



PLACES
SPACES &
MAPPING SCIENCE

scimaps.org

Maps & Macroscopes

Digital Studies of Digital Science

March 15–18, 2021

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



Photos from "Earth from Above" by Yann Arthus-Bertrand



I.1 Cosmographia World Map – Claudius Ptolemy - 1482

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.

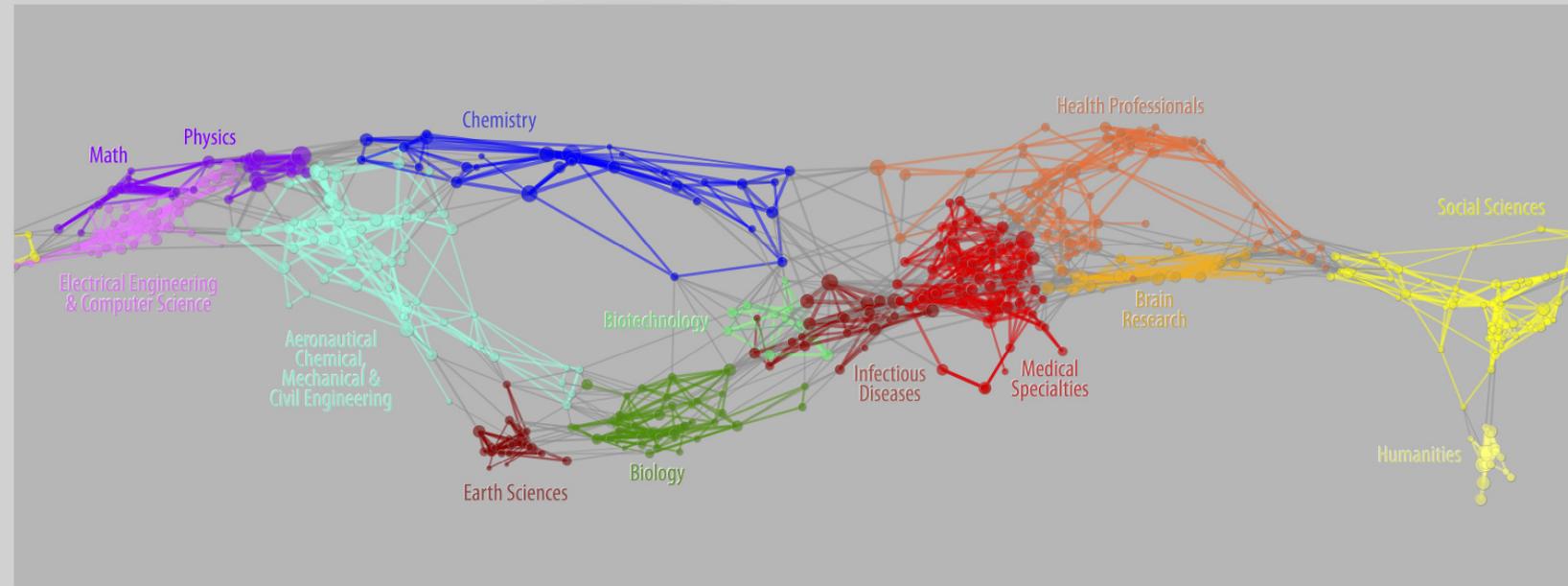
The six map projections shown at the bottom are images of what one would see if looking directly down at the south pole of the map, at six different rotations. When viewed this way, the map looks like a wheel with an inner ring and outer ring. This wheel of science corresponds very closely with the two-dimensional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

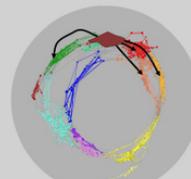
Six stories, representing how the structure is likely to change, are provided below. Maps with white arrows represent instances of distant fields that are likely to be pulled closer to each other in the future. Maps with dark arrows represent fields that are currently close-knit, that are likely to become 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.



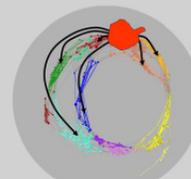
Electrical Engineering & Computer Science (EE/CS), indicated by the pink shape in the view above, is a field whose connectedness has been increasing much more quickly (15%) than expected. Connectedness has increased between EE/CS and all other fields from 2001-2005. The connections with the largest annual 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.



