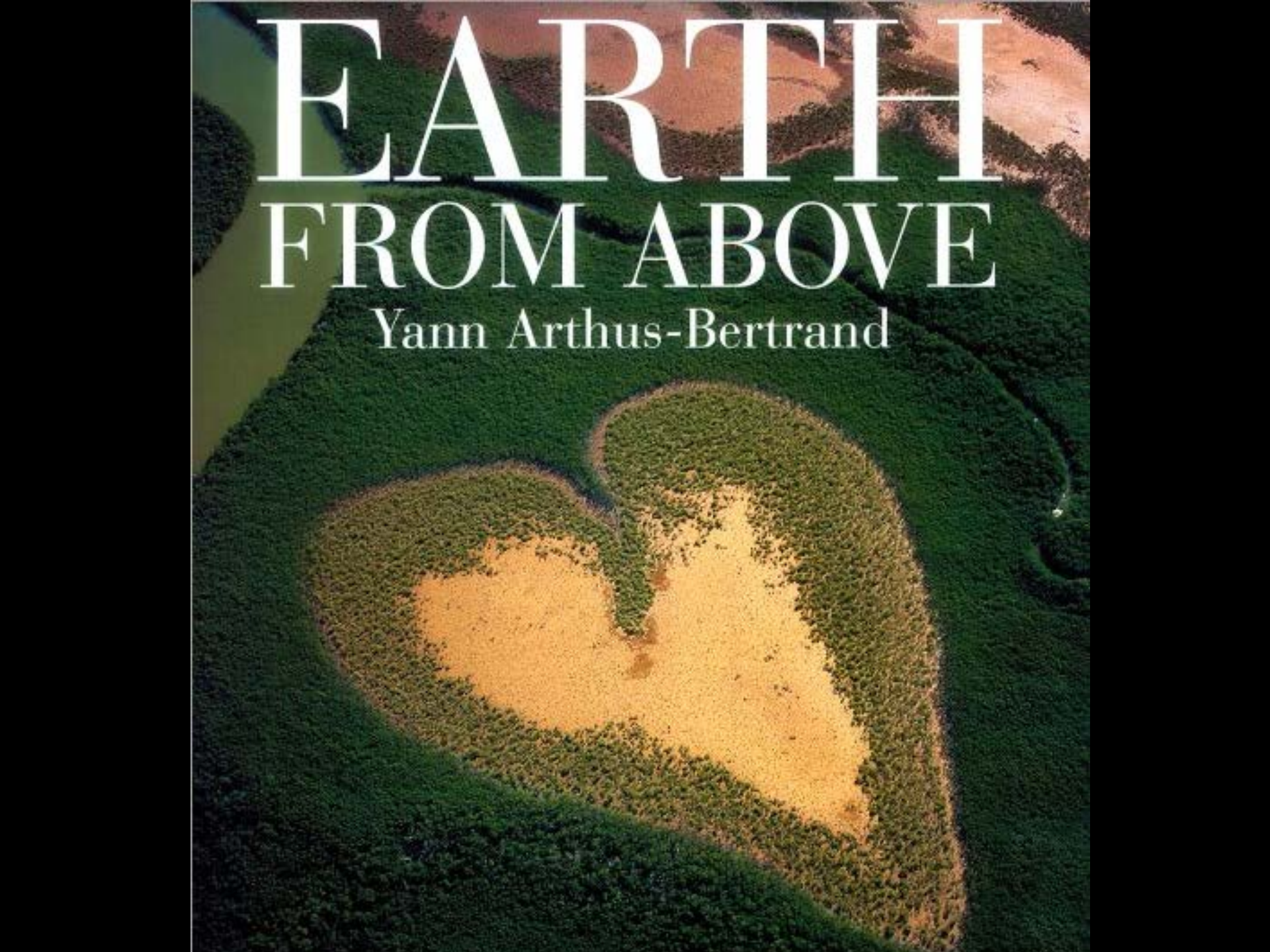


Maps & Macroscopes: Envisioning Science, Technology, and Education

Katy Börner

Victor H. Yngve Distinguished Professor of
Intelligent Systems Engineering & Information Science
Director, Cyberinfrastructure for Network Science Center
School of Informatics and Computing
Indiana University Network Science Institute
Indiana University, USA

*Third Annual Innovation Conference by JCITR
Memorial Union, Indiana University, Bloomington
Thursday, April 6, 2017*

An aerial photograph of a landscape. A winding river flows through the scene. In the foreground, there is a large, irregularly shaped field of golden-brown vegetation, possibly a rice paddy or a similar agricultural field. The surrounding areas are covered in dense green vegetation. The title 'EARTH FROM ABOVE' is overlaid in large white serif font at the top of the image.

EARTH FROM ABOVE

Yann Arthus-Bertrand



How can we communicate the beauty,
structure, and dynamics of science to a
general audience?

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.

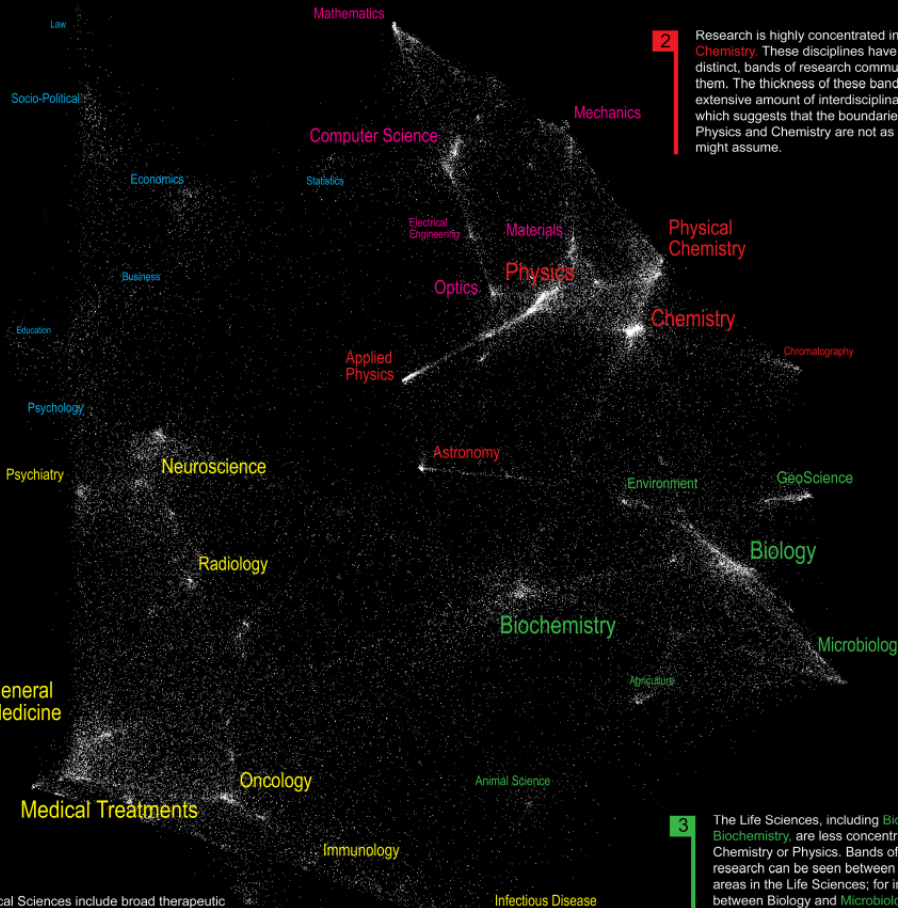
We are all familiar with traditional maps that show the relationships between countries, provinces, states, and cities. Similar relationships exist between the various disciplines and research topics in science. This allows us to map the structure of science.

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

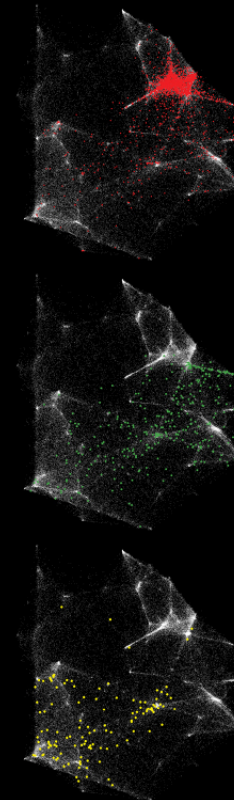
Most research communities in nanotechnology are concentrated in **Physics**, **Chemistry**, and **Materials Science**. However, many disciplines in the Life and Medical Sciences also have nanotechnology applications.

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.





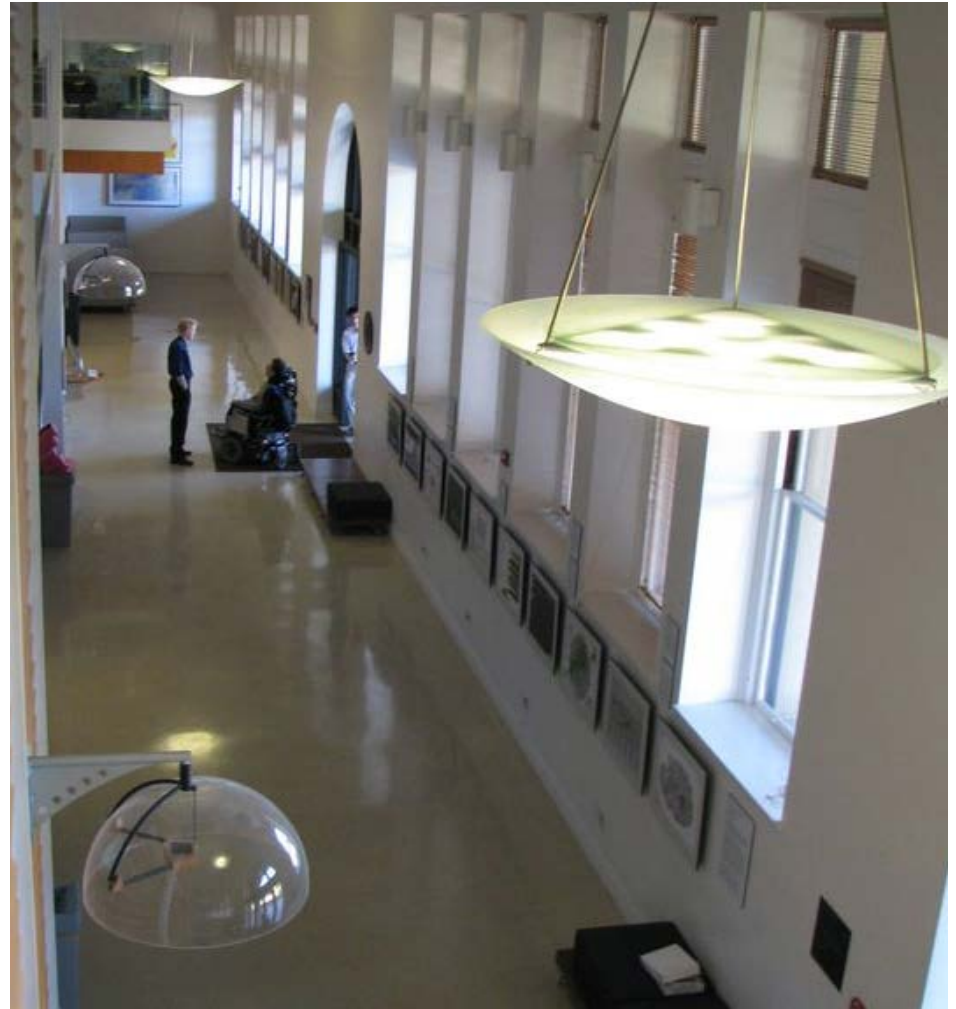
April, 2005: 101st Annual Meeting of the Association of American Geographer, Denver, Colorado.



2005: 101st Annual Meeting
American Geographer, De







Debut of 5th Iteration of the Mapping Science Exhibit at MEDIA X in 2009 at Wallenberg Hall, Stanford University.



Science Maps in “Expedition Zukunft” science train visited 62 cities in 7 months.
Opening on April 23rd, 2009 by German Chancellor Merkel



Ingo Gunther's Worldprocessor globe design on display at the Museum of Emerging Science and Innovation in Tokyo, Japan.



