

# Visualizing Nanoscience and Technology

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Westin Hotel, Arlington, VA

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# Map of Scientific Collaborations from 2005-2009



<http://scimaps.org>

Computed Using Data from Elsevier's Scopus

# The Structure of Science

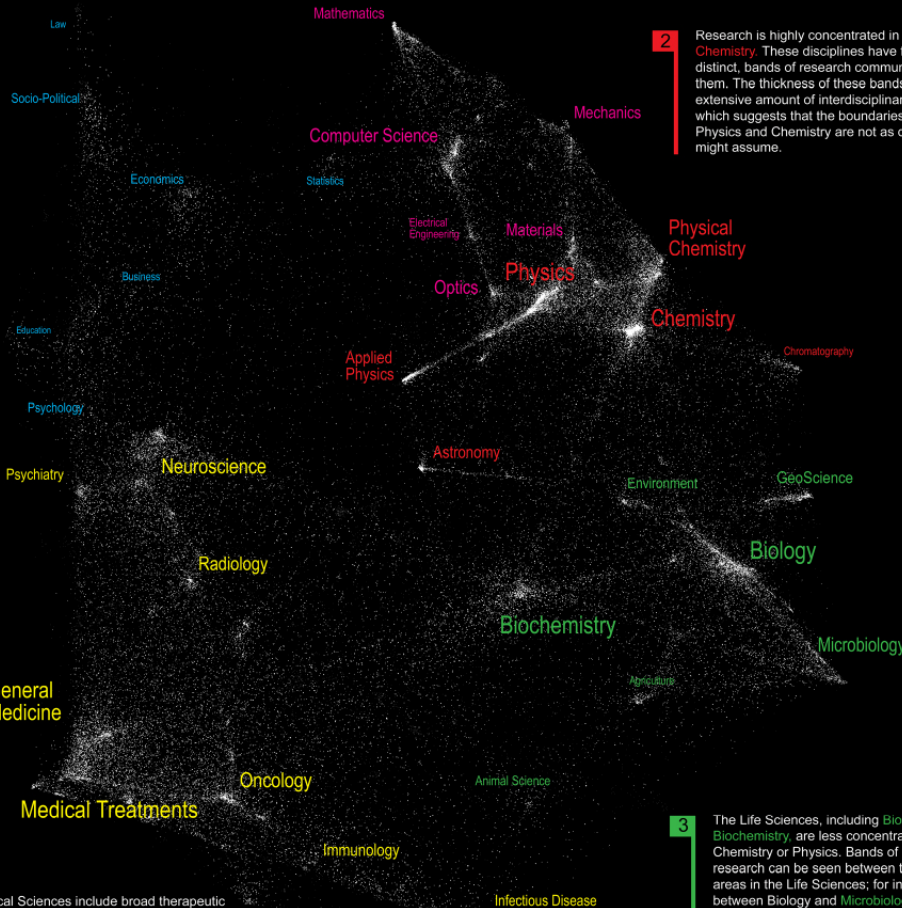
**5** The Social Sciences are the smallest and most diffuse of all the sciences. **Psychology** serves as the link between Medical Sciences (Psychiatry) and the Social Sciences. **Statistics** serves as the link with Computer Science and Mathematics.

**1** **Mathematics** is our starting point, the purest of all sciences. It lies at the outer edge of the map. **Computer Science**, **Electrical Engineering**, and **Optics** are applied sciences that draw upon knowledge in Mathematics and Physics. These three disciplines provide a good example of a linear progression from one pure science (Mathematics) to another (Physics) through multiple disciplines. Although applied, these disciplines are highly concentrated with distinct bands of research communities that link them. Bands indicate interdisciplinary research.

**2** Research is highly concentrated in **Physics** and **Chemistry**. These disciplines have few, but very distinct, bands of research communities that link them. The thickness of these bands indicates an extensive amount of interdisciplinary research, which suggests that the boundaries between Physics and Chemistry are not as distinct as one might assume.

**3** The Life Sciences, including **Biology** and **Biochemistry**, are less concentrated than Chemistry or Physics. Bands of linking research can be seen between the larger areas in the Life Sciences; for instance between Biology and Microbiology, and between Biology and Environmental Science. Biochemistry is very interesting in that it is a large discipline that has visible links to disciplines in many areas of the map, including Biology, Chemistry, Neuroscience, and General Medicine. It is perhaps the most interdisciplinary of the sciences.

**4** The Medical Sciences include broad therapeutic studies and targeted areas of **Treatment** (e.g. central nervous system, cardiology, gastroenterology, etc.) Unlike Physics and Chemistry, the medical disciplines are more spread out, suggesting a more multi-disciplinary approach to research. The transition into Life Sciences (via Animal Science and Biochemistry) is gradual.



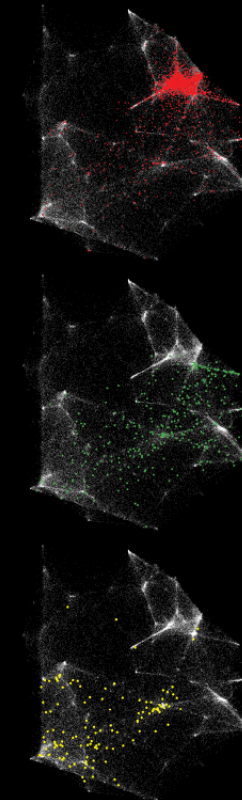
We are all familiar with traditional maps that show the relationships between countries, provinces, states, and cities. Similar relationships exist between the various disciplines and research topics in science. This allows us to map the structure of science.

One of the first maps of science was developed at the Institute for Scientific Information over 30 years ago. It identified 41 areas of science from the citation patterns in 17,000 scientific papers. That early map was intriguing, but it didn't cover enough of science to accurately define its structure.

Things are different today. We have enormous computing power and advanced visualization software that make mapping of the structure of science possible. This galaxy-like map of science (left) was generated at Sandia National Laboratories using an advanced graph layout routine (VxOrd) from the citation patterns in 800,000 scientific papers published in 2002. Each dot in the galaxy represents one of the 96,000 research communities active in science in 2002. A research community is a group of papers (9 on average) that are written on the same research topic in a given year. Over time, communities can be born, continue, split, merge, or die.

The map of science can be used as a tool for science strategy. This is the terrain in which organizations and institutions locate their scientific capabilities. Additional information about the scientific and economic impact of each research community allows policy makers to decide which areas to explore, exploit, abandon, or ignore.

We also envision the map as an educational tool. For children, the theoretical relationship between areas of science can be replaced with a concrete map showing how math, physics, chemistry, biology, and social studies interact. For advanced students, areas of interest can be located and neighboring areas can be explored.



## Nanotechnology

Most research communities in nanotechnology are concentrated in **Physics**, **Chemistry**, and **Materials Science**. However, many disciplines in the Life and Medical Sciences also have nanotechnology applications.

## Proteomics

Research communities in proteomics are centered in **Biochemistry**. In addition, there is a heavy focus in the tools section of chemistry, such as **Chromatography**. The balance of the proteomics communities are widely dispersed among the Life and Medical Sciences.

## Pharmacogenomics

Pharmacogenomics is a relatively new field with most of its activity in **Medicine**. It also has many communities in **Biochemistry** and two communities in the Social Sciences.

# The EMERGENCE of NANOTECHNOLOGY

## MAPPING THE NANO REVOLUTION

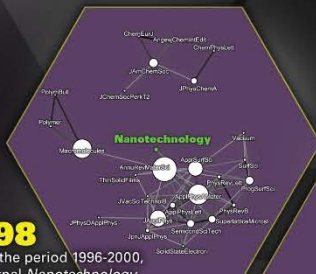
The emergence of nanotechnology has been one of the major scientific-technological revolutions in the last decade and it led to a structural reorganization of major fields of science. Price (1965) showed that fields of science and their development can be mapped using aggregated citations among the journals in the fields and their relevant environments.

The frames to the right show the evolving journal citation network for the years 1998-2003. Distances are proportional to cosine values between the citation patterns of the respective journals. Textual descriptions of key events during the development of *Nanotechnology* are given below each frame. Most notably, leading papers in *Science* and *Nature* catalyzed the breakthrough around 2000.

## CHANGING ROLES OF DIFFERENT JOURNALS

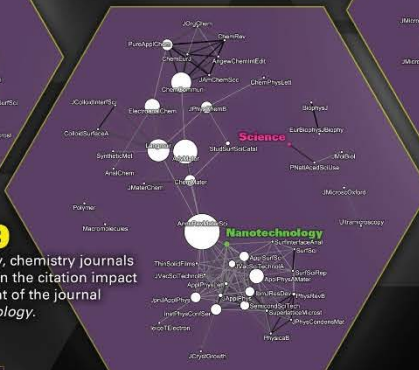
The interdisciplinarity of a journal can be measured using betweenness centrality (BC)—journals that occur on many shortest paths between other journals in a network have higher BC value than those that do not. In the maps, sizes of nodes are proportional to the betweenness centrality of the respective journal in the citation network.

From being a specialist journal in applied physics, the journal *Nanotechnology* obtains a high BC value in the years of the transition, ca. 2001. This is preceded by the "intervention" of *Science*. After the transition, the new field of nanotechnology is established, new journals such as *Nano Letters* published by the influential American Chemical Society take the lead, and a new specialty structure with low BC value journals results.



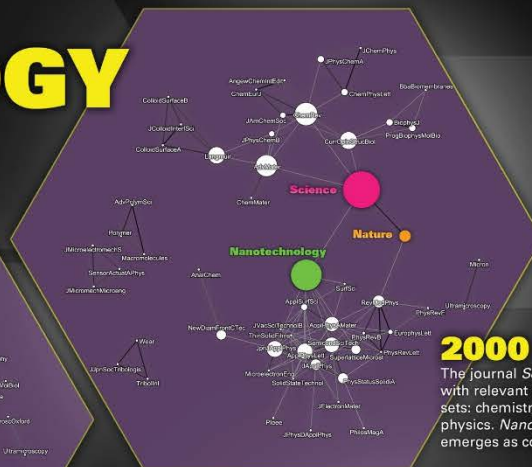
**1998**

During the period 1996-2000, the journal *Nanotechnology* is part of a group of journals in applied physics.



**1999**

Increasingly, chemistry journals play a role in the citation impact environment of the journal *Nanotechnology*.



**2000**

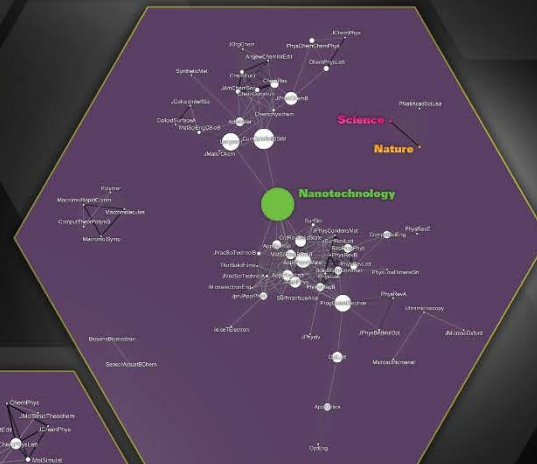
The journal *Science* interfaces with relevant journals in both sets: chemistry and applied physics. *Nanotechnology* emerges as core journal.

### LEGEND

- *Science*
- *Nature*
- *Nanotechnology*
- *Nano Letters*

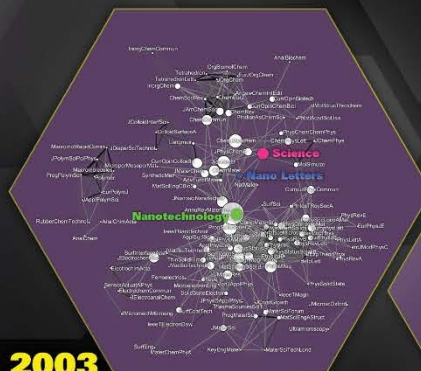
### Values

- 0.8
- 0.22
- 0.33



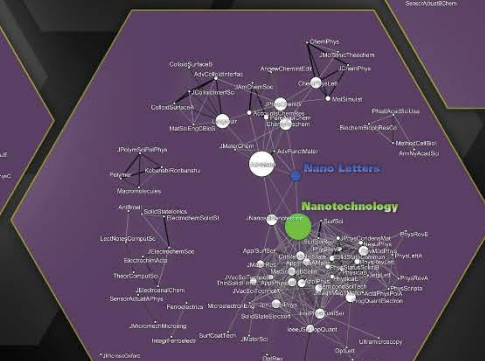
**2001**

The journal *Nanotechnology* now provides the interface between chemistry and physics. The "intervention" by *Science* is no longer needed.