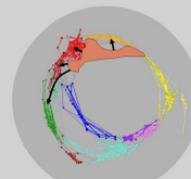
Biotechnology, indicated by the light green shape above, has the largest overall increase in connectedness with other fields (16%). It has relatively few connections with the EE/CS, Math & Physics, and Social Sciences fields, but these three connections had the largest fractional increase. The connection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



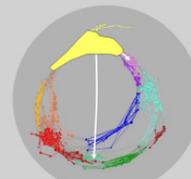
Infectious Diseases, indicated by the dark red shape above, has an overall decrease in connectedness (2%) with other fields. Decreases in connection strength between this field and the fields of Biology, Medical Specialties, Health Professionals and Brain Research (all >3%) are shown as black arrows,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



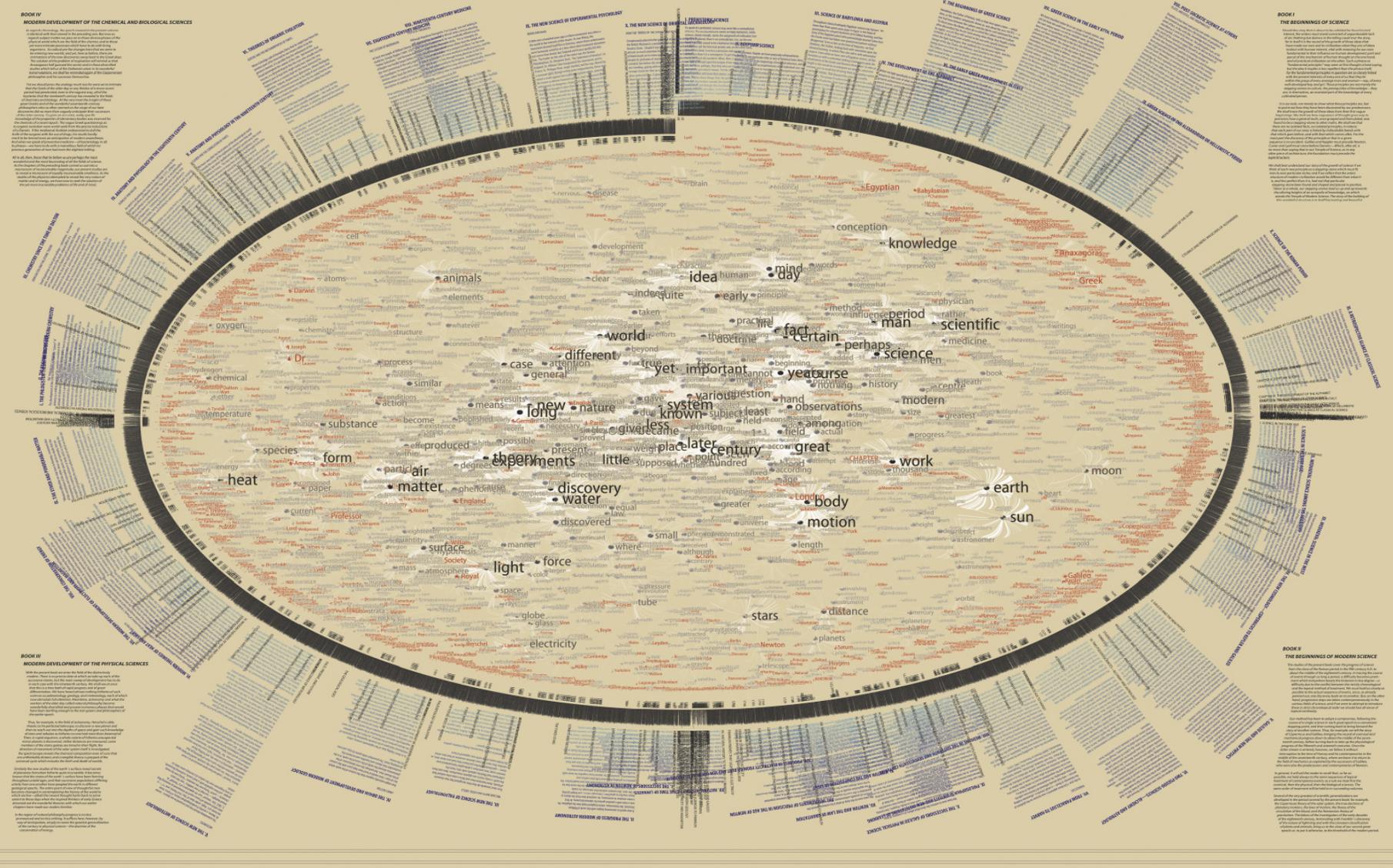
The **Social Sciences**, indicated by the yellow shape above, had an overall increase in connectedness (9%) with other fields. Although its greatest connectedness gains were with EE/CS and Biotechnology (see white arrows), it also had consistent connection increases with nearly all the other fields.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