Places & Spaces Digital Display in North Carolina State's Immersion Theater



Exhibit Advisors
and Ambassadors



Kristi Holmes @kristiholmes · Apr 30
Excited for @cnscenter Places&Spaces at @galterlibrary! @katycns
@NUCATSInstitute #unpackingcrates #viz

Places & Spaces at Northwestern University
May 14 - September 23, 2015

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



CDC Opening Event: Maps of Health

Tutorial and Symposium
February 4-5, 2016



Places & Spaces Exhibit at Vanderbilt University, Nashville, TN.
January 23-April 23, 2017 <http://scimaps.org/vanderbilt>

Maps



PLACES
SPACES &
MAPPING SCIENCE

scimaps.org



10 iterations over 10 years

equal

$10 \times 10 = 100$ maps!



Maps that show

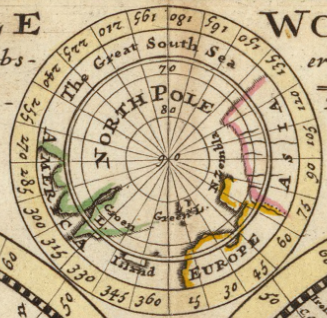
STRUCTURE

scimaps.org

A New Map of the **WHOLE**
According to y^e latest and most Exact Obs-

WORLD with the Trade winds
errations By H. Moll Geographer

In this Maps is inserted A View of y^e General & Coasting Trade Winds, Monsoons or y^e Shifting Trade-winds Note that y^e Arrows among y^e Lines shew y^e Course of those General & Coasting Winds, and y^e Arrows in y^e void Spaces shew y^e Course of y^e Shifting Trade-winds, and y^e Abbreviation sep^r & c. Shew y^e Times of y^e Year when such Winds Blow.



The Signs of the Zodiac, The First 6 are Northern, the other Southern Signs
♈ Aries . March ♌ Leo . July
♉ Taurus . April ♍ Virgo . August
♊ Gemini . May ♎ Libra . September
♋ Cancer . June ♏ Scorpio . October
♐ Sagittarius . November
♑ Capricornus . December
♒ Aquarius . January
♓ Pisces . February



Printed for Tho: Bowles Print and Map Seller next y^e Chapter-Rowse in s.^o Pauls Church-yard; and John Bowles Print and Map Seller at the Black-Horse in Cornhill London.

A New Map of the Whole World with Trade Winds According to the Latest and Most Exact Observations - Herman Moll - 1736

MAPS OF SCIENCE

Forecasting Large Trends in Science

This map of science was constructed by sorting more than 16,000 journals into disciplines. Disciplines, represented as circles, are sets of journals that cite a common literature; links (the lines between disciplines) are pairs of disciplines that share a common literature. A three-dimensional model was used to determine the position of each discipline on the surface of a sphere based on the linkages between disciplines. The model treats links like rubber bands attempting to bring two disciplines close to each other. Pairs of disciplines without links tend to end up on different sides of the map.

The spherical map, which is not shown here, was unrolled in a mercator projection (the same one used to show the continents of the earth on a two-dimensional map) to give the large map shown below. This projection allows inspection of the entire map of science at once. Note that the disciplines tend to string along the middle of the map - if this were a map of the earth it would be like a single continent undulating along the equator. There are no disciplines at the top (north pole) or the bottom (south pole). Mercator projections also introduce distortions. We tend to forget that the left side is connected to the right side, and assume that the middle is most important. In this map, the social sciences (yellow) on the right connect with the computer sciences (pink) on the left in one continuous swath.

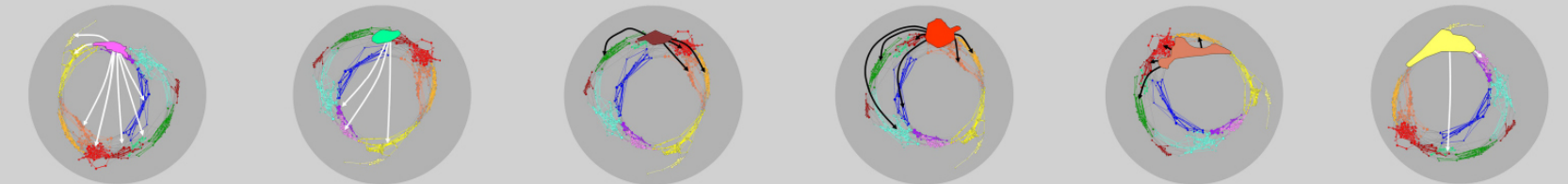
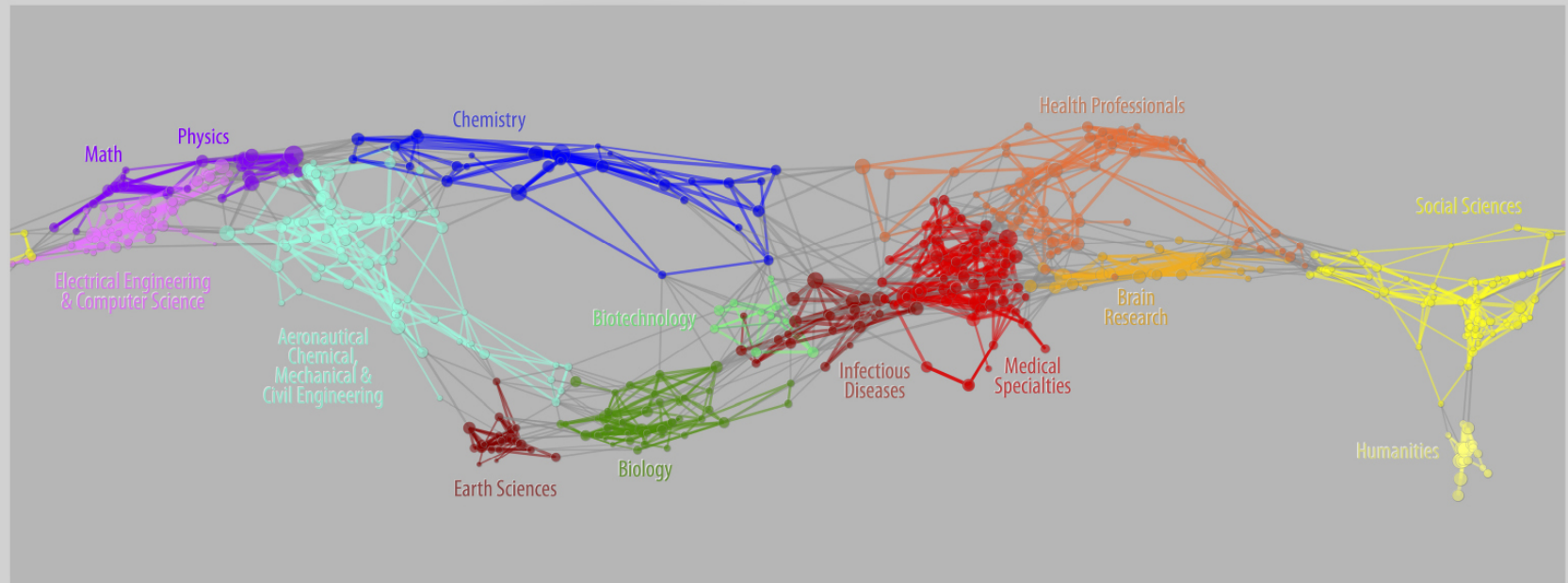
The six map projections shown at the bottom are images of what one would see if looking directly down at the south pole of the map, at six different rotations. When viewed this way, the map looks like a wheel with an inner ring and outer ring. This wheel of science corresponds very closely with the two-dimensional maps we have previously produced.

A visualization of 7.2 million scholarly documents
appearing in over 16,000 journals, proceedings or symposia
between Jan, 2001 and Dec, 2005

Calculations were performed using the large colored groupings of disciplines (fields) to determine if any of them were likely to cause large scale changes in the structure of science over time. Connectedness coefficients between fields were calculated for each individual year, 2001-2005. A simple regression analysis was conducted to see if there were significant changes in these connectedness coefficients from year-to-year.

If the structure of science shown below is moving toward stability, we would expect connectedness between neighboring fields to increase, and connectedness between distant fields to decrease. We found the opposite, suggesting that the underlying structure is unstable and likely to change dramatically over the next decade.

Six stories, representing how the structure is likely to change, are provided below. Maps with white arrows represent instances of distant fields that are likely to be pulled closer to each other in the future. Maps with dark arrows represent fields that are currently close-knit, that are likely to become more dispersed. We expect that future maps of science will show changes in structure corresponding to these observations. Medicine will disperse slightly, while the physical sciences will tighten and draw closer to the medical fields.



Electrical Engineering & Computer Science (EE/CS), indicated by the pink shape in the view above, is a field whose connectedness has been increasing much more quickly (15% than expected). Connectedness has increased between EE/CS and all other fields from 2001-2005. The connections with the largest annual increases (>10%) are shown by white arrows. Over time, these stronger connections will distort the map, and may bring EE/CS into a more central position.

Biotechnology, indicated by the light green shape above, has the largest overall increase in connectedness with other fields (16%). It has relatively few connections with the EE/CS, Math & Physics, and Social Sciences fields, but these three connections had the largest fractional increase. The connection with EE/CS, which had the single largest growth rate (31% of any connection, reflects recent growth in the area of bioinformatics.

Infectious Diseases, indicated by the dark red shape above, has an overall decrease in connectedness (2%) with other fields. Decreases in connection strength between this field and the fields of Biology, Medical Specialties, Health Professionals and Brain Research (all >3%) are shown as black arrows, and will drive a slow dispersion of the medical fields compared to the current structure.

Medical Specialties, indicated by the red shape above, has an overall decrease in connectedness (2%) with other fields. This is dominated by decreasing connection strength to the other medical fields and biology, as shown by the black arrows. The only connection increasing in strength is the one to EE/CS, which is not shown here, but was shown as a white arrow in the first story.

The **Health Professionals** field, indicated by the orange shape above, has the largest overall decrease in connectedness (4%) to other fields. As with the other medical fields, its connection strength with medicine and biology is decreasing in all cases, as shown by the black arrows. With the decreasing connection strengths throughout medicine, we expect the map structure in these areas to relax slightly over time.

The **Social Sciences**, indicated by the yellow shape above, had an overall increase in connectedness (9%) with other fields. Although its greatest connectedness gains were with EE/CS and Biotechnology (see white arrows), it also had consistent connection increases with nearly all the other fields. In general the fields of EE/CS, Biotechnology, and the Social Sciences are become more connected, and are pulling on the physical sciences as well.

Source: University of California, San Diego Knowledge Mapping Laboratory. Color Images: © Regents of the University of California. The underlying data came from two sources: Thomson ISI and Scopus. Mapping methodology and descriptive text by Dick Klavans, President, SciTech Strategies, Inc., and Kevin Boyack, Sandia National Laboratories. Graphics & typography by Ethan Meilner and Mike Patek. Special acknowledgements to Katy Borner, Art Ellis, W. Bradford Paley, Len Simon, and Henry Small. © 2007 by Dick Klavans, all rights reserved.



Maps that show

FLOWS

scimaps.org

LÉGENDE — Quantités et couleurs pour chaque Pays de provenance.

	Etats-Unis	Indes (Gambie, Chine)	Egypte, Siam	Perse, Indes (Indes)	Angleterre, Espagne
1858	532,100 ^m	79,510 ^m	22,810 ^m	8,480 ^m	62,500 ^m
1864	548,100 ^m	185,510 ^m	27,200 ^m	9,580 ^m	132,300 ^m
1865	561,500 ^m	261,000 ^m	71,700 ^m	14,180 ^m	192,100 ^m
1866	575,500 ^m	335,000 ^m	96,000 ^m	17,100 ^m	247,700 ^m
1867	590,000 ^m	410,000 ^m	121,000 ^m	20,100 ^m	302,300 ^m

- A... Importation plus forte que celle de 1858, malgré les rétrocessions de la guerre civile, à cause de la vente de tout le Stock.
- B... Exportation de la guerre civile, et qui est ici suivie plus forte et qui est suivie par les Etats-Unis.
- C... Approvisionnement de la guerre civile, et qui est ici suivie plus forte et qui est suivie par les Etats-Unis.
- D... Approvisionnement de la guerre civile, et qui est ici suivie plus forte et qui est suivie par les Etats-Unis.
- E... Approvisionnement de la guerre civile, et qui est ici suivie plus forte et qui est suivie par les Etats-Unis.
- F... Approvisionnement de la guerre civile, et qui est ici suivie plus forte et qui est suivie par les Etats-Unis.
- G... Approvisionnement de la guerre civile, et qui est ici suivie plus forte et qui est suivie par les Etats-Unis.
- H... Approvisionnement de la guerre civile, et qui est ici suivie plus forte et qui est suivie par les Etats-Unis.

CARTE figurative et approximative des quantités de **COTON BRUT** importés en Europe en 1858 en 1864 et en 1865.

