PLACES & SPACES

MAPPING SCIENCE

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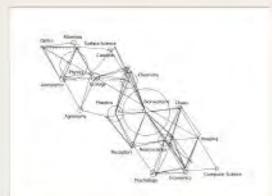
Iteration I (2005)

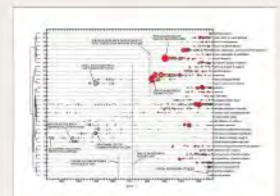
The Power of Maps

I.1

I.3



I.5



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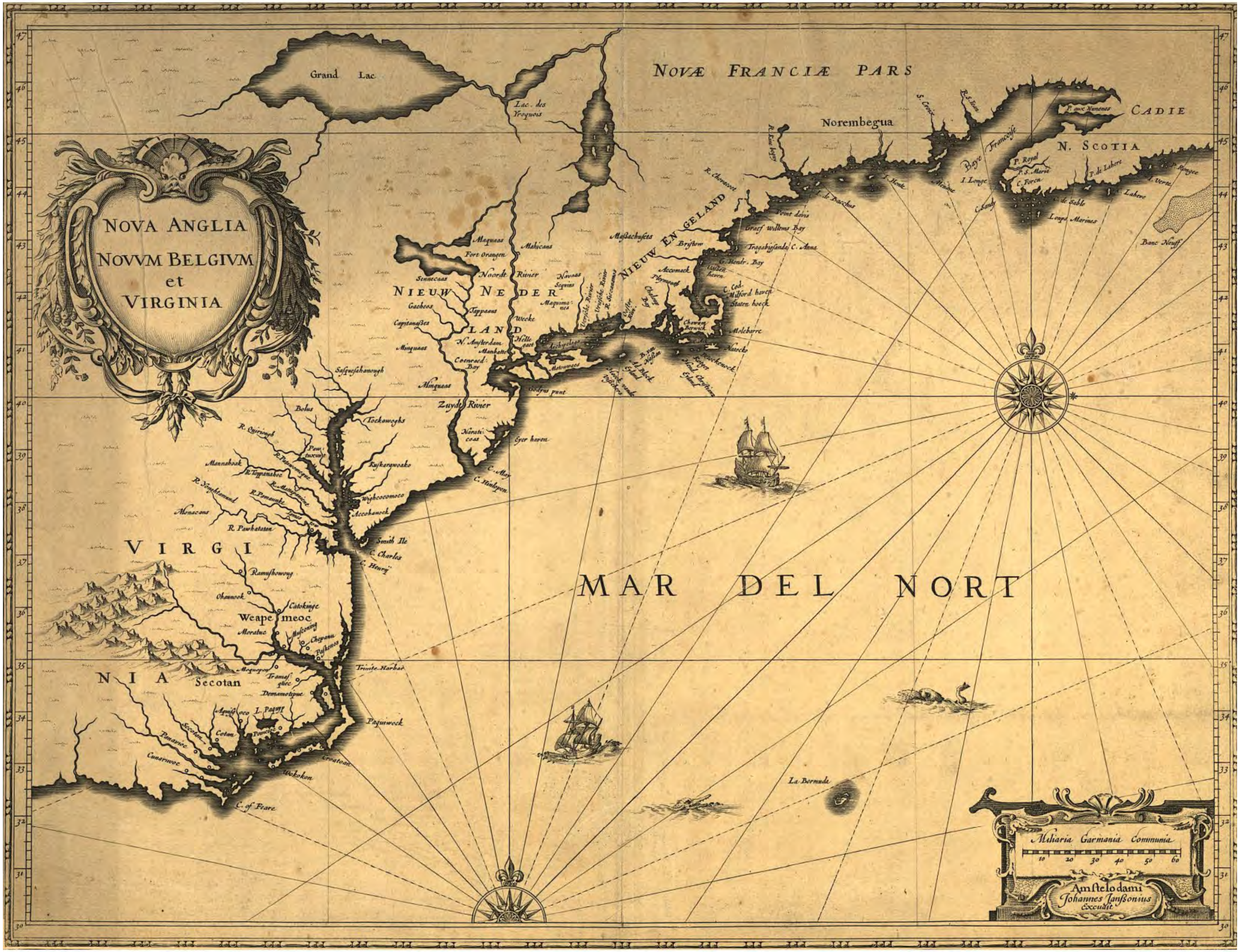
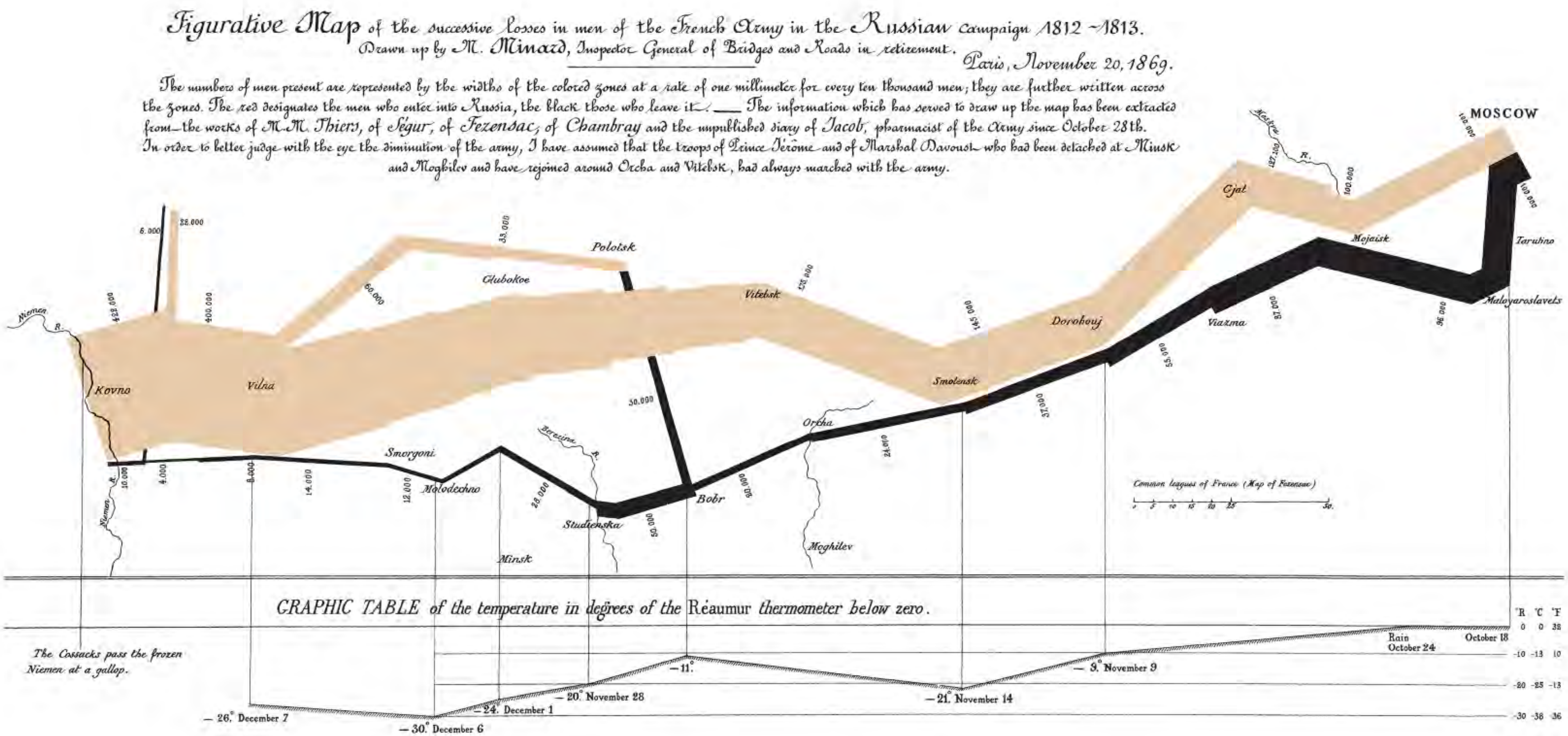
I.1 *Cosmographia World Map* – Claudius Ptolemy - 1482