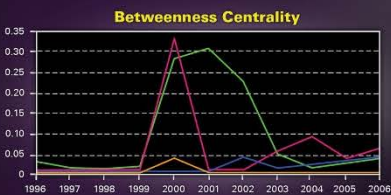
**2002**

The journal *Science* is relevant in the citation impact environment, but now functions as one of the specialist journals in nanotechnology. *Nanoscience* further develops as an increasingly integrated network of journals.



**2003**

Other journals in nanoscience and technology begin to emerge, and the bridging role of the journal *Nanotechnology* gradually subsides. *Nano Letters* and the *Journal of Nanoscience and Nanotechnology* join the new field of nanotechnology.



An animated sequence of this evolution is at: <http://www.leydesdorff.net/journals/nanotech>.

## References

Leydesdorff, L. and T. Schank. 2008. Dynamic Animations of Journal Maps: Indicators of Structural Change and Interdisciplinary Developments. *Journal of the American Society for Information Science and Technology*, 59(11), 1810-1818.

Price, Derek J. de Solla (1965). Networks of scientific papers. *Science*, 149, no. 3683, 510- 515.

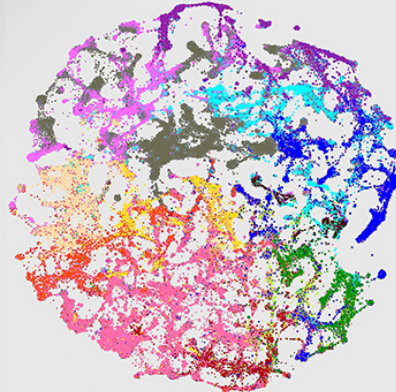
Design by Michael J. Stamper and Katy Börner  
Cyberinfrastructure for Network Science Center | Indiana University  
cns.iu.edu

# IDENTIFYING EMERGING TOPICS IN SCIENCE AND TECHNOLOGY

(finding the needles in the haystack)

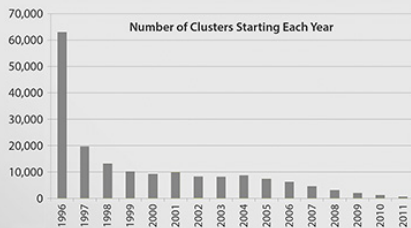
A novel approach to identifying emerging topics in science and technology has been developed. Two models of science and technology have been created using 16 years (1996-2011) of Scopus (20 million articles) and USPTO (3 million patents) data. These two models—one based on direct citation, and one based on co-citation—are used together to nominate the most emergent topics in S&T at a particular point in time.

## Step 1: Map All of Science and Technology

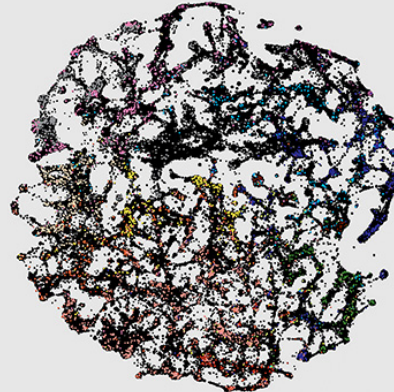


- Computer Science
- Math / Physics
- Chemistry
- Engineering
- Earth Science
- Biology
- Biotechnology
- Infectious Disease
- Medical Specialties
- Health Sciences
- Brain Research
- Humanities
- Social Sciences
- Patents

The map above was created using a combination of direct citation and text mining. First, 20 million articles from Scopus were clustered using direct citation links and the new modularity-based clustering methodology from Waltman & van Eck at Leiden University. Second, 3 million patents from the USPTO were clustered using the same direct citation method. Third, a BM25 text similarity was computed between all clusters, whether articles or patents. Using this text similarity, clusters were positioned relative to each other in the map above. Each of the 149,611 article clusters is colored based on the journals that comprise the cluster. The 27,114 patent clusters are colored gray.



## Step 2: Burn Off the Straw

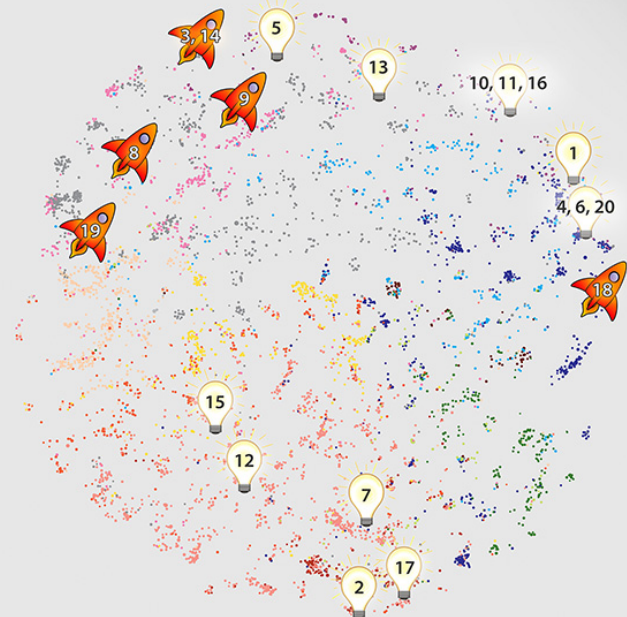


Most of the clusters in the direct citation map are very old (71%), having started a decade or more ago. Another 25% are in their prime, starting between 2002-2007. Emerging topics are, by definition, very new. In the map above, all clusters starting in 2007 or earlier have been blackened, or burned off. The 4% of clusters retaining their original color are those that began in 2008 or later and are still active.

To determine which of these clusters are most emergent, we further filter these clusters to those whose articles are also in new clusters in our co-citation model of science (not shown). Clusters are then ranked using a growth index. The locations of the top-20 emerging clusters for the year 2010 based on the growth index are shown in the map to the right. Emerging clusters can continue to be emergent in additional years if their growth characteristics are strong enough.

Interestingly, some emerging topics are based on scientific discoveries while others spring from technological innovation. Scientific discoveries are those where a new or unexpected finding is made or fundamental knowledge is gained. Technological innovations are those where existing science or technology is used to create new devices or capabilities that serve specific purposes. For the top-20 emerging areas in 2010, roughly one third of them (6) are based on technological innovations. The remainder are based on scientific discoveries.

## Step 3: Highlight the BRIGHTEST Needles



Scientific Discovery



Technological Innovation

### Top-20 Emerging Topics in 2010

- |   |   |
|---|---|
| 1 – iron-based superconductors                | 11 – zigzag graphene nanoribbons              |
| 2 – swine flu (H1N1) pandemic                 | 12 – cardiovascular events in type 2 diabetes |
| 3 – spectrum sensing in cognitive radio       | 13 – transformative optics                    |
| 4 – graphene nanosheets and nanocomposites    | 14 – spectrum allocation in cognitive radio   |
| 5 – Horava-Lifshitz quantum gravity           | 15 – IDH1 and IDH2 mutations in cancer        |
| 6 – graphene oxide nanosheets                 | 16 – epitaxial graphene                       |
| 7 – induced pluripotent stem cells            | 17 – H1N1 pandemic and seasonal flu           |
| 8 – MapReduce framework                       | 18 – crystallographic validation              |
| 9 – signal recovery from compressed sensing   | 19 – social tagging                           |
| 10 – graphene transistors and optical devices | 20 – mechanical properties of graphene        |



X.2 Map of the Internet - Martin Vargic - 2014

<http://scimaps.org>



FACEBOOK

TWITTER

BING YAHOO!

GOOGLE

WIKIPEDIA

YOUTUBE

DATA OCEAN

MICROSOFT

DESPICABLE

BITTORRENT

ANDROID

ARCHIVES

GO DADDY

APP SEA

LIVE JASMIN

WAREZ

HOST GATOR

GOOGLY PLAY

REDTUBE

SEA

SOFTONIC

APP STORE

YOU PORN

ISOHUNT

WORDPRESS

GOOGLY PLAY

SPANK WIRE

ISOHUNT

HOST GATOR

GOOGLY PLAY

EXTRM

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# Increasing Data Visualization Literacy





# Data Visualization Literacy

*Data visualization literacy* (ability to read, make, and explain data visualizations) requires

- *literacy* (ability to read and write text, e.g., in titles, axis labels, legend),
- *visual literacy* (ability to find, interpret, evaluate, use, and create images and visual media), and
- *data literacy* (ability to read, create, and communicate data).



# Information Visualization MOOC 2017

[OVERVIEW](#)[SCHEDULE](#)[EVENTS](#)[INSTRUCTORS](#)[READINGS](#)[GRADING](#)[FAQ](#)[CONTACT](#)

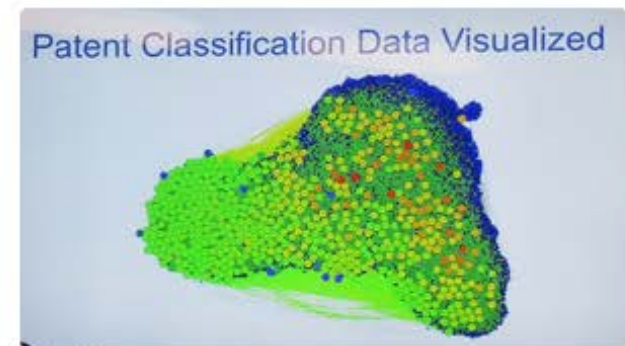
## Tweets about [ivmooc](#)

Lionel Villard Retweeted



**Katy Borner** @katycns

Patent cluster maps in support of automatic classification of 0.5M patent applications /year to patent examiner profiles #cdacmtg #ivmooc




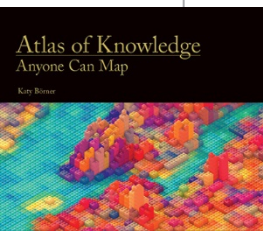
28 Oct

The course can be taken for free or for Indiana University credits as part of the Online Data Science Program or the ILS M.S. program. Register for free at <http://ivmooc.cns.iu.edu>. Next class starts January 10, 2017.