A NEW MAP OF THE HISTORY OF SCIENCE

Being a Treatise of volumes I-IV of A History of Science by Henry Smith Williams, M.D., LL.D., edited by Edward H. Williams, M.D.
Texts arranged in order of their frequency in the text. Words are color-coded by their frequency in each volume. The size of the words is proportional to their average position—i.e. if a word has been pulled toward every page, it will be larger than a word that has been pulled toward only one page.

Words are color-coded by volume. Words are larger and darker the more they are used. This particular text has been arranged in order of their frequency in the text. Words are color-coded by their frequency in each volume. The size of the words is proportional to their average position—i.e. if a word has been pulled toward every page, it will be larger than a word that has been pulled toward only one page.



II.7 TextArc Visualization of The History of Science - W. Bradford Paley - 2006

Check out our **Zoom Maps** online!

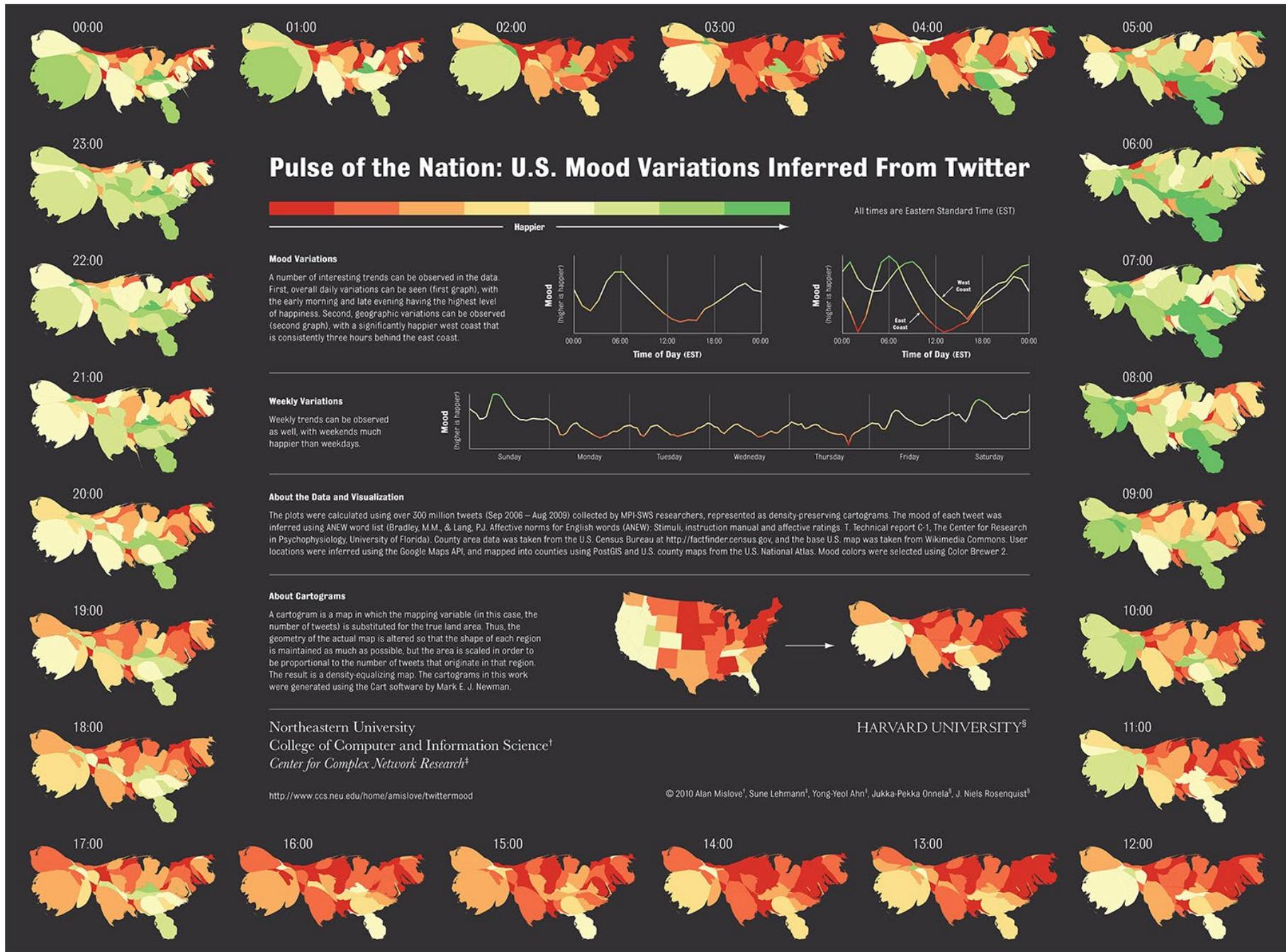
VII.10
History of Science Fiction, by Ward Shelley