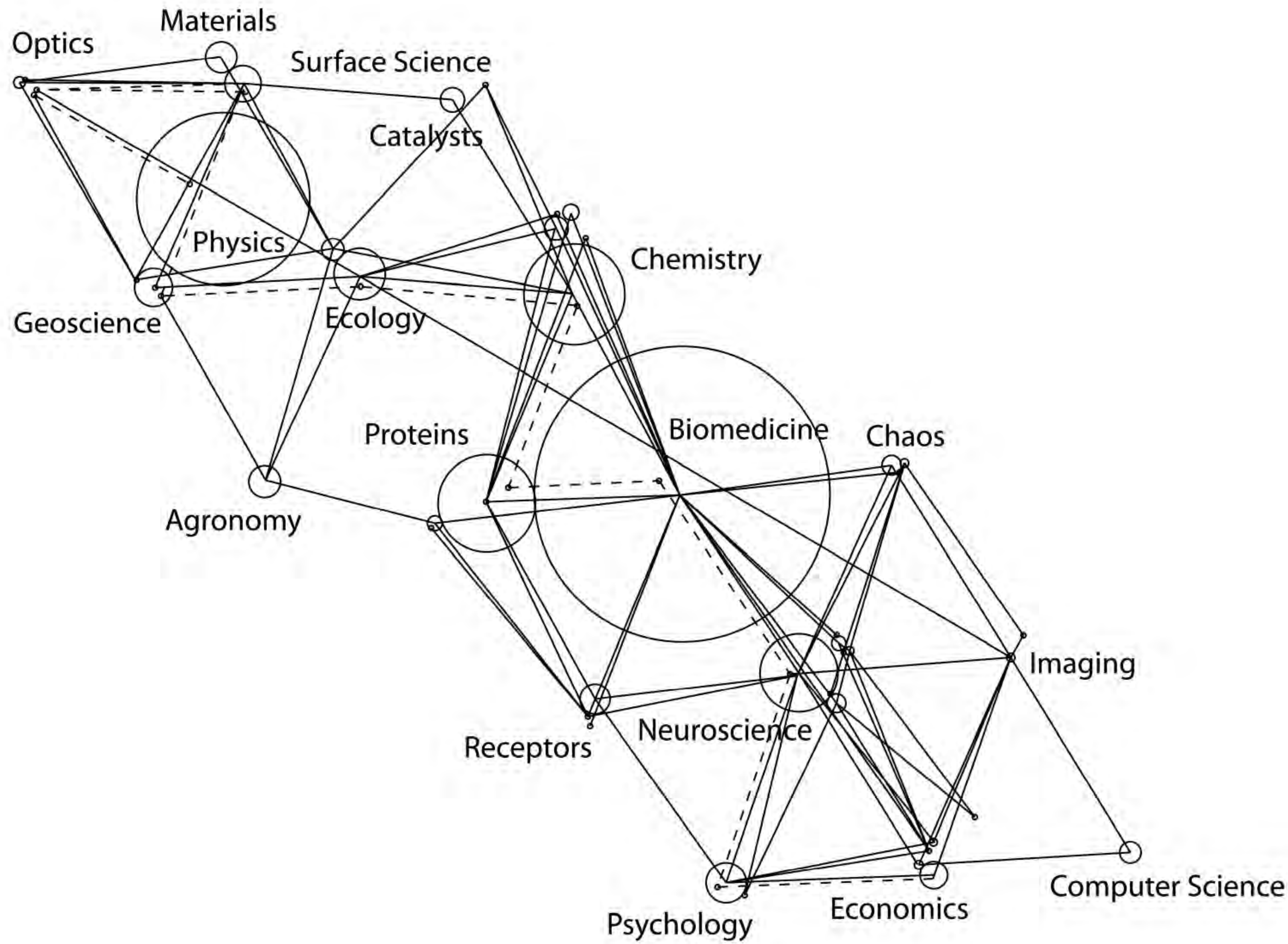


I.2 *Nova Anglia, Novvm Belgivm et Virginia* – Johannes Janssonius - 1642

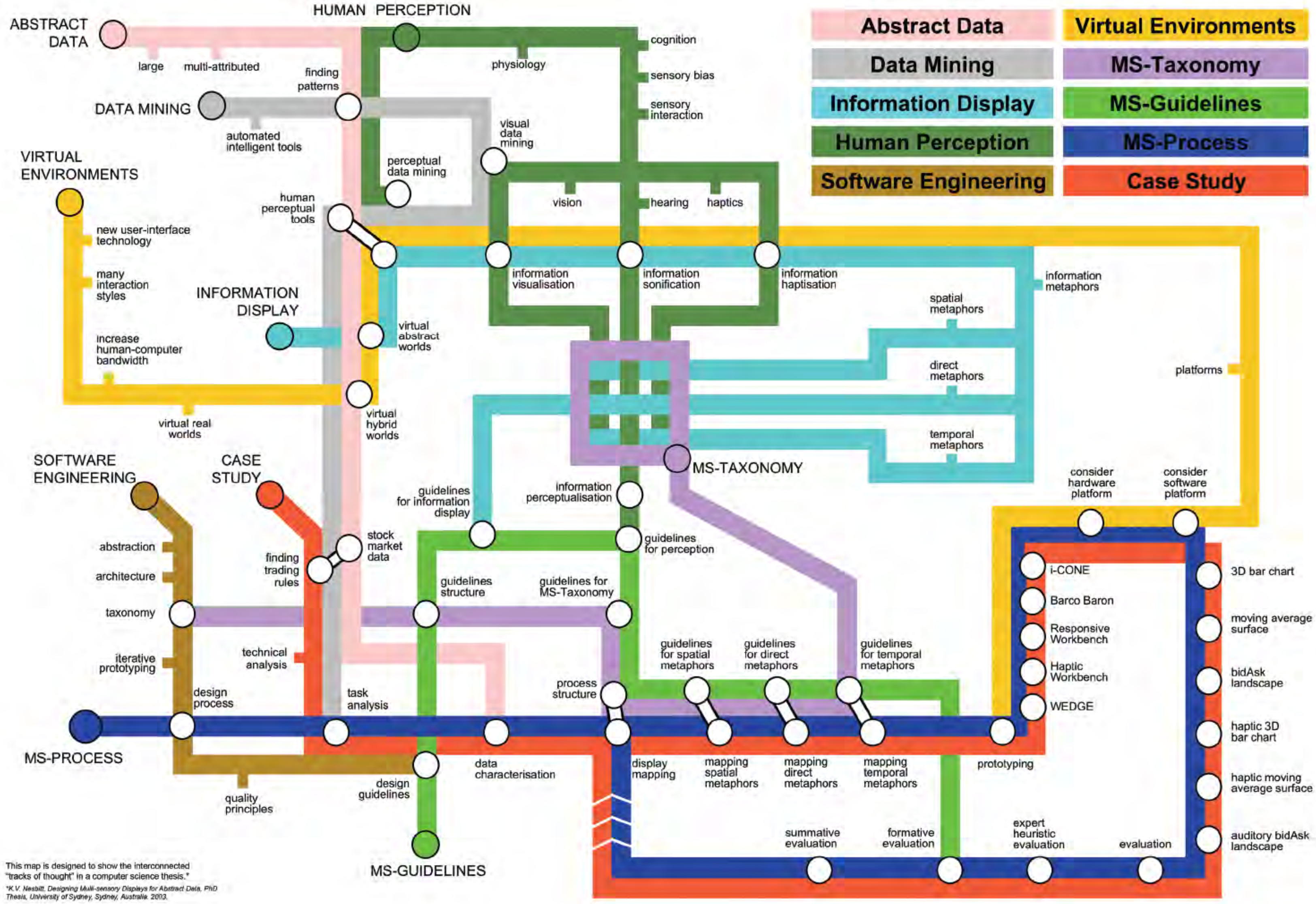
I.3 *A New Map of the Whole World with Trade Winds According to the Latest and Most Exact Observations* - Herman Moll - 1736



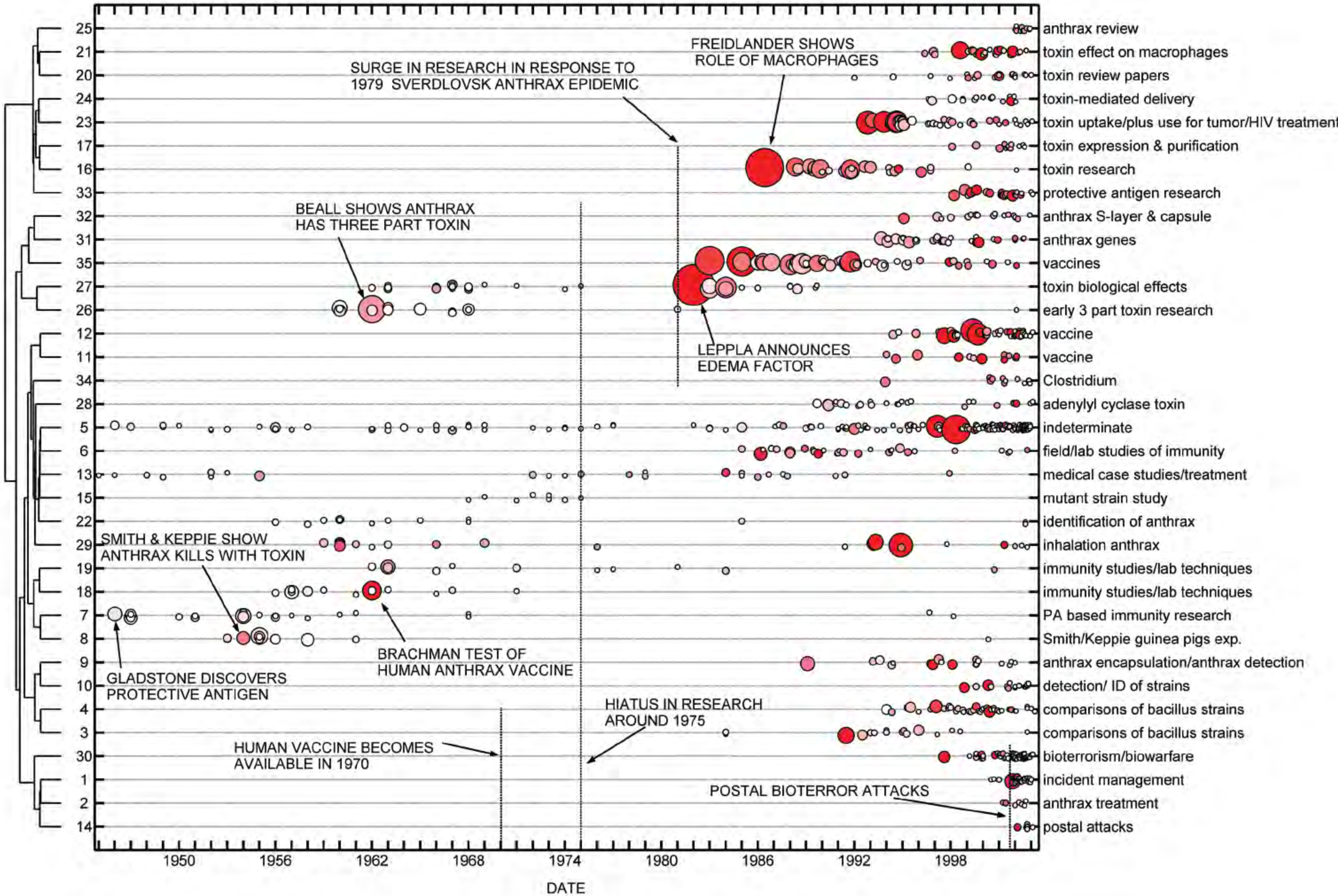
I.4 *Napoleon's March to Moscow* - Charles Joseph Minard - 1869



I.5 *1996 Map of Science: A Network Representation of the 43 Fourth-Level Clusters Based on Data from the 1996 Science Citation Index* - Henry G. Small - 1999