# Tasks

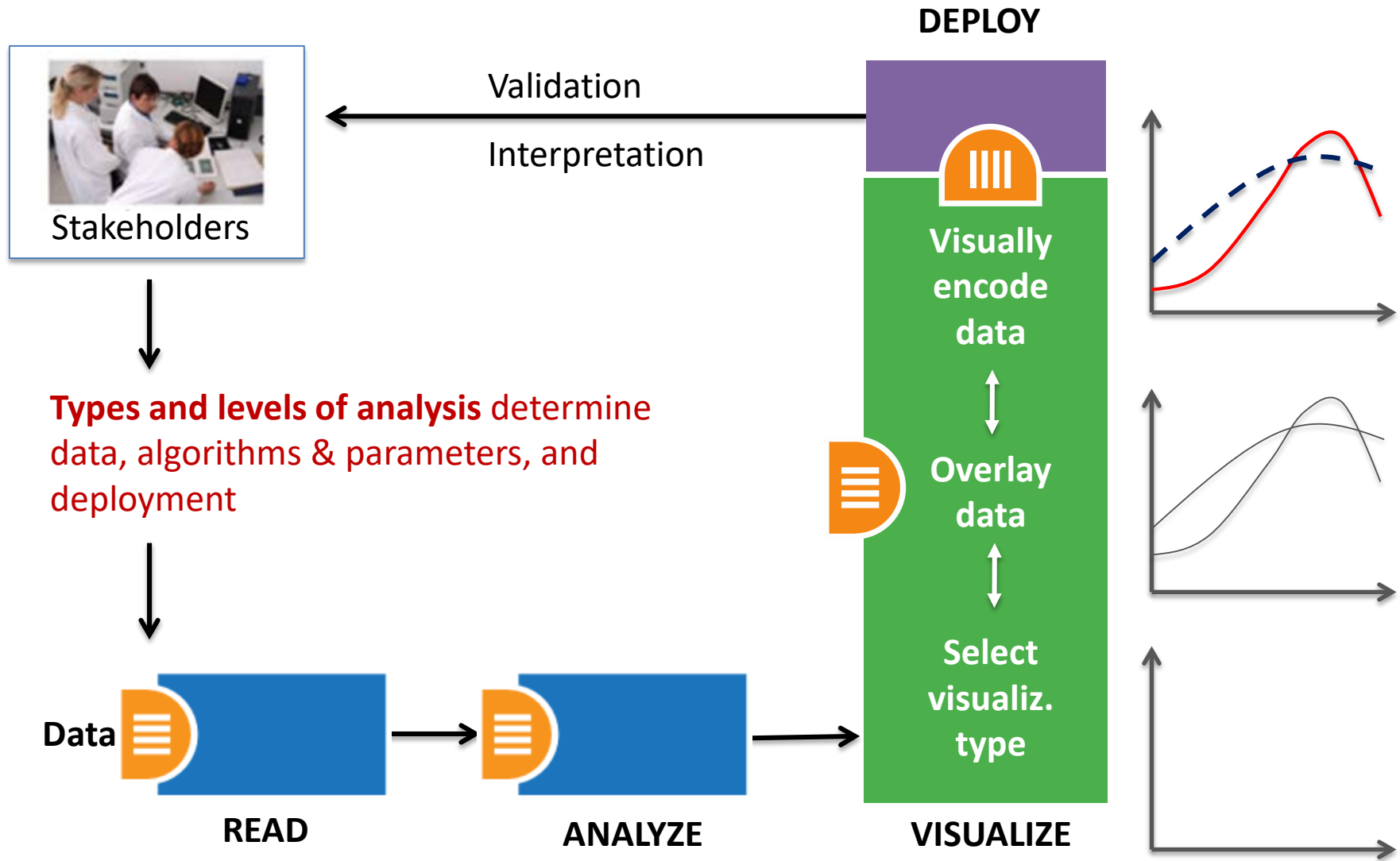
## LEVELS

	<b>MICRO: Individual Level</b> about 1–1,000 records page 6	<b>MESO: Local Level</b> about 1,001–100,000 records page 8	<b>MACRO: Global Level</b> more than 100,000 records page 10
<b>TYPES</b>			
<b>Statistical Analysis</b> page 44	 Knowledge Cartography page 135	 Productivity of Russian life sciences research teams page 105	 Science and Society in Equilibrium Number of scientists versus population and R&D costs versus GNP. page 103
<b>WHEN: Temporal Analysis</b> page 48	 Visualizing decision-making processes page 95	 Key events in the development of the video tape recorder page 85	 Increased travel and communication speeds page 83
<b>WHERE: Geospatial Analysis</b> page 52	 Cell phone usage in Milan, Italy page 109	 Victorian poetry in Europe page 137	 Ecological footprint of countries page 99
<b>WHAT: Topical Analysis</b> page 56	 Evolving patent holdings of Apple Computer, Inc. and Jerome Lemelson page 89	 Evolving journal networks in nanotechnology page 139	 Product space showing co-export patterns of countries page 93
<b>WITH WHOM: Network Analysis</b> page 60	 World Finance Corporation network page 87	 Electronic and new media art networks page 133	 World-wide scholarly collaboration networks page 157

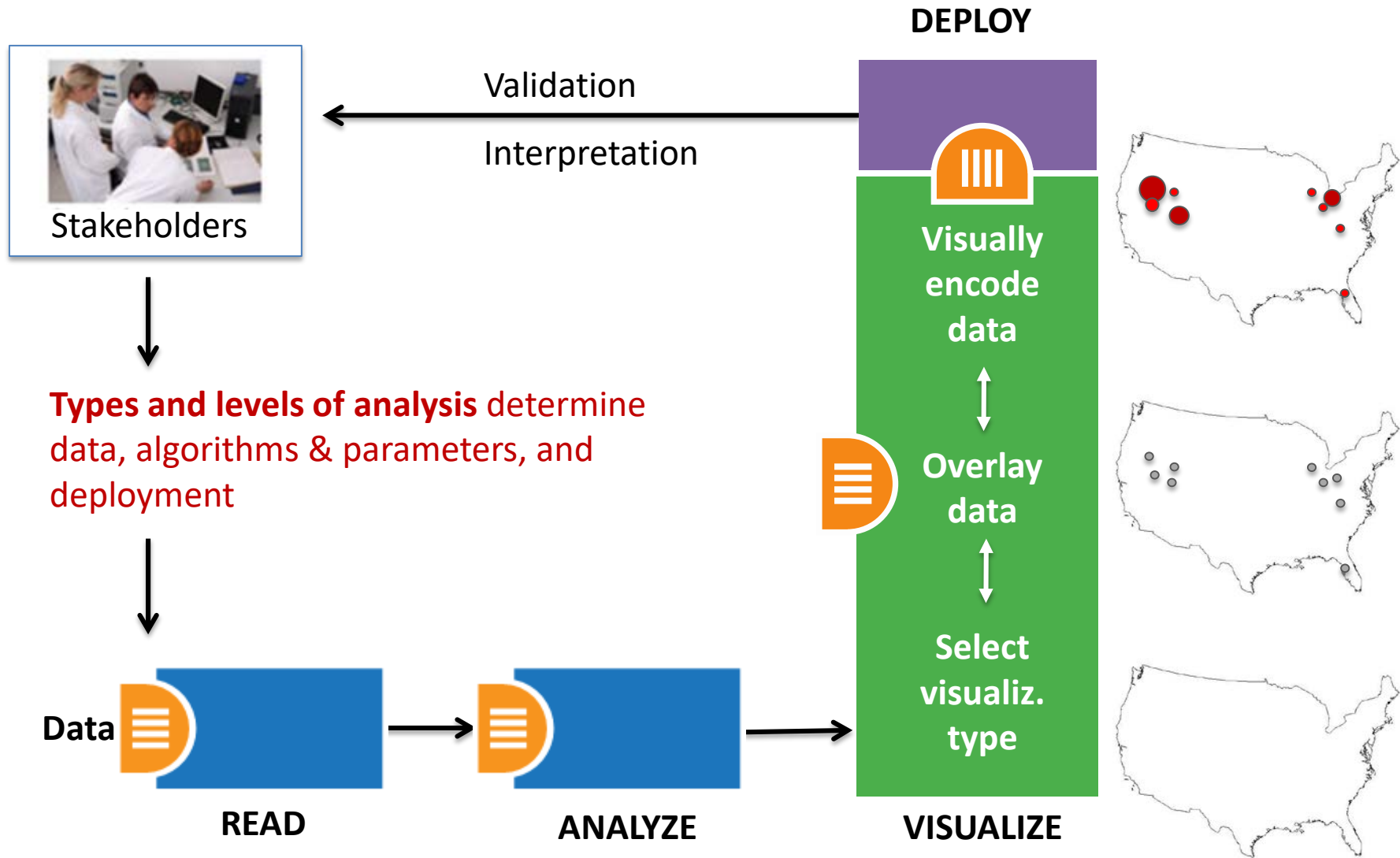


See page 5

# Needs-Driven Workflow Design



# Needs-Driven Workflow Design



# Course Schedule

## Part 1: Theory and Hands-On

- **Session 1** – Workflow Design and Visualization Framework
- **Session 2** – “When:” Temporal Data
- **Session 3** – “Where:” Geospatial Data
- **Session 4** – “What:” Topical Data

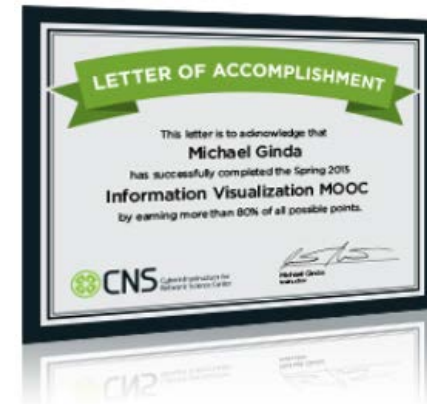
## Mid-Term

- **Session 5** – “With Whom:” Trees
- **Session 6** – “With Whom:” Networks
- **Session 7** – Dynamic Visualizations and Deployment

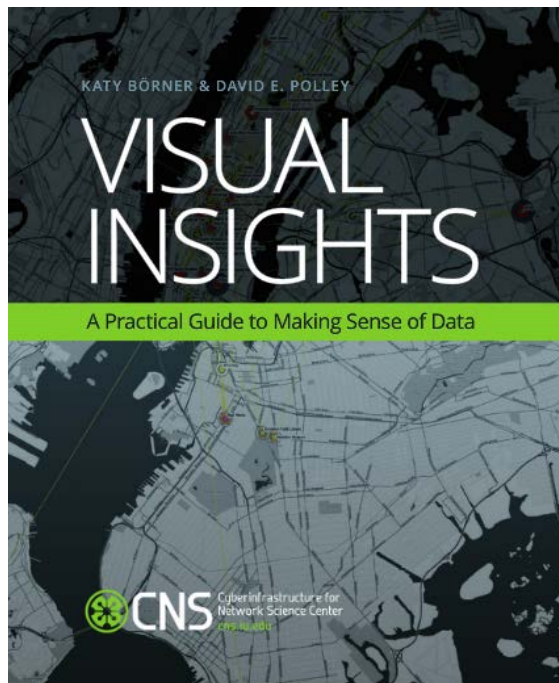
## Final Exam

## Part 2: Students work in teams on client projects.

Final grade is based on Homework (10%), Midterm (20%), Final Exam (30%), Client Project (30%), and Class Participation (10%).

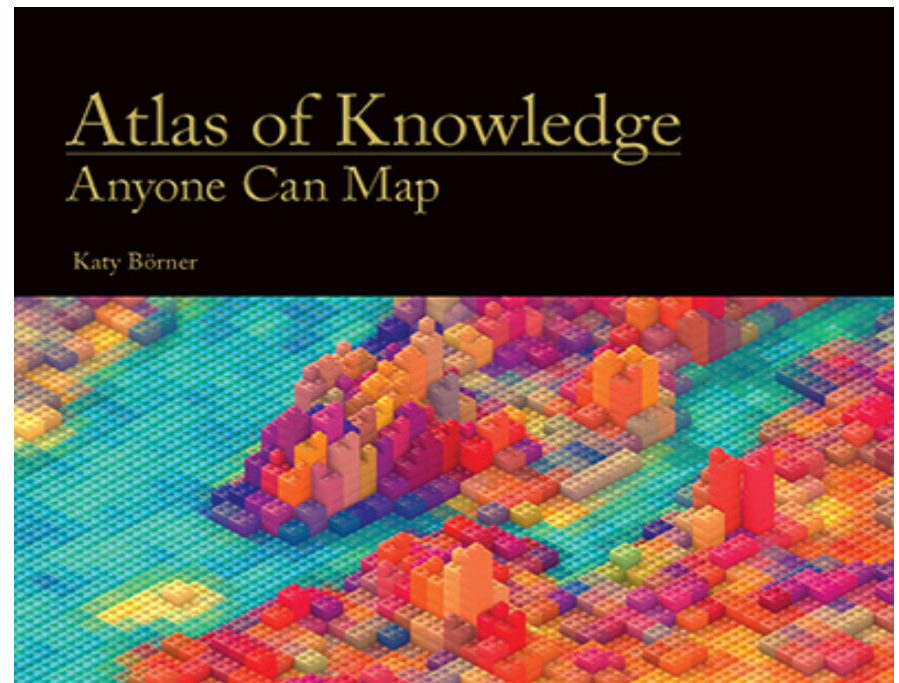


# Books Used in the IVMOOC



## Teaches timely knowledge:

Advanced algorithms, tools, and hands-on workflows.



## Teaches timeless knowledge:

Visualization framework—exemplified using generic visualization examples and pioneering visualizations.

# Load **One** File and Run **Many** Analyses and Visualizations

Times Cited	Publication Year	City of Publisher	Country	Journal Title (Full)	Title	Subject Category	Authors
12	2011	NEW YORK	USA	COMMUNICATIONS OF THE ACM	Plug-and-Play Microscopes	Computer Science	Borner, K
18	2010	MALDEN	USA	CTS-CLINICAL AND TRANSLATIONAL SCIENCE	Advancing the Science of Team Science	Research & Experimental Medicine	Falk-Krzesinski, HJ Borner, K Contractor, N Fiore, SM Hall, KL Keyton, J Spring, B Stokols, D Trochim, W Uzzi, B
13	2010	WASHINGTON	USA	SCIENCE TRANSLATIONAL MEDICINE	A Multi-Level Systems Perspective for the Science of Team Science	Cell Biology   Research & Experimental Medicine	Borner, K Contractor, N Falk-Krzesinski, HJ Fiore, SM Hall, KL Keyton, J Spring, B Stokols, D Trochim, W Uzzi, B

Statistical Analysis—p. 44

Location	Count	# Citations
Netherlands	13	292
United States	9	318
Germany	11	36
United Kingdom	1	2

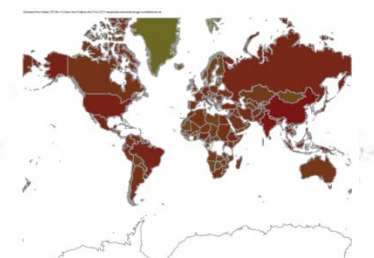
Temporal Burst Analysis—p. 48



Geospatial Analysis—p. 52



Geospatial Analysis—p. 52

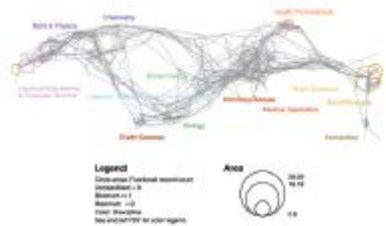




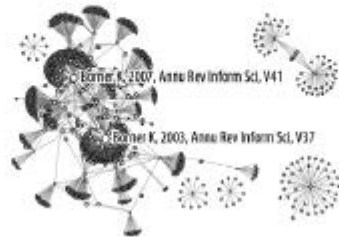
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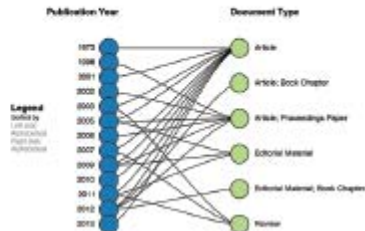
Topical Analysis—p. 56



Paper Citation Network—p. 60



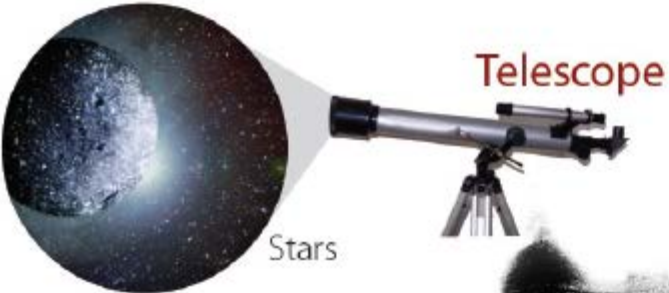
Bi-Modal Network—p. 60



Co-author and many other bi-modal networks.