BROOKLYN, NY, 2011
Courtesy of Ward Shelley Studios

Ward Shelley is an artist identified with the Williamsburg scene in Brooklyn, New York, who has been writing and illustrating about art and culture. This map plots the science fiction literary genre from its nascence in the late 18th century, emerging out of the data, here the narrative structure precedes and organizes the data. The map is a complex web of interconnected nodes and lines, representing the evolution of science fiction literature. It includes various sub-genres like 'FANTASY ADVENTURE', 'SCIENCE ADVENTURE', 'SPACE OPERA', and 'CYBER PUNK'. Key authors and works are highlighted, such as Mary Shelley's 'Frankenstein', Jules Verne's 'The Steam Engine', and Victor Hugo's 'The Hunchback of Notre Dame'. The map is presented in a zoomed-in view with a navigation interface on the left side.

PLACES & SPACES & THINGS

Visit scimaps.org and check out all our maps in stunning detail!



IX.4 Pulse of the Nation - Alan Mislove, Sune Lehmann, Yong-Yeol Ahn, Jukka-Pekka Onnela, and James Niels Rosenquist - 2010



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



101st Annual Meeting of the Association of American Geographers, Denver, CO.
April 5th - 9th, 2005 (First showing of Places & Spaces)



University of Miami, Miami, FL.
September 4 - December 11, 2014.



Duke University, Durham, NC.
January 12 - April 10, 2015

<http://scimaps.org>

The David J. Sencer CDC Museum, Atlanta, GA.
January 25 - June 17, 2016.



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



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

Exhibit Curators



Lisel Record, Katy Börner, and Todd Theriault; Linnea Holt (not pictured)



Advisory Board

The pieces that make up the *Places & Spaces* exhibit are chosen annually in a process that begins with a call for submissions. Then, the team of international reviewers and exhibit advisors shown below work with the Indiana University exhibit team to select the most stunning and innovative submissions. The Indiana University exhibit team benefits greatly from the expert input it receives from this international advisory board.



Gary Berg-Cross

Cognitive psychologist (PhD, SUNY–Stony Brook). Potomac, MD, USA



Lev Manovich

Professor, [The Graduate Center](#), City University of New York; Director, [Software Studies Initiative](#) (big data, digital humanities, visualization)



Donna J. Cox, MFA, Ph.D.