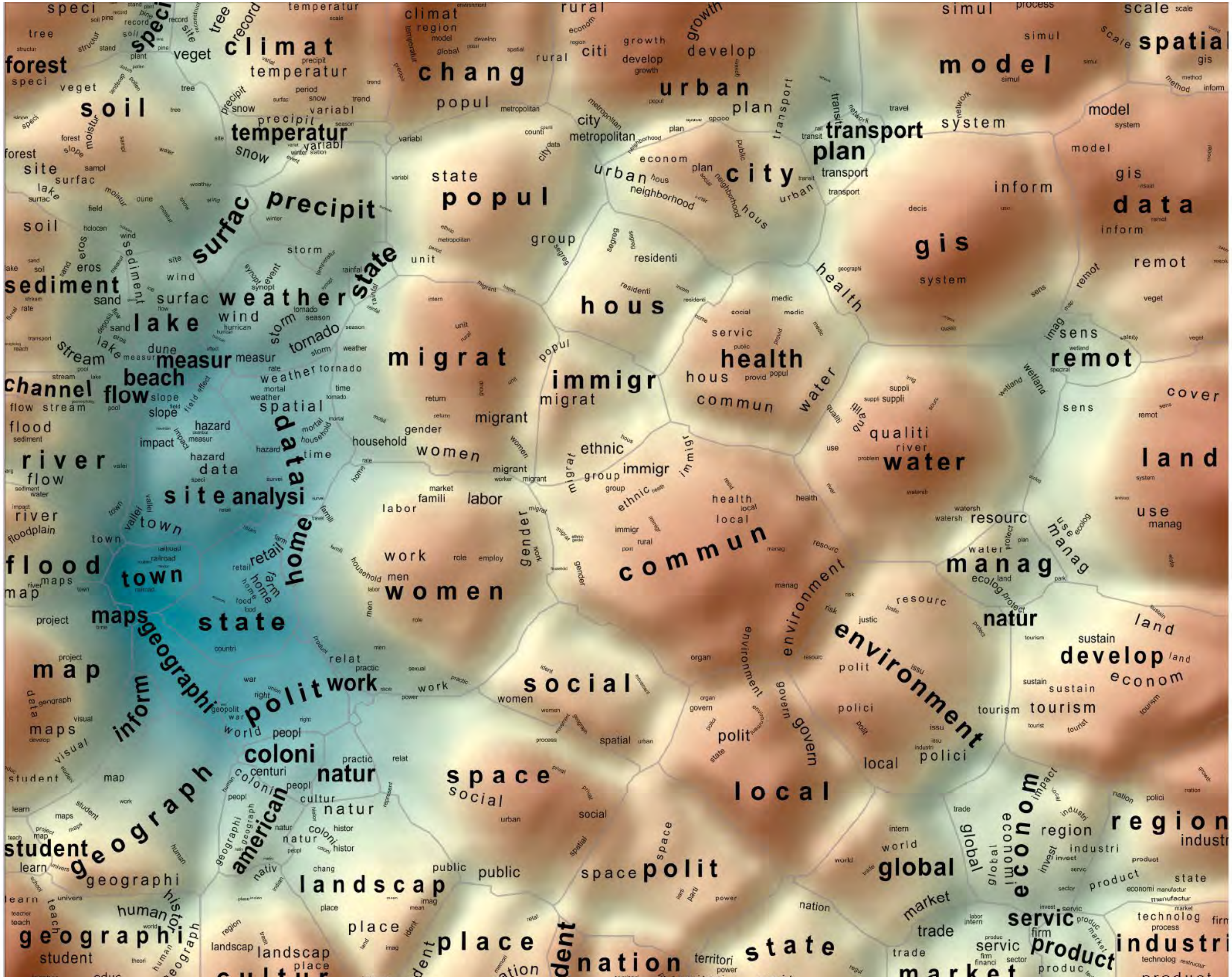


I.6 *Ph.D. Thesis Map* - Keith V. Nesbitt - 2004

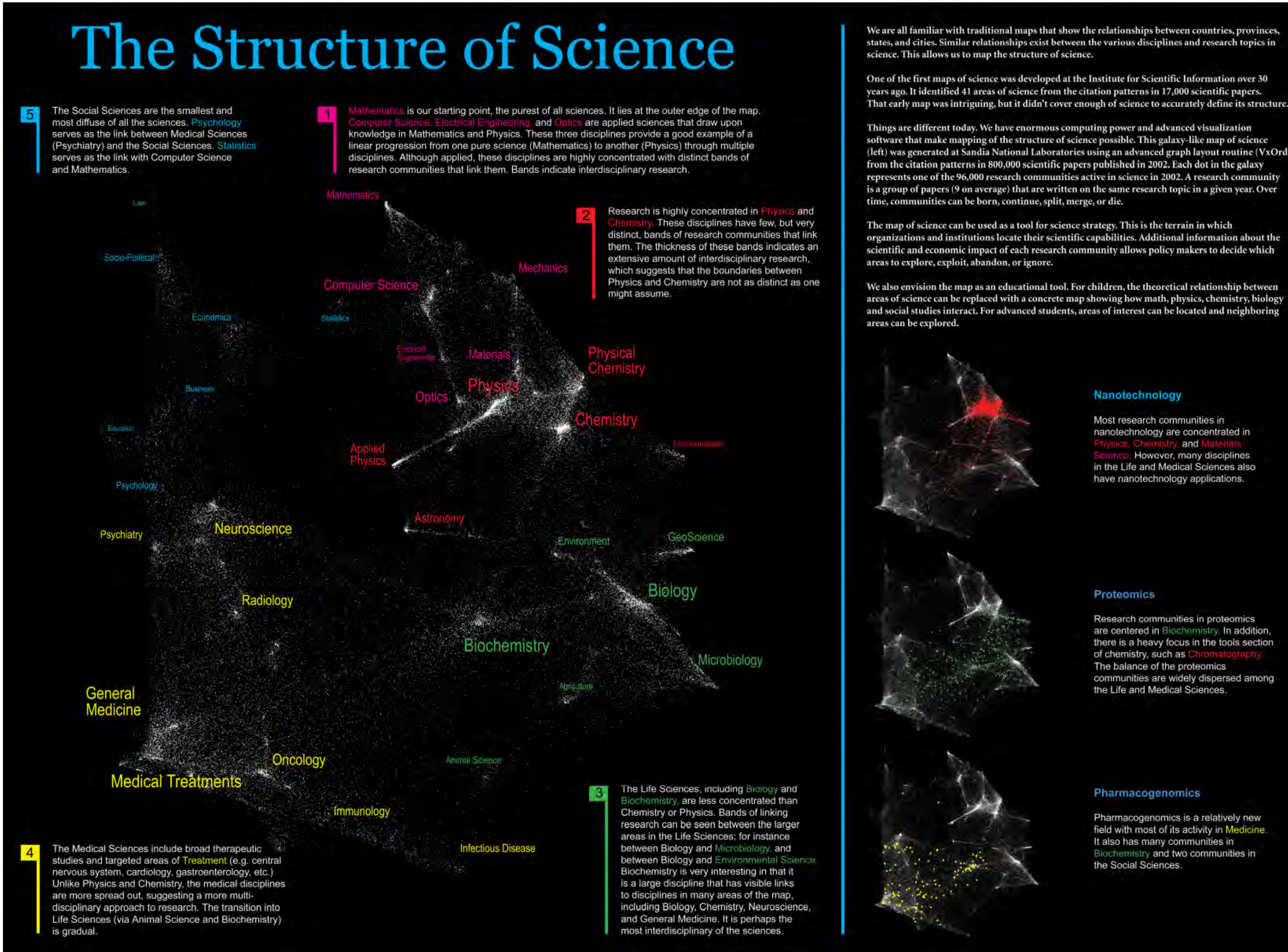


25 anthrax review
21 toxin effect on macrophages
20 toxin review papers
24 toxin-mediated delivery
23 toxin uptake/plus use for tumor/HIV treatment
17 toxin expression & purification
16 toxin research
33 protective antigen research
32 anthrax S-layer & capsule
31 anthrax genes
35 vaccines
27 toxin biological effects
26 early 3 part toxin research
12 vaccine
11 vaccine
34 Clostridium
28 adenylyl cyclase toxin
5 indeterminate
6 field/lab studies of immunity
13 medical case studies/treatment
15 mutant strain study
22 identification of anthrax
29 inhalation anthrax
19 immunity studies/lab techniques
18 immunity studies/lab techniques
7 PA based immunity research
8 Smith/Keppie guinea pigs exp.
9 anthrax encapsulation/anthrax detection
10 detection/ ID of strains
4 comparisons of bacillus strains
3 comparisons of bacillus strains
30 bioterrorism/biowarfare
1 incident management
2 anthrax treatment
14 postal attacks
FREIDLANDER SHOWS ROLE OF MACROPHAGES
SURGE IN RESEARCH IN RESPONSE TO 1979 SVERDLOVSK ANTHRAX EPIDEMIC
BEALL SHOWS ANTHRAX HAS THREE PART TOXIN
LEPPLA ANNOUNCES EDEMA FACTOR
SMITH & KEPPIE SHOW ANTHRAX KILLS WITH TOXIN
BRACHMAN TEST OF HUMAN ANTHRAX VACCINE
GLADSTONE DISCOVERS PROTECTIVE ANTIGEN
HIATUS IN RESEARCH AROUND 1975
HUMAN VACCINE BECOMES AVAILABLE IN 1970
POSTAL BIOTERROR ATTACKS
1950
1956
1962
1968
1974
1980
1986
1992
1998
DATE

I.8 *Treemap View of 2004 Usenet Returnees* - Marc Smith and Danyel Fisher - 2005



