Teaching Children the Structure of Science

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Teaching Children the Structure of Science

How can children start to understand the complex interplay of the different sciences?

How can they get an intuitive understanding of the importance of math and how much it is needed to succeed in many if not all of the other sciences?

What does it mean for teaching, learning, and job opportunities if the biomedical sciences account for 50% of all sciences?

Can we make them see the central position of computer science and its evolving symbiosis with all other aptly named 'computational X' sciences?

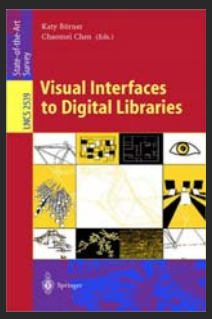
Can we offer them a means to see the emergence and evolution of new sciences, e.g., nano* or neuro*?

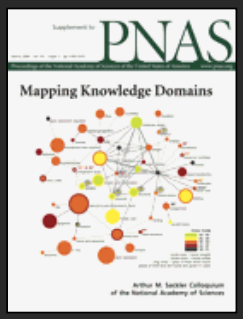
How can we empower them to search for a certain expertise in the correct scientific discipline?

How can we teach them to appreciate the very diverse cultures, research approaches, and languages that exist in the different sciences and enable them to 'speak' more than one science in order to collaborate across scientific boundaries?

Last but not least, how can we engage children in the work of real scientists, have them share the excitement of discovery, and allow them to find their own 'place' in science?

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

- ***Places & Spaces: Mapping Science*** *exhibit, see also http://scimaps.org.*

Process of Analyzing and Mapping Knowledge Domains

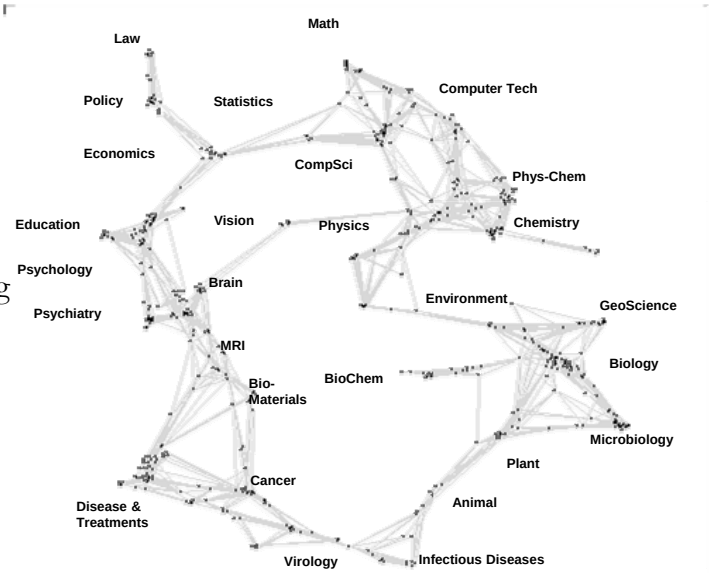
DATA EXTRACTION	UNIT OF ANALYSIS	MEASURES	LAYOUT (often one code does both similarity and ordination steps)		DISPLAY
			SIMILARITY	ORDINATION	
SEARCHES ISI INSPEC Eng Index Medline ResearchIndex Patents etc. BROADENING By citation By terms	COMMON CHOICES Journal Document Author Term	COUNTS/FREQUENCIES Attributes (e.g. terms) Author citations Co-citations By year THRESHOLDS By counts	SCALAR (unit by unit matrix) Direct citation Co-citation Combined linkage Co-word / co-term Co-classification VECTOR (unit by attribute matrix) Vector space model (words/terms) Latent Semantic Analysis (words/terms) incl. Singular Value Decomp (SVD) CORRELATION (if desired) Pearson's R on any of above	DIMENSIONALITY REDUCTION Eigenvector/ Eigenvalue solutions Factor Analysis (FA) and Principal Components Analysis (PCA) Multi-dimensional scaling (MDS) LSA, **Topics** Pathfinder networks (PFNet) Self-organizing maps (SOM) includes SOM, ET-maps, etc. CLUSTER ANALYSIS SCALAR Triangulation Force-directed placement (FDP)	INTERACTION Browse Pan Zoom Filter Query Detail on demand ANALYSIS

Börner, Katy, Chen, Chaomei, and Boyack, Kevin. (2003) Visualizing Knowledge Domains. In Blaise Cronin (Ed.), Annual Review of Information Science & Technology, Volume 37, Medford, NJ: Information Today, Inc./American Society for Information Science and Technology, chapter 5, pp. 179-255.

Latest 'Base Map' of Science

Kevin W. Boyack, Katy Börner, & Richard Klavans (2007). Mapping the Structure and Evolution of Chemistry Research. 11th International Conference on Scientometrics and Informetrics. pp. 112-123.

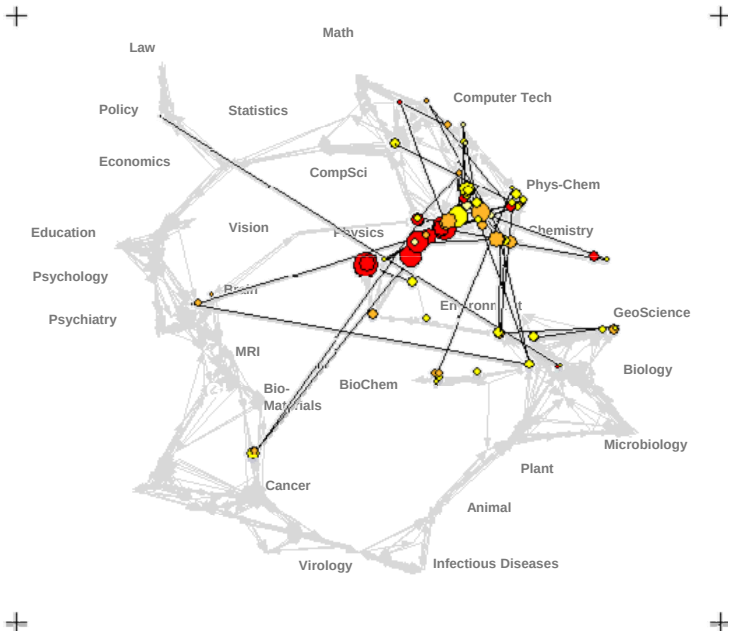
- Uses combined SCI/SSCI from 2002
  - 1.07M papers, 24.5M references, 7,300 journals
  - Bibliographic coupling of papers, aggregated to journals
- Initial ordination and clustering of journals gave 671 clusters
- Coupling counts were reaggregated at the journal cluster level to calculate the
  - (x,y) positions for each journal cluster
  - by association, (x,y) positions for each journal



Science map applications: Identifying core competency

Kevin W. Boyack, Katy Börner, & Richard Klavans (2007).

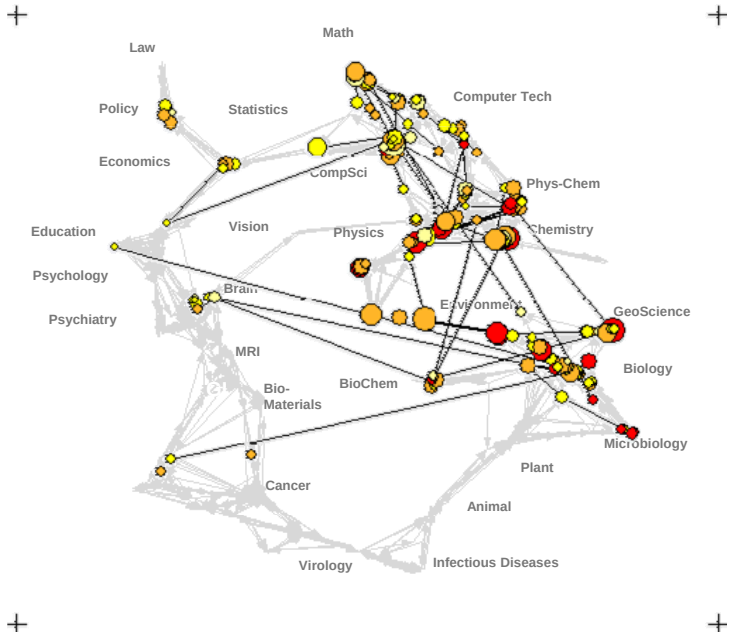
Funding patterns of the US Department of Energy (DOE)



Science map applications: Identifying core competency

Kevin W. Boyack, Katy Börner, & Richard Klavans (2007).