# Microscopes, Telescopes, Macrosopes Plug-and-Play Macrosopes

The Infinitely Great



The Infinitely Small

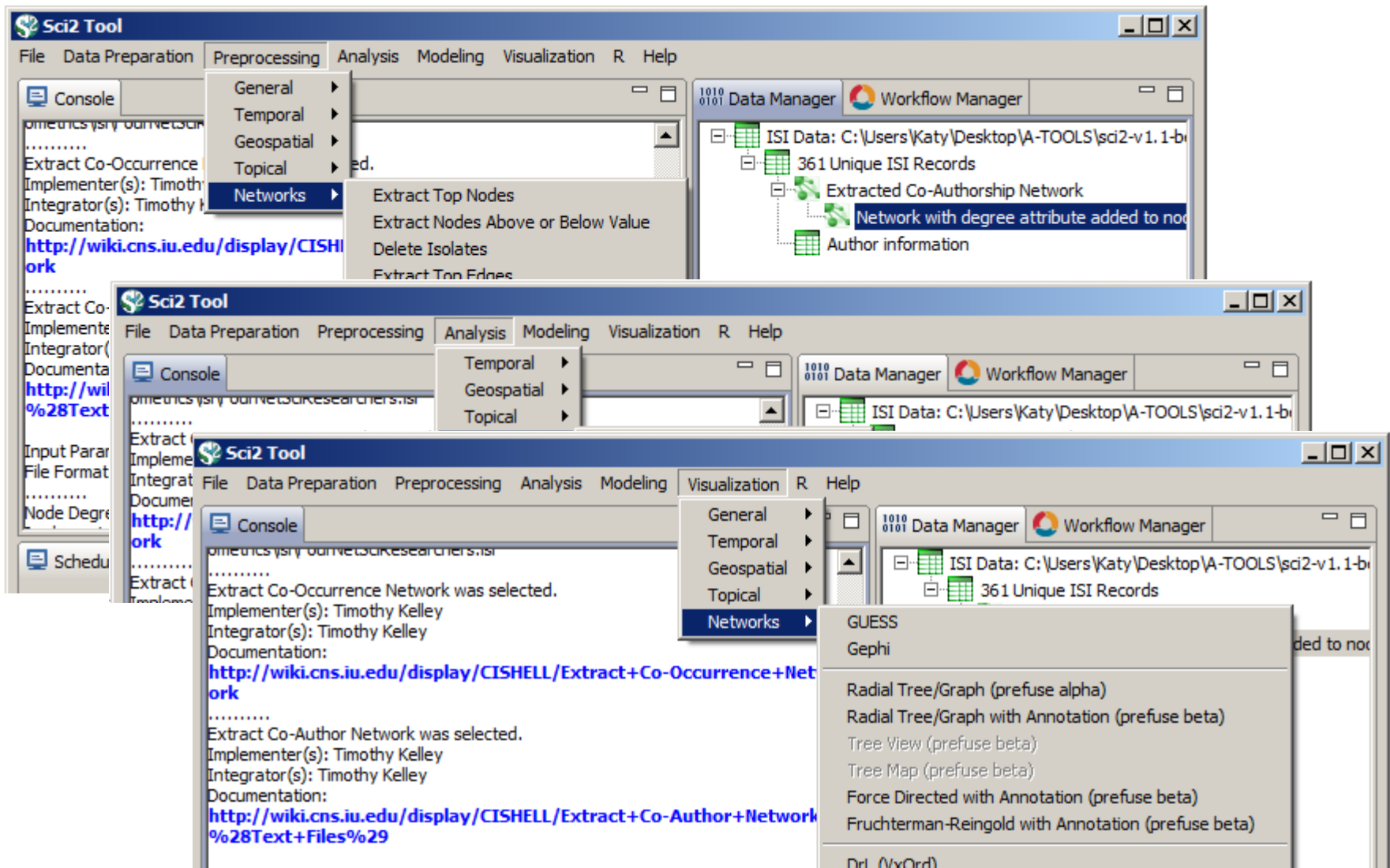


The Infinitely Complex



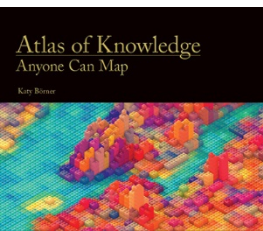
# Sci2 Tool Interface Components

Download tool for free at <http://sci2.cns.iu.edu>



# Visualization Framework

Insight Need Types page 26	Data Scale Types page 28	Visualization Types page 30	Graphic Symbol Types page 32	Graphic Variable Types page 34	Interaction Types page 26
<ul style="list-style-type: none"><li>• categorize/cluster</li><li>• order/rank/sort</li><li>• distributions (also outliers, gaps)</li><li>• comparisons</li><li>• trends (process and time)</li><li>• geospatial</li><li>• compositions (also of text)</li><li>• correlations/relationships</li></ul>	<ul style="list-style-type: none"><li>• nominal</li><li>• ordinal</li><li>• interval</li><li>• ratio</li></ul>	<ul style="list-style-type: none"><li>• table</li><li>• chart</li><li>• graph</li><li>• map</li><li>• network layout</li></ul>	<ul style="list-style-type: none"><li>• geometric symbols<ul style="list-style-type: none"><li>point</li><li>line</li><li>area</li><li>surface</li><li>volume</li></ul></li><li>• linguistic symbols<ul style="list-style-type: none"><li>text</li><li>numerals</li><li>punctuation marks</li></ul></li><li>• pictorial symbols<ul style="list-style-type: none"><li>images</li><li>icons</li><li>statistical glyphs</li></ul></li></ul>	<ul style="list-style-type: none"><li>• spatial<ul style="list-style-type: none"><li>position</li></ul></li><li>• retinal<ul style="list-style-type: none"><li>form</li><li>color</li><li>optics</li><li>motion</li></ul></li></ul>	<ul style="list-style-type: none"><li>• overview</li><li>• zoom</li><li>• search and locate</li><li>• filter</li><li>• details-on-demand</li><li>• history</li><li>• extract</li><li>• link and brush</li><li>• projection</li><li>• distortion</li></ul>



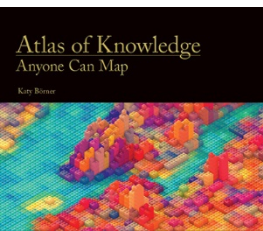
See page 24

# Visualization Framework

Basic Task Types								
Bertin, 1967	Wehrend & Lewis, 1996	Few, 2004	Yau, 2011	Rendgen & Wiedemann, 2012	Frankel, 2012	Tool: Many Eyes	Tool: Chart Chooser	Börner, 2014
selection	categorize			category				categorize/ cluster
order	rank	ranking					table	order/rank/ sort
	distribution	distribution					distribution	distributions (also outliers, gaps)
	compare	nominal comparison & deviation	differences		compare and contrast	compare data values	comparison	comparisons
		time series	patterns over time	time	process and time	track rises and falls over time	trend	trends (process and time)
		geospatial	spatial relations	location		generate maps		geospatial
quantity		part-to- whole	proportions		form and structure	see parts of whole, analyze text	composition	compositions (also of text)
association	correlate	correlation	relationships	hierarchy		relations between data points	relationship	correlations/ relationships

# Visualization Framework

Insight Need Types page 26	Data Scale Types page 28	Visualization Types page 30	Graphic Symbol Types page 32	Graphic Variable Types page 34	Interaction Types page 26
<ul style="list-style-type: none"><li>• categorize/cluster</li><li>• order/rank/sort</li><li>• distributions (also outliers, gaps)</li><li>• comparisons</li><li>• trends (process and time)</li><li>• geospatial</li><li>• compositions (also of text)</li><li>• correlations/relationships</li></ul>	<ul style="list-style-type: none"><li>• nominal</li><li>• ordinal</li><li>• interval</li><li>• ratio</li></ul>	<ul style="list-style-type: none"><li>• table</li><li>• chart</li><li>• graph</li><li>• map</li><li>• network layout</li></ul>	<ul style="list-style-type: none"><li>• geometric symbols<ul style="list-style-type: none"><li>point</li><li>line</li><li>area</li><li>surface</li><li>volume</li></ul></li><li>• linguistic symbols<ul style="list-style-type: none"><li>text</li><li>numerals</li><li>punctuation marks</li></ul></li><li>• pictorial symbols<ul style="list-style-type: none"><li>images</li><li>icons</li><li>statistical glyphs</li></ul></li></ul>	<ul style="list-style-type: none"><li>• spatial<ul style="list-style-type: none"><li>position</li></ul></li><li>• retinal<ul style="list-style-type: none"><li>form</li><li>color</li><li>optics</li><li>motion</li></ul></li></ul>	<ul style="list-style-type: none"><li>• overview</li><li>• zoom</li><li>• search and locate</li><li>• filter</li><li>• details-on-demand</li><li>• history</li><li>• extract</li><li>• link and brush</li><li>• projection</li><li>• distortion</li></ul>



See page 24

# Graphic Variable Types Versus Graphic Symbol Types

			Geometric Symbols					
			Point		Line		Area	
Spatial	x	quantitative						
	y	quantitative						
	z	quantitative						
Retinal	Form	Size	quantitative	NA (Not Applicable)				
		Shape	qualitative	NA				
		Rotation	quantitative	NA				
		Curvature	quantitative	NA				
		Angle	quantitative	NA				
		Closure	quantitative	NA				
	Color	Value	quantitative					
Hue		qualitative						
Saturation		quantitative						

# Graphic Variable Types Versus Graphic Symbol Types

		Geometric Symbols					Linguistic Symbols Text, Numerals, Punctuation Marks		Pictorial Symbols Images, Icons, Statistical Glyphs	
		point	line	area	surface	volume				
Symbol	1									
	2									
	3									
Form	size	NA (Not applicable)								
	shape	NA								
	orientation	NA								
	curvature	NA								
	angle	NA								
	closure	NA								
	value									
	hue									
	saturation									
Texture	spacing									
	complexity									
	ratio									
	orientation	NA								
	accent									
	blur									
	transparency									
	shading									
	stereoscopic depth	Point in foreground - background	Line in foreground - background	Area in foreground - background	Surface in foreground - background	Volume in foreground - background	Text in foreground - background	Text in foreground - background	Icons in foreground - background	Icons in foreground - background
	speed									
Motion	velocity									
	strobium	Blinking point slow - fast	Blinking line slow - fast	Blinking area slow - fast	Blinking surface slow - fast	Blinking volume slow - fast	Blinking text slow - fast	Blinking text slow - fast	Blinking icons slow - fast	Blinking icons slow - fast