I.9 *In Terms of Geography* – André Skupin - 2005



I.10 *The Structure of Science* - Kevin W. Boyack and Richard Klavans - 2005

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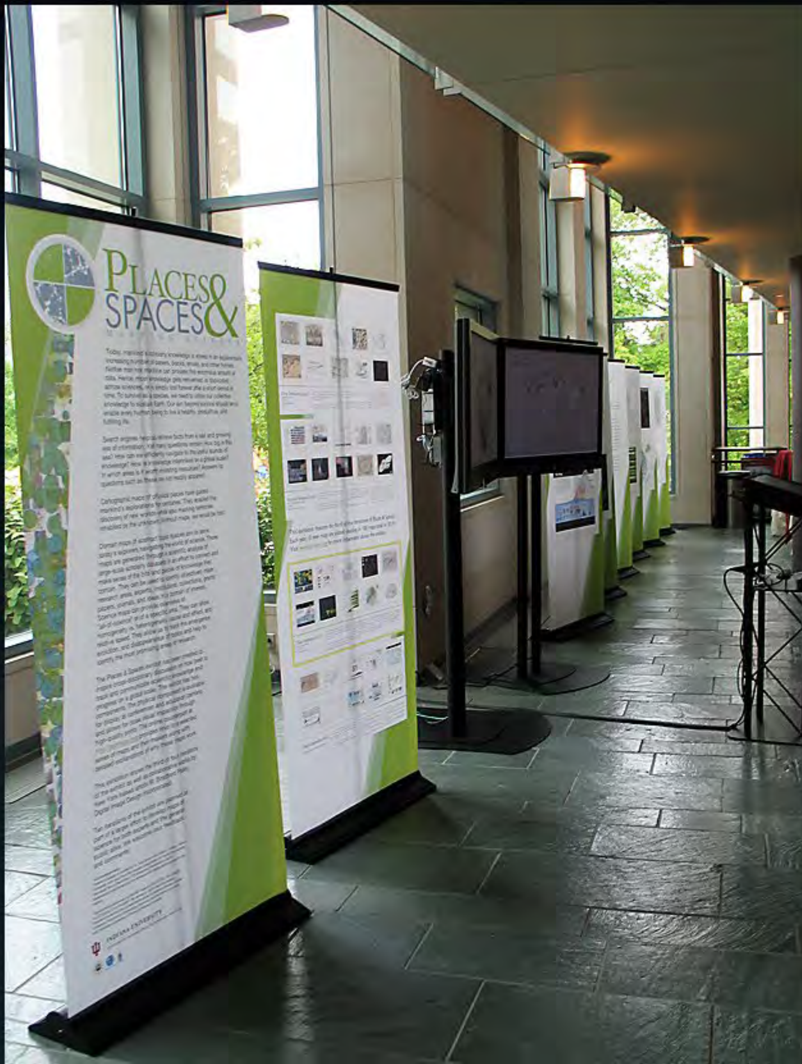

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Iteration II (2006)

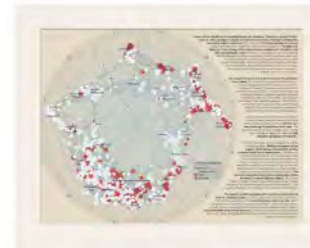
The Power of Reference Systems

II.1

II.3

II.5

II.7



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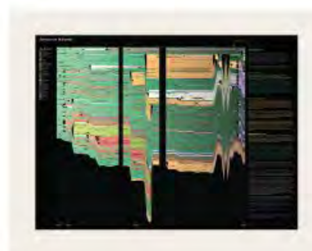

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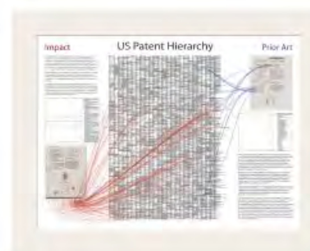

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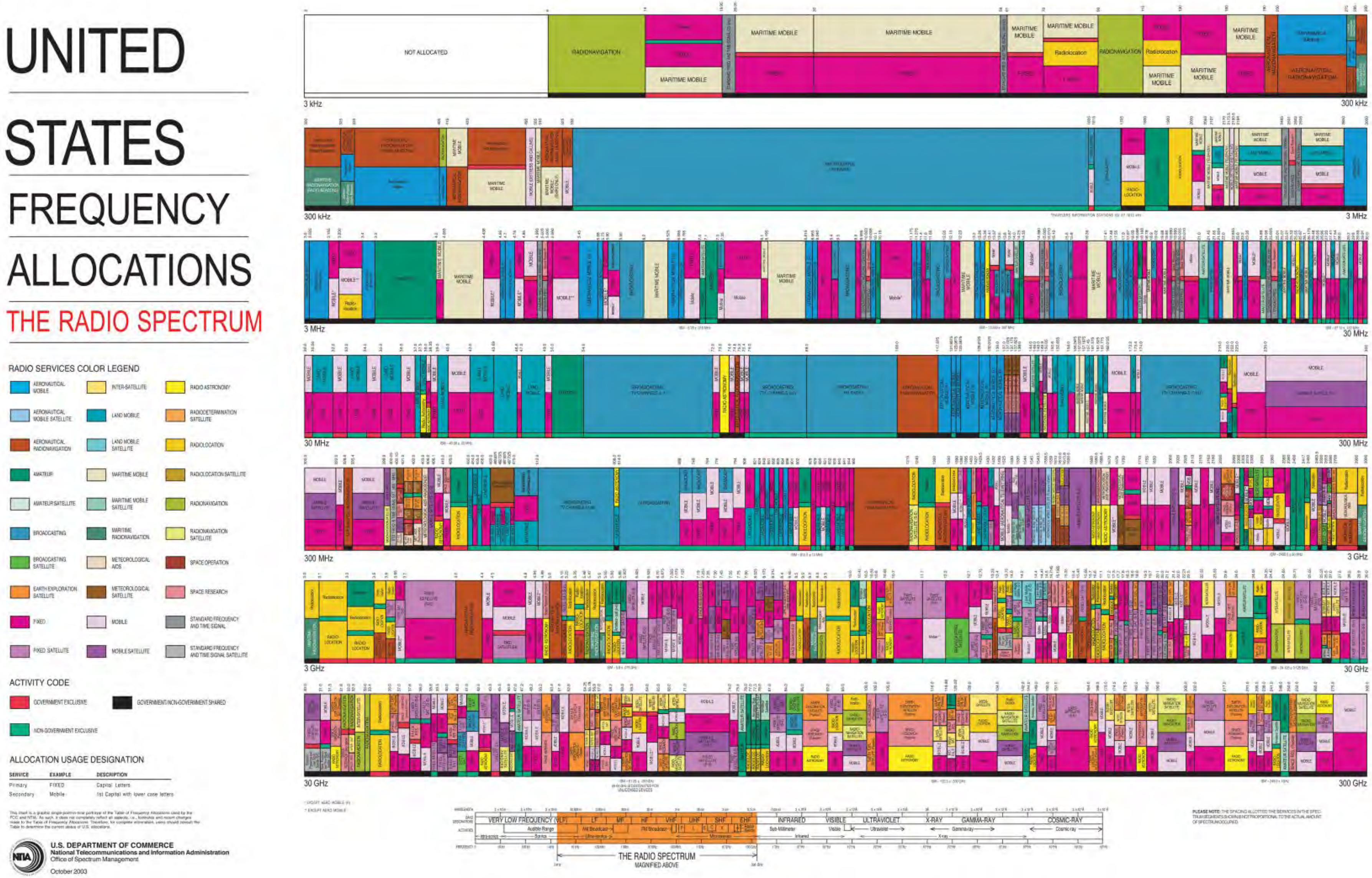
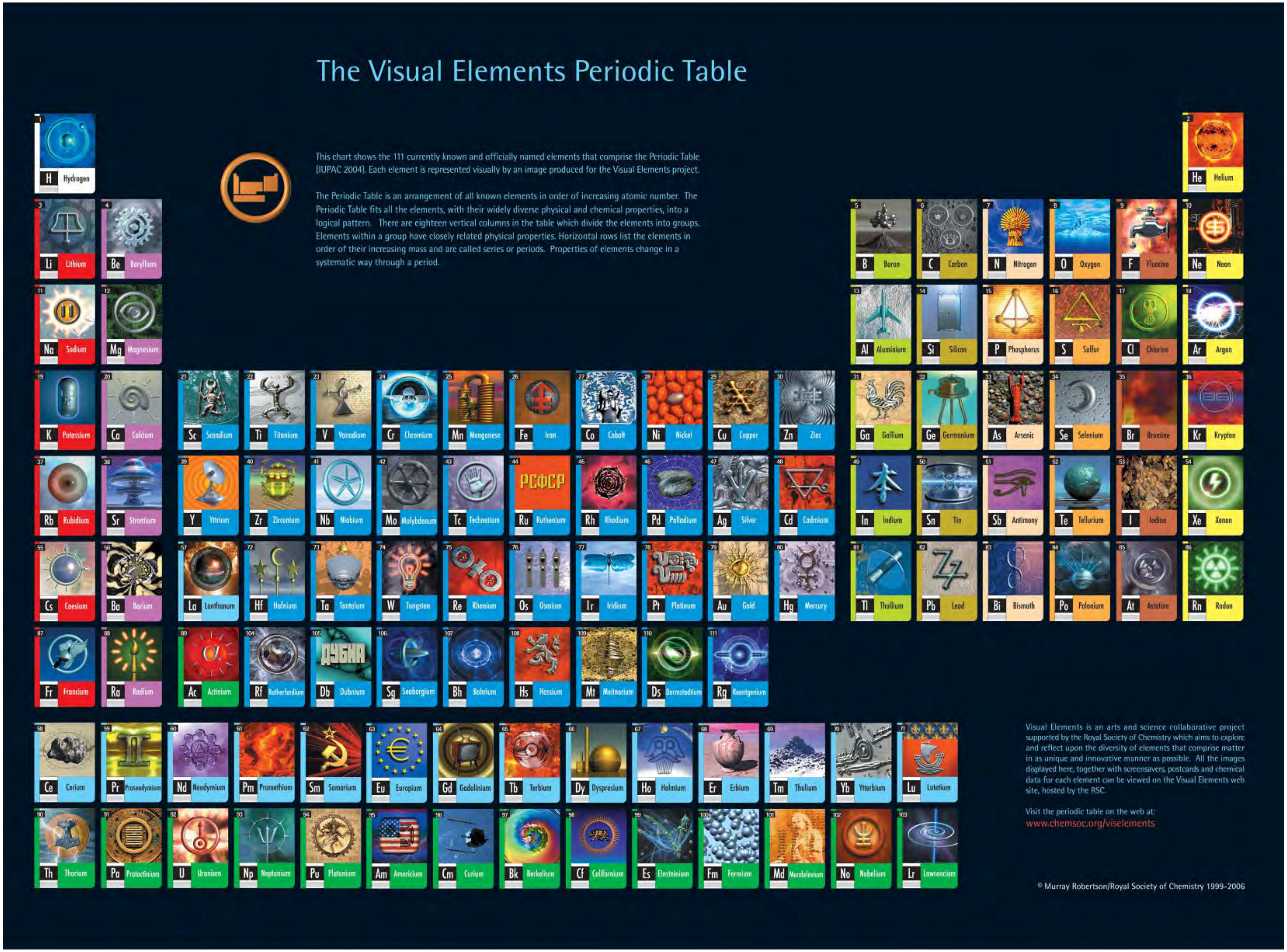
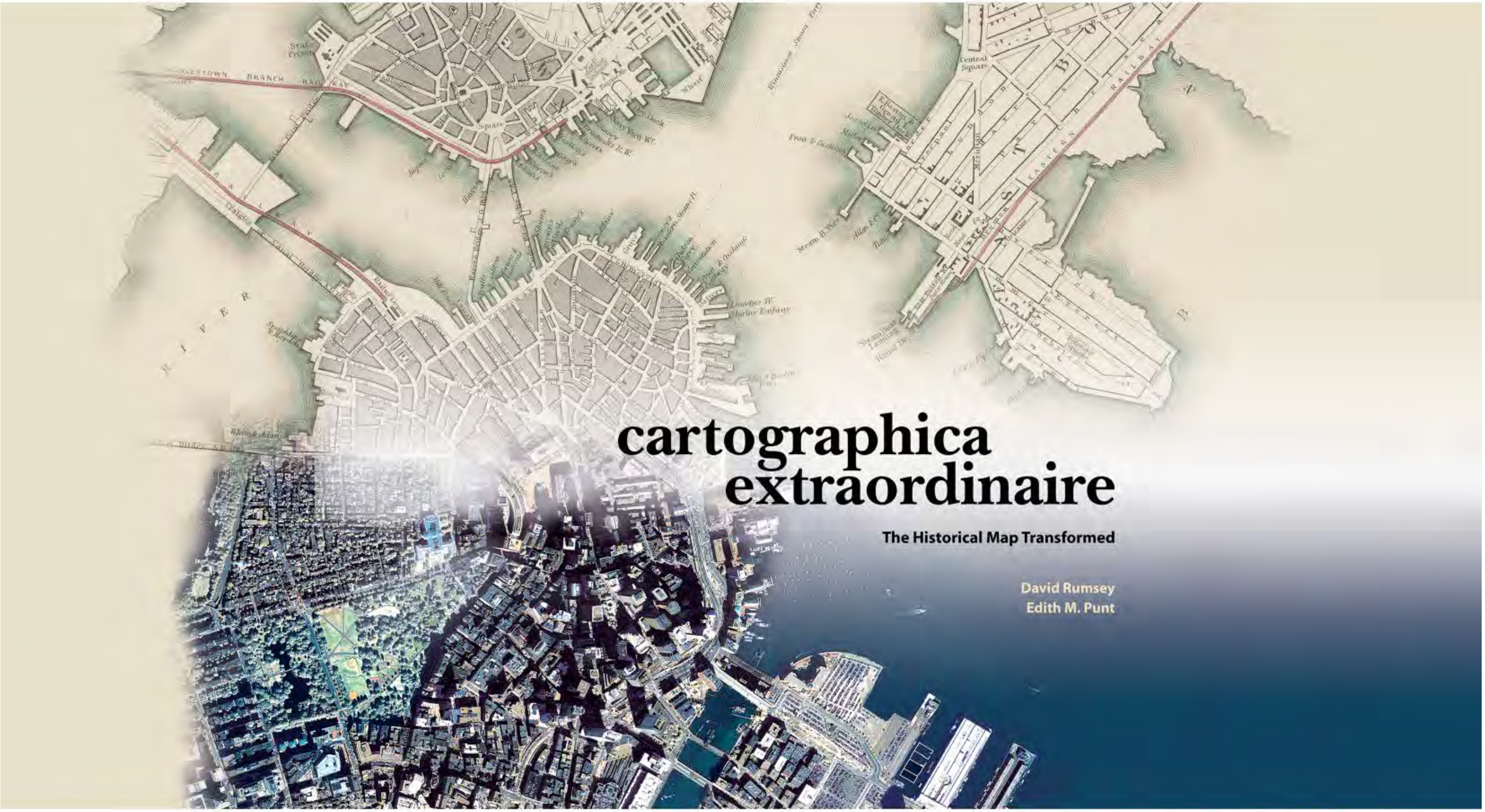