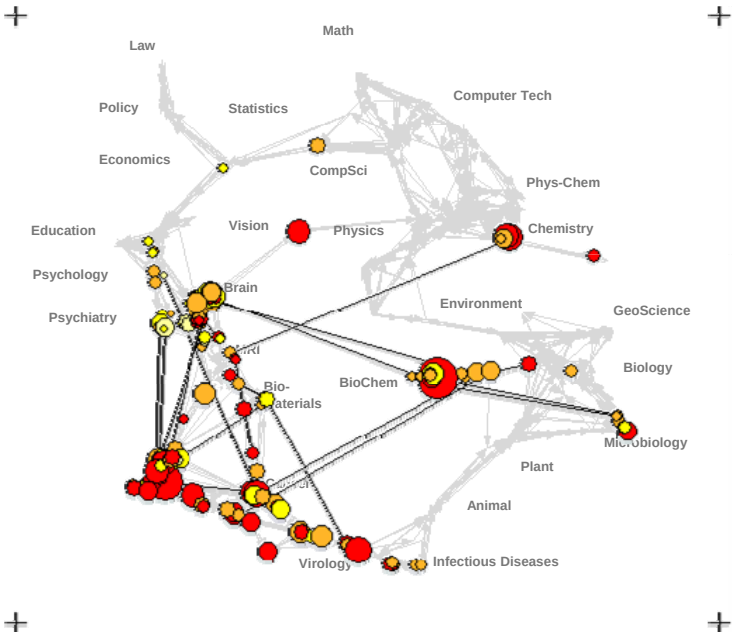
Funding Patterns of the National Science Foundation (NSF)

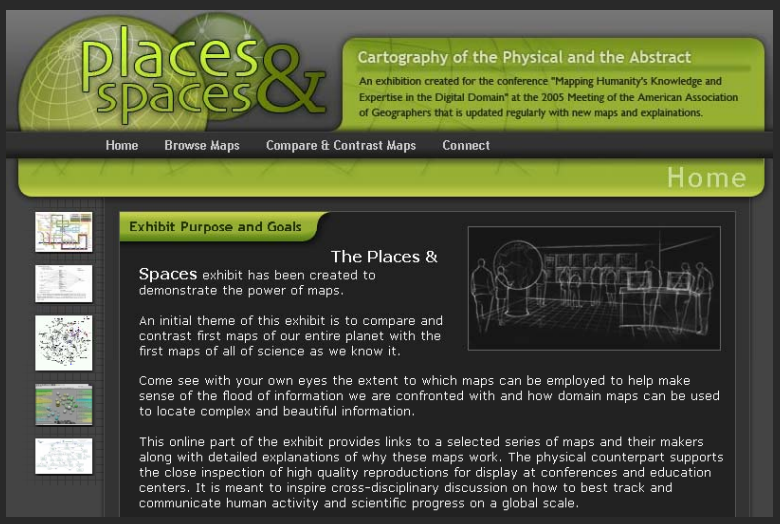


Science map applications: Identifying core competency

Kevin W. Boyack, Katy Börner, & Richard Klavans (2007).

Funding Patterns of the National Institutes of Health (NIH)



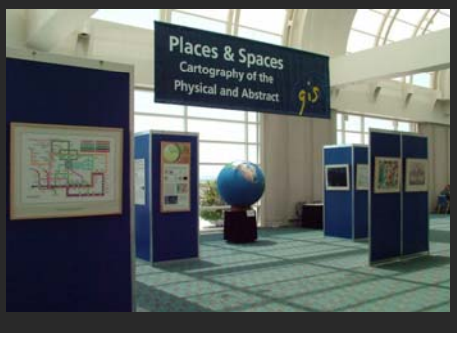


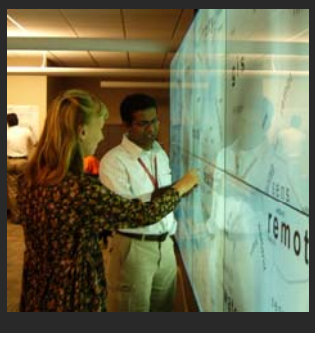
Places & Spaces: Mapping Science

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

http://scimaps.org.

Exhibit Curators: Dr. Katy Börner & Elisha F. Hardy

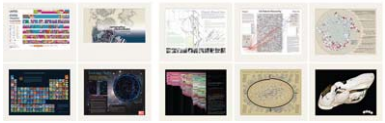




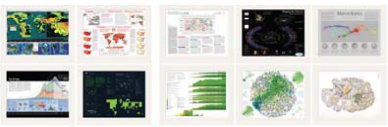
Mapping Science Exhibit – 10 Iterations in 10 years

The Power of Maps (2005)

The Power of Reference Systems (2006)



The Power of Forecasts (2007)



Science Maps for Economic Decision Makers (2008)

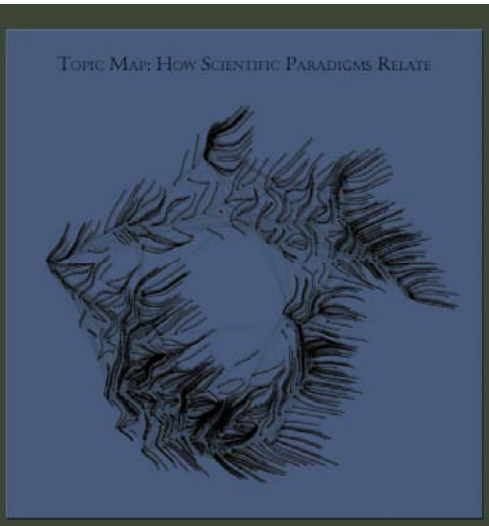
Science Maps for Science Policy Makers (2009)
Science Maps for Scholars (2010)
Science Maps as Visual Interfaces to Digital Libraries (2011)
Science Maps for Kids (2012)
Science Forecasts (2013)

How to Lie with Science Maps (2014)

scimaps.org

Illuminated Diagram Display

W. Bradford Paley, Kevin W. Boyack, Richard Kalvans, and Katy Börner (2007) Mapping, Illuminating, and Interacting with Science. SIGGRAPH 2007, San Diego, CA.



You may run your finger over each of these maps to control the lighting on the other: touching a place on the world map will light up topics studied in that place; touching a paradigm on the topic map will light up the places that study that topic.

