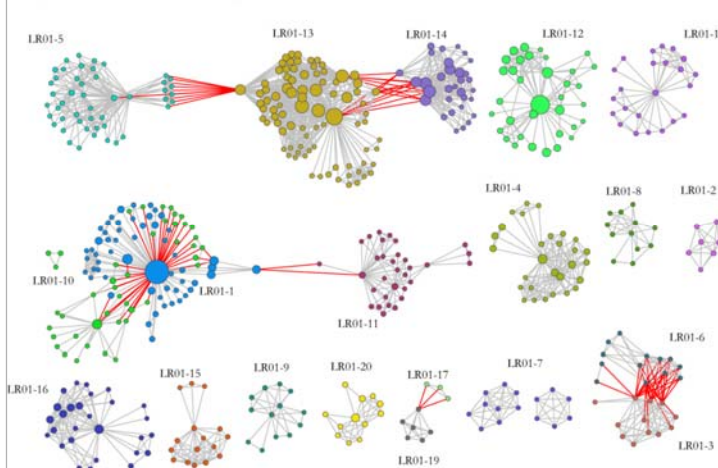
Zoss & Börner, forthcoming.

Supported by NIH/NCI Contract HHSN261200800812

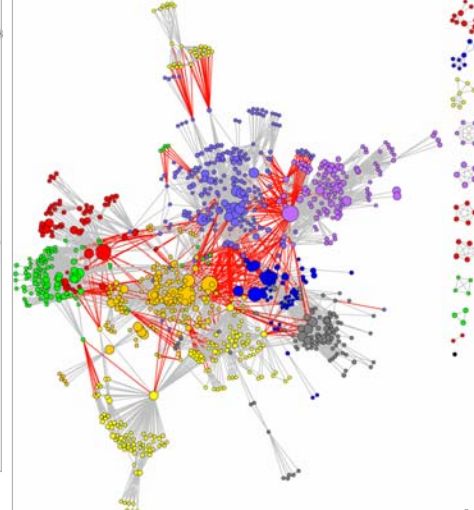
R01 & TTURC Project Information



Longitudinal R01 Co-Authorship Network



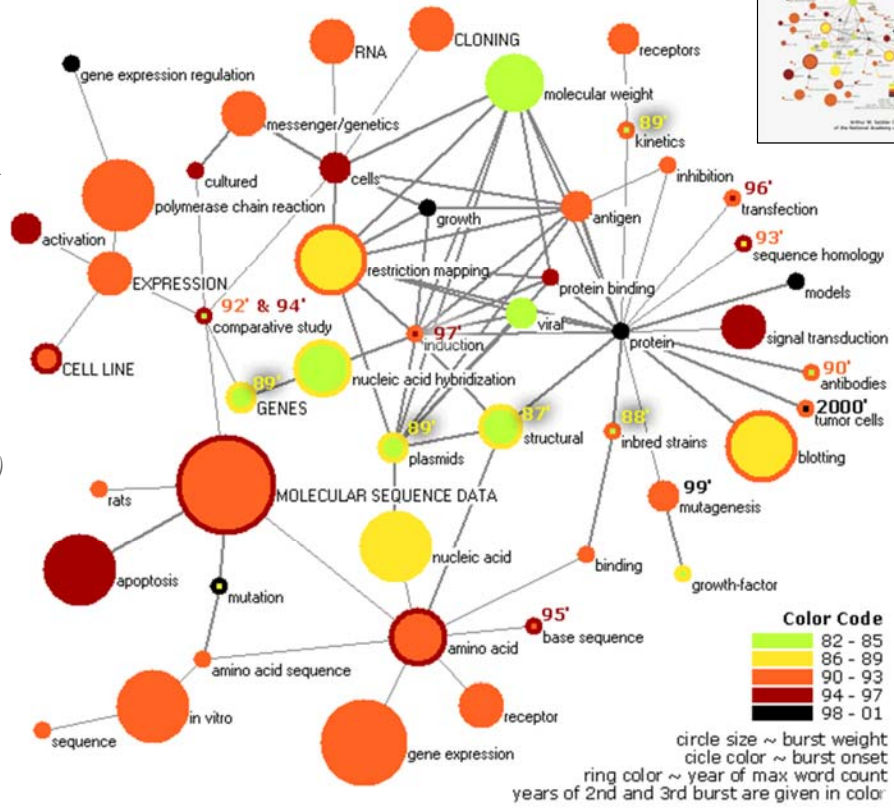
TTURC Co-Authorship Network



## 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.



## 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>

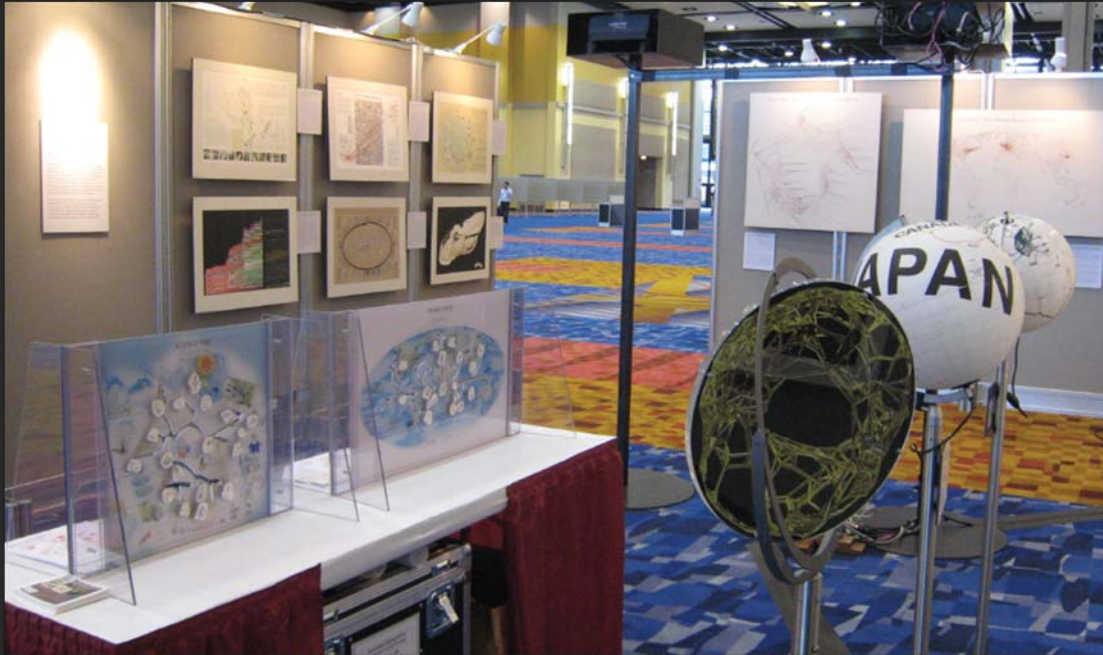
Börner, Katy (2010) **Atlas of Science**. MIT Press.  
<http://scimaps.org/atlas>