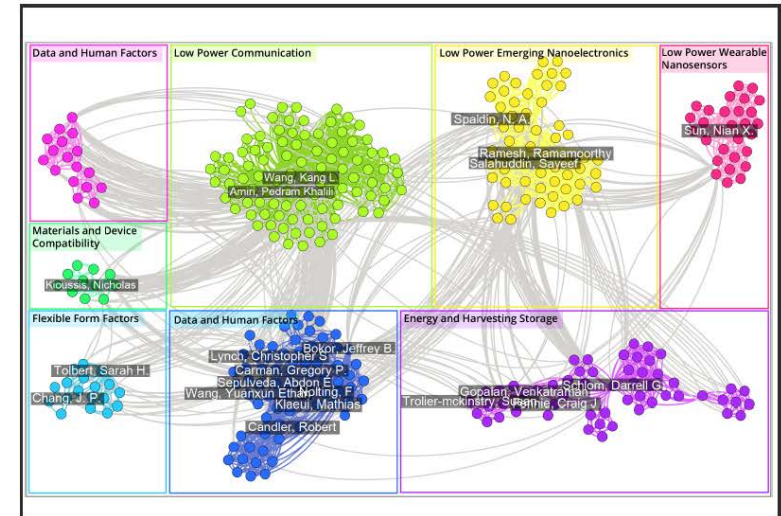
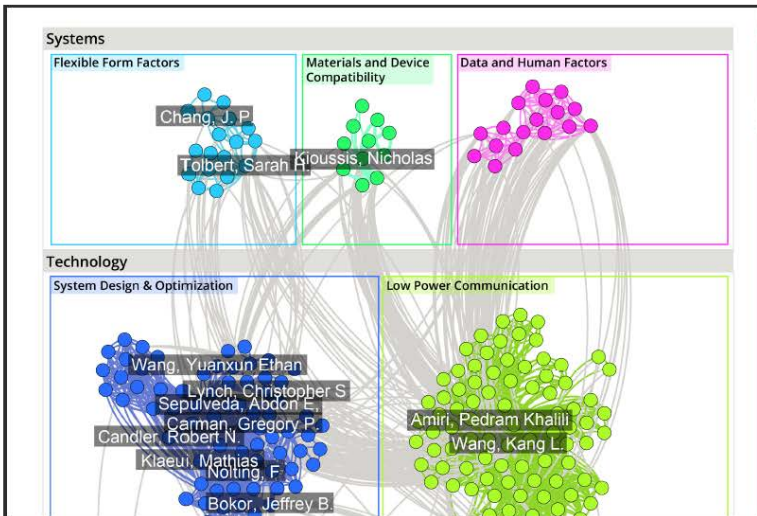
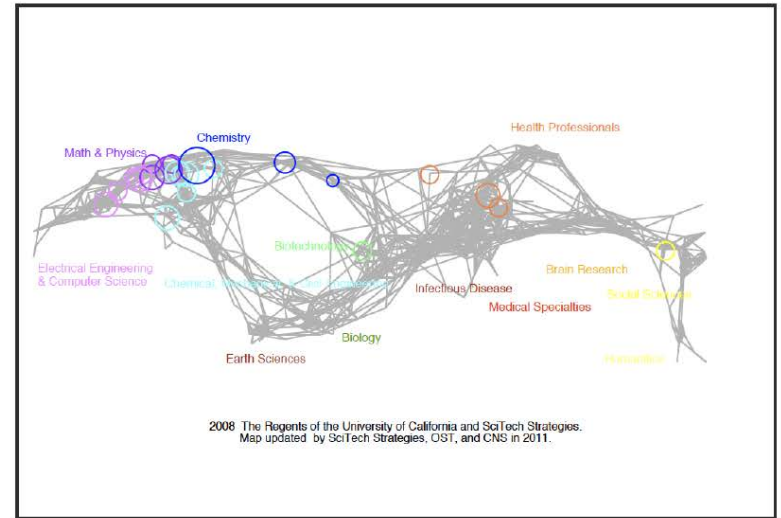
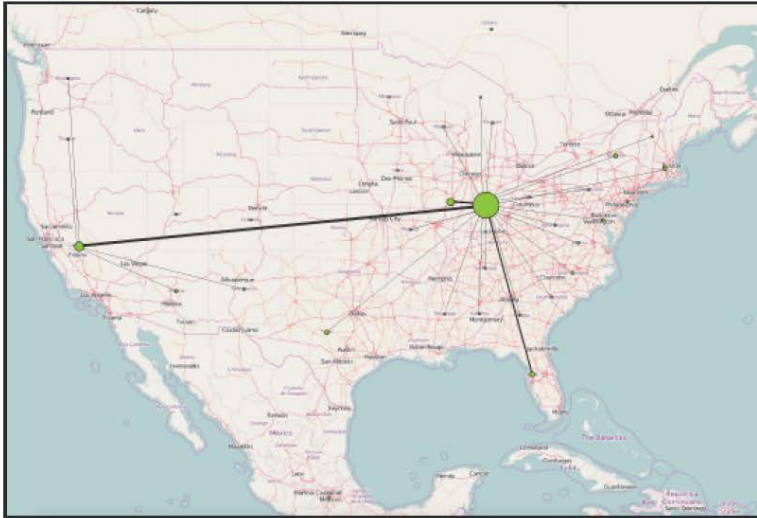


# Visualizing Engineering Research Centers



# Engineering Research Observatory

CNS Team at ISE, IU and NanoHub team at Purdue U



**TANMS Engineering Research Center**  
**Evolving Co-Authorship Network**  
CNS @ Indiana University  
2016

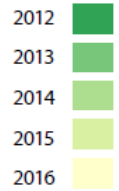
Displayed Year: 2012

**Legend**

Nodes ~ Authors  
Node area size ~ Number of papers published  
Node color ~ Year of first paper

Edges ~ Co-authorship relations  
Edge thickness ~ Number of times co-authored

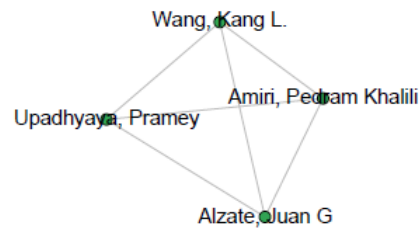
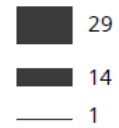
**Node Color Code**



**Node Area Size**



**Edge Thickness**



**TANMS Engineering Research Center**  
**Evolving Co-Authorship Network**  
 CNS @ Indiana University  
 2016

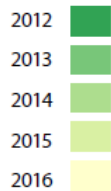
Displayed Year: 2013

**Legend**

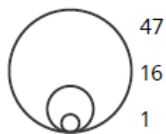
Nodes ~ Authors  
 Node area size ~ Number of papers published  
 Node color ~ Year of first paper

Edges ~ Co-authorship relations  
 Edge thickness ~ Number of times co-authored

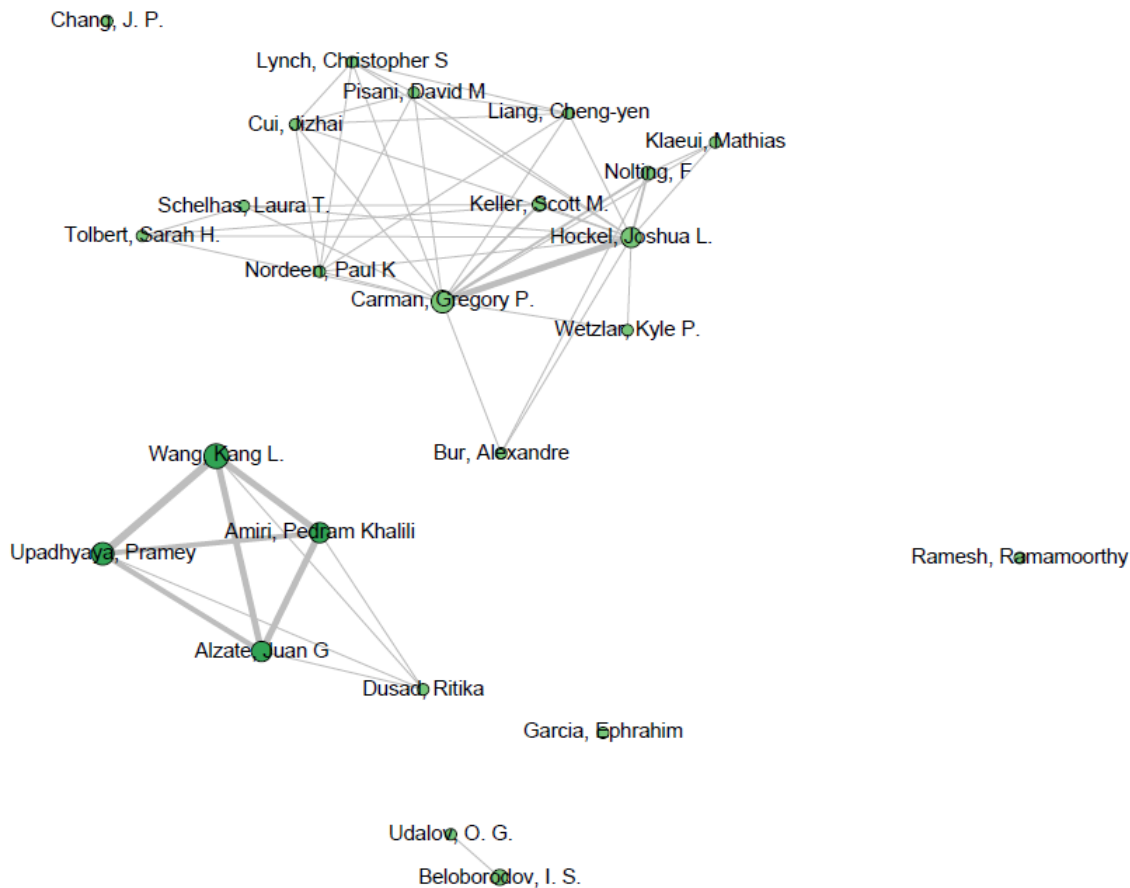
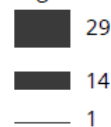
**Node Color Code**



**Node Area Size**



**Edge Thickness**



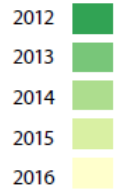
**TANMS Engineering Research Center**  
**Evolving Co-Authorship Network**  
 CNS @ Indiana University  
 2016

Displayed Year: 2014

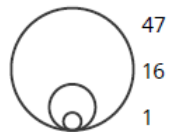
**Legend**

Nodes ~ Authors  
 Node area size ~ Number of papers published  
 Node color ~ Year of first paper  
 Edges ~ Co-authorship relations  
 Edge thickness ~ Number of times co-authored

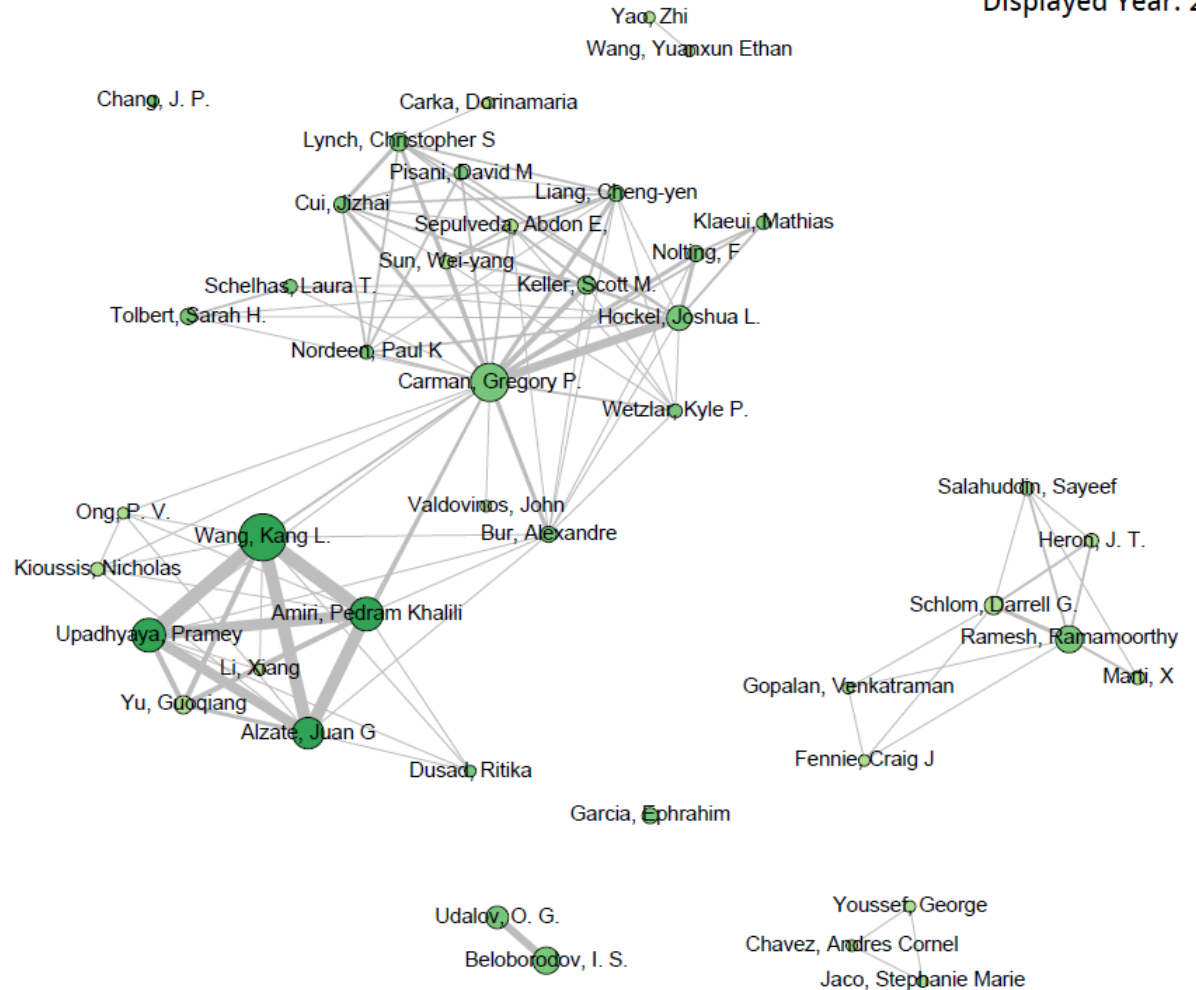
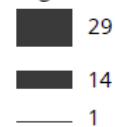
**Node Color Code**