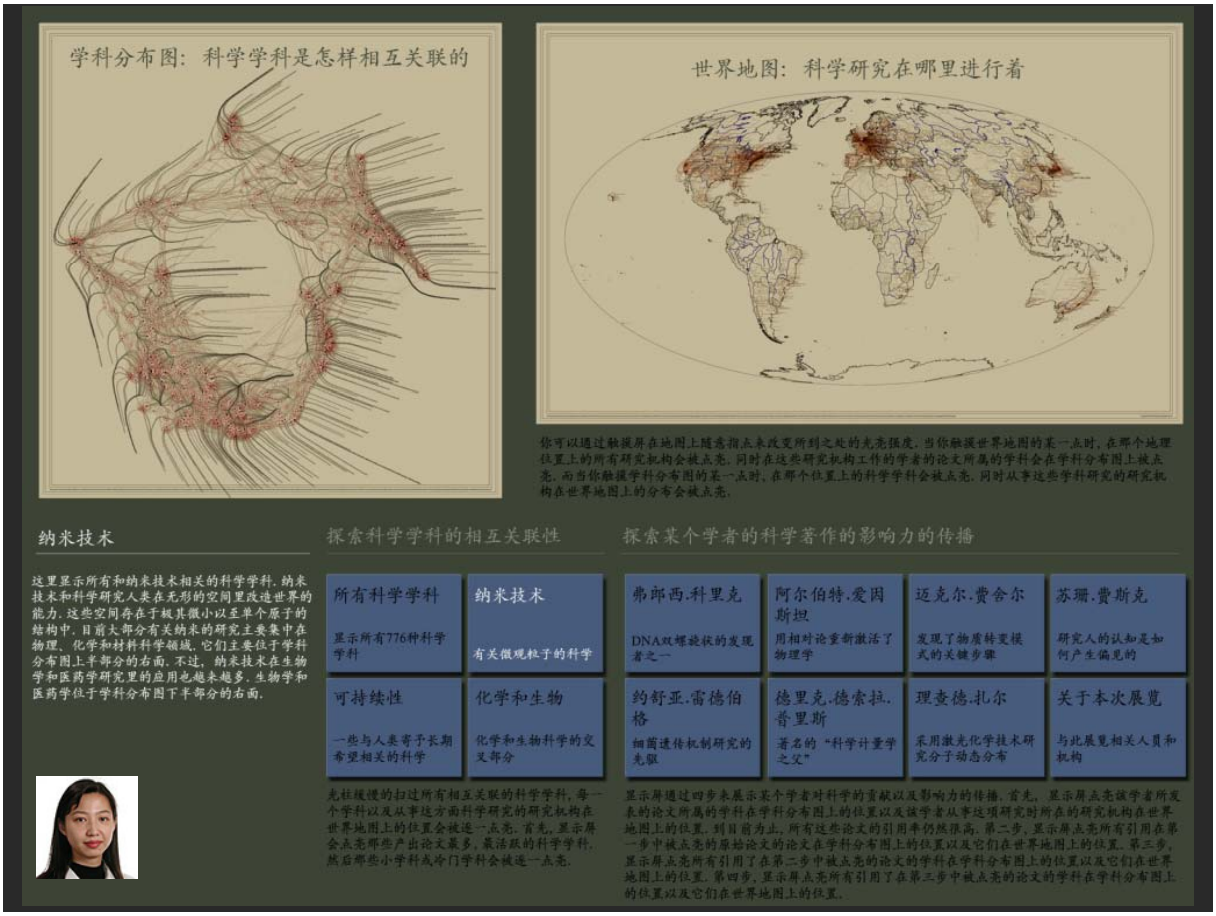
Nanotechnology

This overlay shows the distribution of nanotechnology within the paradigms of science. The majority of current work in nanotechnology takes places in physics, chemistry, and materials science, at the upper right portion of the map. However, an increasing amount of nanotechnology is being applied in the biological and medical sciences, at the lower right.

All Topics *Sweep through all 776 scientific paradigms*	**Nanotechnology** *Science on the tiny scale of molecules*	**Francis H. C. CRICK** *Co-discovered DNA's double helix*	**Albert EINSTEIN** *Revitalized physics with Relativity theories*	**Michael E. FISHER** *Models critical phase transitions of matter*	**Susan T. FISKE** *Connects perception and stereotypes*
Sustainability *The science behind our long-term hopes*	**Biology & Chemistry** *The interface between these two vital fields*	**Joshua LEDERBERG** *Pioneer in bacterial genetic mechanisms*	**Derek J. de Solla PRICE** *Known as the "Father of Scientometrics"*	**Richard N. ZARE** *Uses laser chemistry in molecular dynamics*	**About this display** *People & organizations that helped create it*

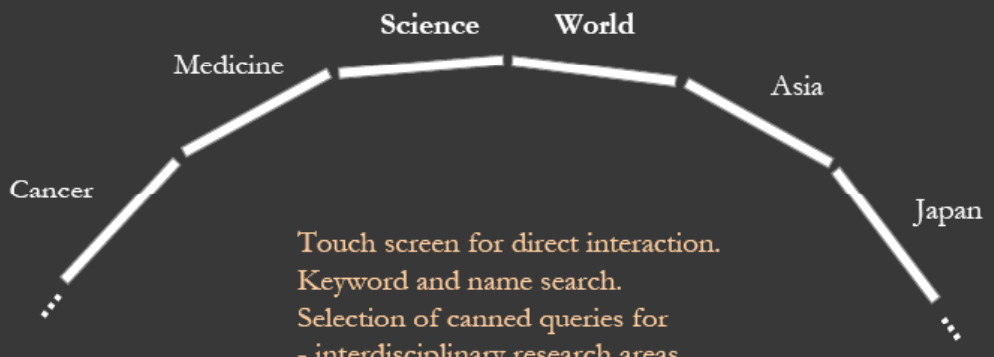
We sweep slowly through adjoining related topics, lighting up the places in the world that study each topic. You may select a subset of the topics that deal with these three interesting subjects by touching it.

A single person's spreading influence is shown as a series of four snapshots. First, we light only topics and places relating to that person's papers—papers that are still highly cited today. The second lights everything that cites that original work. Note that this first-generation impact extends to far more topics than did the original work. The third shapshot lights science that cites the second; and the fourth lights science that cites the third.

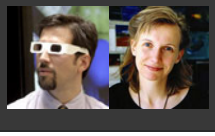


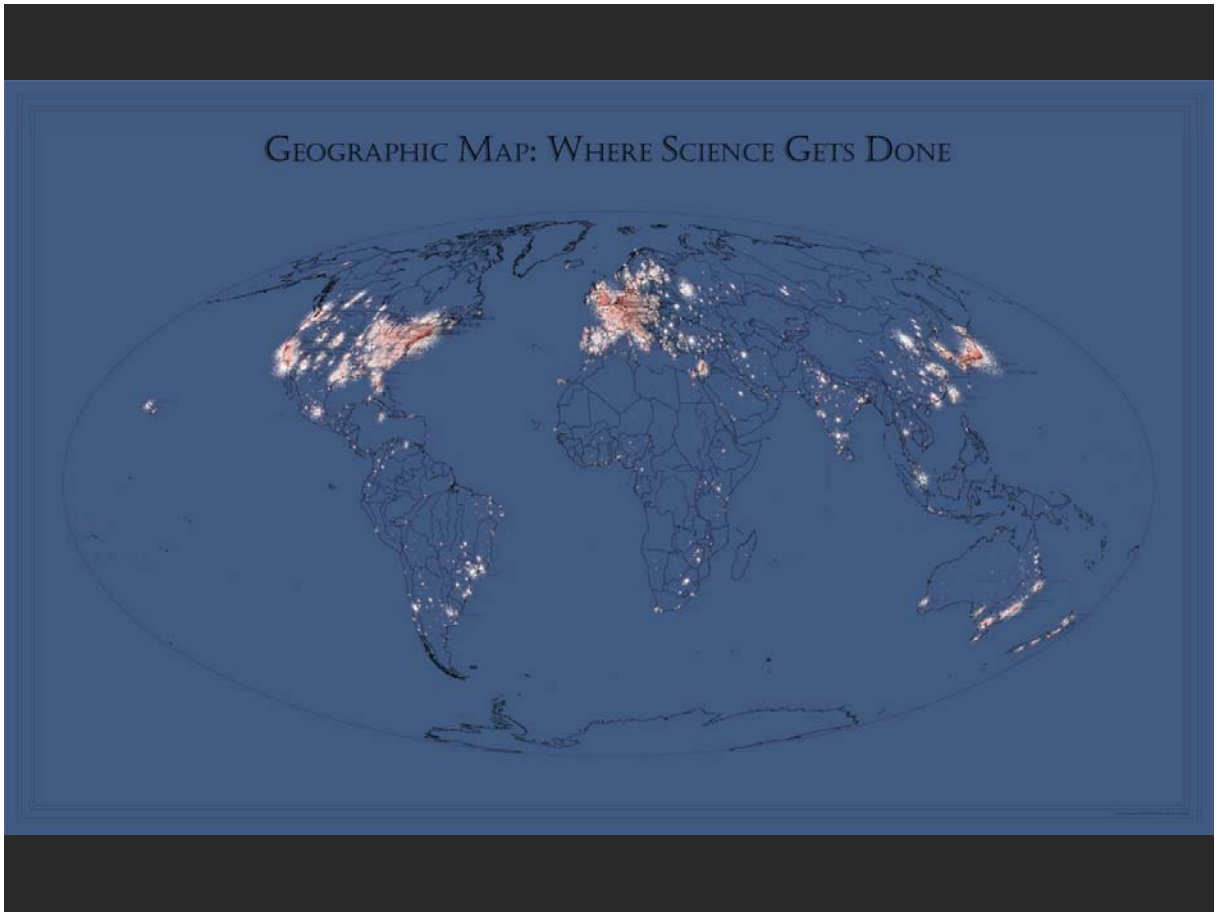
Re-implementation of Illuminated Diagram Software
by Advanced Visualization Lab, Indiana University