Dressée par M. MINARD, Inspecteur Général des Ponts et Chaussées en retraite.
Paris, le 14 Mai 1866.

Les tonnages de coton transportés sont représentés par les largeurs des arcs indiqués à raison d'un millimètre pour cinq mille tonnes, et sont de plus exprimés par les nombres inscrits en toutes lettres et dans l'ordre où ils sont.

Les Cartes ont été dressées sur les Documents de Messieurs François, Agassiz, Bédard, Hollander, Bédard, Anversin.

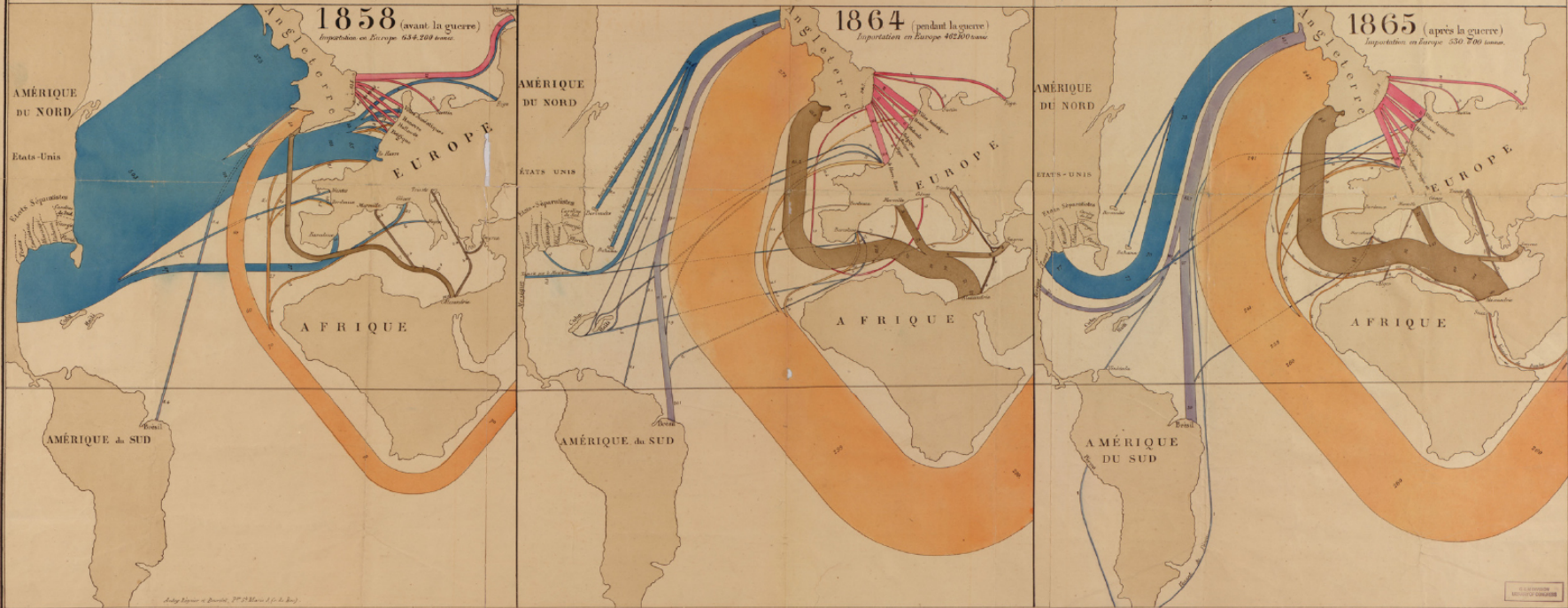
Le Dictionnaire du Commerce, le Traité de Messieurs de M.J.A. Moreau, le tableau circulaire et la publication de Messieurs de L'Observateur.

Observation: Les importations sont un peu plus fortes que celles de la Carte, parce que j'ai négligé celles d'une demi-tonne et que les Diagrammes indiquent en bleu les trois parties principales de toute provenance, je n'ai eu à l'appeler les importations.

De l'importation du Coton en 1865. — Les quantités importées de coton en Europe ont augmenté depuis que la guerre civile des Etats-Unis a cessé.

Les Etats-Unis ont été le pays qui a fourni le plus de coton brut en Europe, et qui a fourni le plus de coton brut en Europe, et qui a fourni le plus de coton brut en Europe.

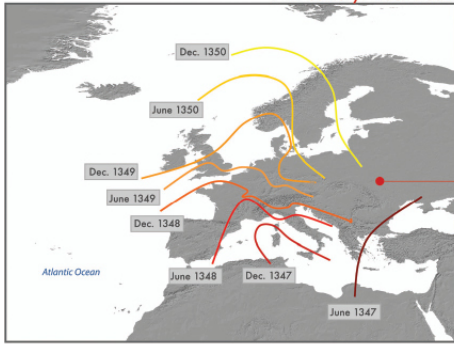
Les Etats-Unis ont été le pays qui a fourni le plus de coton brut en Europe, et qui a fourni le plus de coton brut en Europe, et qui a fourni le plus de coton brut en Europe.



Europe Raw Cotton Imports in 1858, 1864 and 1865 - Charles Joseph Minard - 1866

Impact OF Air Travel ON Global Spread OF Infectious Diseases

14th Century: Black Death

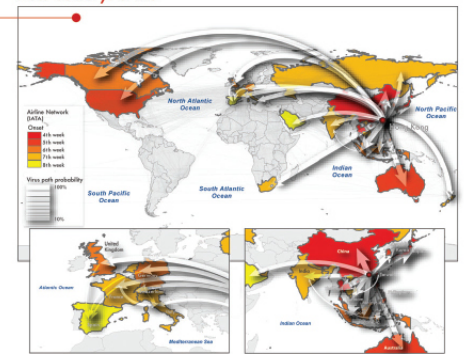


Epidemic spreading pattern changed dramatically after the development of modern transportation systems.

In pre-industrial times disease spread was mainly a spatial diffusion phenomenon. During the spread of Black Death in the 14th century Europe, only few traveling means were available and typical trips were limited to relatively short distances on the time scale of one day. Historical studies confirm that the disease diffused smoothly generating an epidemic front traveling as a continuous wave through the continent at an approximate velocity of 200-400 miles per year.

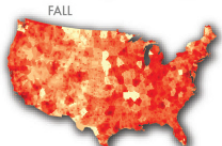
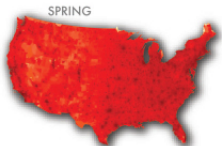
The SARS outbreak on the other hand was characterized by a patched and heterogeneous spatio-temporal pattern mainly due to the air transportation network identified as the major channel of epidemic diffusion and ability to connect far apart regions in a short time period. The SARS maps are obtained with a data-driven stochastic computational model aimed at the study of the SARS epidemic pattern and analysis of the accuracy of the model's predictions. Simulation results describe a spatio-temporal evolution of the disease (color coded countries) in agreement with the historical data. Analysis on the robustness of the model's forecasts leads to the emergence and identification of epidemic pathways as the most probable routes of propagation of the disease. Only few preferential channels are selected (arrows; width indicates the probability of propagation along that path) out of the huge number of possible paths the infection could take by following the complex nature of airline connections (light grey, source: IATA).

21st Century: SARS



Forecasts OF THE Next Pandemic Influenza

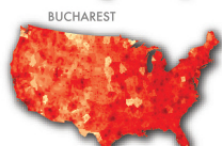
Seasonal



Forecasts are obtained with a stochastic computational model which explicitly incorporates data on worldwide air travel and detailed census data to simulate the global spread of an influenza pandemic.

The modeling approach considers infection dynamics (i.e., virus transmission, onset of symptoms, infectiousness, recovery, etc.) among individuals living in urban areas around the world, and assumes that individuals are allowed to travel from one city to another by means of the airline transportation network.

Geographical

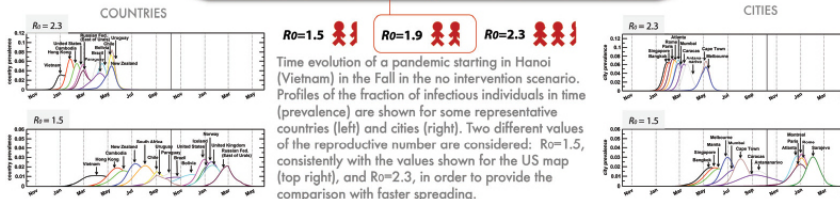
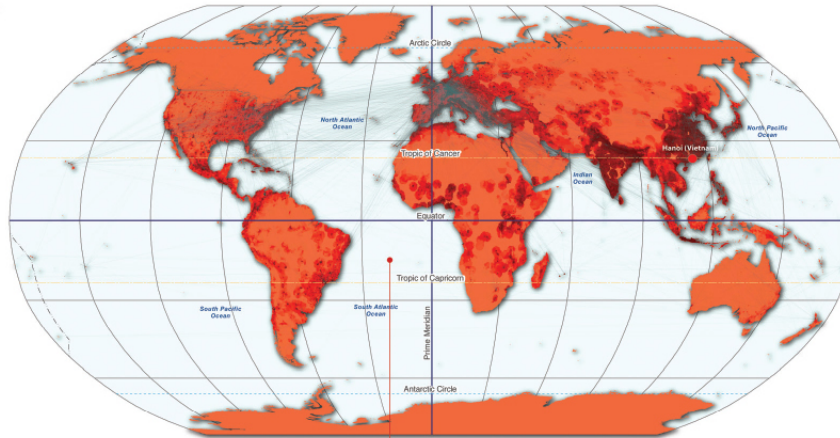


Numerical simulations provide results for the temporal and geographic evolution of the pandemic influenza in 3,100 urban areas located in 220 different countries. The model allows to study different spreading scenarios, characterized by different initial outbreak conditions, both geographical and seasonal.

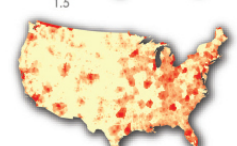
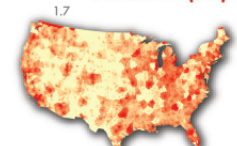
The central map represents the cumulative number of cases in the world after the first year from the start of a pandemic influenza with $R_0=1.9$ originating in Hanoi (Vietnam) in the Spring.



The US maps focus on the situation in the US after one year, and show the effect of changes in the original scenario analyzed. Different color coding is used for the sake of visualization.



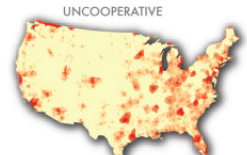
Reproductive Number (R_0)