**Node Area Size**



**Edge Thickness**



# TANMS Engineering Research Center Evolving Co-Authorship Network

CNS @ Indiana University  
2016

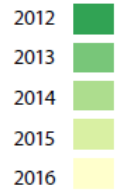
Displayed Year: 2015

## Legend

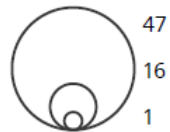
Nodes ~ Authors  
Node area size ~ Number of papers published  
Node color ~ Year of first paper

Edges ~ Co-authorship relations  
Edge thickness ~ Number of times co-authored

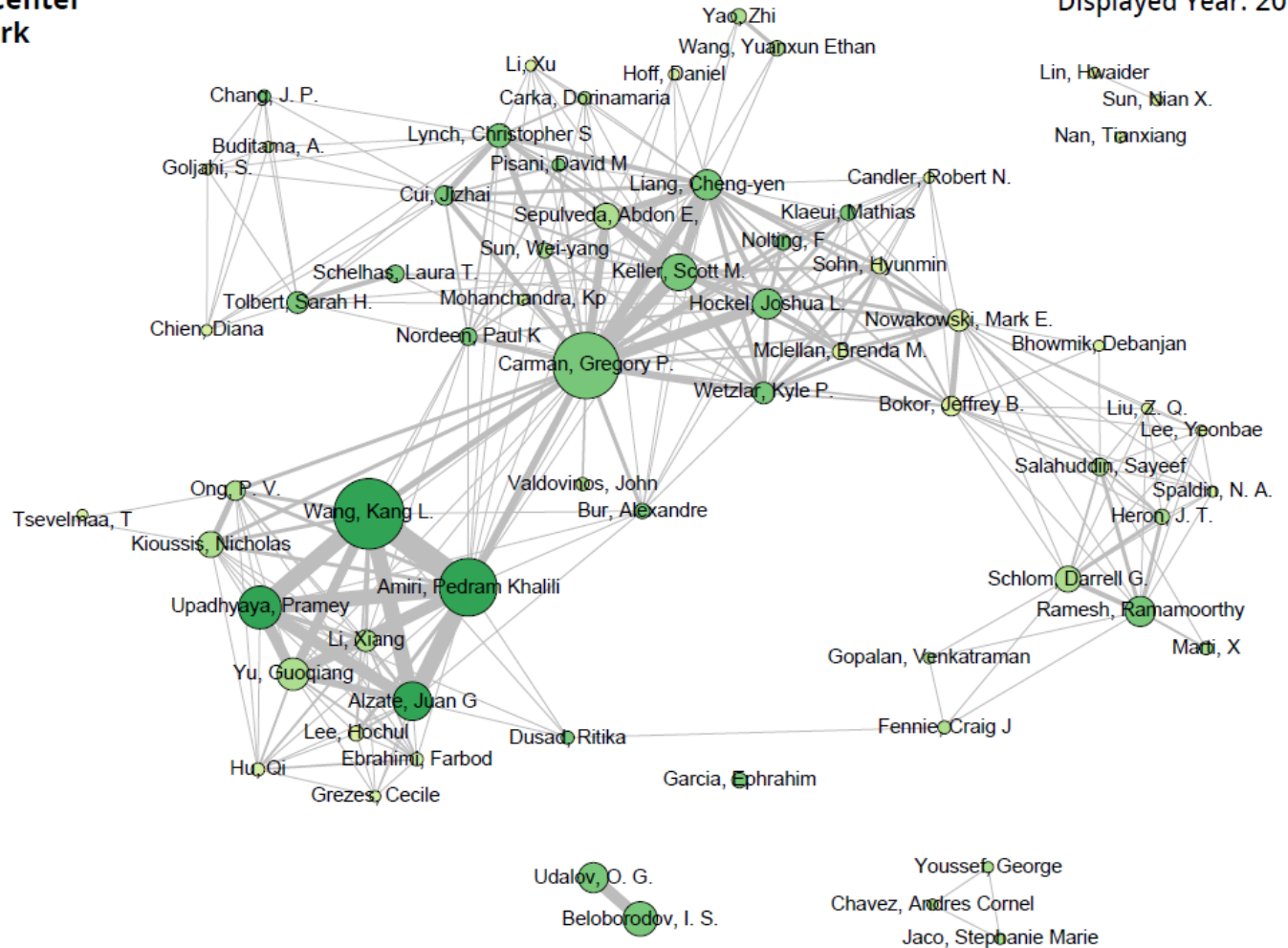
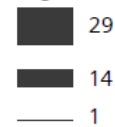
### Node Color Code



### Node Area Size



### Edge Thickness



# TANMS Engineering Research Center Evolving Co-Authorship Network

CNS @ Indiana University  
2016

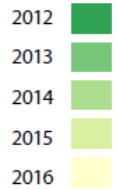
Displayed Year: 2016

## Legend

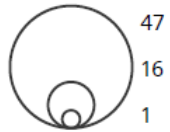
Nodes ~ Authors  
Node area size ~ Number of papers published  
Node color ~ Year of first paper

Edges ~ Co-authorship relations  
Edge thickness ~ Number of times co-authored

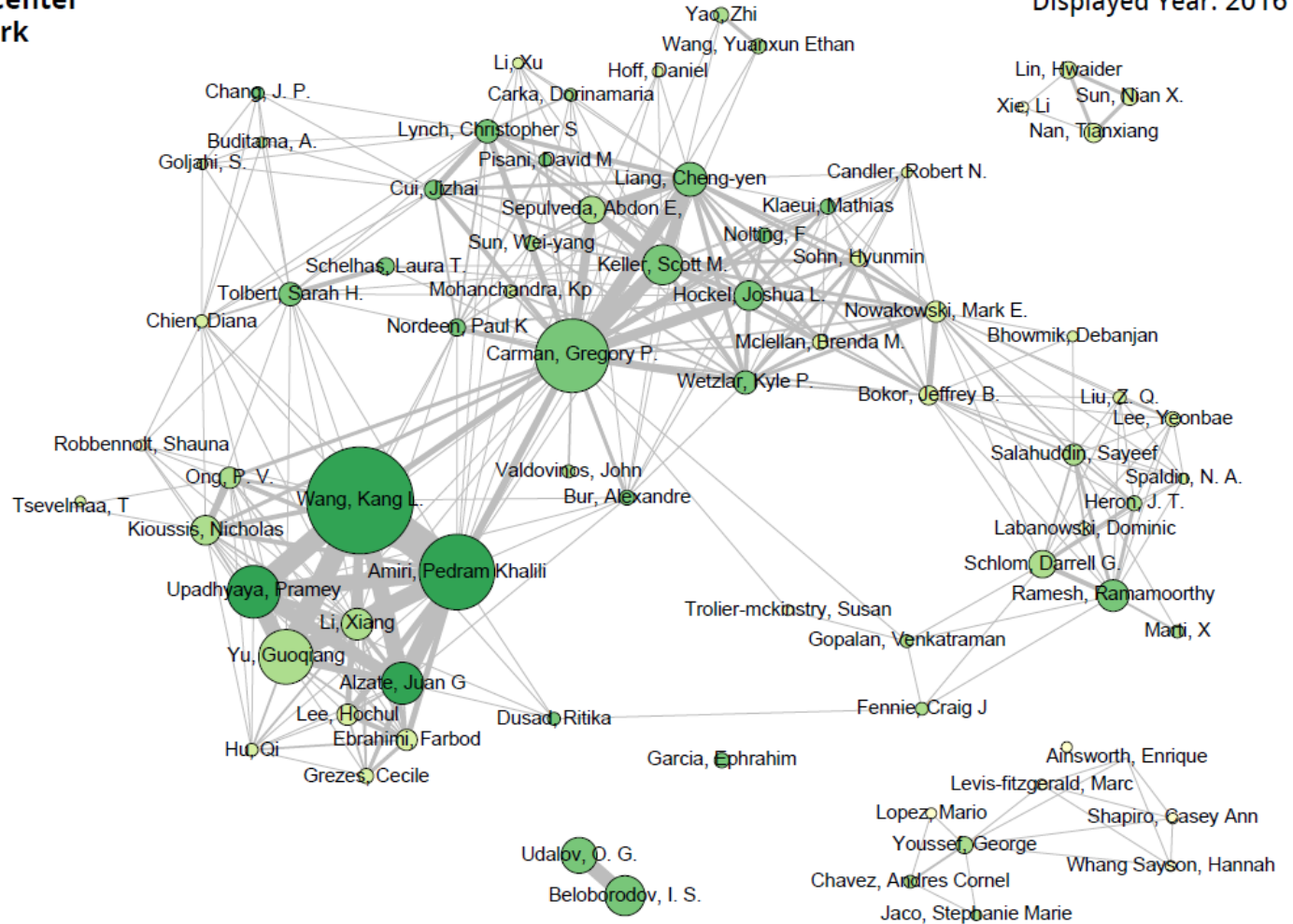
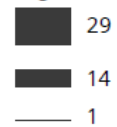
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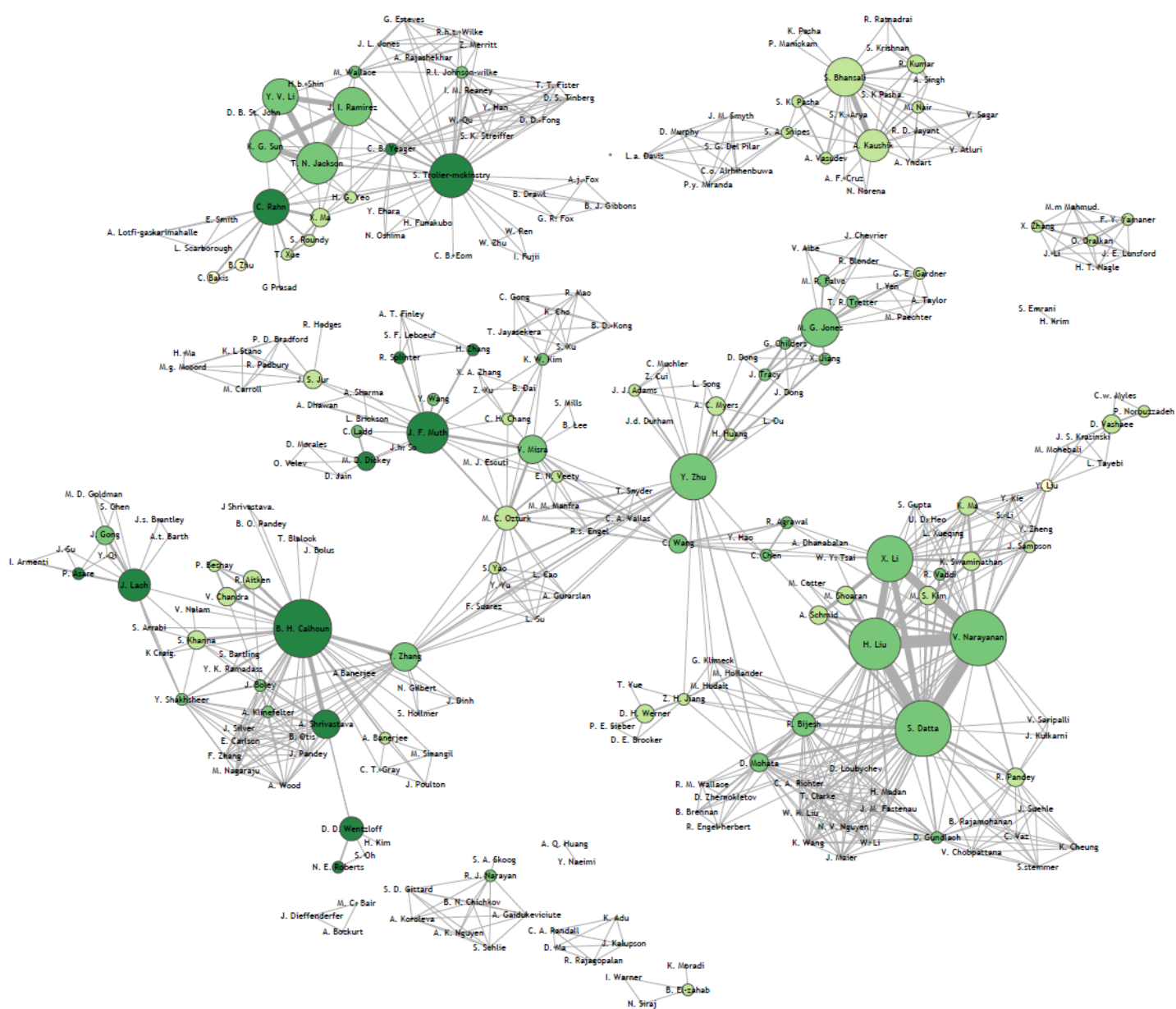