Director of the [Advanced Visualization Laboratory](#) at the National Center for Supercomputing Applications, University of Illinois at Urbana-Champaign, IL, USA



Elijah Meeks

Senior Data Visualization Engineer at [Netflix](#), Los Gatos, CA, USA



Bonnie DeVarco

[Media X](#) Distinguished Visiting Scholar at Stanford University, Palo Alto, CA, USA



André Skupin

Associate Professor of Geography at San Diego State University, California



Ingo Günther

Professor at the [Karlsruhe University of Art and Design](#), Karlsruhe, Germany



Olga Subirós

Curator of Big Bang Data and Founder of [Olga Subirós Studio](#) in Barcelona, Spain



Peter A. Hook

Head of Digital and Scholarly Services and LawArXiv Administrator, Cornell Law Library. Ithaca, NY, USA



Stephen Uzzo

Vice President of Science and Technology for the [New York Hall of Science](#)



Francis Harvey

Professor of Visual Communication in Geography at the Leibnitz Institute for Regional Geography, Leipzig University, Germany



Benjamin Wiederkehr

Founding Partner and Managing Director of [Interactive Things](#) in Zürich, Switzerland

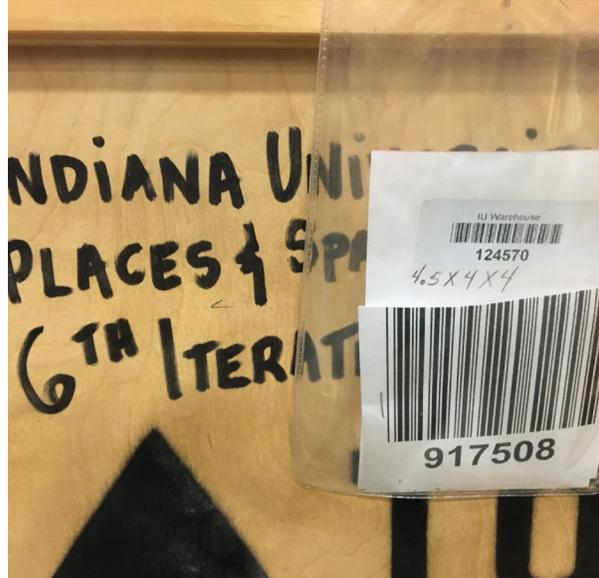
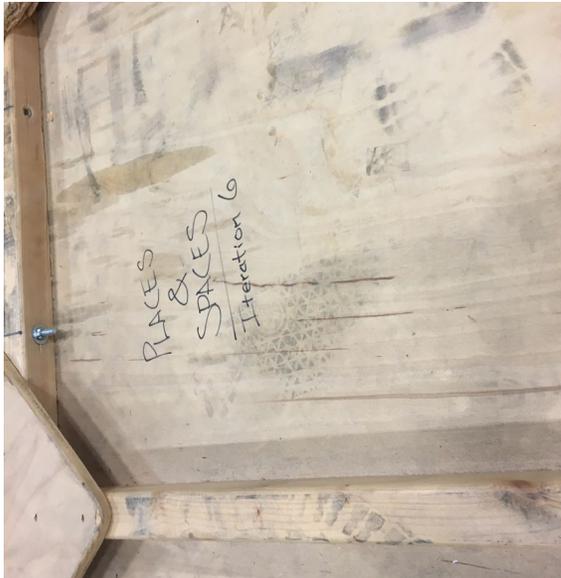




Exhibit Advisors
and Ambassadors

Places & Spaces: Mapping Science Exhibit

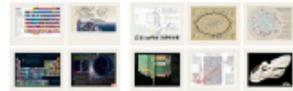
1st Decade (2005-2014)

Maps

Iteration I (2005)
The Power of Maps



Iteration II (2006)
The Power of Reference Systems



Iteration III (2007)
The Power of Forecasts



Iteration IV (2008)
Science Maps for Economic Decision Makers



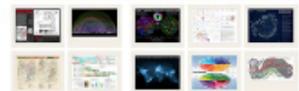
Iteration V (2009)
Science Maps for Science Policy Makers