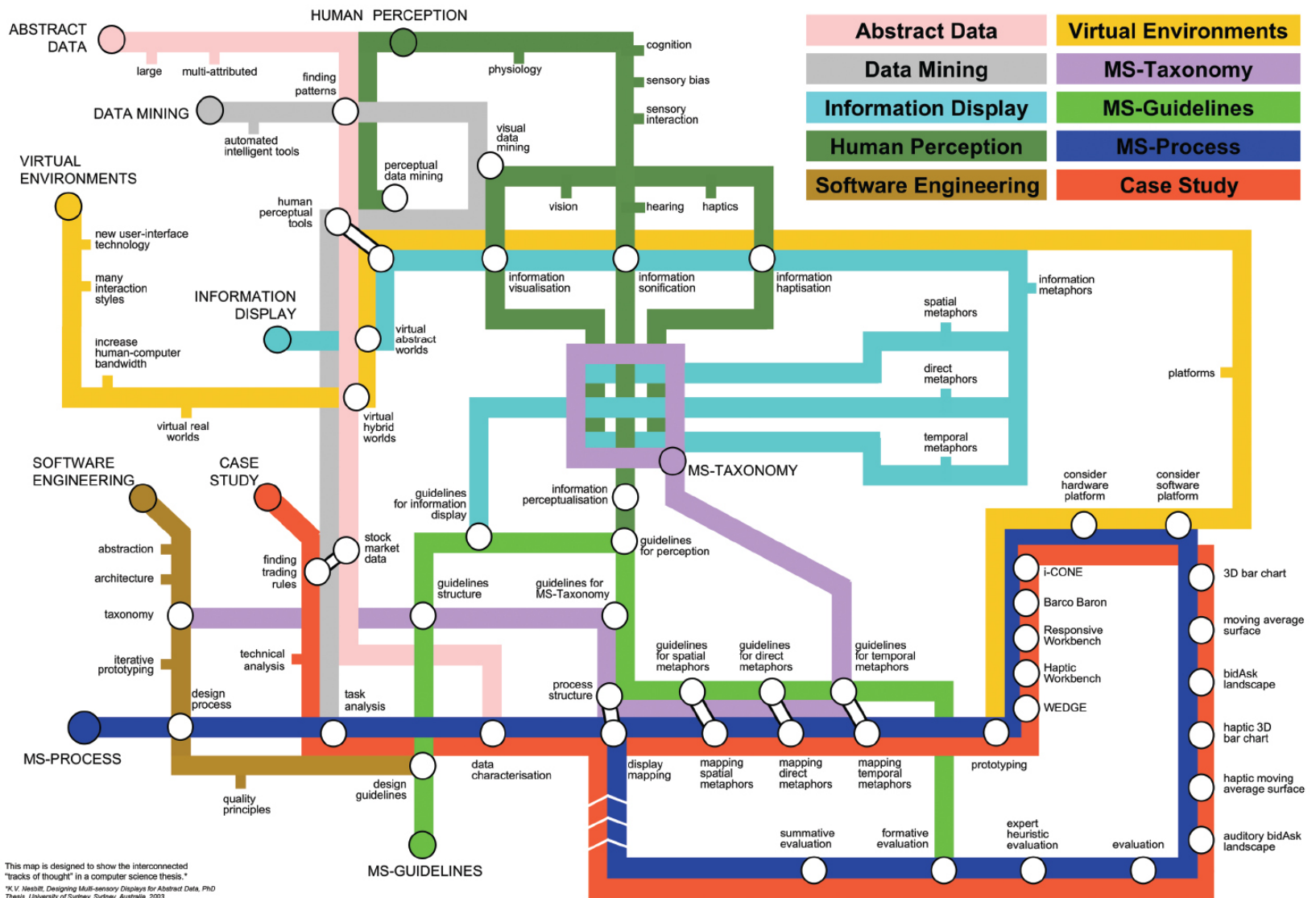
The model includes the worldwide air transportation network (source: IATA) composed of 3,100 airports in 220 countries and $E=17,182$ direct connections, each of them associated to the corresponding passenger flow. This dataset accounts for 99% of the worldwide traffic and is complemented by the census data of each large metropolitan area served by the corresponding airport.

Additional spreading scenarios can be obtained by modeling different levels of infectiousness of the virus, as expressed in terms of the reproductive number R_0 , representing the average number of infections generated by a sick person in a fully susceptible population.

Intervention



Intervention strategies modeling the use of antiviral drugs can be considered. Two scenarios are compared: an uncooperative strategy in which countries only use their own stockpiles, and a cooperative intervention which envisions a limited worldwide sharing of the resources.



Ph.D. Thesis Map - Keith B. Nesbitt - 2004

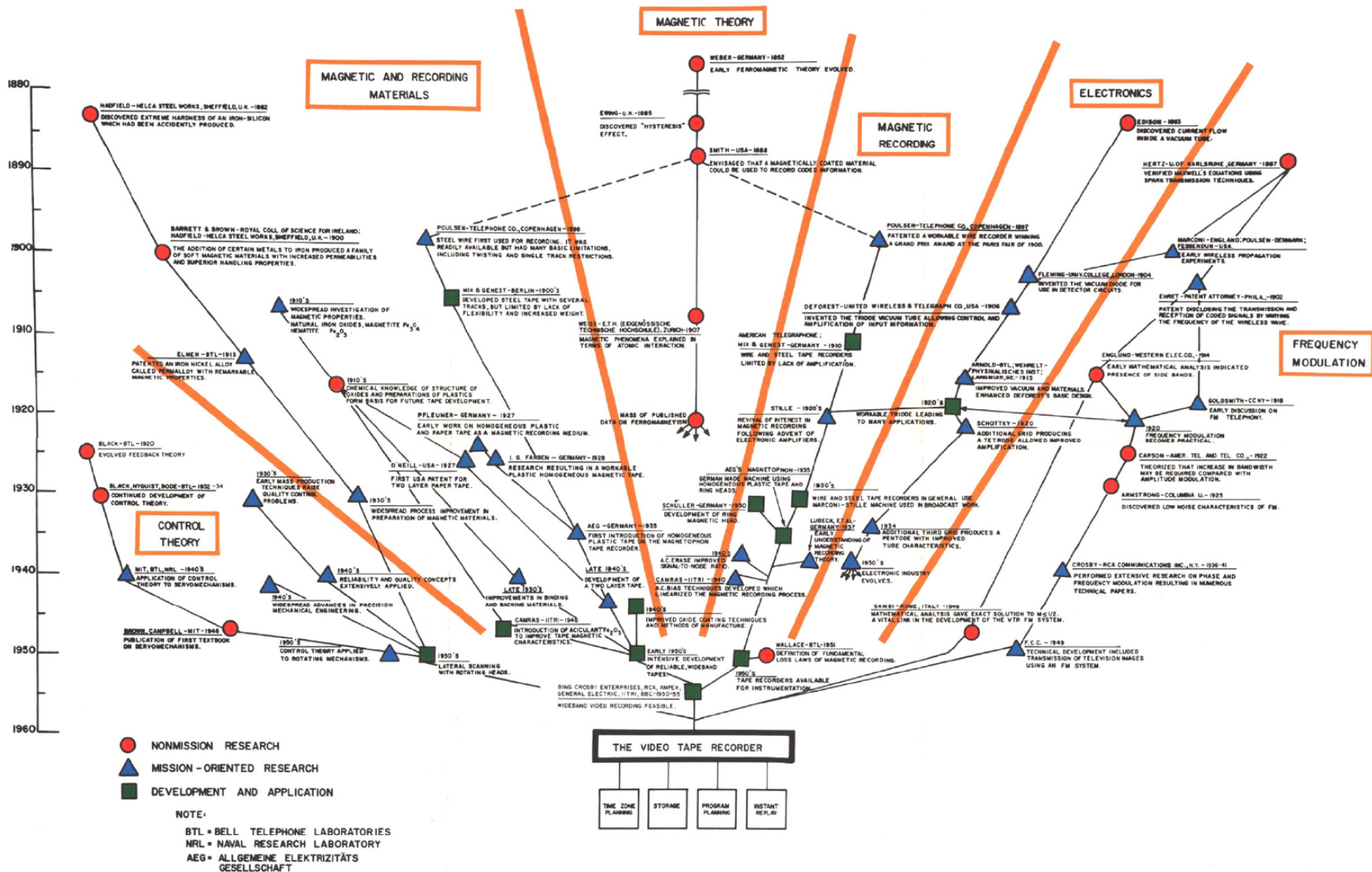


FIG. 7. THE VIDEO TAPE RECORDER

Tracing of Key Events in the Development of the Video Tape Recorder - Mr. G. Benn, Francis Narin - 1968

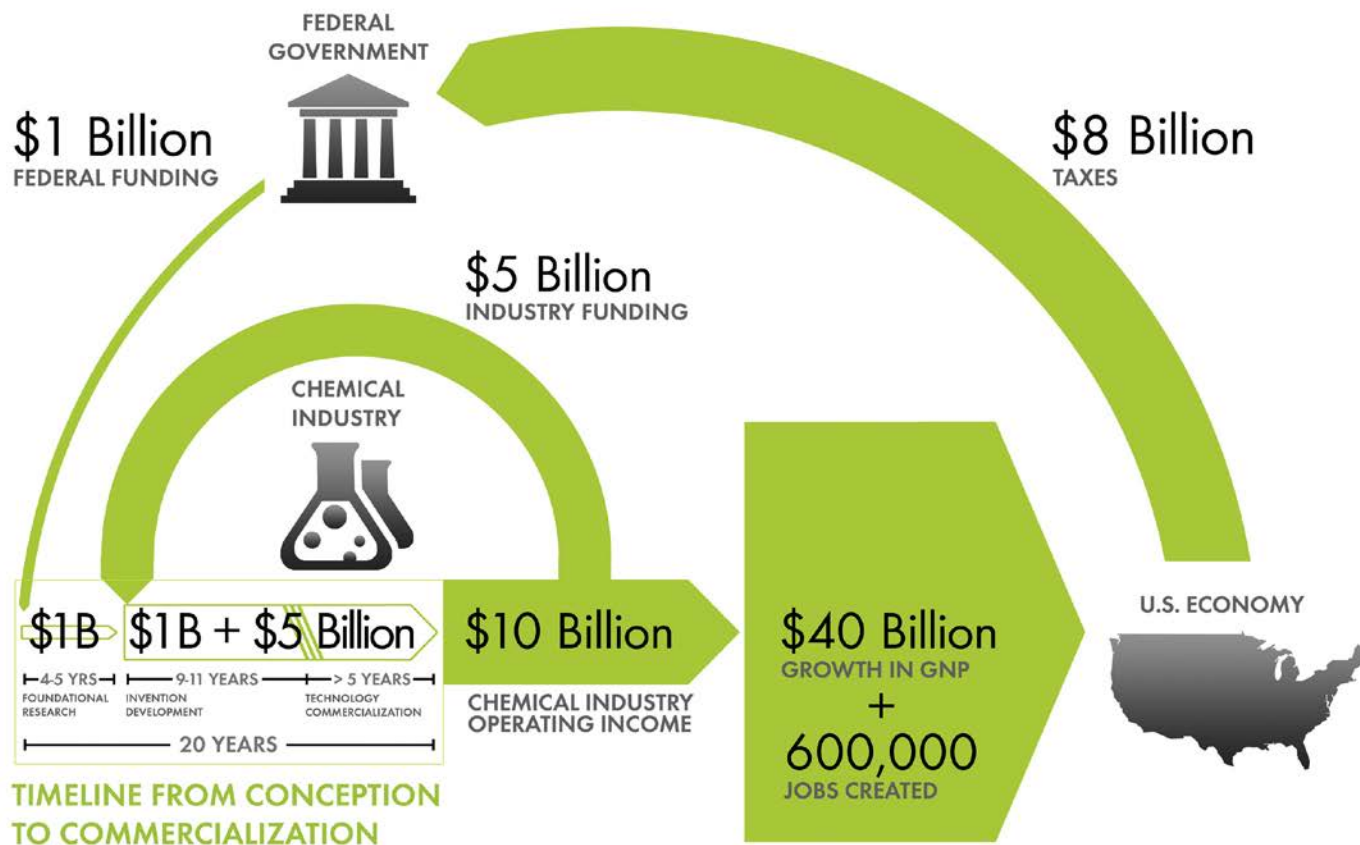
Chemical Research & Development Powers the U.S. Innovation Engine

Macroeconomic Implications of Public and Private R&D Investments in Chemical Sciences



has provided the U.S. Congress and government policy makers with important results regarding the impact of Federal Research & Development (R&D) investments on U.S. innovation and global competitiveness through its commissioned 5-year two phase study. To take full advantage of typically brief access to policy makers, CCR developed the graphic below as a communication tool that distills the complex data produced by these studies in direct, concise and clear terms.