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





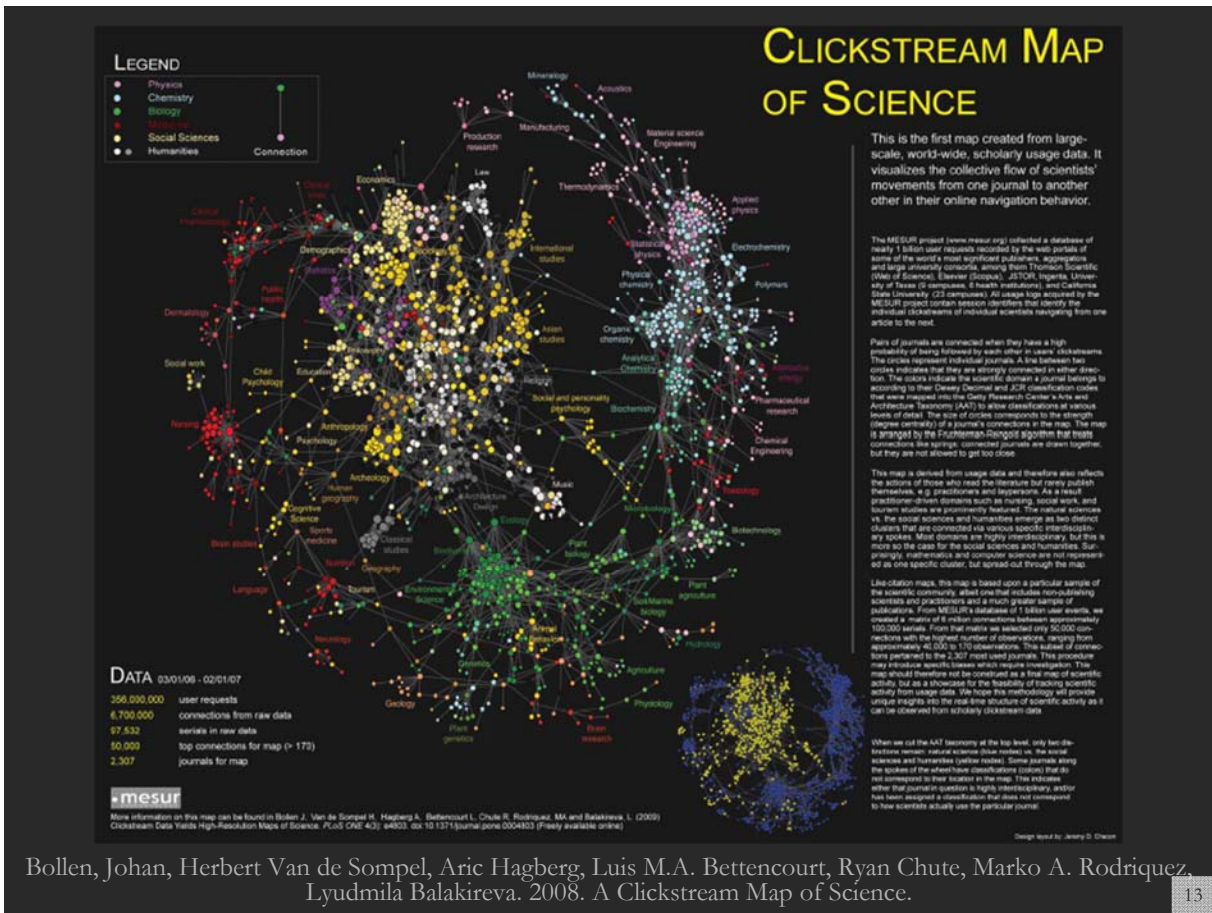
Places & Spaces: Mapping Science Exhibit (<http://scimaps.org>)



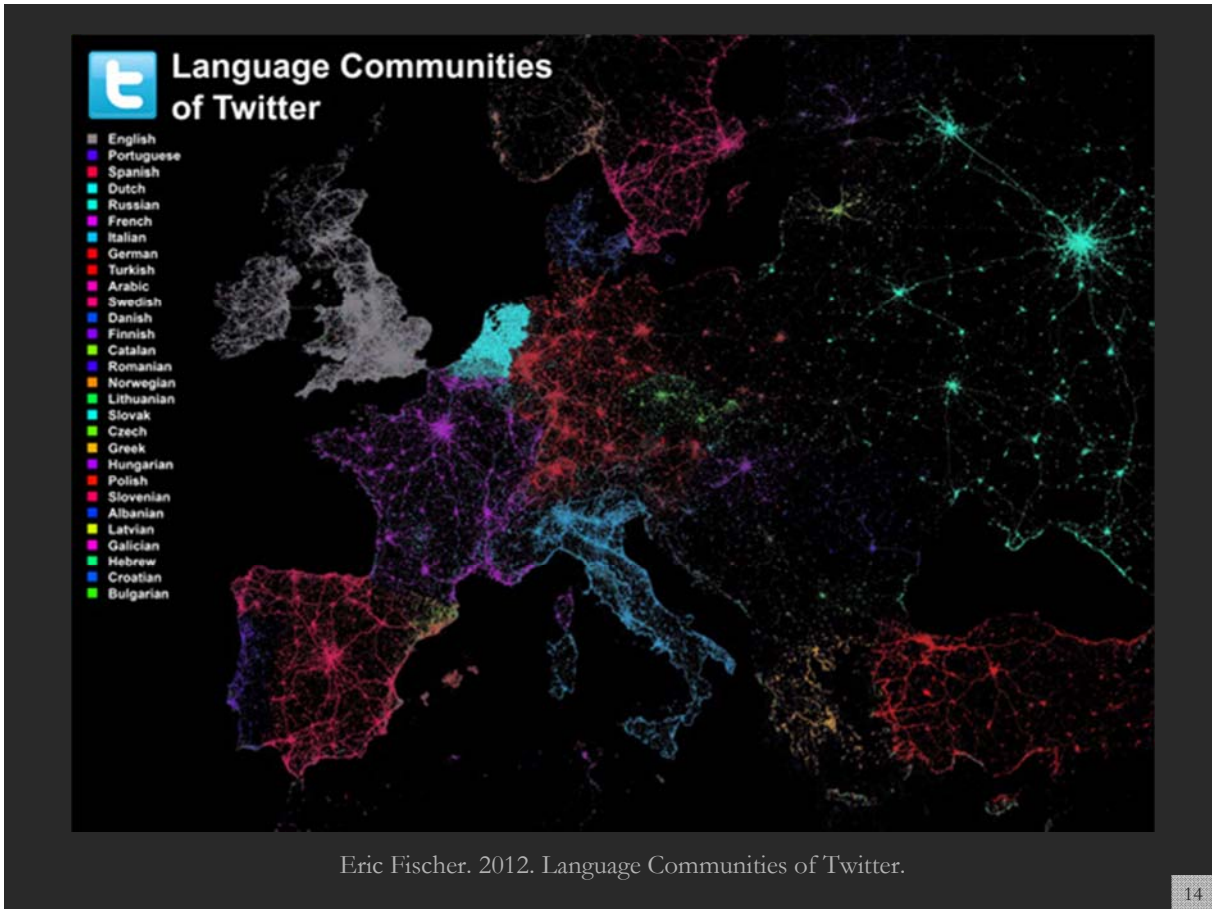
*After eight years, there now exist 80 out of 100 maps.*