## Node Area Size



## Edge Thickness





**Legend**

Nodes ~ Authors  
 Node area size ~ Number of papers published  
 Node color ~ Year of first paper

Edges ~ Co-authorship relations  
 Edge thickness ~ Number of times co-authored

**Node Color Code**

2012 ■  
 2013 ■  
 2014 ■  
 2015 ■

**Node Area Size**

19  
 4  
 1

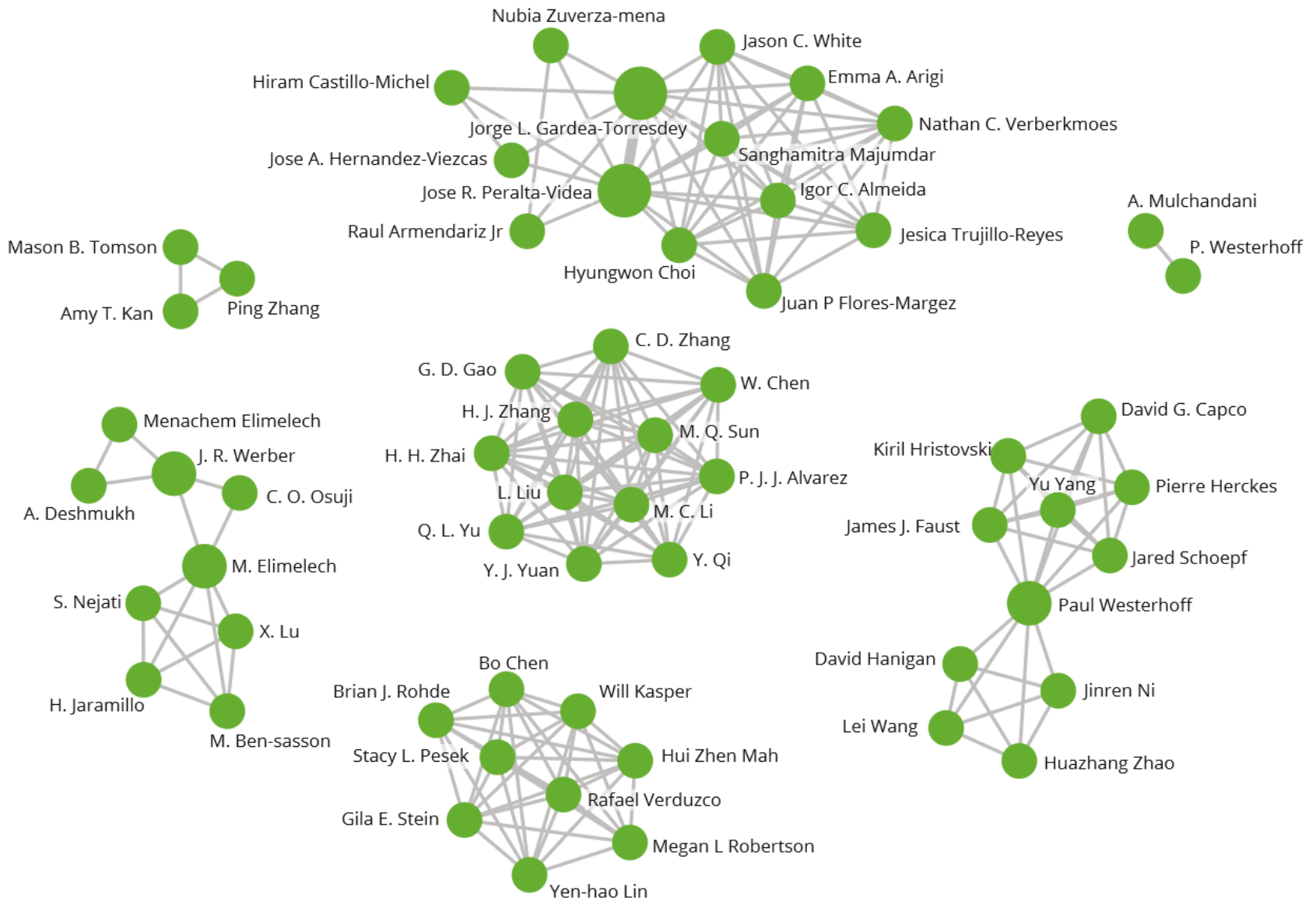
**Edge Thickness**

14  
 7  
 1

Displayed Year: 2015

**ASSIST Engineering Research Center**  
**Evolving Co-Authorship Network**  
 CNS @ Indiana University  
 2016





## Legend

Node area size



Number of papers published

Edge weight



Number of papers co-authored

**NEWT Co-authorship for 2015 - 2016**

CNS @ Indiana University

2016

# Modelling S&T Developments





# Modeling Science, Technology & Innovation Conference

WASHINGTON D.C. | MAY 17-18, 2016

[View Agenda](#)

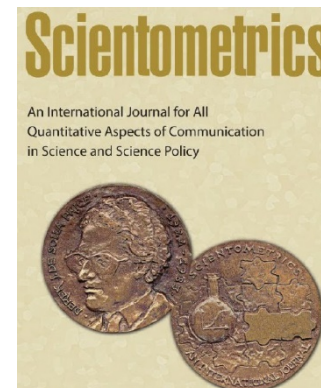
Government, academic, and industry leaders discussed challenges and opportunities associated with using big data, visual analytics, and computational models in STI decision-making.

Conference slides, recordings, and report are available via <http://modsti.cns.iu.edu/report>



# Special Issue of *Scientometrics*: **Simulating the Processes of Science, Technology, and Innovation**

Bruce Edmonds, Andrea Scharnhorst, Katy Börner &  
Staša Milojević (Editors)



- **Rogier De Langhe:** Towards the Discovery of Scientific Revolutions in Scientometric Data
- **Sabine Brunswicker, Sorin Matei, Michael Zentner, Lynn Zentner and Gerhard Klimeck:** Creating Impact in the Digital Space: Digital Practice Dependency in Scientific Developer Communities
- **Johan Bollen et al.:** An Efficient System to Fund Science: From Proposal Review to Peer-to-Peer Distributions
- **Petra Ahrweiler:** Agent-based Simulation for Science, Technology and Innovation Policy
- **David Chavalarias:** What's Wrong With Science? Modeling Collective Discovery Processes With the Nobel Game
- **Jeff Alstott, Giorgio Triulzi, Bowen Yan and Jianxi Luo:** Mapping Technology Space by Normalizing Patent Technology Networks

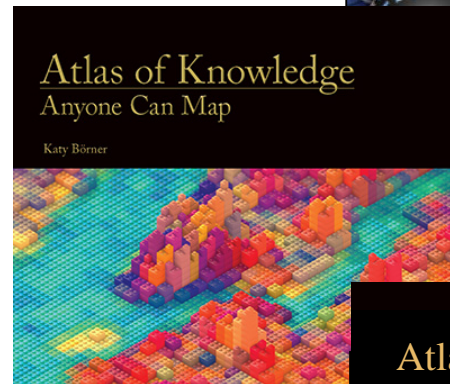
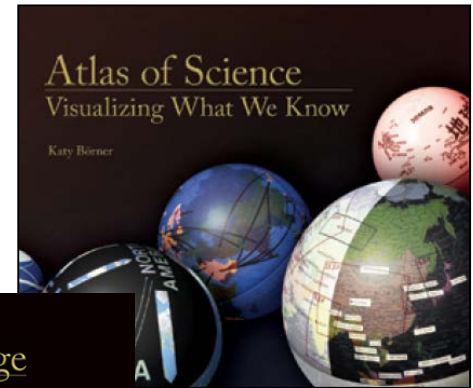
# Atlas Trilogy

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

Börner, Katy (2015) **Atlas of Knowledge: Anyone Can Map**. The MIT Press.  
<http://scimaps.org/atlas2>

Börner, Katy (2020) **Atlas of Forecasts: Predicting and Broadcasting Science, Technology, and Innovation**. The MIT Press.

Upcoming Sackler Colloquium on "**Modelling and Visualizing Science and Technology Developments**" will take place in December 2017 at the Beckman Center, Irvine, CA.



# Communicating S&T Development to Different Audiences







Hidalgo, César A., Bailey Klinger, Albert-László Barabási, and Ricardo Hausmann. 2007. See also *The Product Space* map from Phase I of *Places & Spaces*.

## Call for Macroscope Tools for the *Places & Spaces: Mapping Science* Exhibit (2017) <http://scimaps.org/call>

### Background and Goals

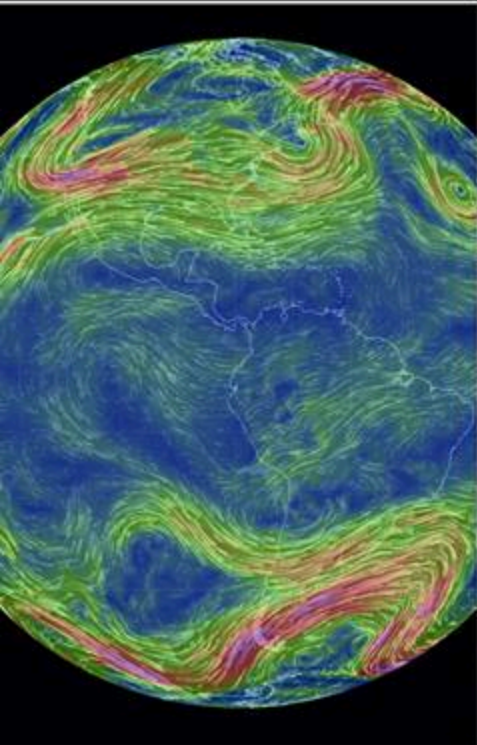
The *Places & Spaces: Mapping Science* exhibit was created to in communicate human activity and scientific progress on a glol that enable the close inspection of large-scale maps in public conferences; (2) novel, interactive macroscope tools that let t

Themes for the upcoming iterations/years are:

- 11th Iteration (2015): Macroscopes for Interacting With Science
- 12th Iteration (2016): Macroscopes for Making Sense of Science
- 13th Iteration (2017): Macroscopes for Forecasting Science
- 14th Iteration (2018): Macroscopes for Economic Decision Makers
- 15th Iteration (2019): Macroscopes for Science Policy Makers