INVESTMENT IN CHEMICAL SCIENCE R&D



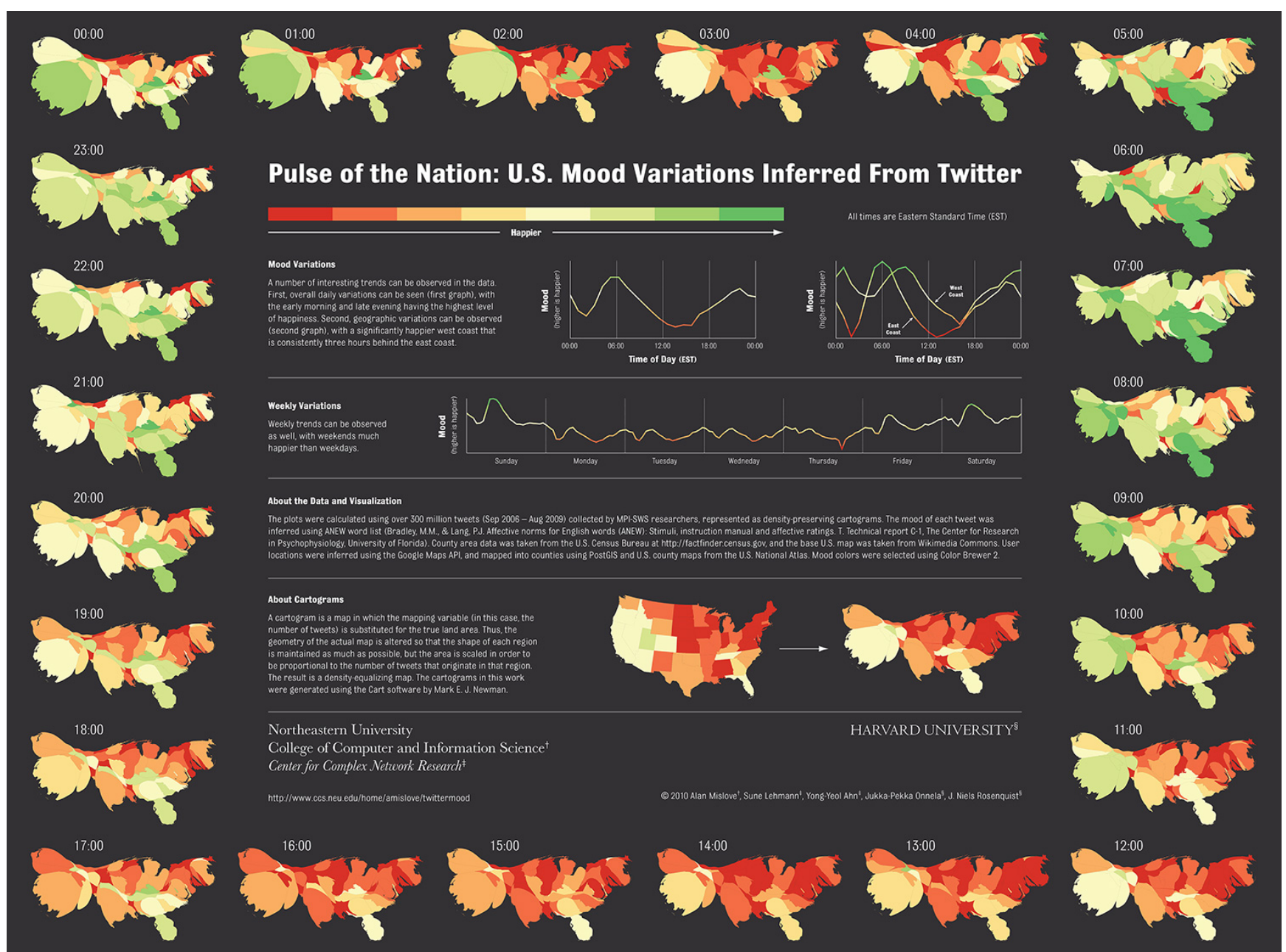
The design shows that an input of \$1B in federal investment, leveraged by \$5B industry investment, brings new technologies to market and results in \$10B of operating income for the chemical industry, \$40B growth in the Gross National Product (GNP) and further impacts the US economy by generating approximately 600,000 jobs, along with a return of \$8B in taxes. Additional details, also reported in the CCR studies, are depicted in the map to the left. This map clearly shows the two R&D investment cycles; the shorter industry investment at the innovation stage to commercialization cycle; and the longer federal investment cycle which begins in basic research and culminates in national economic and job growth along with the increase tax base that in turn is available for investment in basic research.



Maps that show

TRENDS

scimaps.org



Pulse of the Nation - Alan Mislove, Sune Lehmann, Yong-Yeol Ahn, Jukka-Pekka Onnela, and James Niels Rosenquist - 2010

The EMERGENCE of NANOTECHNOLOGY

MAPPING THE NANO REVOLUTION

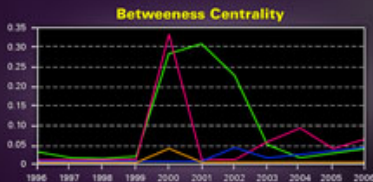
The emergence of nanotechnology has been one of the major scientific-technological revolutions in the last decade and it led to a structural reorganization of major fields of science. Price (1965) showed that fields of science and their development can be mapped using aggregated citations among the journals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



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.

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*.

LEGEND

- Science
- Nature
- Nanotechnology
- Nano Letters

Values



2003

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.

2002

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.

2000

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

2001

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

Macrosopes



PLACES
SPACES &
MAPPING SCIENCE

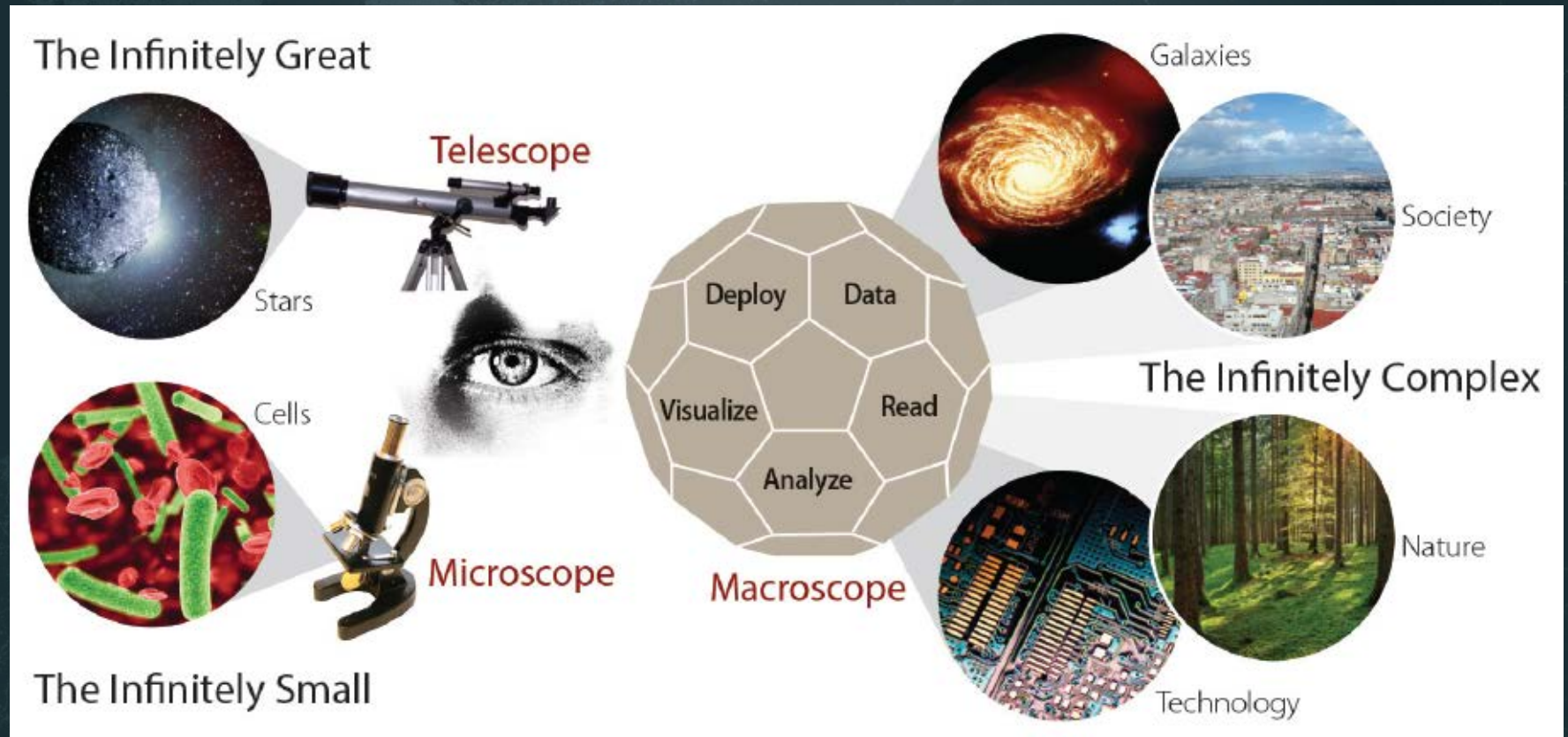
scimaps.org



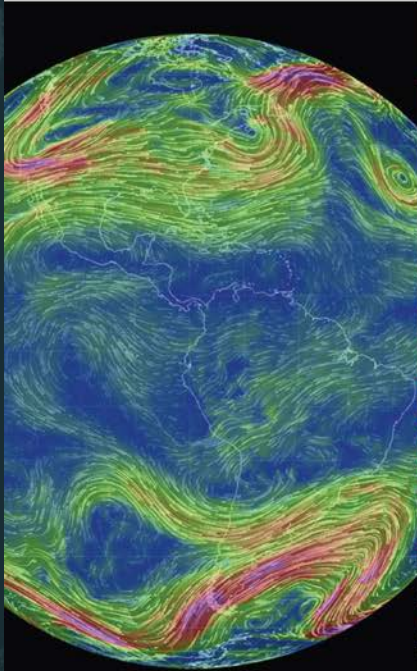
MAPS
vs.
MACROSCOPES



Microscopes & Telescopes vs. MACROSCOPES



i MACROSCOPES FOR INTERACTING WITH SCIENCE



Earth

Weather on a worldwide scale



AcademyScope

Exploring the scientific landscape



Mapping Global Society

Local news from a global perspective

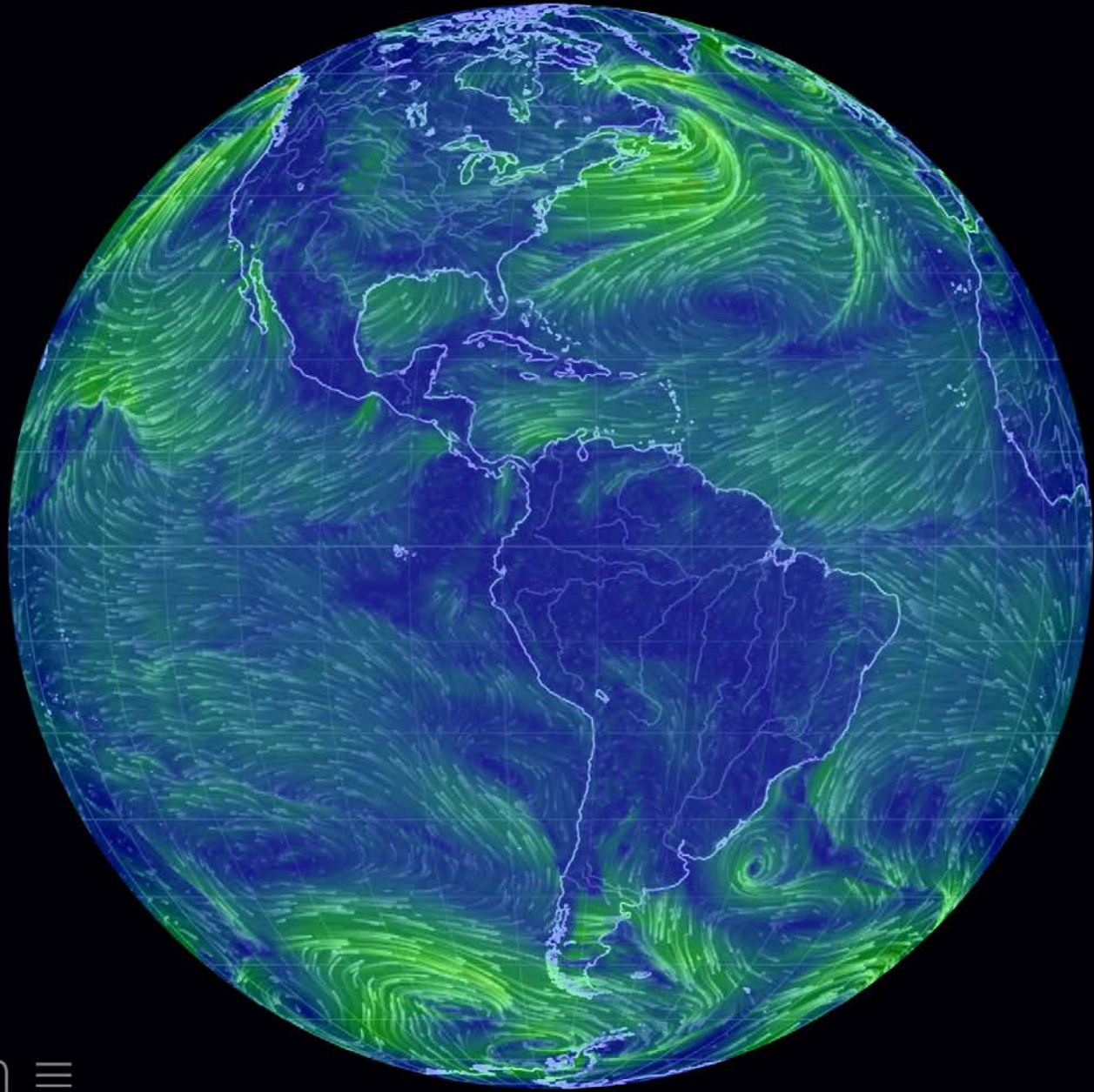


Charting Culture

2,600 years of human history in 5 minutes

Iteration XI (2015): Macroscopes for Interacting with Science

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



earth ≡

Earth – Cameron Beccario

The News Co-occurrence Globe

An interactive visualization of how countries are mentioned together in the world's news media