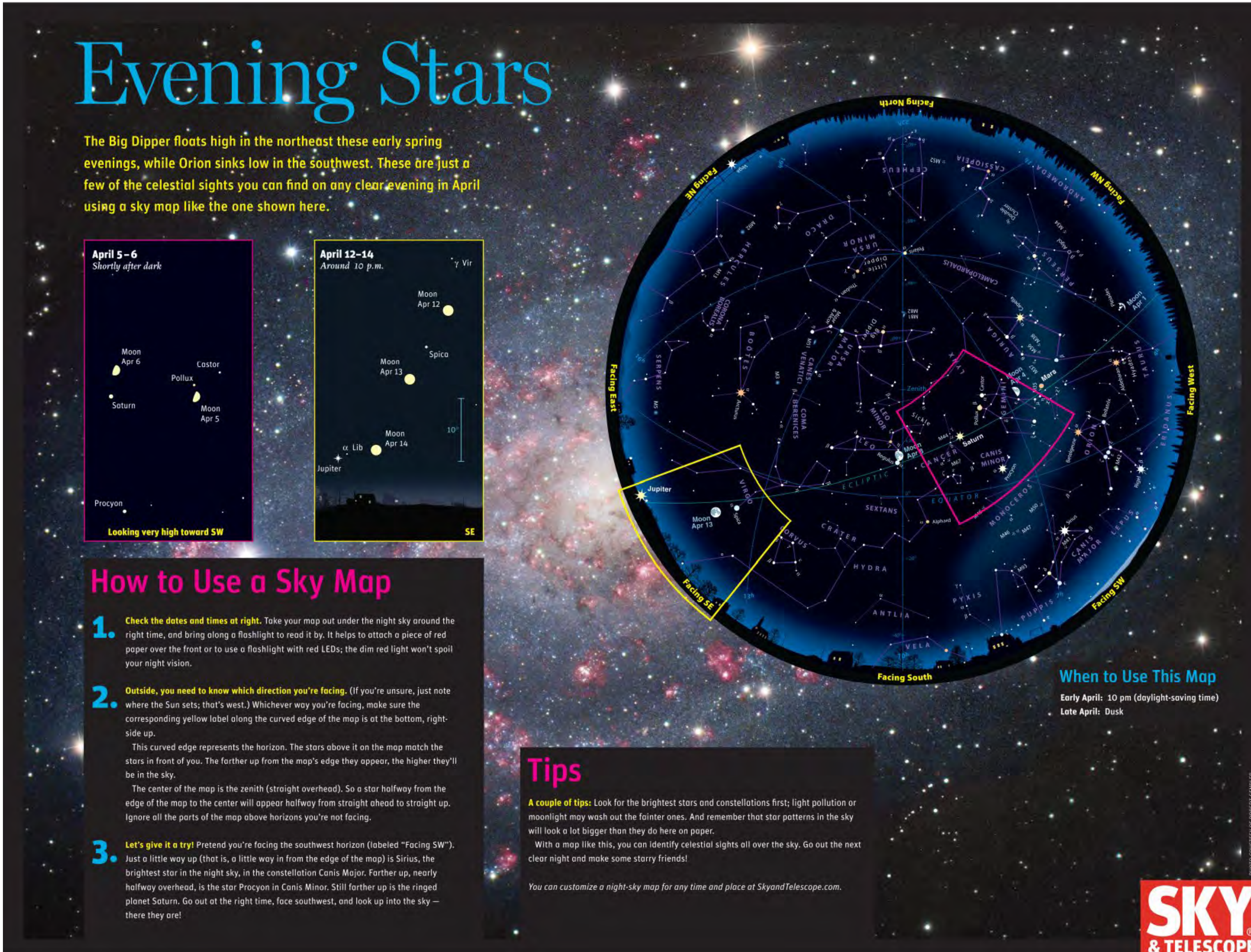
II.1 *U.S. Frequency Allocations Chart* - National Telecommunications and Information Administration - 2003