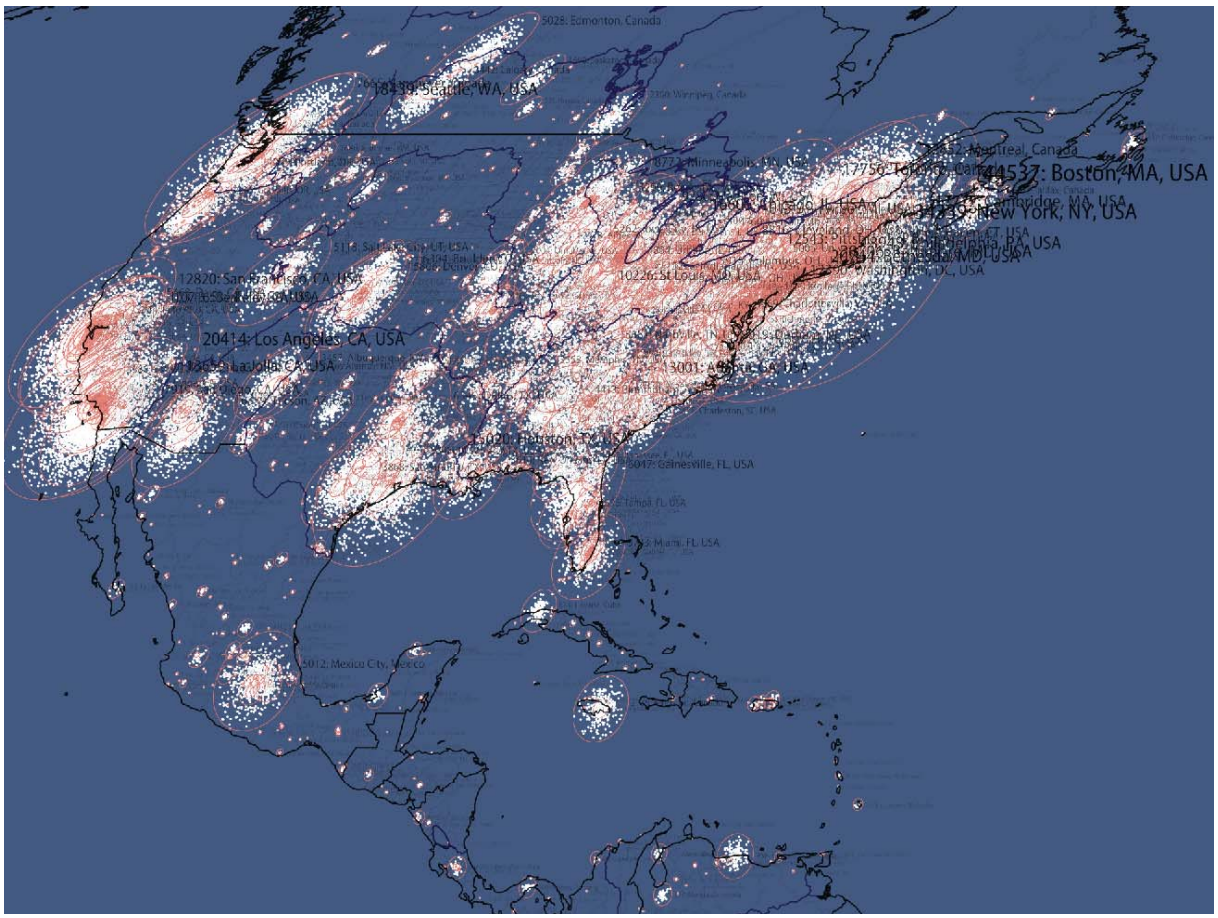
Drives unlimited number of ID screens.