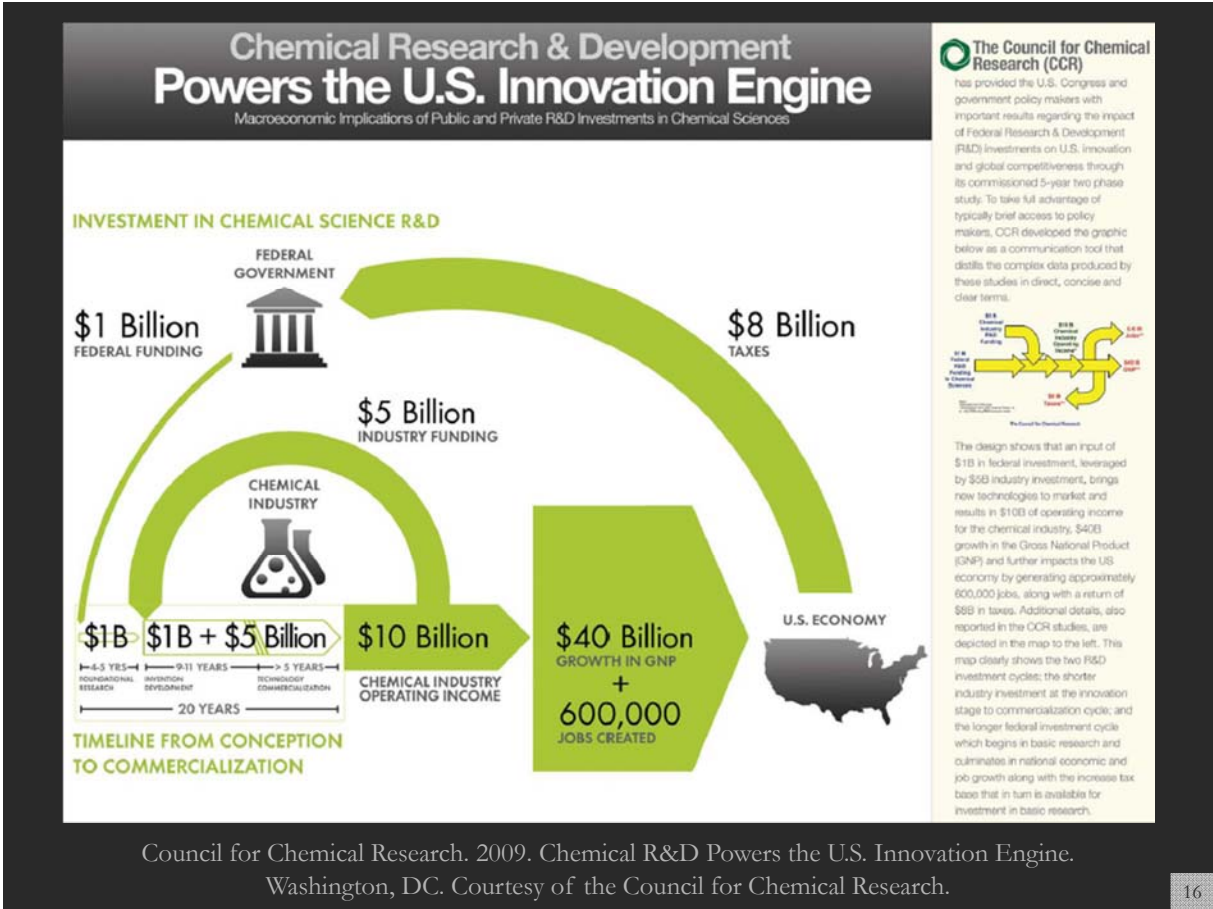
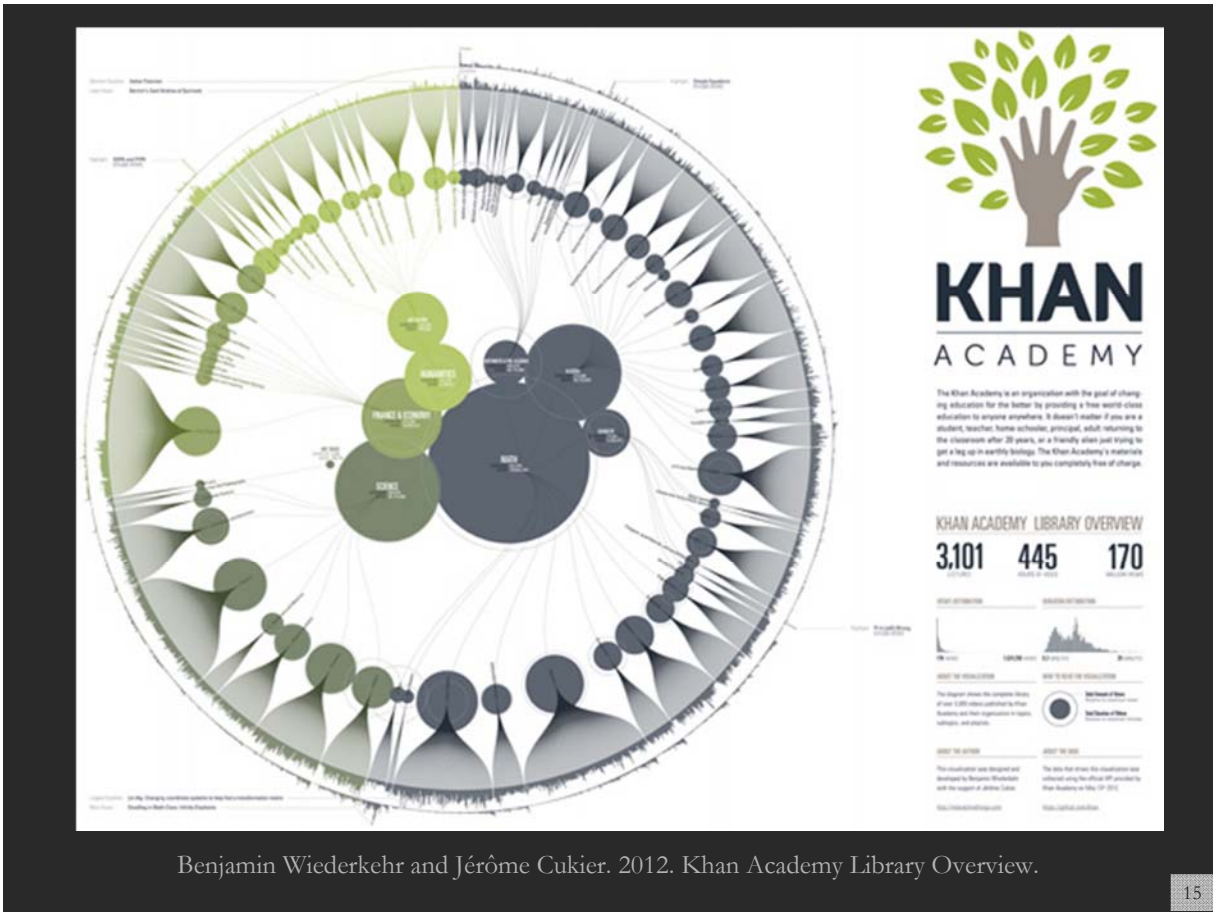
Mapping Science Exhibit at MEDIA X, Wallenberg Hall, Stanford University, 2009  
<http://mediax.stanford.edu>, <http://scaleindependentibought.typepad.com/photos/scimaps>



Bollen, Johan, Herbert Van de Sompel, Aric Hagberg, Luis M.A. Bettencourt, Ryan Chute, Marko A. Rodriguez, Lyudmila Balakireva. 2008. A Clickstream Map of Science. 13











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>



Illuminated Diagram Display  
 on display at the Smithsonian in DC.  
[http://scimaps.org/exhibit\\_info/#ID](http://scimaps.org/exhibit_info/#ID)

### Geographic Map: Where Science Gets Done

### Science Map: How Scientific Disciplines Relate

**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 lectern or use the keyboard) with an overlay of moving light.

<http://scimaps.org>

**Top Five Continents**

- North America - 4,000 records
- South & East Asia - 3,589
- Australia - 2,431
- Africa - 2,208
- South America - 1,562

**Top Five Scientific Disciplines**

- Math & Physics - 4,000 records
- Health Professionals - 3,589
- Social Sciences - 2,431
- Aeronautical, Chemical, Mechanical & Civil Engineering - 2,208
- Humanities - 1,562

**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.

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People & Topics

19

### Geographic Map: Where Science Gets Done

### Science Map: How Scientific Disciplines Relate

**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 lectern or use the keyboard) with an overlay of moving light.

<http://scimaps.org>

**Elinor Ostrom - Nobel Prize in Economic Sciences 2009**

**Born:** 7 August 1933, New York, NY, USA

**Affiliation at the time of the award:** Indiana University, Bloomington, IN, USA, Arizona State University, Tempe, AZ, USA

**Prize motivation:** "for her analysis of economic governance, especially the commons"

**Field:** Economic governance

**Contribution:** Challenged the conventional wisdom by demonstrating how local property can be successfully managed by local commons without any regulation by central authorities or privatization.