+ - UNITED KINGDOM SEARCH ABOUT



2.92K
COOCCUR%

UNITED KINGDOM cooccurrences in: 2,922%
cooccurrences out: 80%

Timeline: 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



COOCCUR

IN%

OUT%



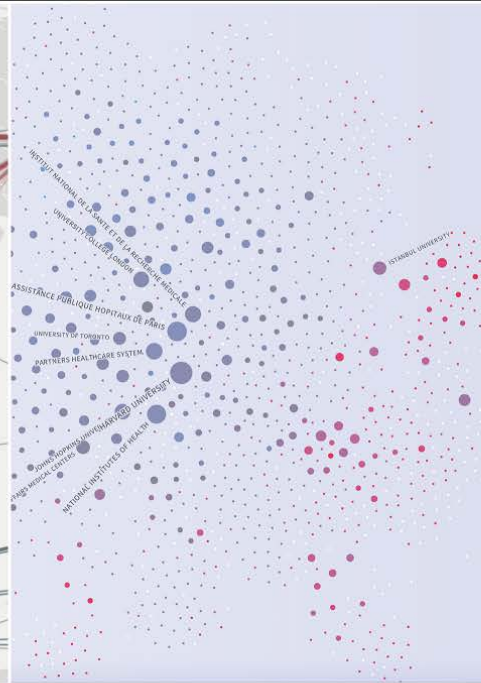
Smelly Maps

Charting urban smellscapes



HathiTrust

Storehouse of knowledge



Excellence Networks

Publish or perish together

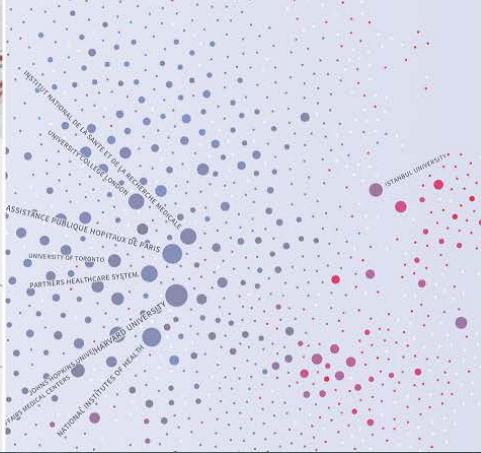


FleetMon Explorer

Tracking the seven seas

Iteration XII (2016): Macrosopes for Making Sense of Science

<http://scimaps.org/iteration/12>



Four new macrosopes debut at Vanderbilt University:

1. **Smelly Maps:** Features a “smellscape” of 12 cities mapped by smell using social media
2. **HathiTrust:** Highlights the diversity of publications collected in digital form by HathiTrust.
3. **Excellence Networks:** Compares how research institutions, such as Indiana and Vanderbilt universities, collaborate with one another.
4. **FleetMon:** Shows how the amount of shipping traffic that navigates the Strait of Malacca compared to other major shipping lanes of the world.

<http://scimaps.org/vanderbilt>



A visitor explores the macroscope kiosk at the Eskenazi Museum of Art at Indiana University.

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 is designed to open people's hearts and minds to the value, complexity, and beauty of maps of science and technology.

Drawing from across cultures and across scholarly disciplines, the *Places & Spaces: Mapping Science* exhibit demonstrates the

IVMOOC.cns.iu.edu



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scimaps.org



Register for free: <http://ivmooc.cns.iu.edu>. Class started Jan 10, 2017.

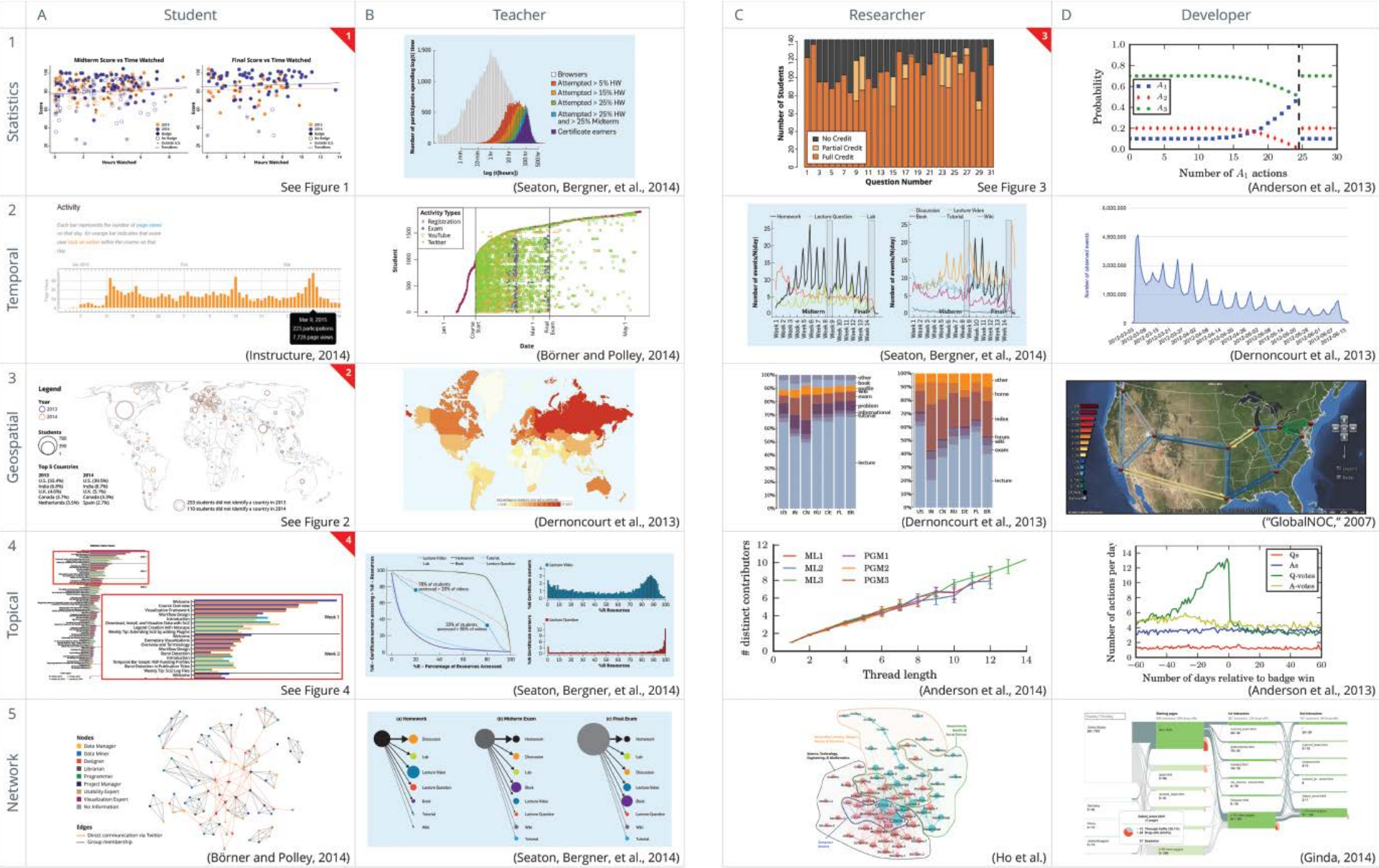


Figure 1: Analysis types vs. user needs, taken from

Emmons, Light, and Börner. "[MOOC Visual Analytics: Empowering Teachers, Students, Researchers, and Developers of Massively Open Online Courses](#)". *Journal of the Association for Information Science and Technology* (in press).

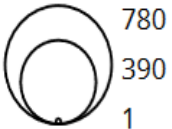
Students' Countries

Legend

Year



Students



Top 5 Countries

2013

U.S. (33.4%)

India (6.8%)

U.K. (4.6%)

Canada (3.7%)

Netherlands (3.5%)

2014

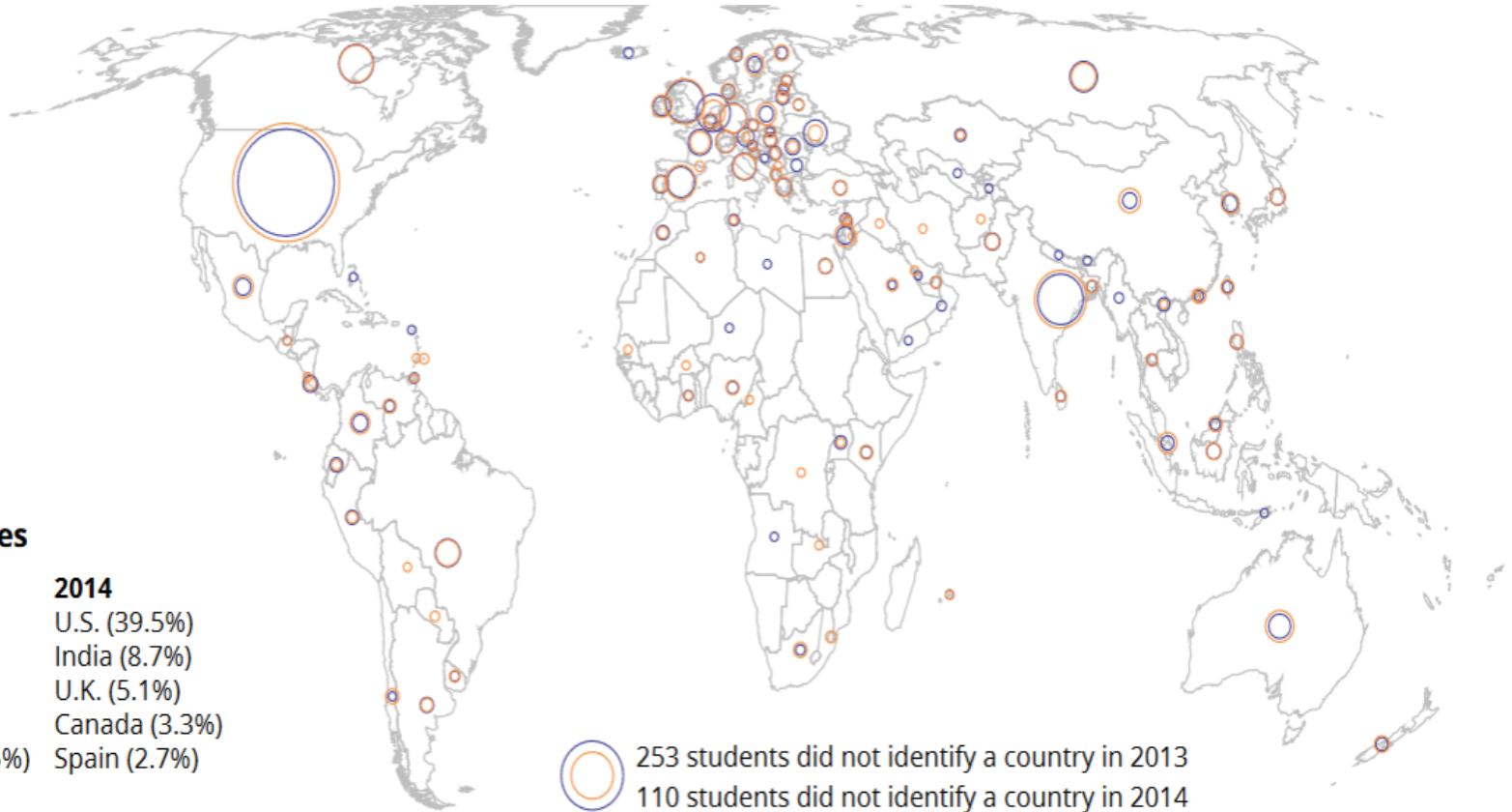
U.S. (39.5%)

India (8.7%)

U.K. (5.1%)

Canada (3.3%)