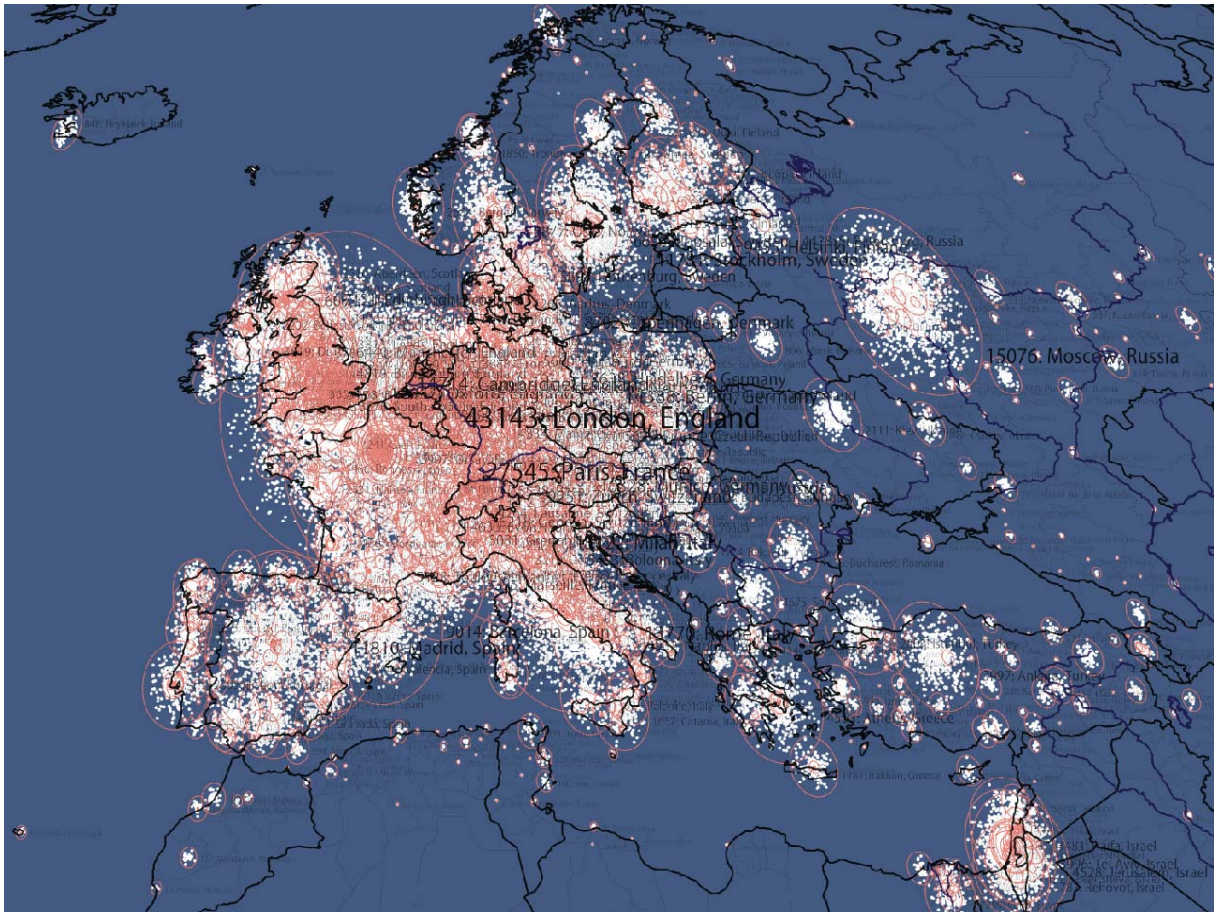


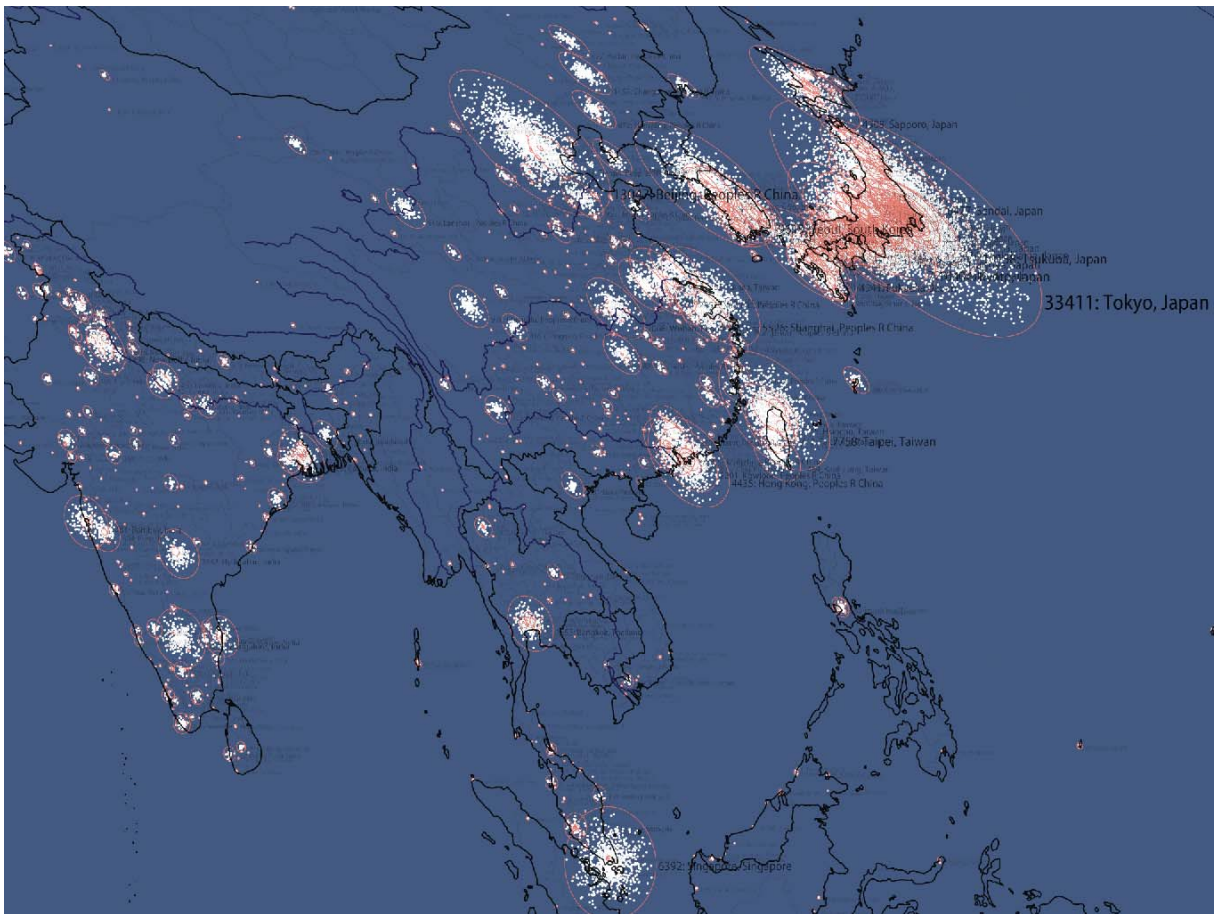
Touch screen for direct interaction.
Keyword and name search.
Selection of canned queries for
- interdisciplinary research areas
- famous people
- activity patterns, e.g., bursts, trends, etc.