**Interact**

Select any location on the Geographic Map location (by brushing your finger over an area on the lectern's touch screen) and topics studied in that area will highlight on the Science Map; the brighter a topic glows, the more papers on that topic originated in the selected area. Conversely, touching a scientific area in the Science Map illuminates places on the Geographic Map where that topic is studied. People and topic buttons support the exploration of publication output by selected Noble laureates and particular lines of research using MEDLINE data from 2000-2009.

Cancer

Cloning

HIV

Robert G. Edwards

Roger D. Kornberg

Elinor Ostrom

Obesity

Quality of Life

Smoking

Stanley B. Prusiner

Ahmed H. Zewail

View All

Keyword Search

20





## Scholarly Database at IU

Supports federated search of 25 million publication, patent, grant records.

Results can be downloaded as data dump and (evolving) co-author, paper-citation networks.

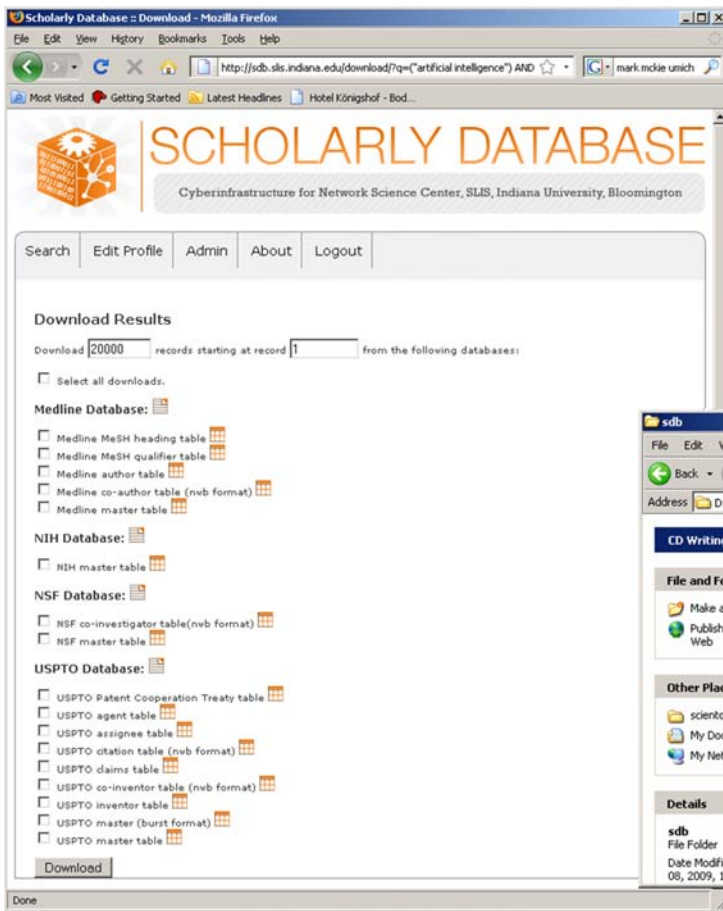
The image shows two screenshots of the Scholarly Database website. The left screenshot displays the login page with options for 'IU User' and 'Non-IU User'. The 'IU User' section includes a 'Go to IU Login' button, while the 'Non-IU User' section has fields for 'Email' and 'Password' with a 'Login' button. Below the login options, there is a 'Not Registered Yet?' section with a 'Register as an IU User' link and a 'Register as a Non-IU User' link. A 'In the news' section lists a citation: 'Wetland, John. 2008. Group Theory. Nature, 455, 7: 720-722.' Below that is a 'Please Cite As' section with a citation: 'La Roca, Gavin, Andrea, Surveit, Sargun, John, Yu, Weizhan and Bömer, Katy. (2007) The Scholarly Database and Its Utility for Scientometric Research. In Proceedings of the 13th International Conference on Scientometrics and Informatics, Madrid, Spain, June 28-30, 2007, pp. 487-492. http://sdb.iu.indiana.edu/~katy/paper/IF%20sdb.pdf'. An 'Acknowledgements' section follows, mentioning funding from the School of Library and Information Science and the National Science Foundation. The right screenshot shows the search interface with a navigation bar (Search, Edit Profile, Admin, About, Logout) and a search form. The form includes fields for 'Creators', 'Title', 'Abstract' (containing 'RNAi'), 'Full Text', 'First Year' (1898), and 'Last Year' (2008). There are checkboxes for 'Medline (1898 - 2008)', 'NIH (1961 - 2002)', 'NSF (1985 - 2004)', and 'USPTO (1976 - 2007)'. A 'Search' button is at the bottom. To the right of the form is explanatory text about search syntax, such as 'If multiple terms are entered in a field, they are automatically combined using "OR".' and 'You can put AND between terms to combine with "AND".' It also explains the use of double quotation marks for exact phrases and the importance of a particular term in a query.

Register for free access at <http://sdb.cns.iu.edu>

The image is a screenshot of a Mozilla Firefox browser window displaying the Scholarly Database search results page. The browser's address bar shows the URL: [http://sdb.sls.indiana.edu/search/results?q=\(\"artificial intelligence\"\)](http://sdb.sls.indiana.edu/search/results?q=(\). The page header features the 'SCHOLARLY DATABASE' logo and the text 'Cyberinfrastructure for Network Science Center, SLIS, Indiana University, Bloomington'. Below the header is a navigation bar with 'Search', 'Edit Profile', 'Admin', 'About', and 'Logout'. The main content area is titled 'Browse Results' and shows the search results: 'Your search returned 13,231 results in 0.295 seconds.' with a 'Download' button. Below this, it lists 'Total results per database: NIH: 2,103, Medline: 10,235, USPTO: 279, NSF: 614.' and 'Results 1 through 20.' with a 'Next>>' link. A table of results is displayed with columns for 'Source', 'Authors/Creators', 'Year', 'Title', and 'Score (out of 5.71)'. The table contains the following entries:

| Source  | Authors/Creators        | Year | Title                                      | Score (out of 5.71) |
|---------|-------------------------|------|--|---------------------|
| Medline | LaCombe                 | 1987 | Artificial intelligence.                   | 5.71                |
| Medline |                         | 1989 | Artificial intelligence: expert systems.   | 5.71                |
| Medline | Schmitt                 | 1990 | [Artificial intelligence in dentistry]     | 5.71                |
| Medline | Adlassnig and Adlassnig | 2002 | Artificial-intelligence-augmented systems. | 5.60                |
| Medline | Touretzky               | 1980 | Artificial intelligence.                   | 4.86                |
| Medline | Goldenberg              | 1980 | Artificial intelligence.                   | 4.86                |



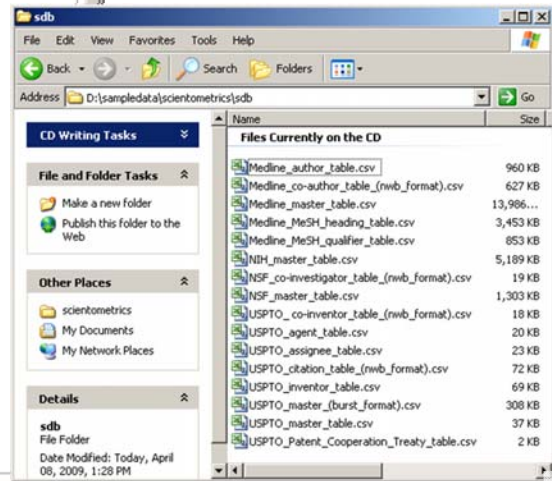


Since March 2009:

Users can download networks:

- Co-author
- Co-investigator
- Co-inventor
- Patent citation

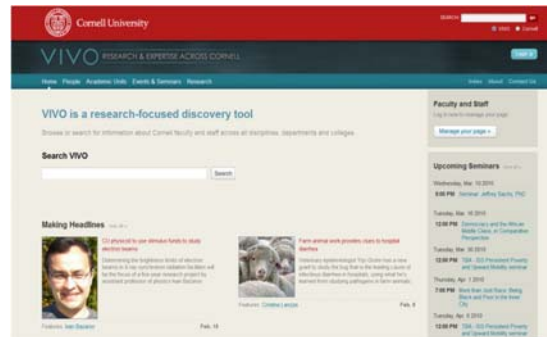
and tables for burst analysis in NWB.