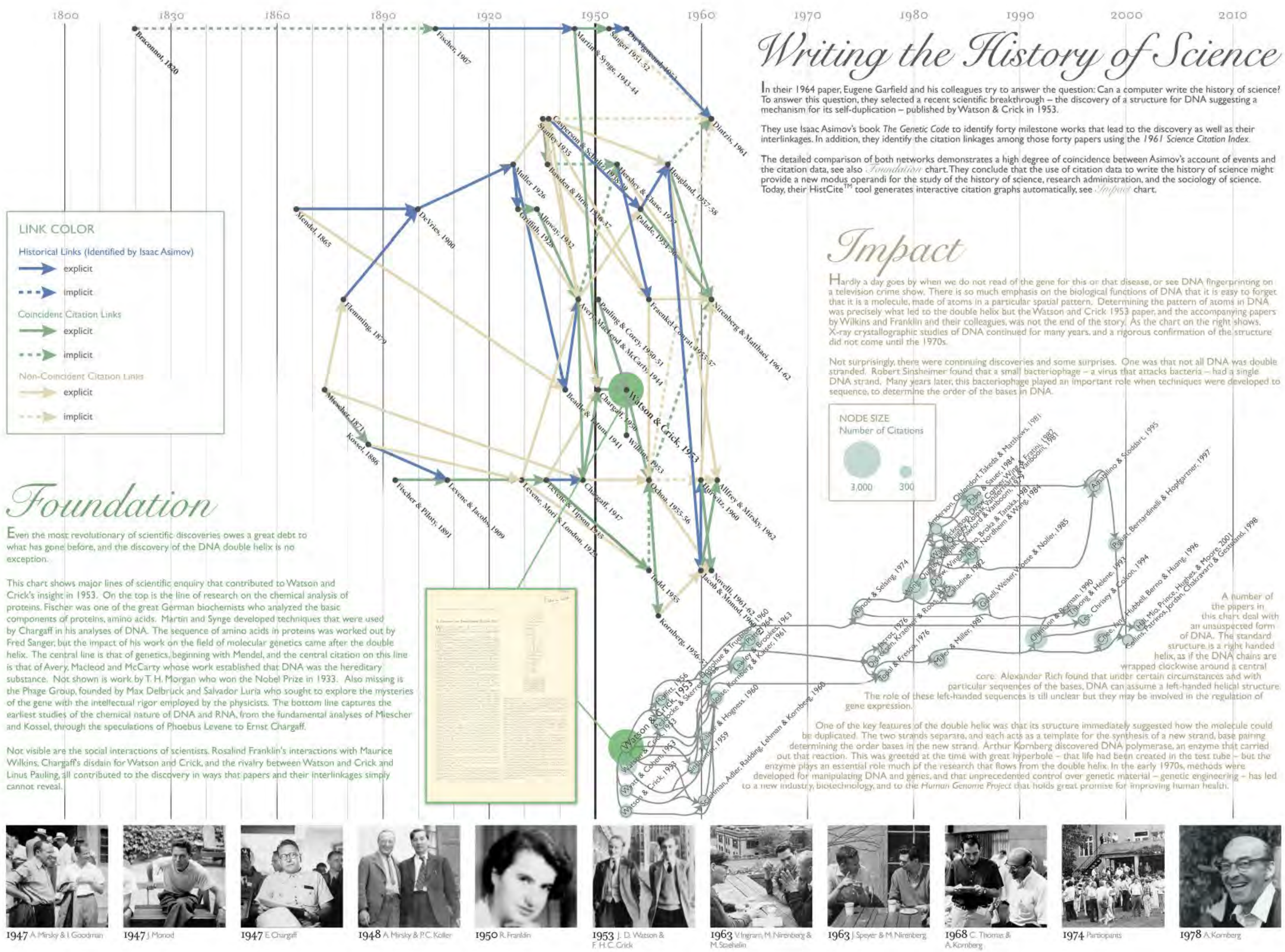
II.2 *Visual Periodic Table of the Elements* - Murray Robertson and John Emsley - 2005



II.3 *Cartographica Extraordinaire: The Historical Map Transformed* - David Rumsey and Edith M. Punt - 2004

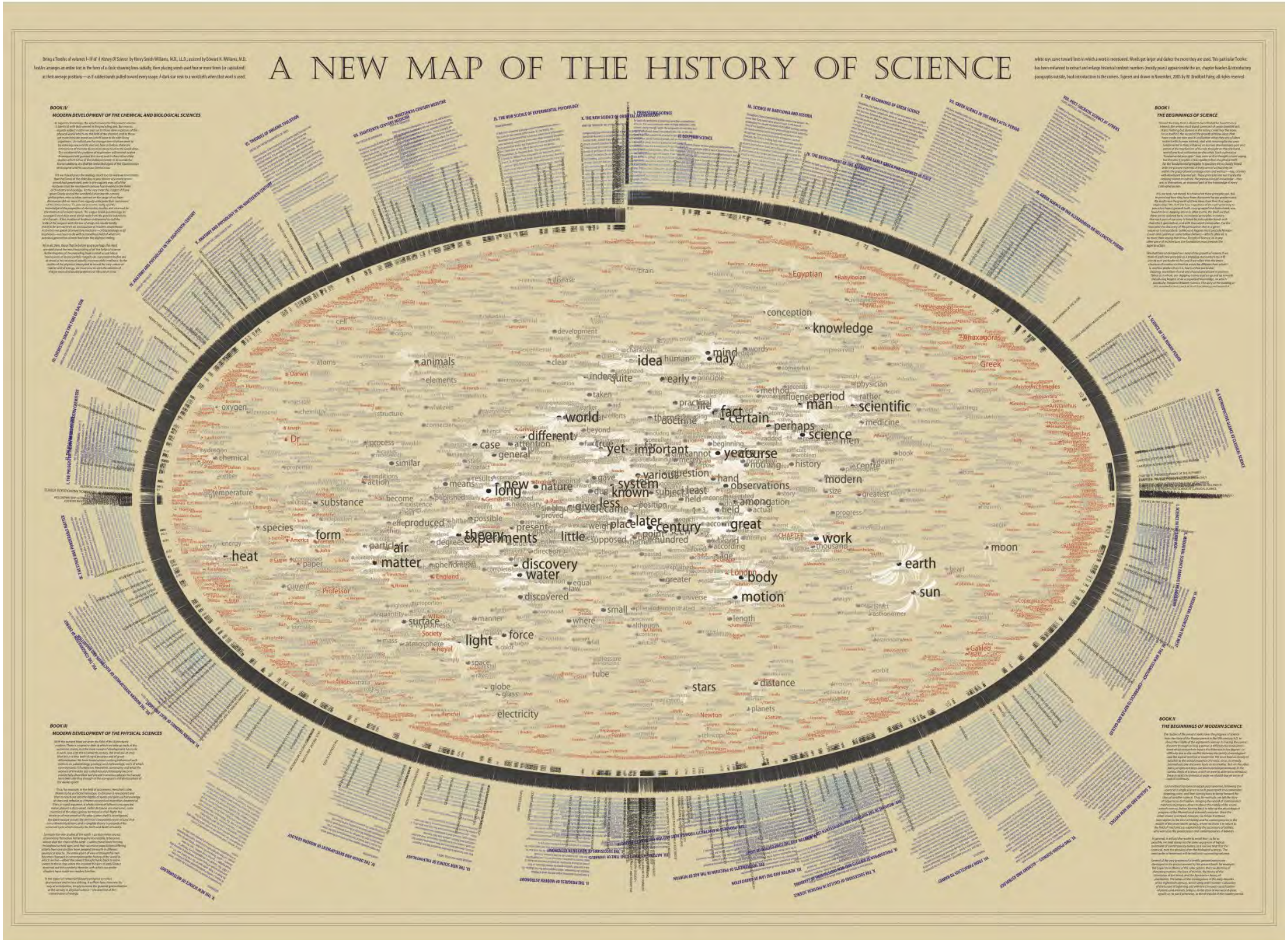


II.4 *Sky Chart of New York City in April 2006* - Roger W. Sinnott and the Interactive Factory - 2006

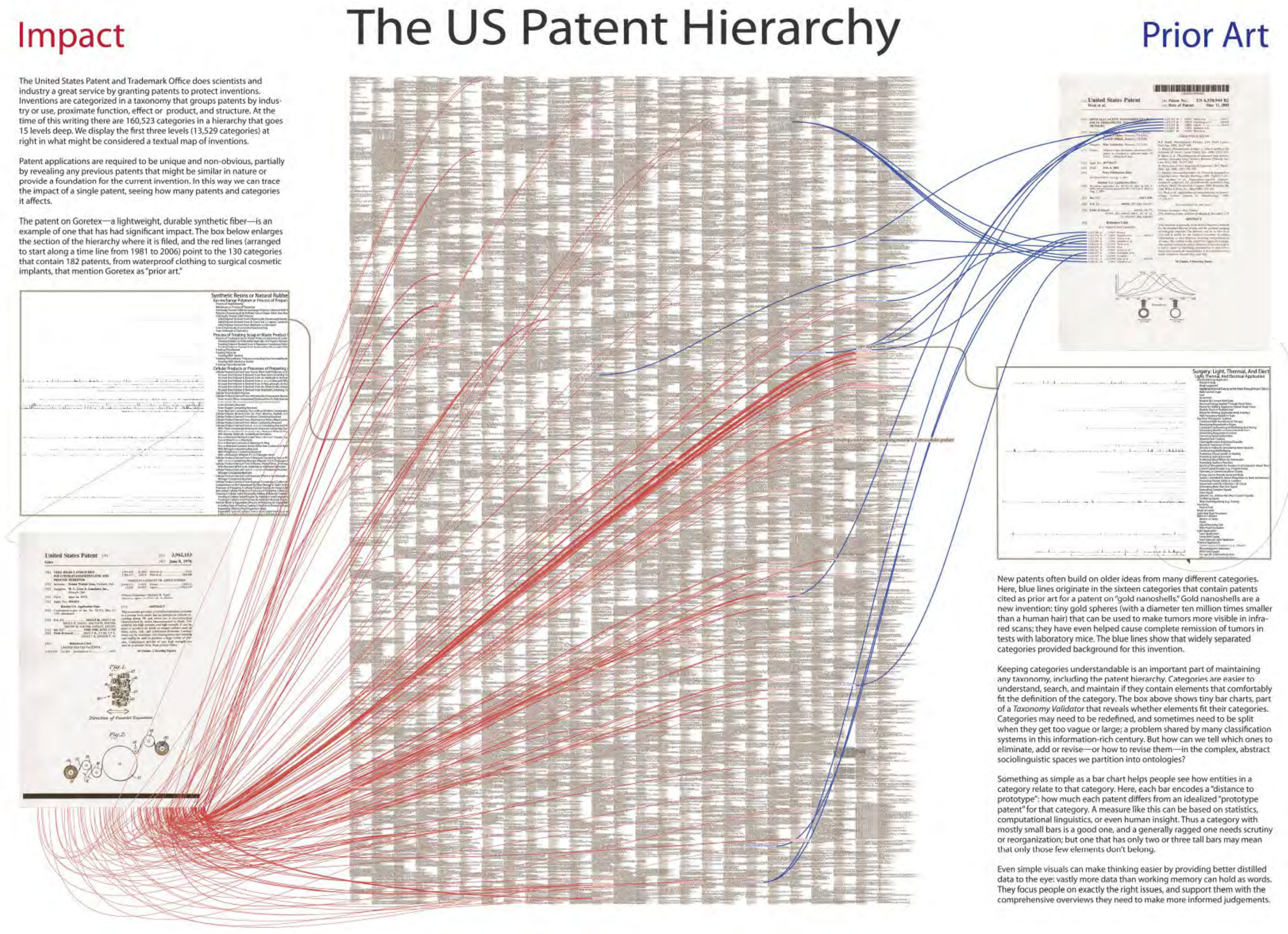


II.5 *HistCite™ Visualization of DNA Development* - Eugene Garfield, Elisha F. Hardy, Katy Börner, Ludmila Pollock, and Jan Witkowski - 2006