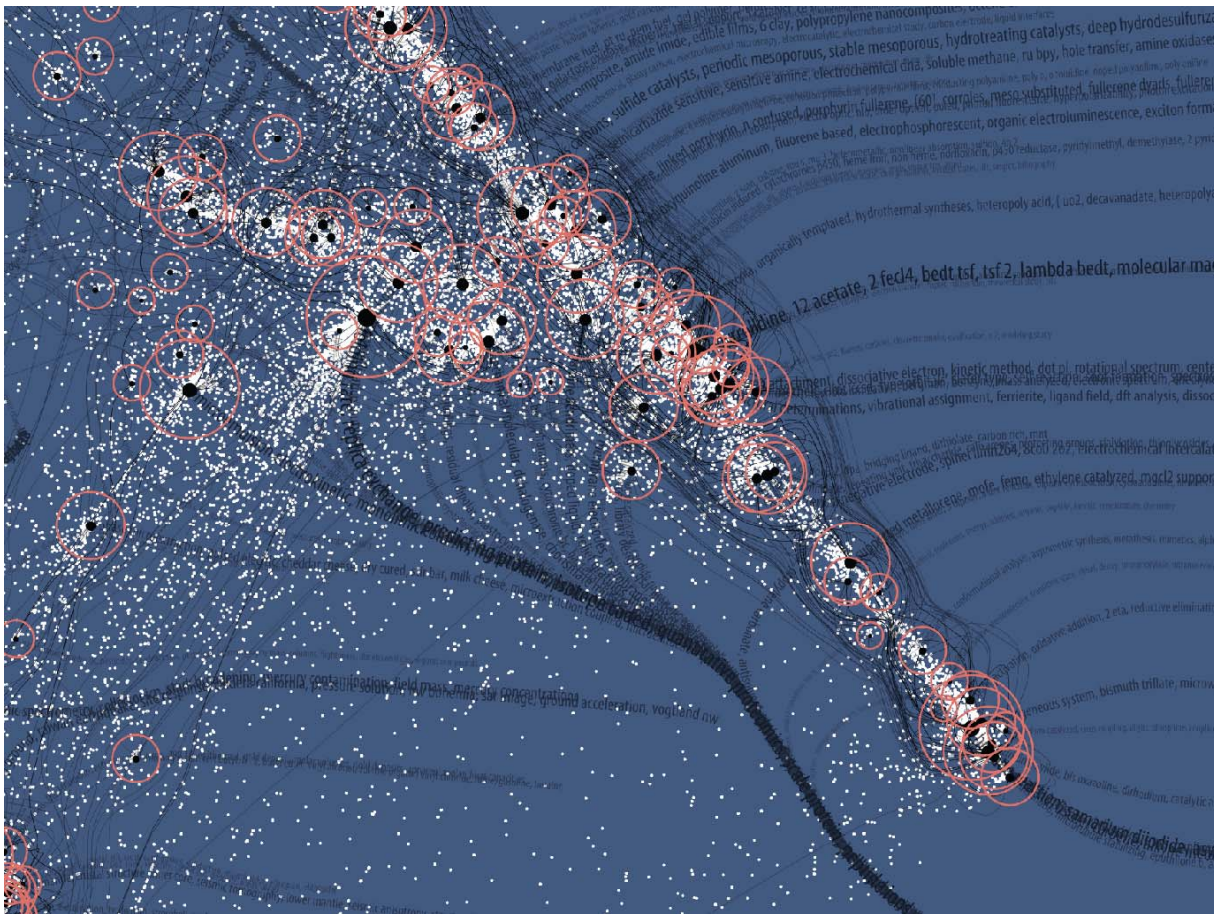

Geographic Map: Where Science Gets Done


5028: Edmonton, Canada
18439: Seattle, WA, USA
Montreal, Canada
44537: Boston, MA, USA
12543: Philadelphia, PA, USA
20414: Los Angeles, CA, USA
12820: San Francisco, CA, USA
10226: St Louis, MO, USA
5017: Gainesville, FL, USA
5012: Mexico City, Mexico

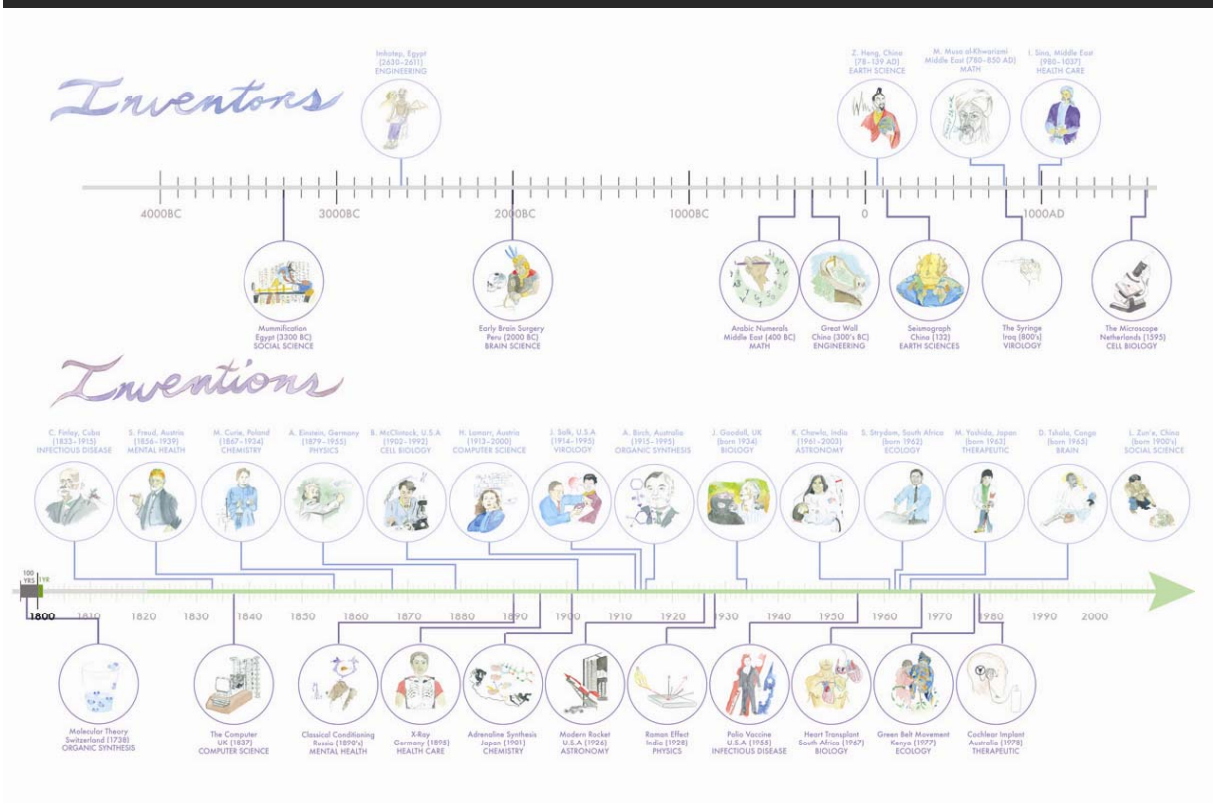

15076: Moscow, Russia
43143: London, England
27545: Paris, France


33411: Tokyo, Japan


Topic Map: How Scientific Paradigms Relate



Hands-On Science Maps for Kids, by Fileve Fellmer (Painting), Julie Smith (Data Acquisition), Elisha Hardy and Katy Börner (Graphic Design). BLOOMINGTON, IN, 2006. Courtesy of Indiana University. Learn more at www.scimaps.org. This map plots the locations of where scientific papers were published: each light green dot represents 10 or fewer papers; they are scattered around the exact location for visibility, within a labelled green circle whose size is proportional to the number of papers published in that place. The base map is part of an "illuminated diagram" display which used a computer and two projectors, projecting spots of light on the prints to highlight different kinds of scientific research (on a sibling map of scientific paradigms) and the areas in the world where such