# VIVO International Researcher Network

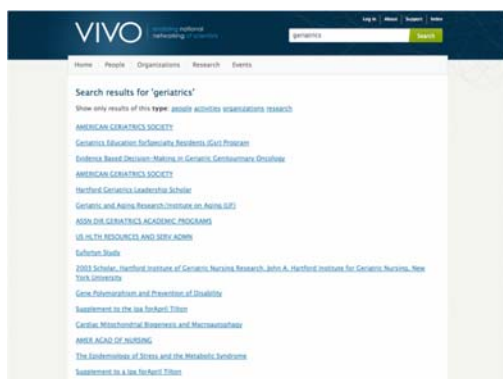
## VIVO: A Semantic Approach to Creating a National Network of Researchers (<http://vivoweb.org>)

- 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

enabling national networking of scientists

Index Log in

Search

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

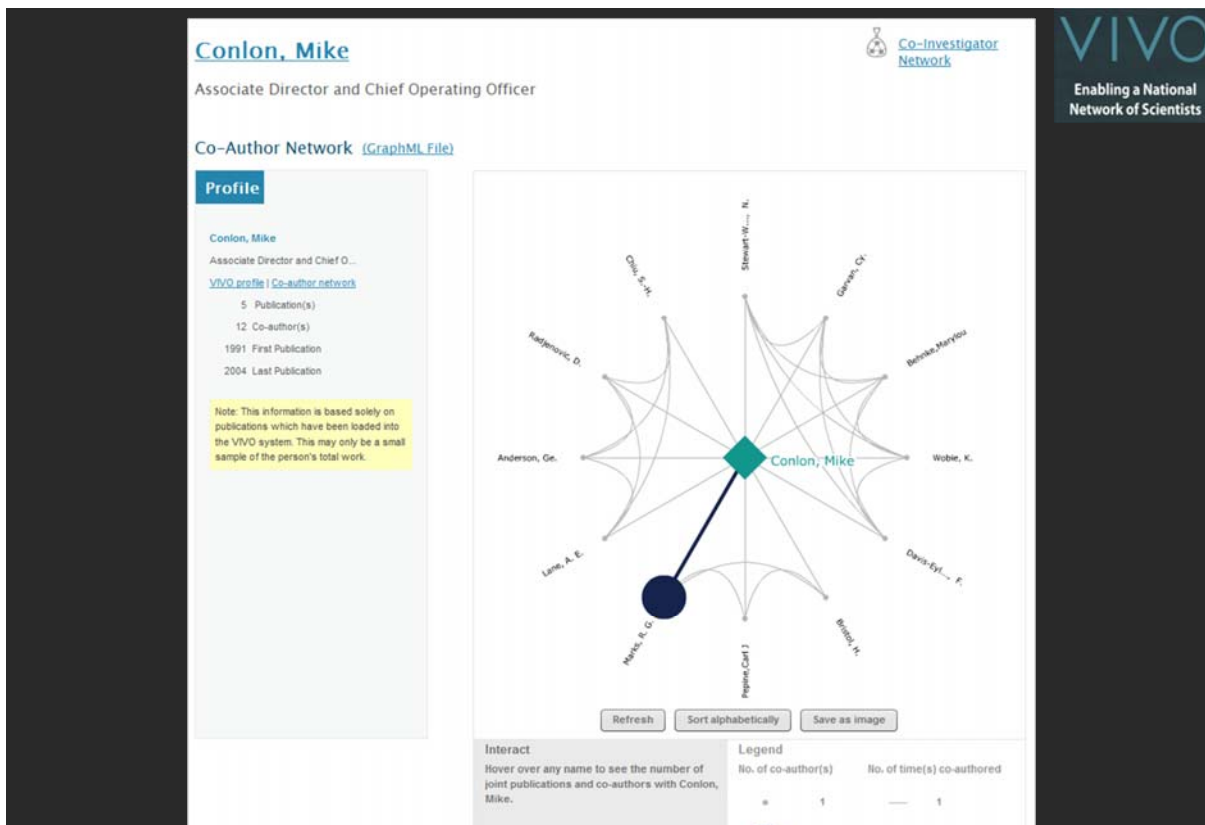
| Sub-Disciplines                 | # of pubs. | % activity |
|---------------------------------|------------|------------|
| Pest Management Science         | 24.2       | 5.0        |
| Wildlife Research               | 19.1       | 3.9        |
| Protein Science                 | 13.1       | 2.7        |
| 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        |