① **MACROSCOPES FOR INTERACTING WITH SCIENCE**



**Earth**



**AcademyScope**

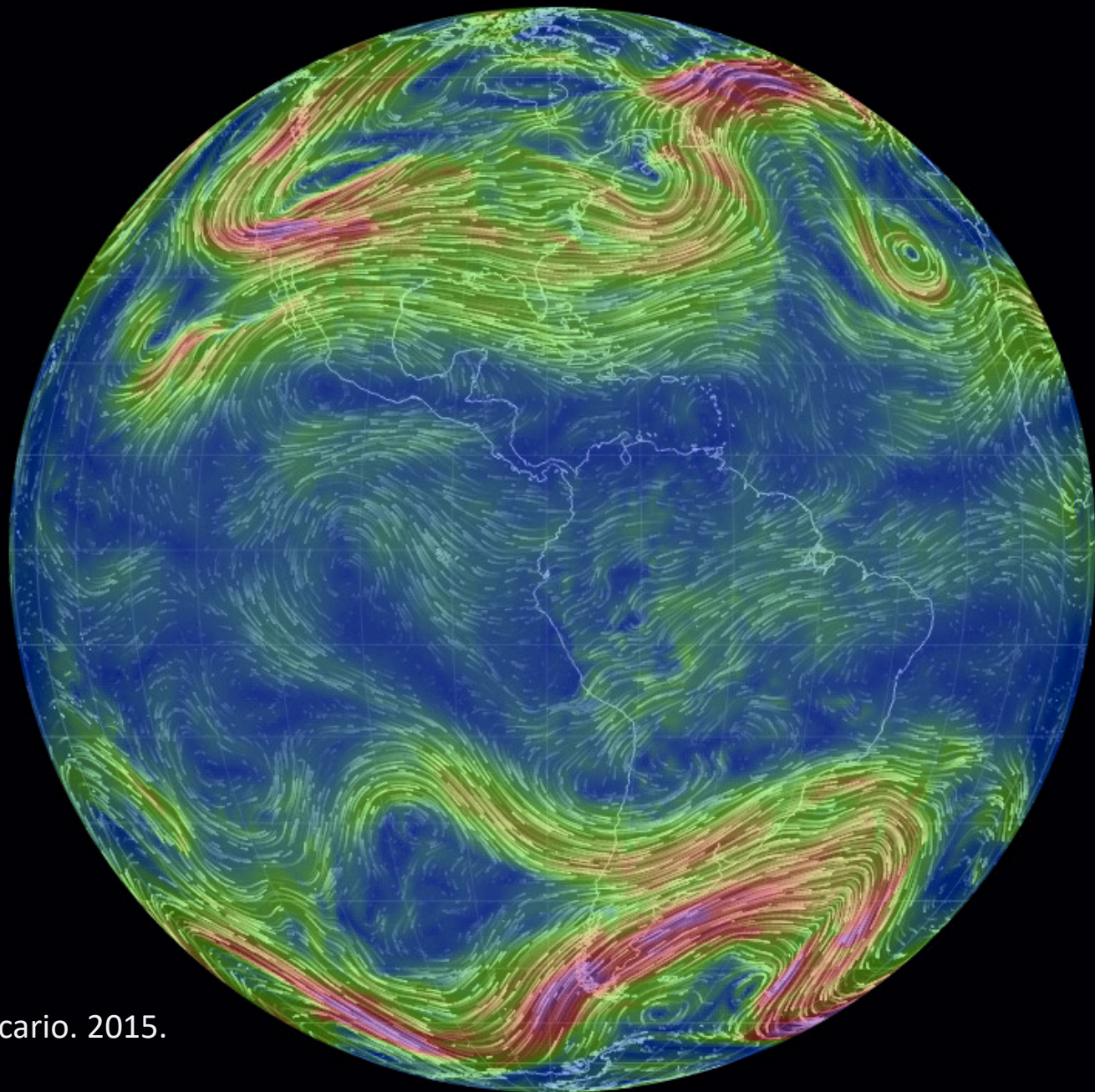


**Mapping Global Society**

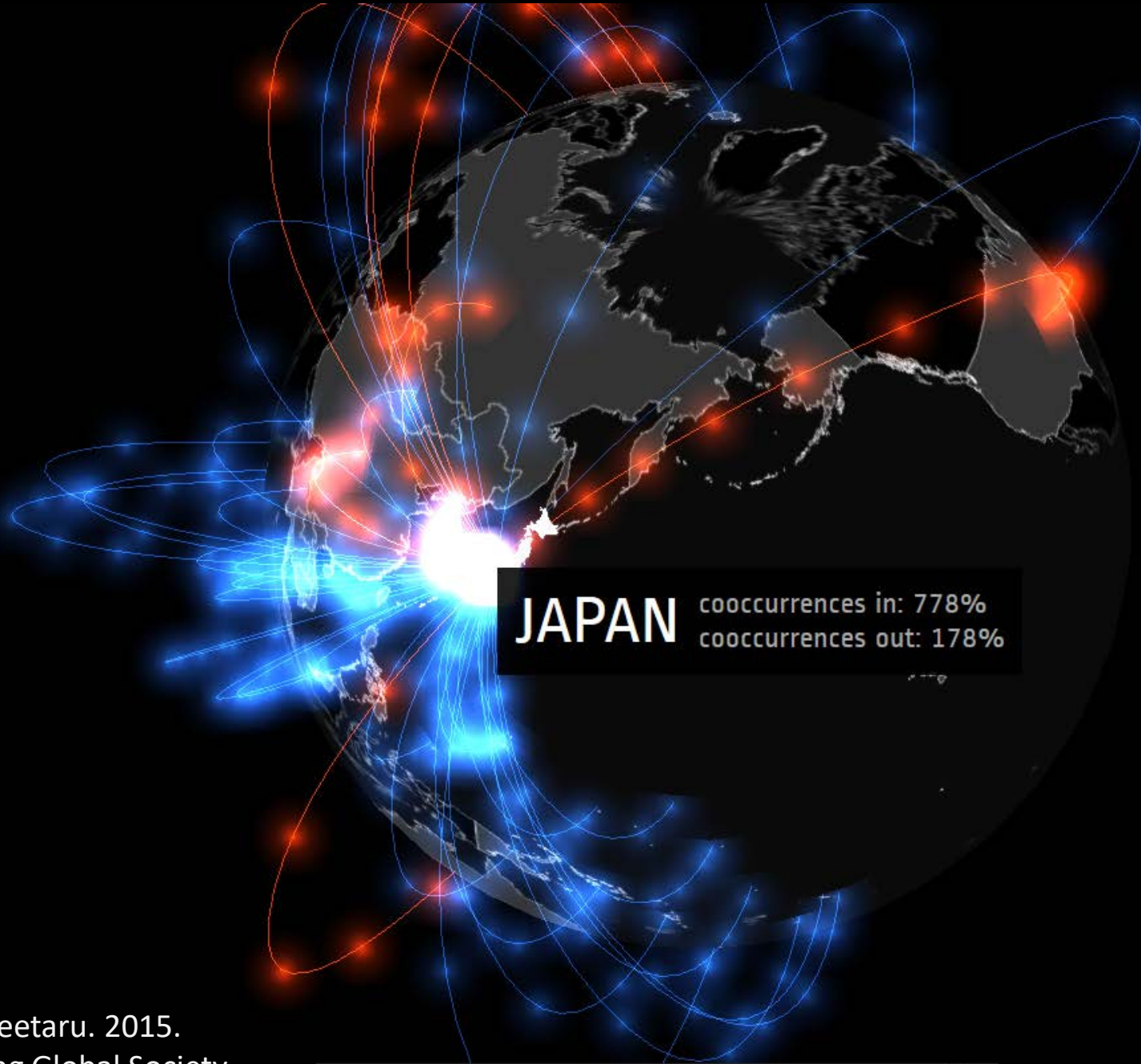


**Charting Culture**

<http://scimaps.org/iteration/11>



Cameron Beccario. 2015.  
Earth.



Kalev Leetaru. 2015.  
Mapping Global Society.

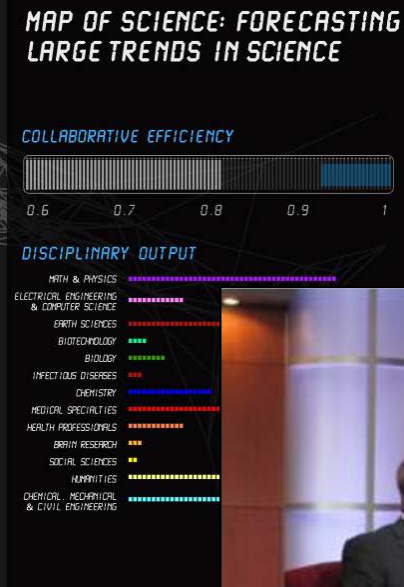
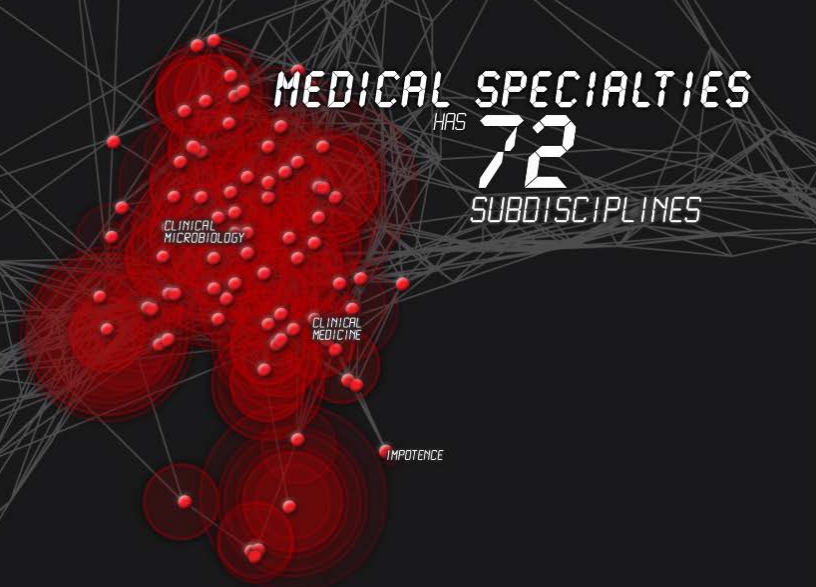
Feb 22 Mar 1 Mar 8 Mar 15 Mar 22 Mar 29 Apr 5 Apr 12 Apr 19 Apr 26 May 3 May 10 May 17 May 24





*Places & Spaces Exhibit* at the David J. Sencer CDC Museum, Atlanta, GA  
January 25-June 17, 2016





# Science Forecast S1:E1, 2015



Dr. Johan Bollen

# Science Forecast S1:E2, 2016

2015 AUDITORY, PERCEPTION,  
COGNITION AND ACTION MEETING (APCAM)

UNIVERSITY OF MANITOBA

"Sounding Like A Criminal: The effect of  
Similarity and Voice Frequency on  
Earwitness Confidence ratings"

UNIVERSITY OF TEXAS

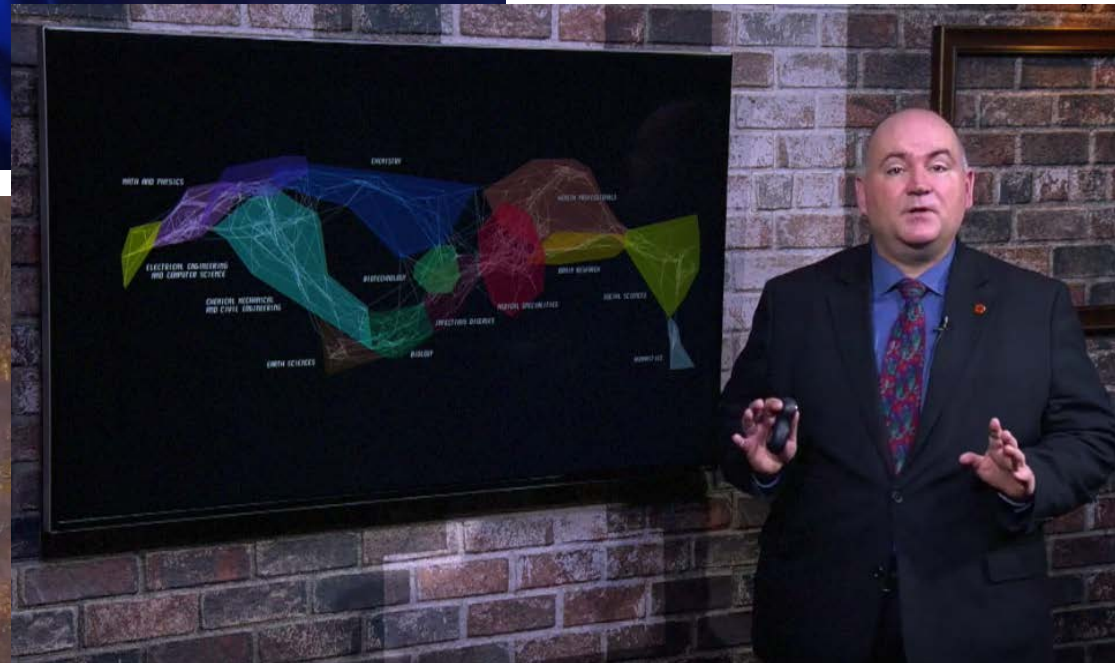
"Metaphorical priming of Music  
Concepts"

UNIVERSITY OF GAVLE



Dr. Rob Porter

# Science Forecast S1:E3, 2016



Dr. Bernice Pescosolido





We work closely with clients to provide custom-made data, visualization, and software solutions

#### Research



Open Data and Open Code for Big Science of Science Studies

#### Latest News



Put your money where your citations are: a proposal for a new funding system (website accessed 9/05/13)

#### Upcoming Events

**OCT 1**

Katy Börner attends PIUG 2013 Northeast Conference

10.13 Katy Börner presents Mapping Science Exhibit at WSSF

10.15 Ted Polley & Google Team present IVMOOC at EDUCAUSE

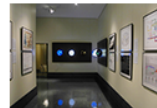
10.22 Katy Börner presents at the SciELO 15 Years Conference

#### Development



Behind the scenes of the design and development of *AcademyScope*

#### Outreach



See some of the most fascinating data visualizations in the world.

#### Videos



Watch Katy Börner's full presentation from TEDxBloomington

#### Teaching



Successful IVMOOC will be offered again in January of 2014

#### Our Products



We work closely with clients to provide custom-made data, visualization, and software solutions

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

These slides are at <http://cns.iu.edu/presentations>

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

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