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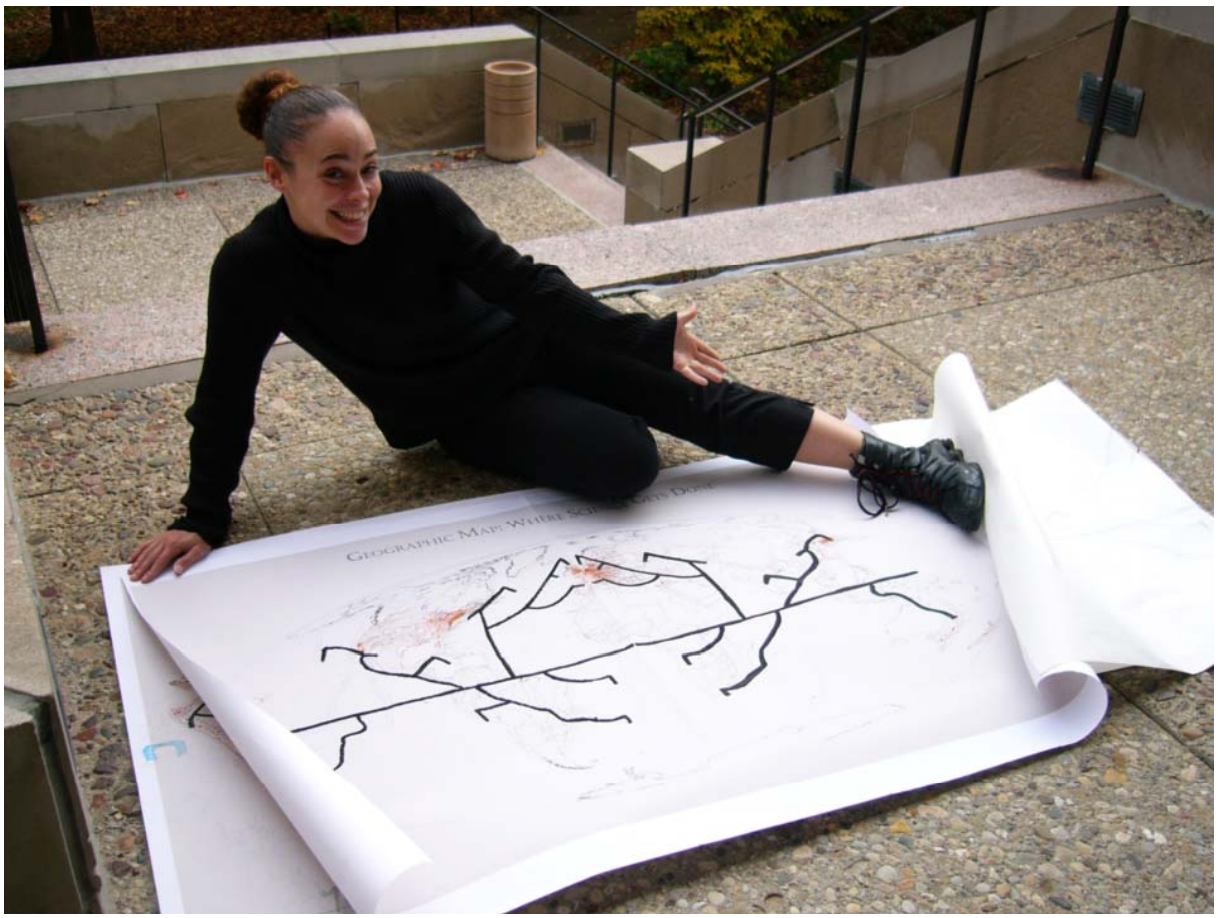
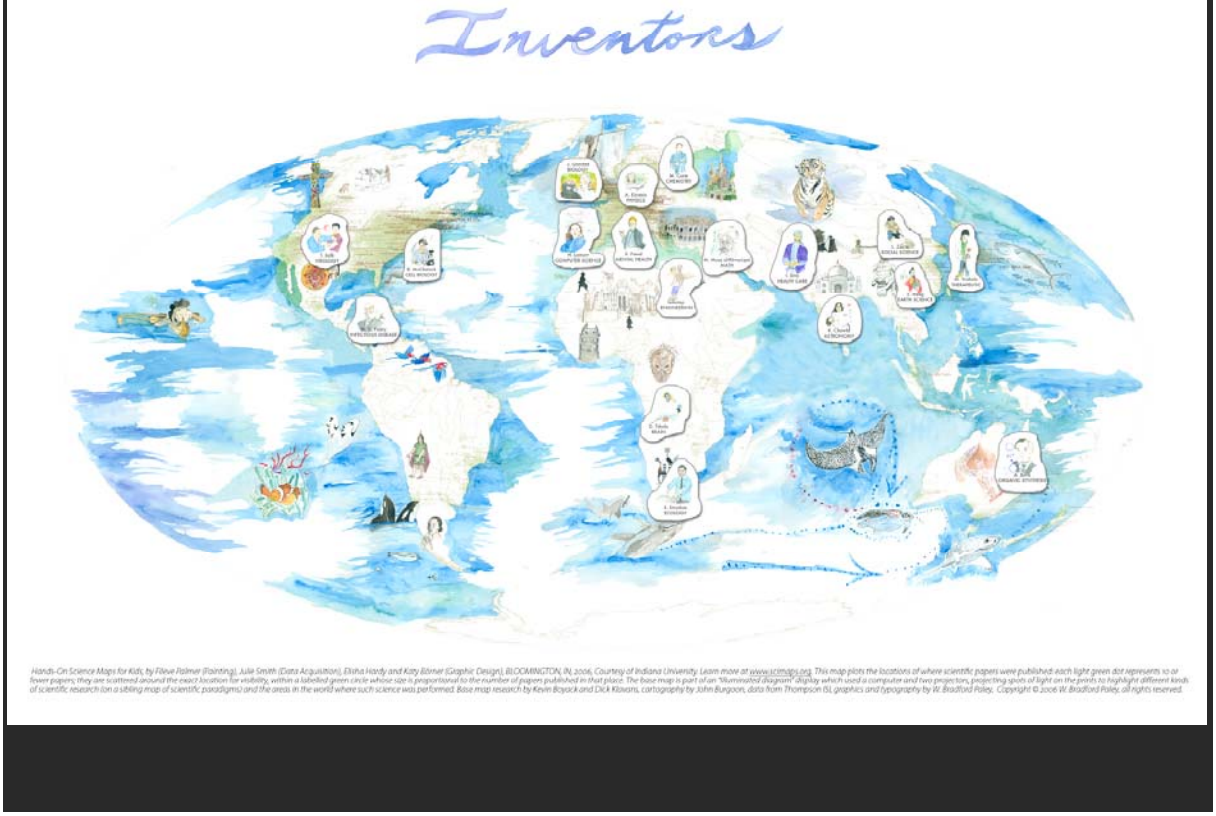


Science Puzzle Map for Kids by Fileve Palmer, Julie Smith, Elisha Hardy and Katy Börner, Indiana University, 2006. (Base map taken from Illuminated Diagram display by Kevin Boyack, Richard Klavans, and W. Bradford Paley.)