Show discipline labels

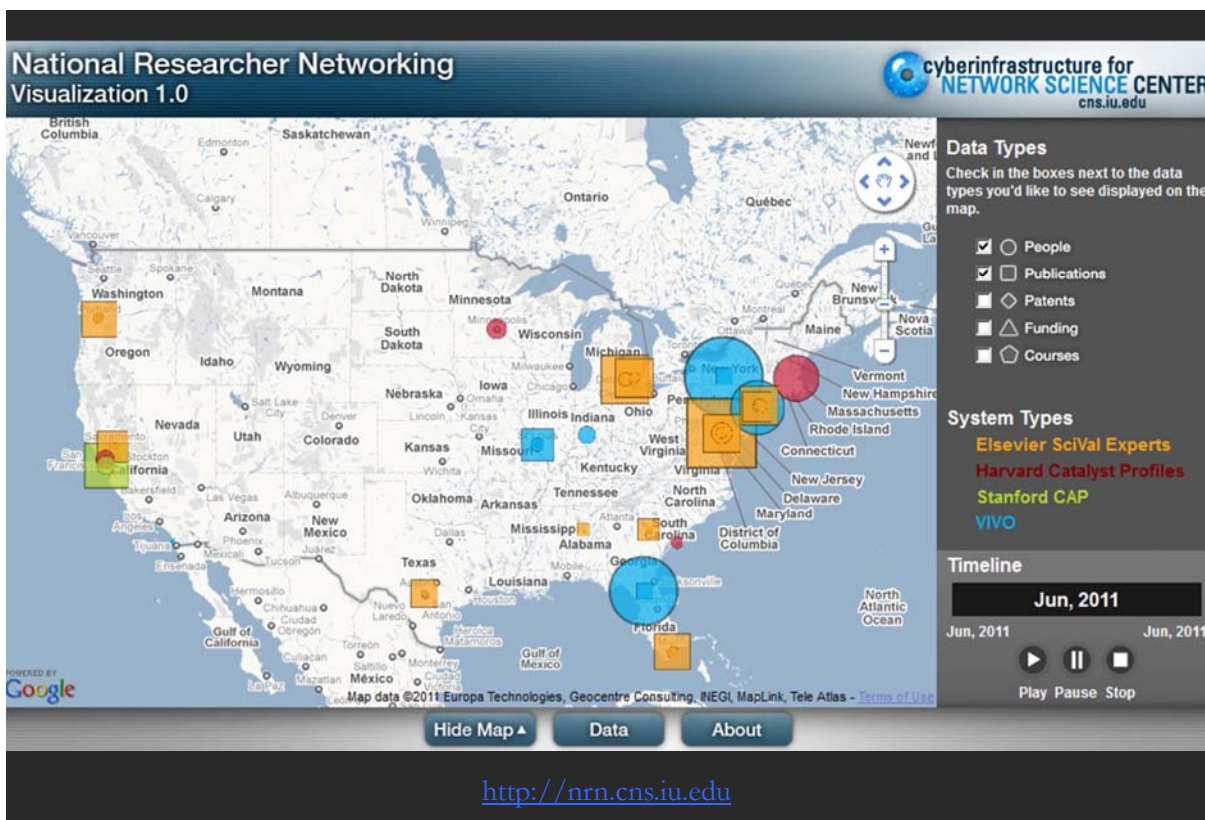
Top 290 disciplines shown

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? 31



**Geospatial Analysis (Where)** Where is what science performed by whom? Science is global and needs to be studied globally. 32

## VIVO On-The-Go

## Overview, Interactivity, Details on Demand

come to  
commonly  
used devices  
and environments



## 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](#)

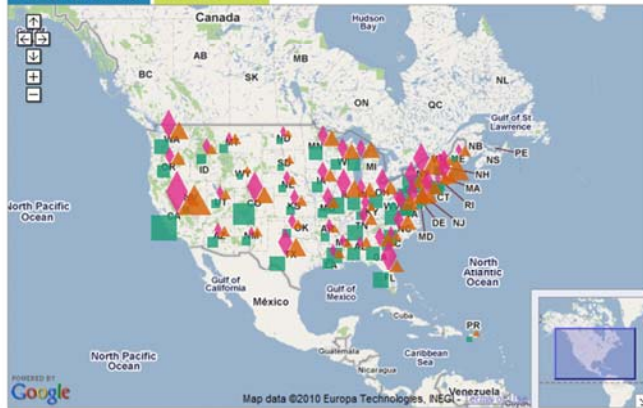
##### Demo Links

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





Geographic Map Science Map



Funding  
 NIH  
 NSF  
 USDA

Publications  
 DOE  
 ISI  
 Medline

Patents  
 USPTO

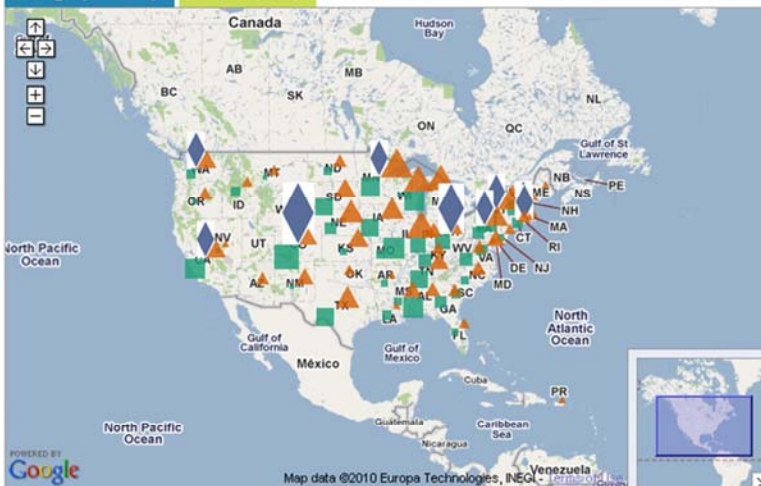
Citations  Count  Amount

From year 1901 to year 2009

Search by keyword

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

Geographic Map Science Map



Funding  
 NIH  
 NSF  
 USDA

Publications  
 DOE  
 ISI  
 Medline

Patents  
 USPTO

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.

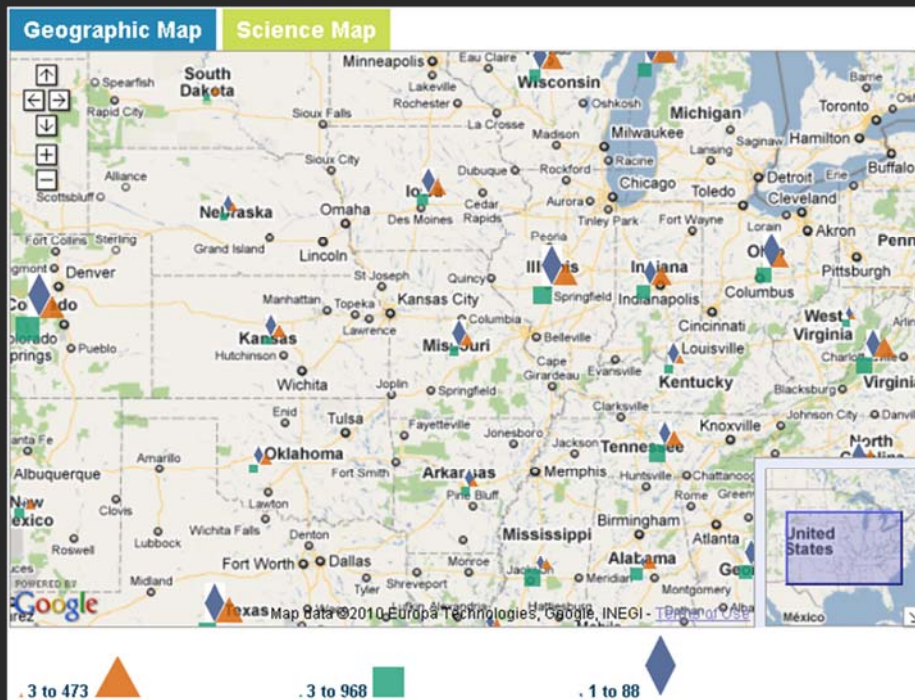
US Department of Agriculture (USDA) awards made available by a staff member of the Office of Scientific and Technical Information from the US Department of Energy (DOE).

### Publications

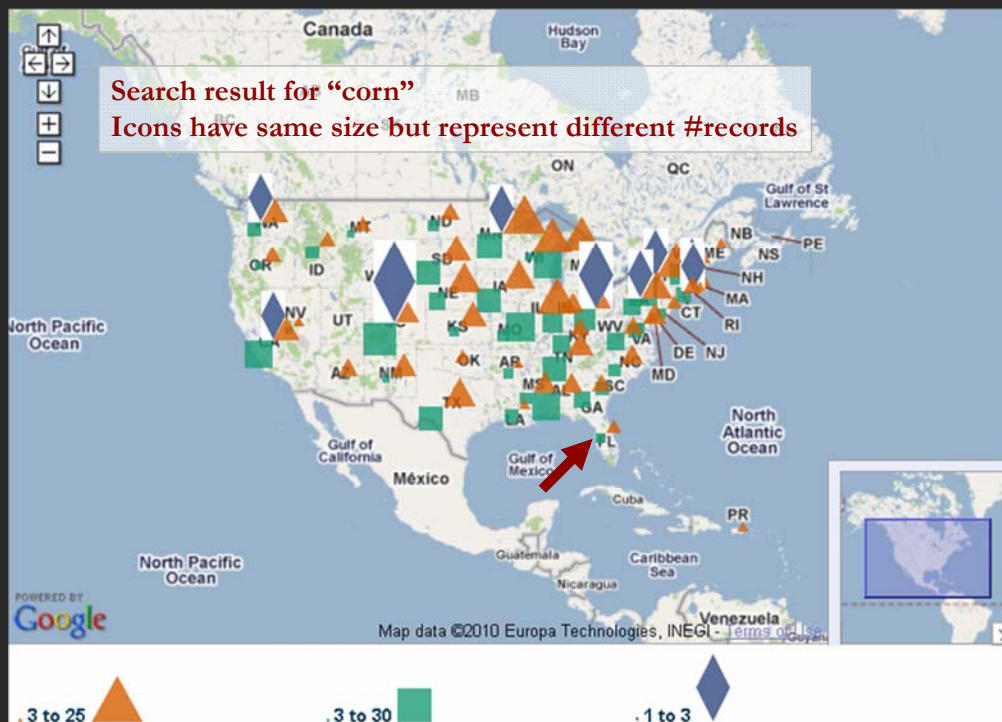
MEDLINE papers by the National Library of Medicine retrieved from the Scholarly Database (<http://sdb.slis.indiana.edu>) at Indiana University on 11/20/2010. Search query used was biomass OR biofuel OR "bio mass" OR "bio fuel" in the 'All Text' field.