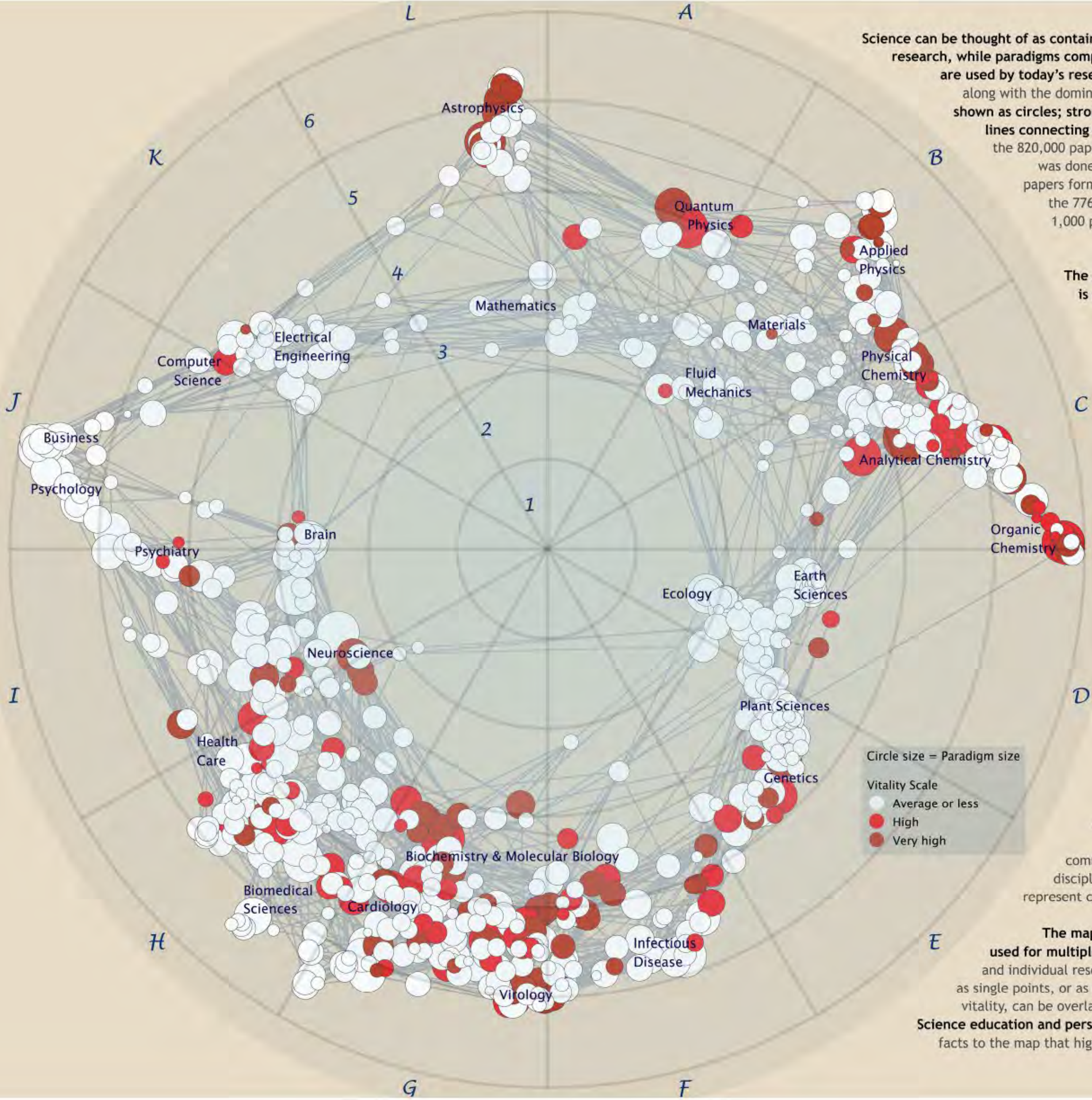
II.6 *History Flow Visualization of the Wikipedia Entry on "Abortion"* - Martin Wattenberg and Fernanda B. Viégas - 2006



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



II.8 *Taxonomy Visualization of Patent Data* - Katy Börner, Elisha F. Hardy, Bruce W. Herr II, Todd Holloway, and W. Bradford Paley - 2006



Science can be thought of as containing themes and paradigms. Themes are areas of current research, while paradigms comprise the dominant tool sets and existing knowledge that are used by today's researchers. This map shows **776 major paradigms in science** along with the dominant relationships between these paradigms. **Paradigms are shown as circles; strong relationships between paradigms are indicated by the lines connecting the circles.** The map was created by recursively clustering the 820,000 papers referenced most often in 2003. Clustering at each level was done using VxOrd, a force-directed graph layout routine. These papers formed 53,000 clusters, 6,100 higher-level clusters, and finally the 776 paradigms. Although each paradigm contains, on average, 1,000 papers, some are larger and some are smaller, as shown by different sized circles on the map.

The ring-like structure that is formed by scientific paradigms is very robust. We find similar structures for different years, and for maps generated from scientific journals. "The Structure of Science", a galaxy map shown in the first iteration of Places & Spaces, is a map based on clustering of scientific journals, with superimposition of papers on the journal structure, whereas this map was generated directly from highly-cited papers. "The Structure of Science" shows current science in a disciplinary context, while this map can show the breadth of disciplines that contribute to single paradigms.

Because of the robust nature of the structure of science and its paradigms, we have placed our 776 scientific paradigms within a **reference system containing 12 radial slices and 6 rings.** This allows the position of each paradigm to be codified and available for lookup; for instance ***Fluid Mechanics*** **paradigms are in grid B3.**

We have also calculated and displayed the vitality of each paradigm. ***Vitality*** **is a measure of the speed at which a group of researchers reaches consensus about major improvements.** Paradigms are constantly being improved, but it usually takes years to reach consensus about which improvements are major. The white circles represent communities where consensus is reached relatively slowly. This is a common phenomenon in the social sciences, ecological sciences, computer sciences, and mathematics disciplines. **The red circles represent communities of researchers where consensus is reached relatively rapidly.** This is more common in physics, chemistry, biochemistry, and many medical disciplines. Very dark circles (such as those in *Astrophysics, L5-6*) represent communities where consensus is reached extremely quickly.

The map of scientific paradigms and its reference system can be used for multiple purposes. Countries, industries, companies, universities, and individual researchers can all **locate themselves within the map**, either as single points, or as a specific collection of paradigms. Various metrics, such as vitality, can be overlayed on this reference system to highlight specific impacts. **Science education and personal discovery** can also be enhanced by linking stories and facts to the map that highlight scientific history, current advances and relationships between scientific paradigms.

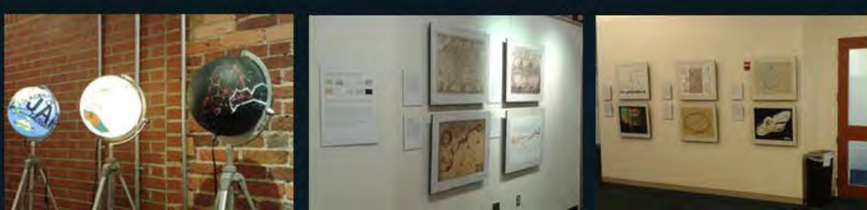
II.9 *Map of Scientific Paradigms* - Kevin W. Boyack and Richard Klavans - 2006

II.10 *Zones of Invention—Patterns of Patents* - Ingo Günther - 2006

Exhibit Venues

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.

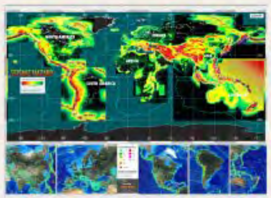


Duke University, Durham, NC.
January 12 - April 10, 2015

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

Iteration III (2007)

The Power of Forecasts



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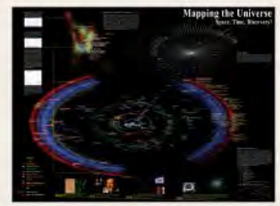

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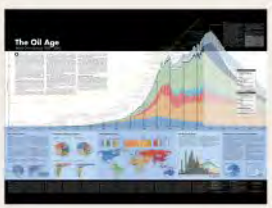

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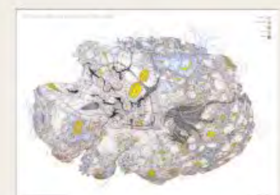