Iteration VI (2010)
Science Maps for Scholars



Iteration VII (2011)
Science Maps as Visual Interfaces to Digital Libraries



Iteration VIII (2012)
Science Maps for Kids



Iteration IX (2013)
Science Maps Showing Trends and Dynamics



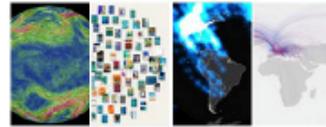
Iteration X (2014)
The Future of Science Mapping



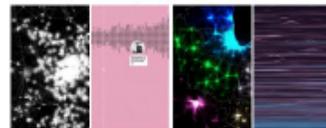
2nd Decade (2015-2024)

Macroscopes

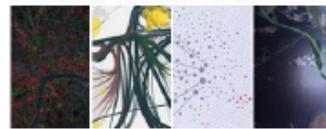
Iteration XI (2015)
Macroscopes for Interacting with Science



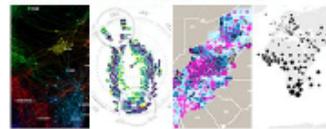
Iteration XIII (2017)
Macroscopes for Playing with Scale



Iteration XII (2016)
Macroscopes for Making Sense of Science



Iteration XIV (2018)
Macroscopes for Ensuring our Well-being



100

MAPS
in large format, full color, and
high resolution.

49



MACROSCOPE MAKERS
including one whose job title is
"Truth and Beauty Operator."

396

DISPLAY VENUES
from the Cannes Film Festival
to the World Economic Forum.

36



**WORKSHOPS
ORGANIZED**

215



MAPMAKERS
from fields as disparate as art,
urban planning, engineering,
and the history of science.

20

MACROSCOPES
for touching all kinds of data.

221



PRESS ITEMS
including articles in *Nature*,
Science, *USA Today*, and *Wired*.