The geographic map at state level.



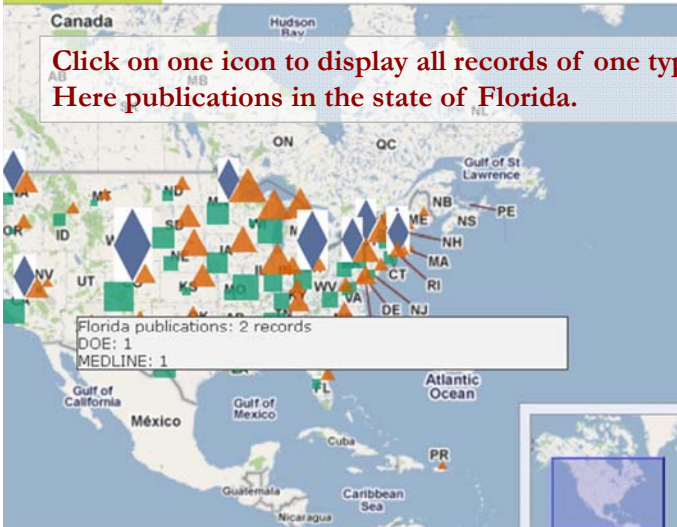


The geographic map at city level.





## Science Map



## Maps

Detail

Data

About

> Florida

MEDLINE

2002

- [Recovery Of Dairy Manure Nutrients By Benthic Freshwater Algae](#)

DOE

1985

- [Enzymatic Hydrolysis And Fermentation Of Corn For Fuel Alcohol](#)

41

Information Bridge: DOE Scientific and Technical Information - - Document #5789929 - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://www.osti.gov/bridge/product.biblio.jsp?osti\_id=5789929

MapSustain Information Bridge: DOE Scientifi...

DOE Scientific and Technical Information

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**Title** Enzymatic hydrolysis and fermentation of corn for fuel alcohol  
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**Creator/Author** [Mullins, J.T.](#)

**Publication Date** 1985 Jan 01

**OSTI Identifier** OSTI ID: 5789929

**Other Number(s)** Journal ID: CODEN: BIBA

**Resource Type** Journal Article

**Resource Relation** Journal Name: Biotechnol. Bioeng.; (United States); Journal Volume: 27:3

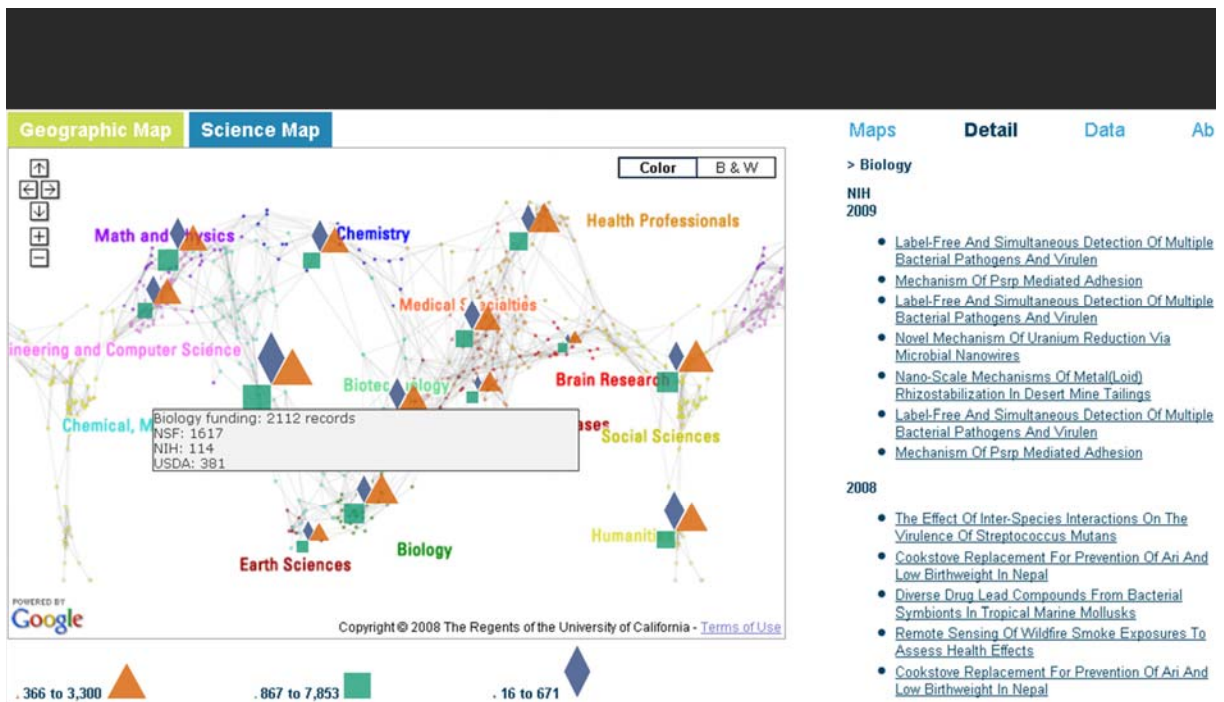
**Research Org** Univ. of Florida, Gainesville

**Subject** 09 BIOMASS FUELS; 32 ENERGY CONSERVATION, CONSUMPTION, AND UTILIZATION; ETHANOL FUELS; BIOSYNTHESIS; MAIZE; ENZYMATIC HYDROLYSIS; FERMENTATION; PRODUCTIVITY; COST; ENERGY EFFICIENCY; EXPERIMENTAL DATA; WASTE PRODUCT UTILIZATION; ALCOHOL FUELS; BIOCONVERSION; CEREALES; CHEMICAL REACTIONS; DATA; DECOMPOSITION; EFFICIENCY; FUEL; GLASS; HYDROLYSIS; INFORMATION; LYSIS; NUMERICAL DATA; PLANTS;