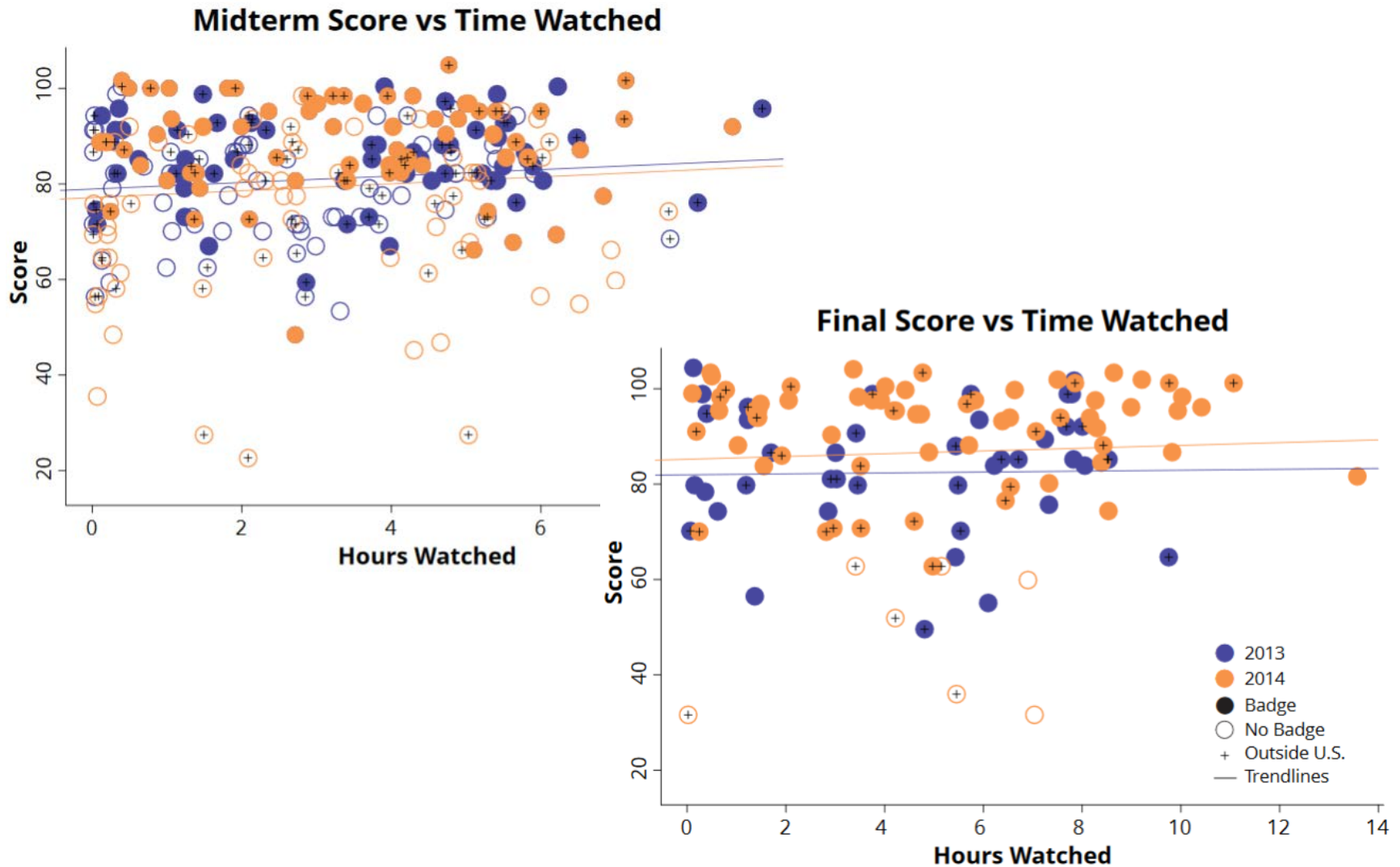
Spain (2.7%)



Proportional symbol map of the world showing the location of IVMOOC students from 2013 (blue) and 2014 (orange). Circles are area size coded by the number of students per country.

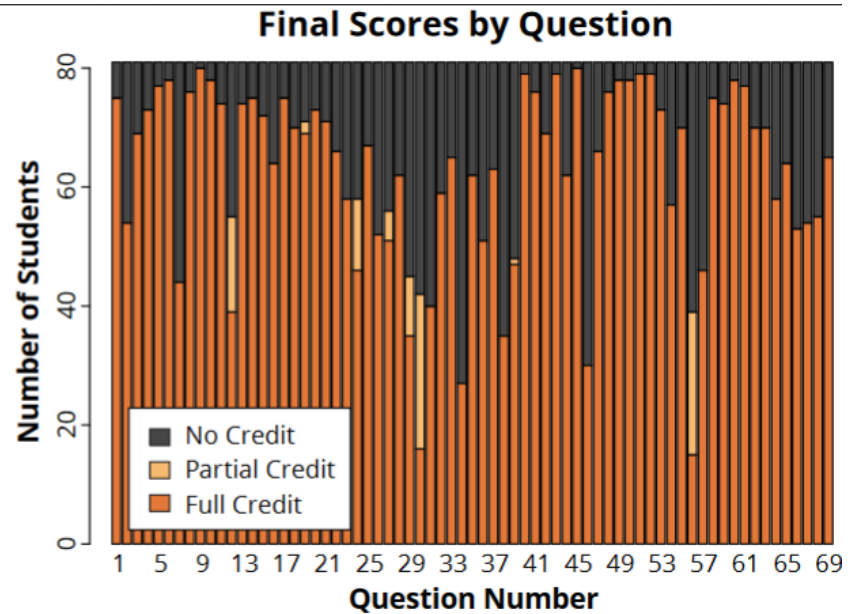
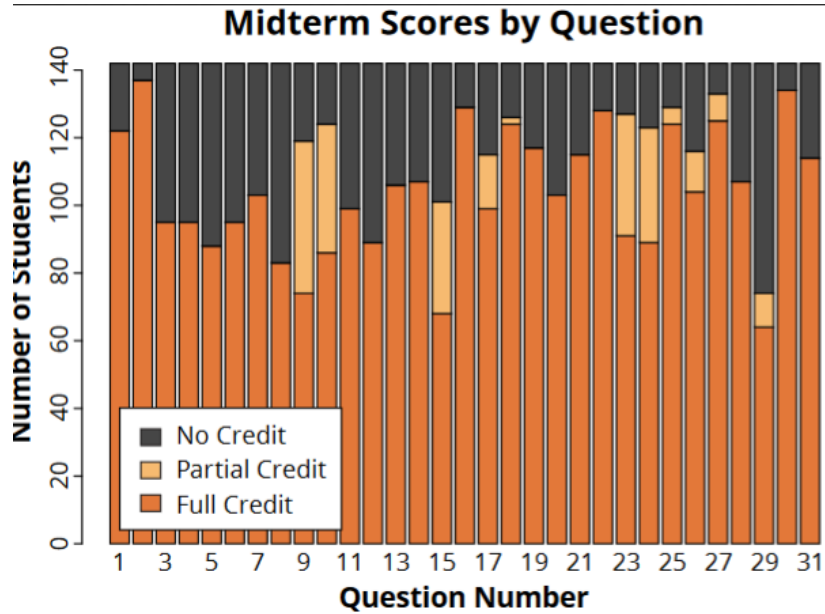


Student Final Score vs. Hours Watched

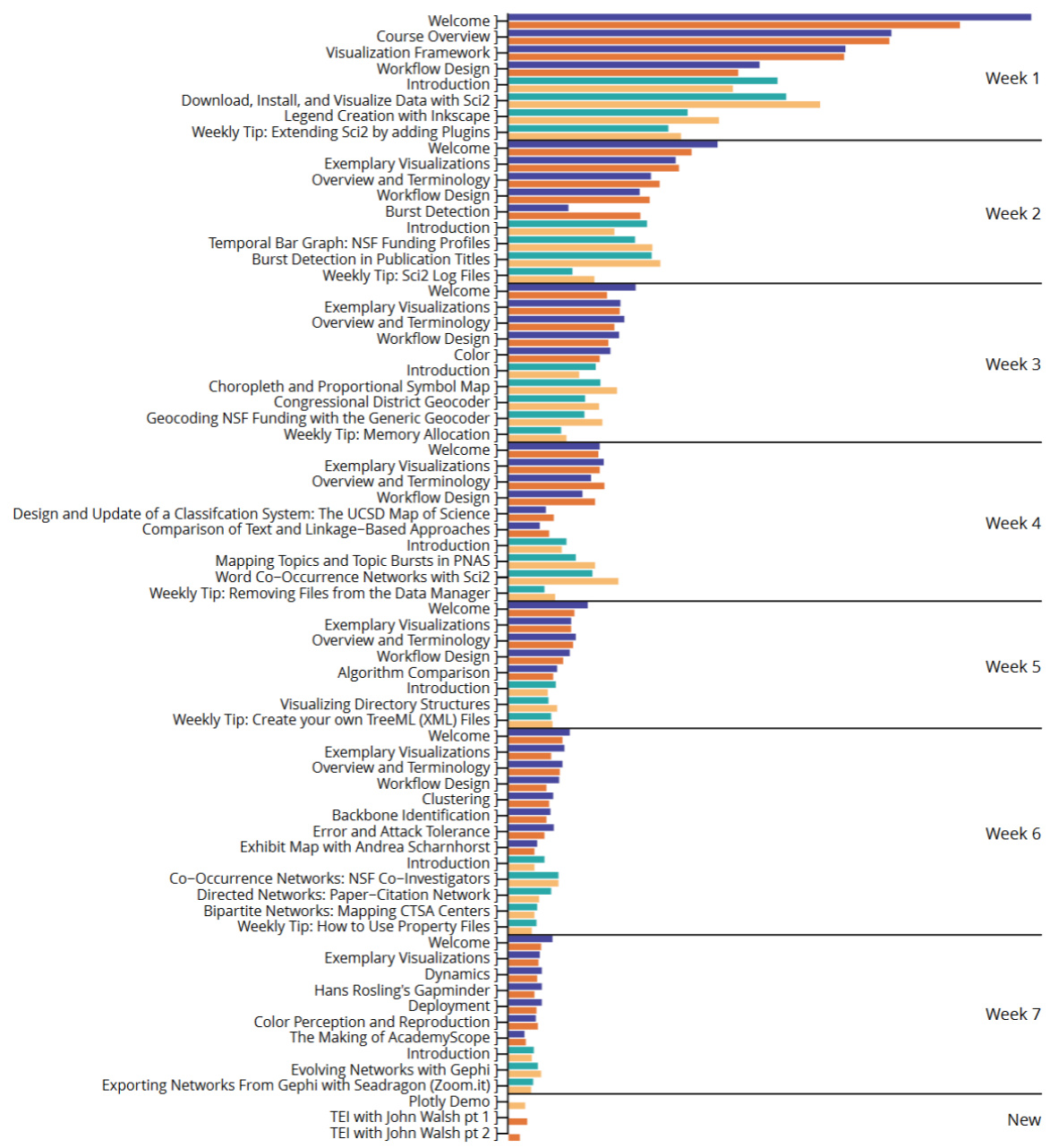


Scores vs. time invested watching course videos for students who took the 2013 (blue) and 2014 (orange) IVMOOC midterm (left) and final exam (right) and got at least 50% correct.

Exam Scores by Question

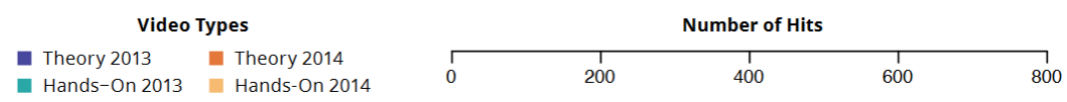


Student scores per question for midterm (left) and final exam (right) for IVMOOC 2014.