6,086,047

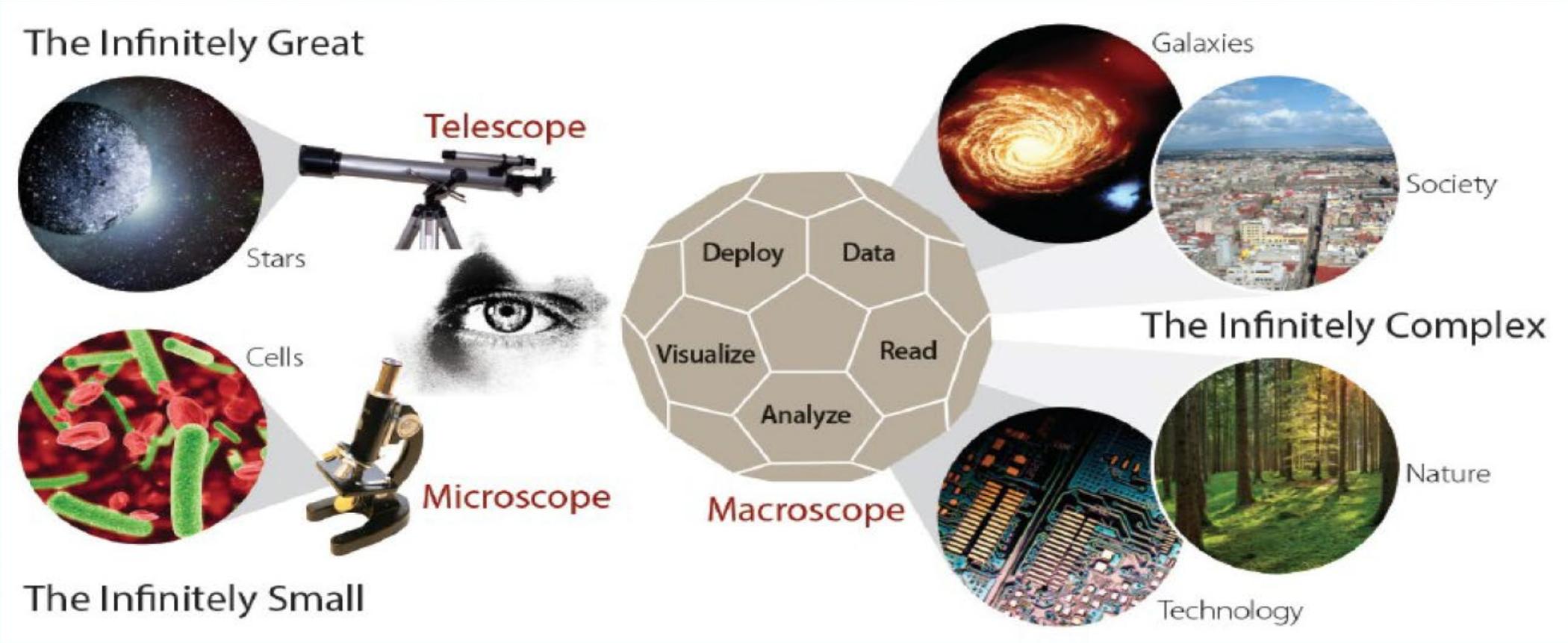
WEBSITE VISITS

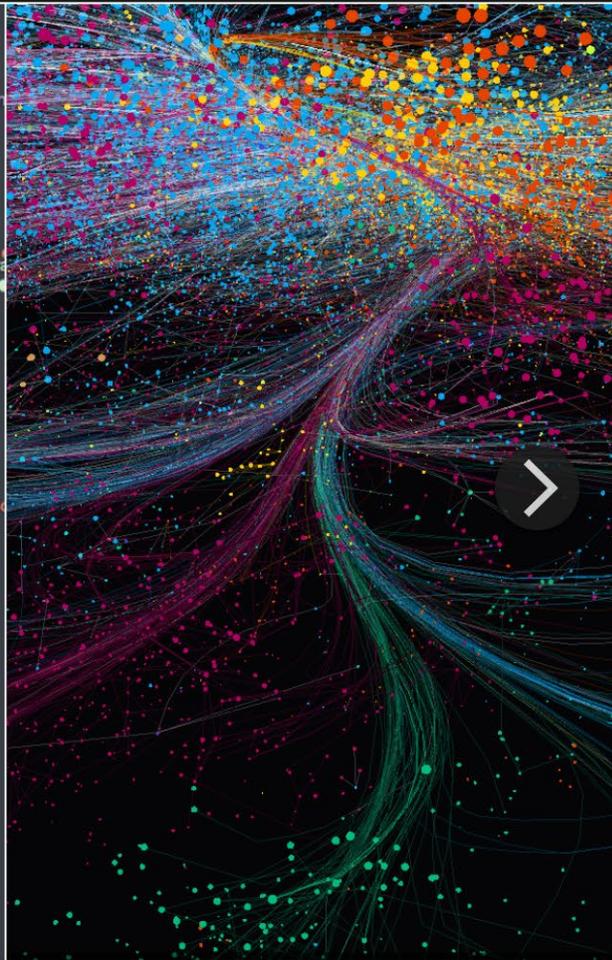
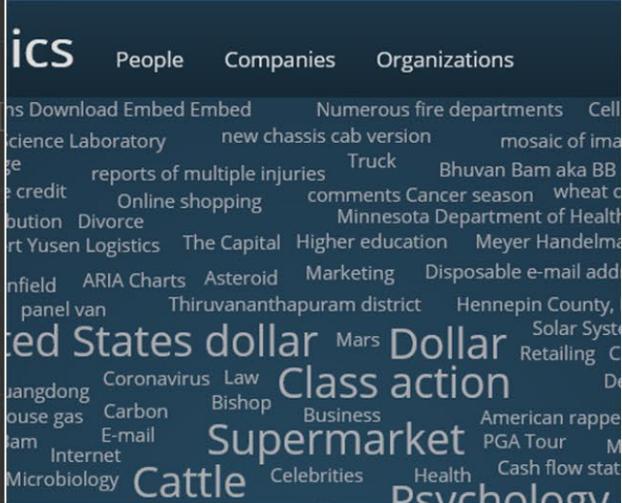


MAPS
vs.
MACROSCOPES



Microscopes & Telescopes vs. MACROSCOPES





United States Water Crisis

And how to reverse it

Watson News Explorer

Converting news into networks

An Alternative Data Driven Country Map

Using data to redraw the map

Nature 150

A network of influence