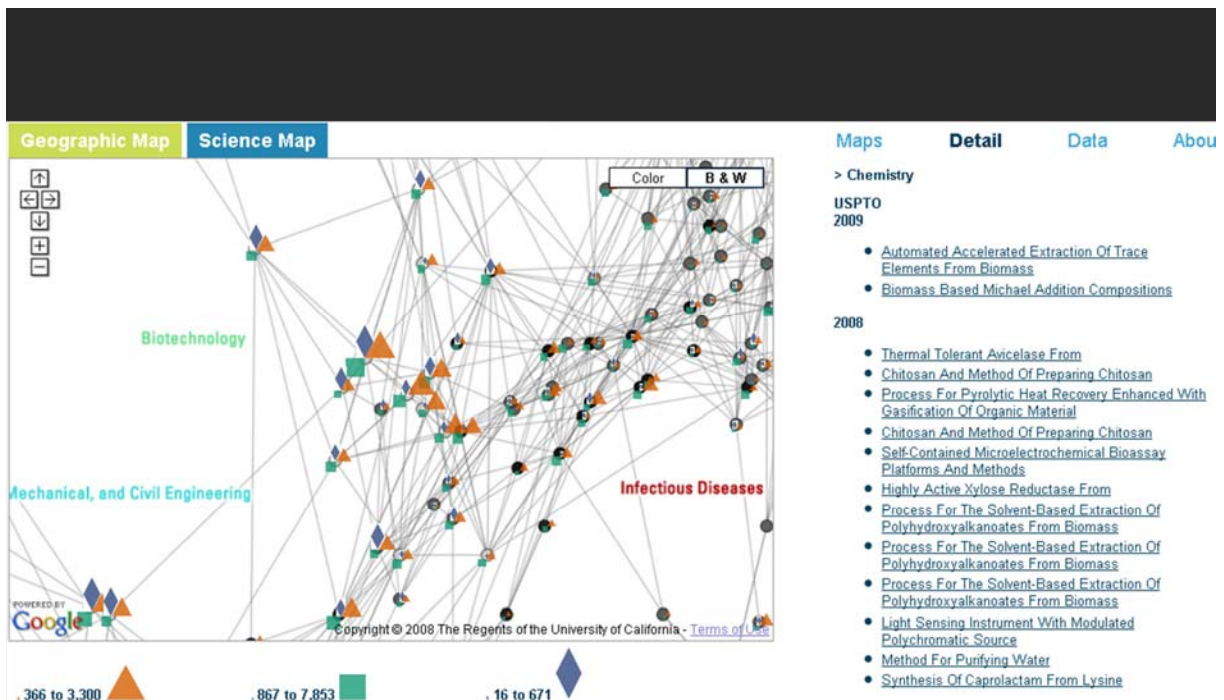
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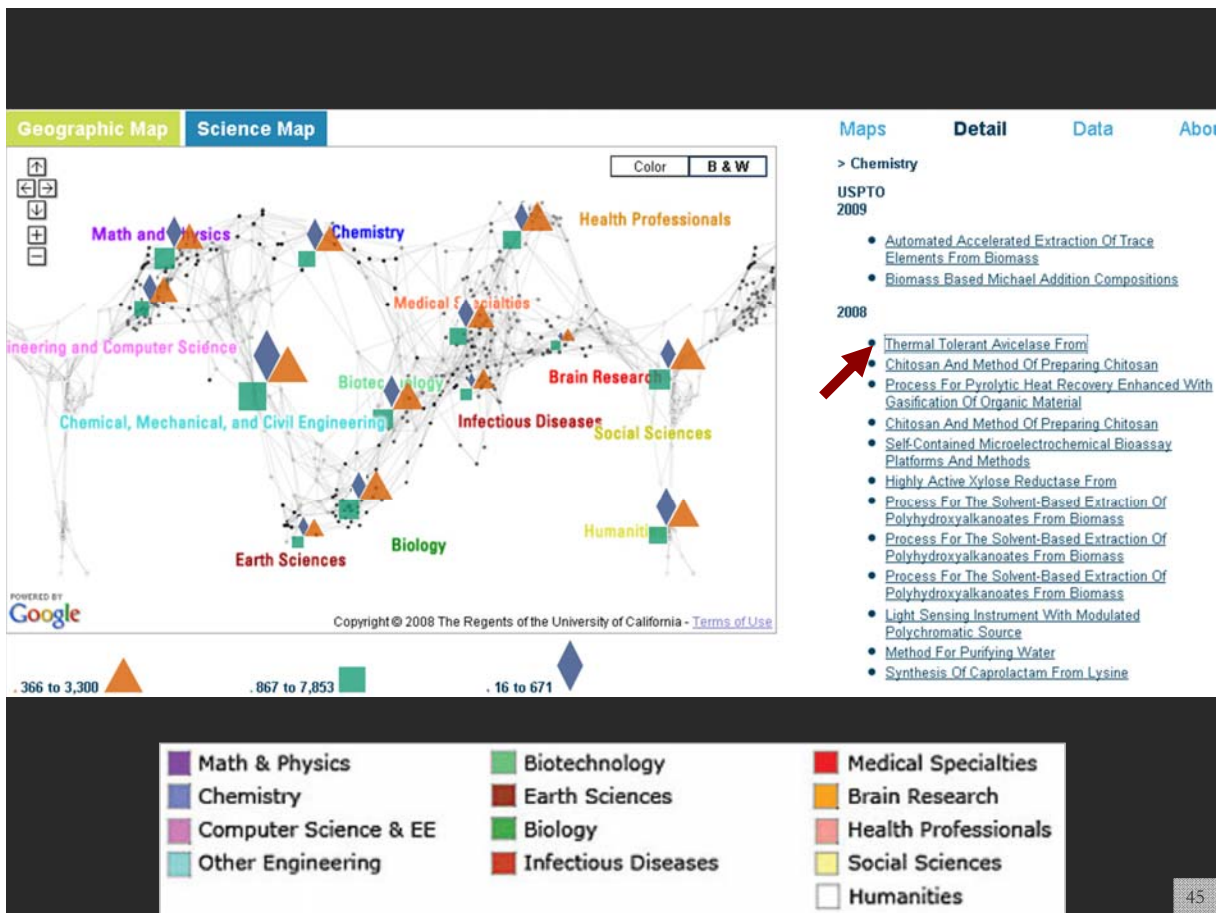
42



The science map at 13 top-level scientific disciplines level.



The science map at 554 sub-disciplines level.



Maps Detail Data About

> Chemistry

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

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United States Patent 7,364,890  
Ding, et al. April 29, 2008

**Thermal tolerant avicelase from *Acidothermus cellulolyticus***

**Abstract**

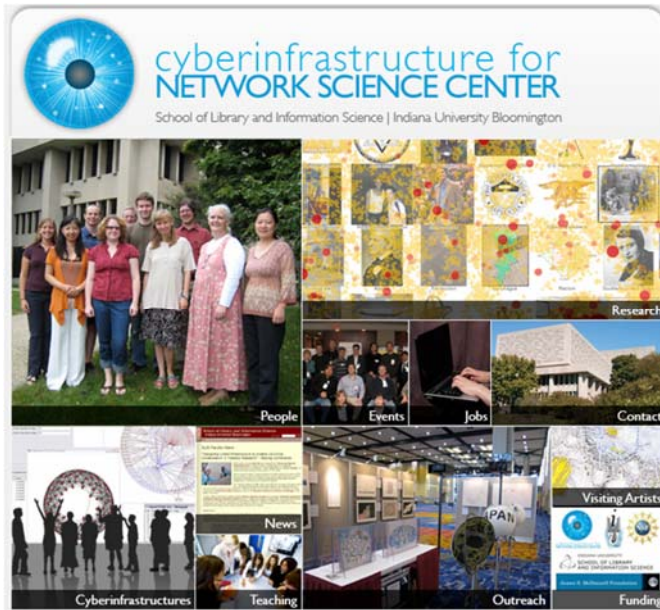
The invention provides a thermal tolerant (thermostable) cellulase, AvIII, that is a member of the glycoside hydrolase (GH) family. AvIII was isolated and characterized from *Acidothermus cellulolyticus* and, like many cellulases, the disclosed polypeptide and/or its derivatives may be useful for the conversion of biomass into biofuels and chemicals.

Inventors: Ding; Shi-You (Golden, CO), Adney; William S. (Golden, CO), Vinzant; Todd B. (Golden, CO), Himmel; Michael E. (Littleton, CO)  
Assignee: Midwest Research Institute (Kansas City, MO)  
Appl. No.: 09/017,276

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46





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