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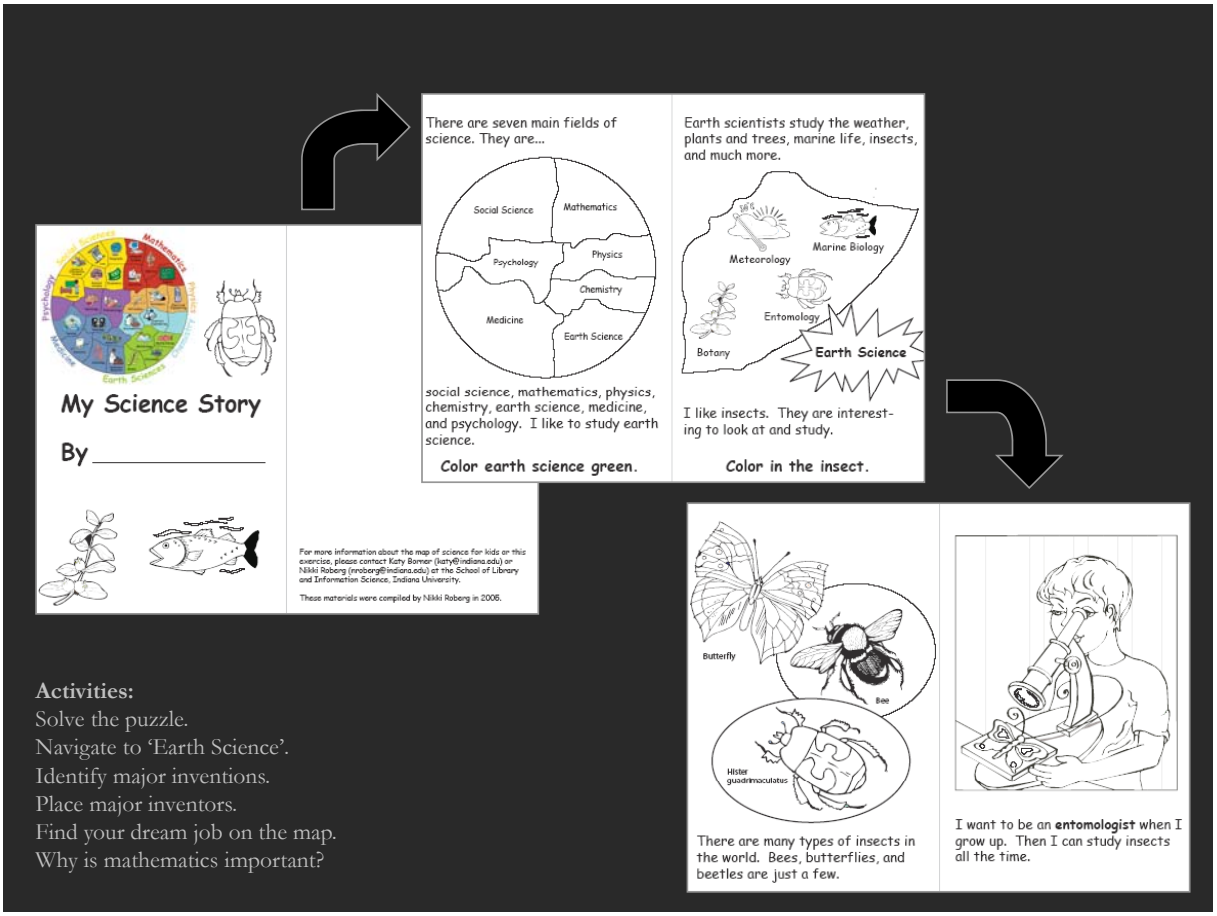
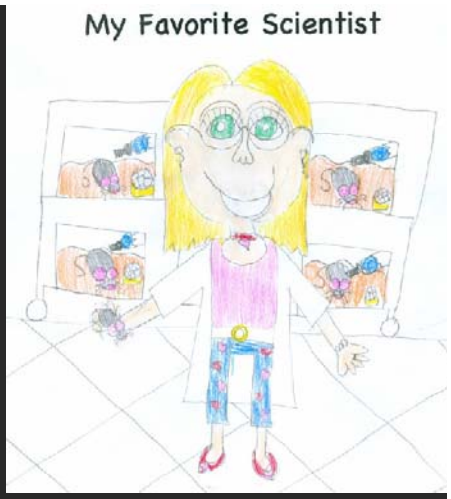
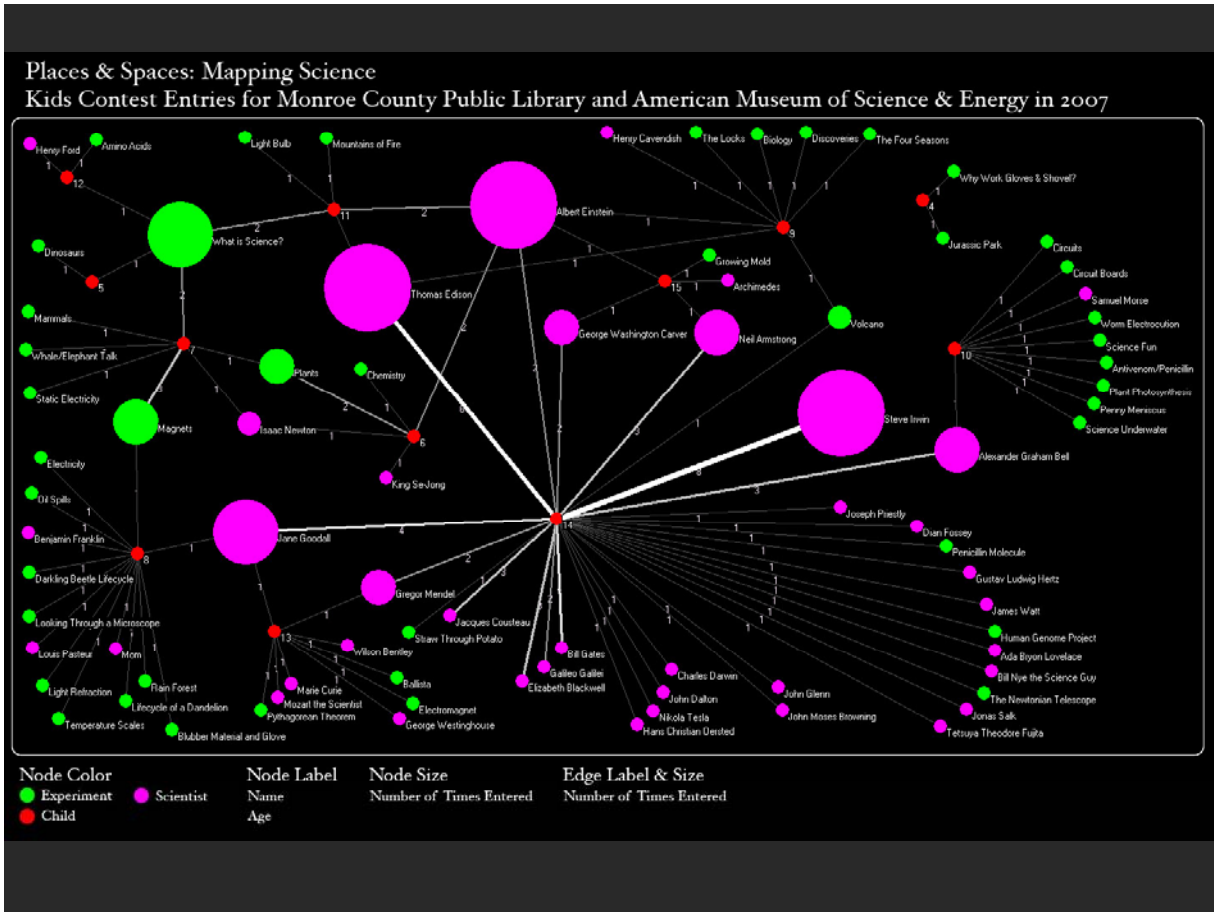
SOCCER

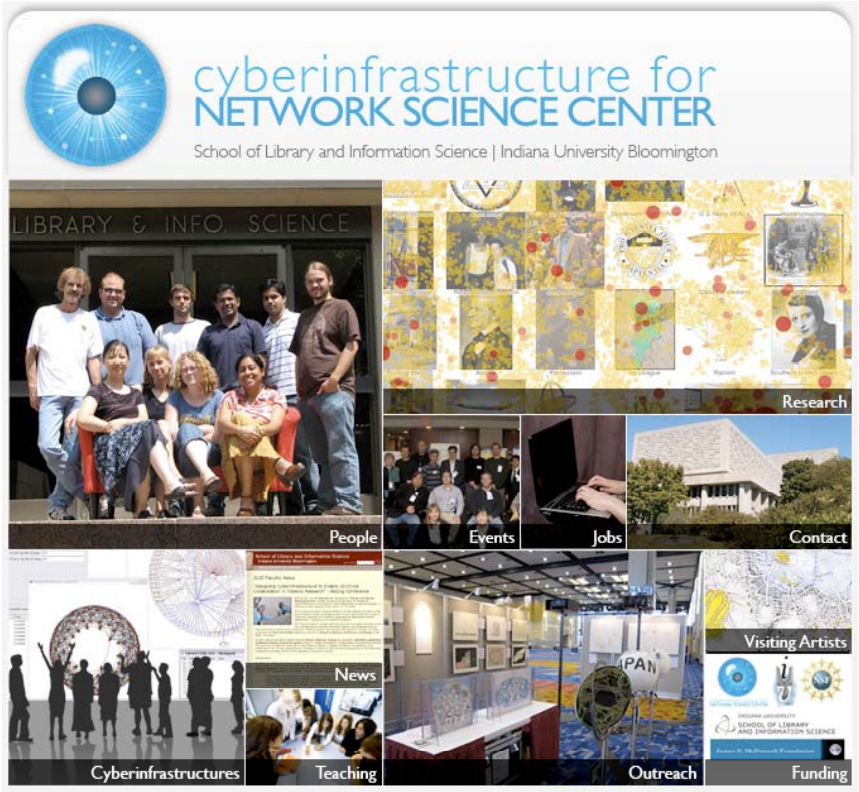


Activities:
Solve the puzzle.
Navigate to 'Earth Science'.
Identify major inventions.
Place major inventors.
Find your dream job on the map.
Why is mathematics important?



Winners @ AMSE
JoHanna Sanders, age 12, a picture of someone enjoying nature and a theme that science is all around us.
Sascha Richey, age 8, drew a picture of her mother and explained why her mother is her favorite scientist.





http://cns.slis.indiana.edu