IVMOOC Video Views

IVMOOC video views in 2013 (blue) and 2014 (orange)





Student Client Projects: All Interactions



Student Engagement and Performance

Learning Analytics

IVMOOC 2015 Student Group Engagement and Scores

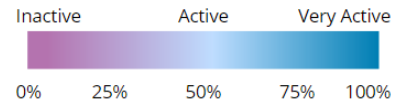
	Pre-Course	Week 1	Week 2	Week 3	Week 4	Midterm	Week 5	Week 6	Week 7	Week 8	Week 9	Final	Curr. Score
IVMOOC	26.05%	38.32%	31.32%	29.96%	27.1%	28.34%	31.07%	24.28%	16.86%	18.23%	13.08%	13.41%	20.87%
Z637-29374	33.01%	52.91%	49.89%	59.22%	50.89%	82.56%	65.04%	49.99%	39.59%	61.63%	54.91%	82.25%	82.4%
Z637-32593	25.08%	54.54%	43.58%	50.67%	53.63%	77.67%	65.7%	59.48%	52.19%	65.71%	47.27%	72.59%	75.13%
Z637-33781	29.33%	55.38%	49.26%	62.18%	77.47%	85%	87.4%	69.8%	55.56%	57.6%	45.69%	70.89%	77.94%

IVMOOC 2015 Student Group Engagement for Midterm

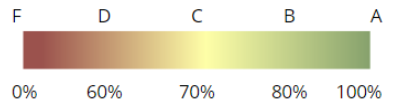
	Midterm	Final	Curr. Score	Overall Engagement
Student 198	100%	85.33%	92.67%	30.34%
Student 210	100%	84%	92%	33.91%
Student 242	97.14%	98.67%	97.9%	55.89%
Student 265	95.71%	92%	93.86%	82.64%
Student 216	95.71%	24%	59.86%	34.92%
Student 257	94.29%	98.67%	96.48%	68.25%
Student 264	94.29%	89.33%	91.81%	80.47%
Student 262	94.29%	85.33%	89.81%	79.65%

Legends

Engagement



Score

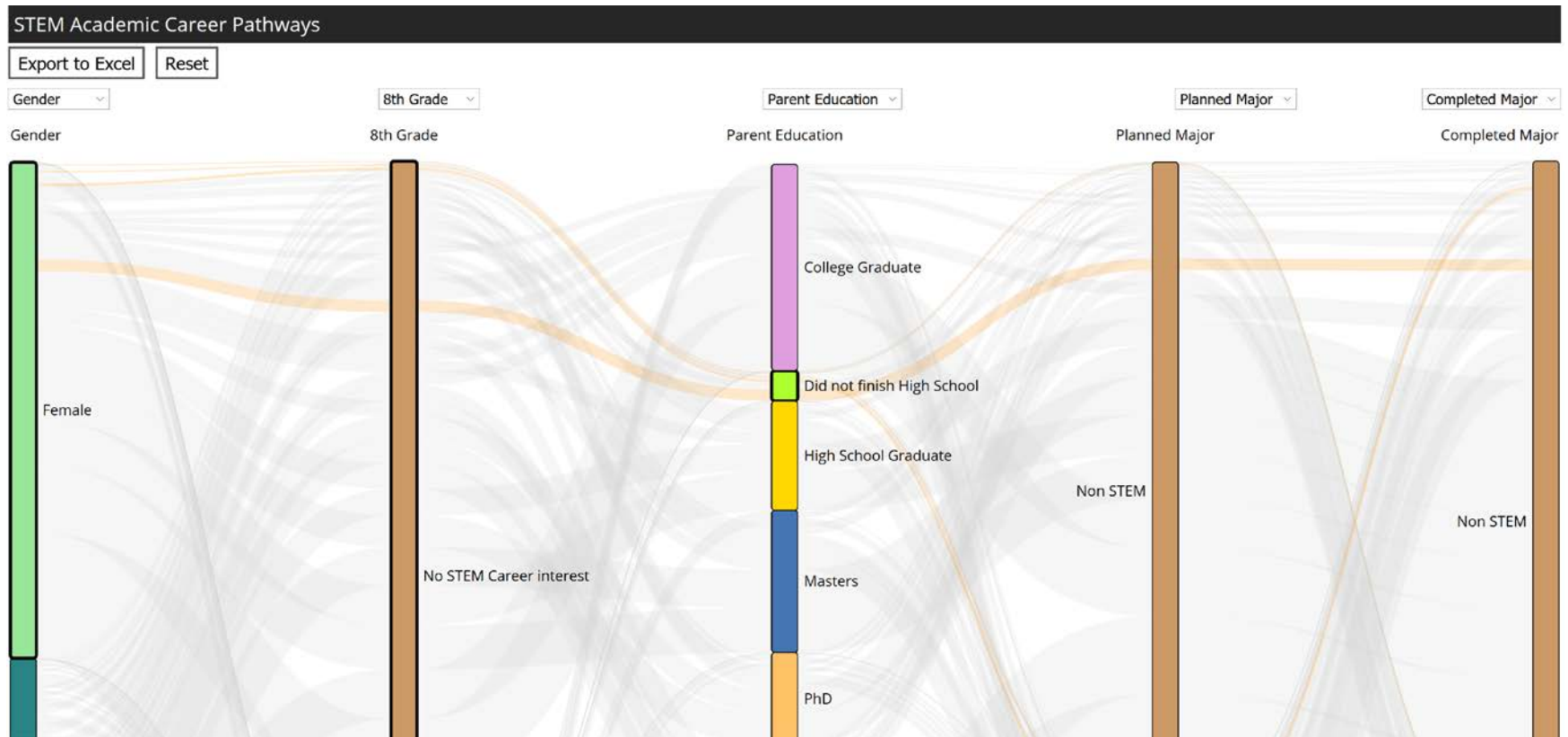


Description

The heat map visualization is a representation of student engagement (magenta to blue color scale) and performance (red to green color scale) throughout a course. The visualization has two levels. The top level provides an overview of engagement and performance for groups of students, while the bottom level provides a detailed break out of student engagement statistics for individuals with an identified group.

Custom interactive visualizations of 2015 IVMOOC student engagement and performance data, explore functionality online at <http://goo.gl/TYixCn>

Student Flows – STEM Academic Career Pathways



Measuring and Visualizing STEM Pathways. NSF NCSE-1538763 Award (Adam Maltese, Katy Börner) Aug. 15, 2015 - Jan. 2017.

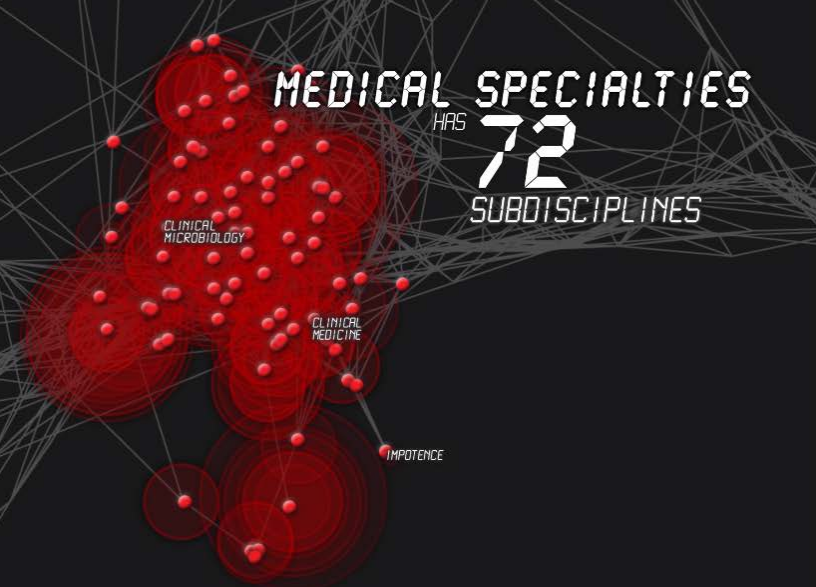
Interactive web site: <http://demo.cns.iu.edu/client/stem>

Forecasting S&T

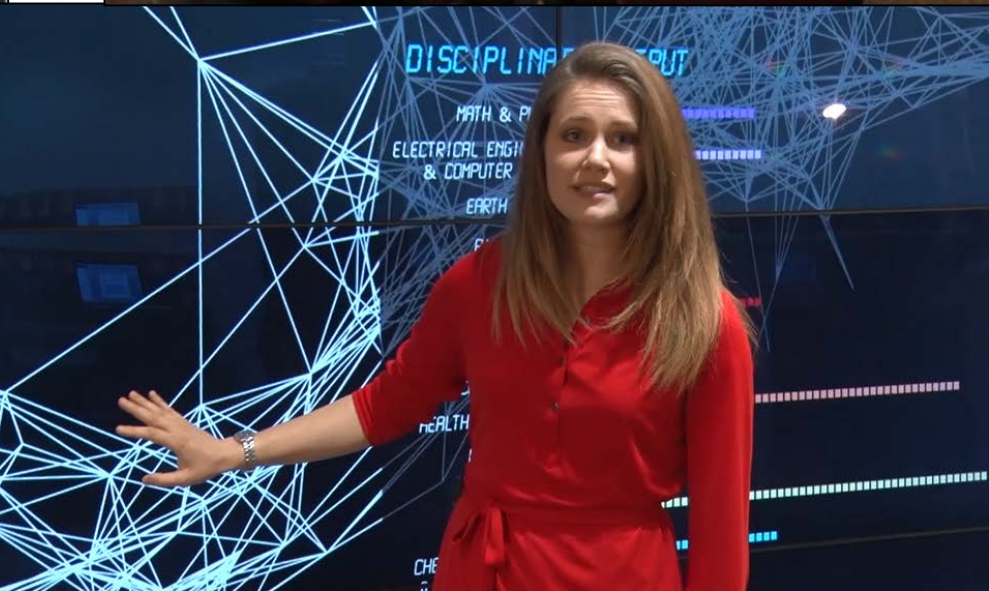


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Science Forecast S1:E1, 2015





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>





- PROGRAMS**
- Awards
- Koshland Science Museum
- Cultural Programs
- Sackler Colloquia**
 - » About Sackler Colloquia
 - » Upcoming Colloquia
 - » Completed Colloquia
 - » Video Gallery
 - » Connect with Sackler Colloquia
 - » Give to Sackler Colloquia
- Kavli Frontiers of Science
- Distinctive Voices



Upcoming Colloquia

Unless otherwise indicated, most Sackler colloquia are held at the Arnold and Mabel Beckman Center, in Irvine, California.

Reproducibility of Research: Issues and Proposed Remedies

March 8-10, 2017; Washington, D.C.
Organized by David B. Allison, Richard Shiffrin and Victoria Stodden
Registration now open

Science of Science Communication III

November 15-16, 2017; Washington, D.C.
Organized by Karen Cook, Baruch Fischhoff, Alan I. Leshner and Dietram A. Scheufele
Registration will open May 2017

Modelling and Visualizing Science and Technology Developments

December 4-5, 2017; Irvine, CA
Organized by Katy Börner, William Rouse and H. Eugene Stanley
Registration will open August 2017

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

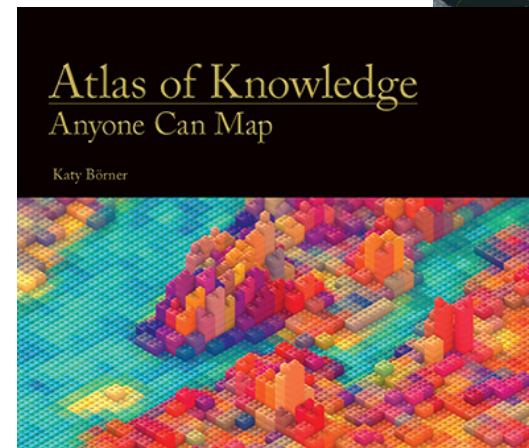
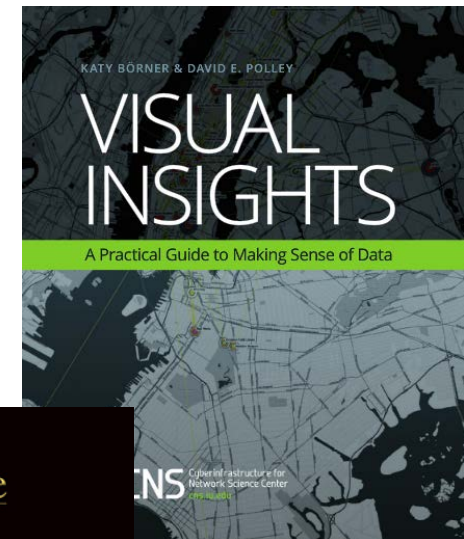
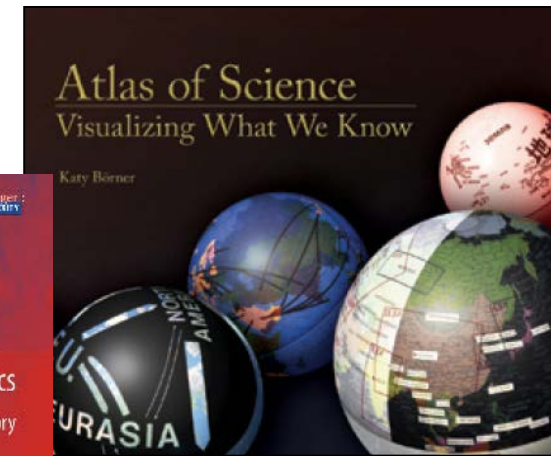
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Katy Börner, Michael Conlon, Jon Corson-Rikert, Cornell, Ying Ding (2012) **VIVO: A Semantic Approach to Scholarly Networking and Discovery**. Morgan & Claypool.

Katy Börner and David E Polley (2014) **Visual Insights: A Practical Guide to Making Sense of Data**. The MIT Press.

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






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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

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