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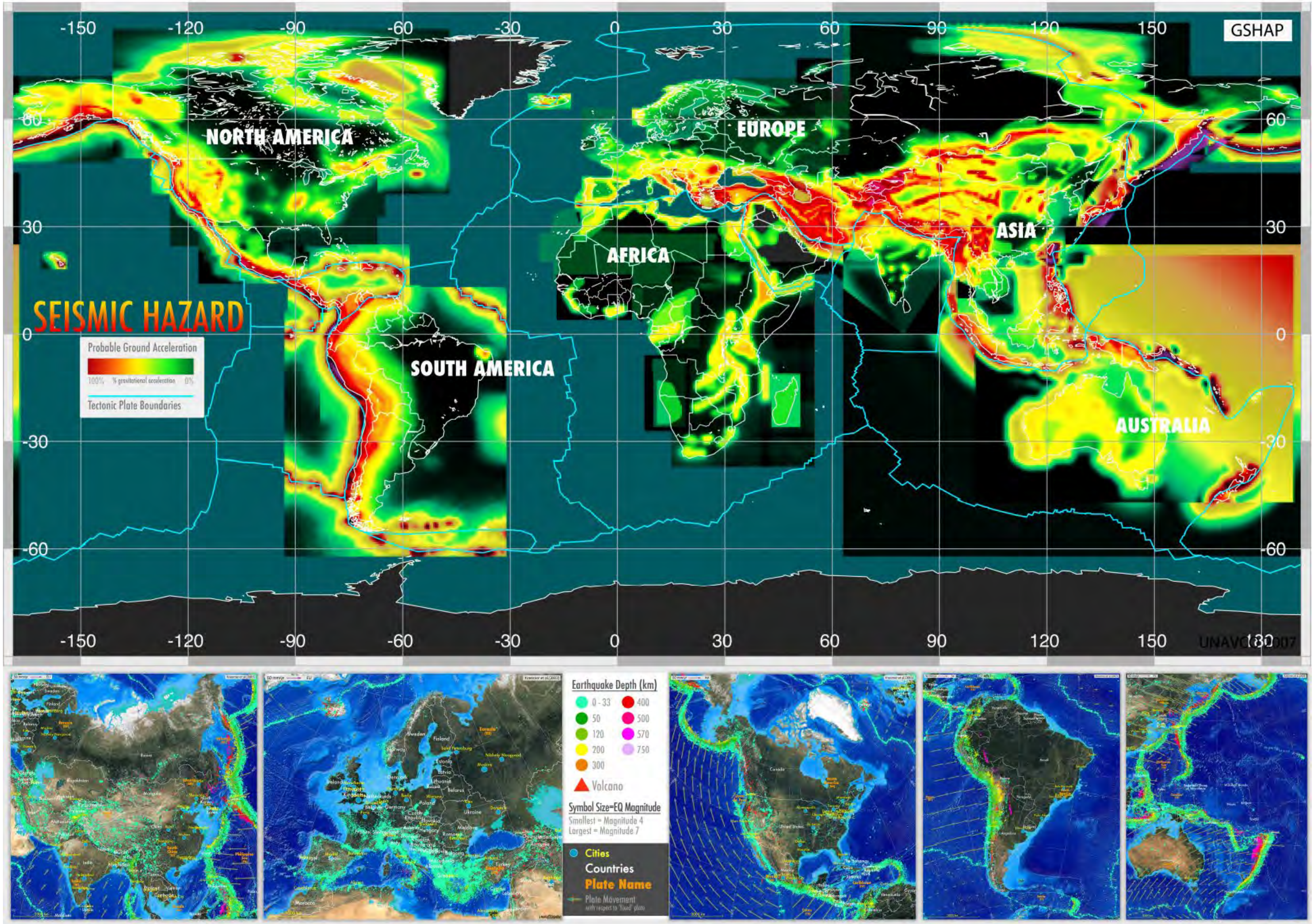
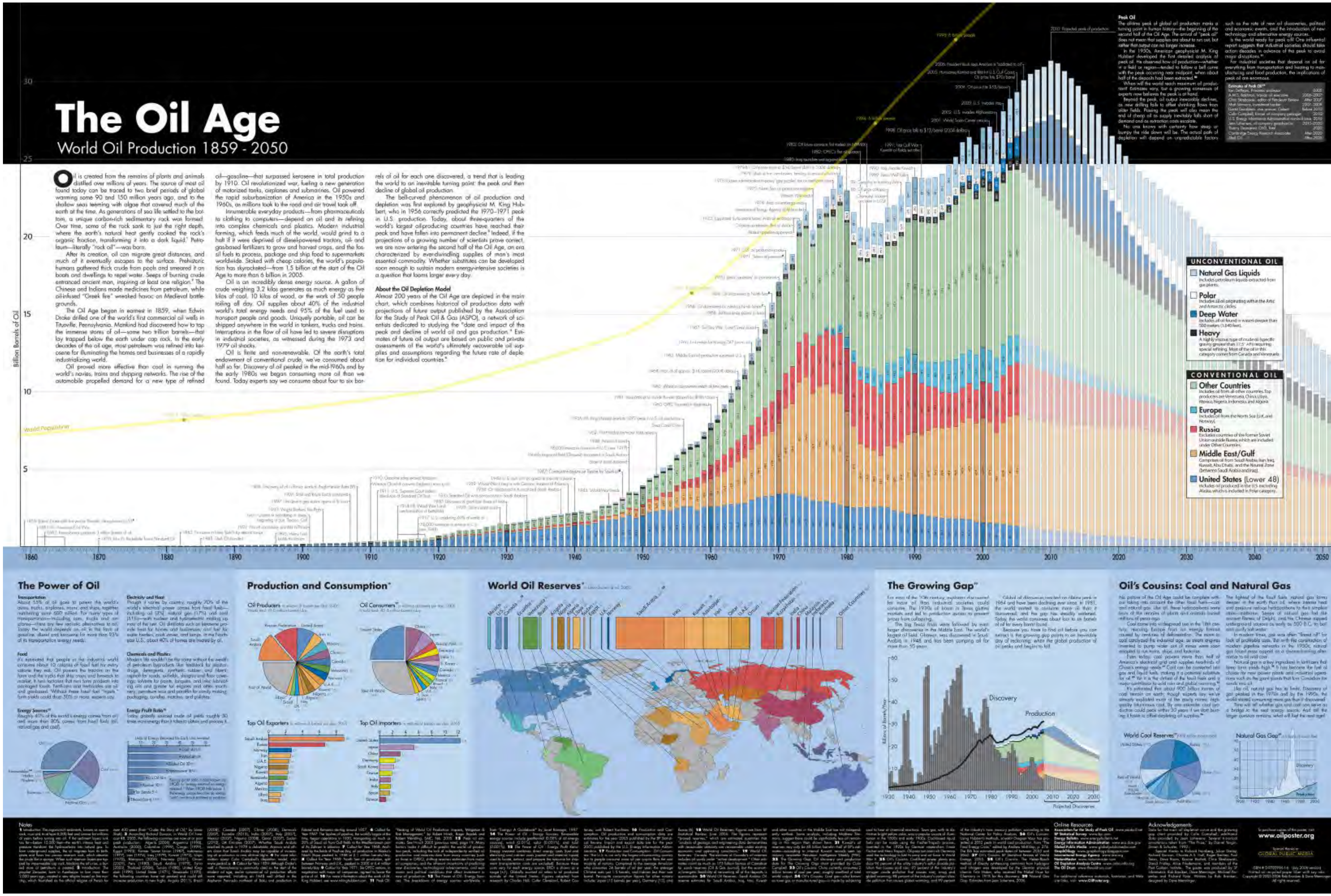
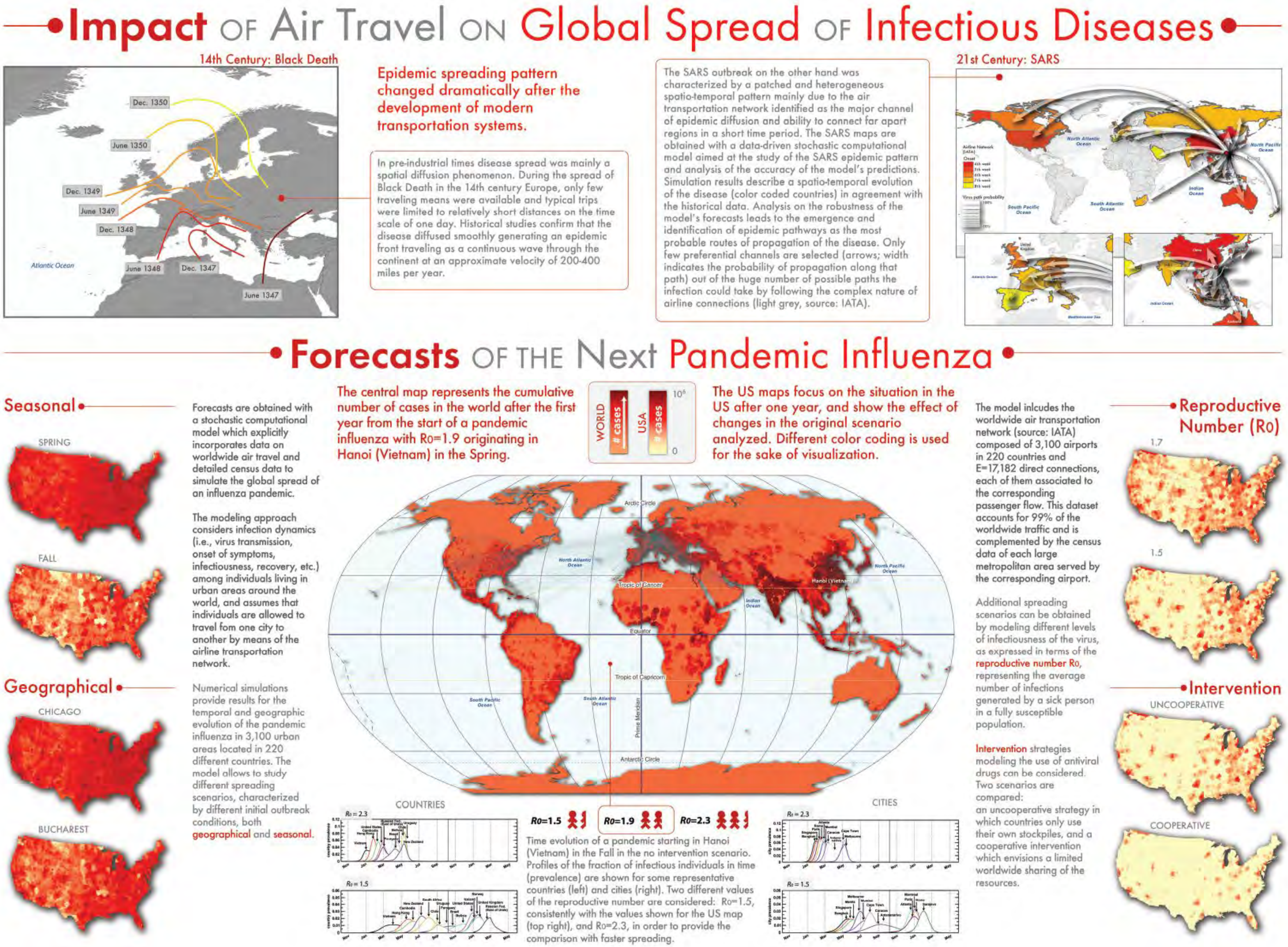


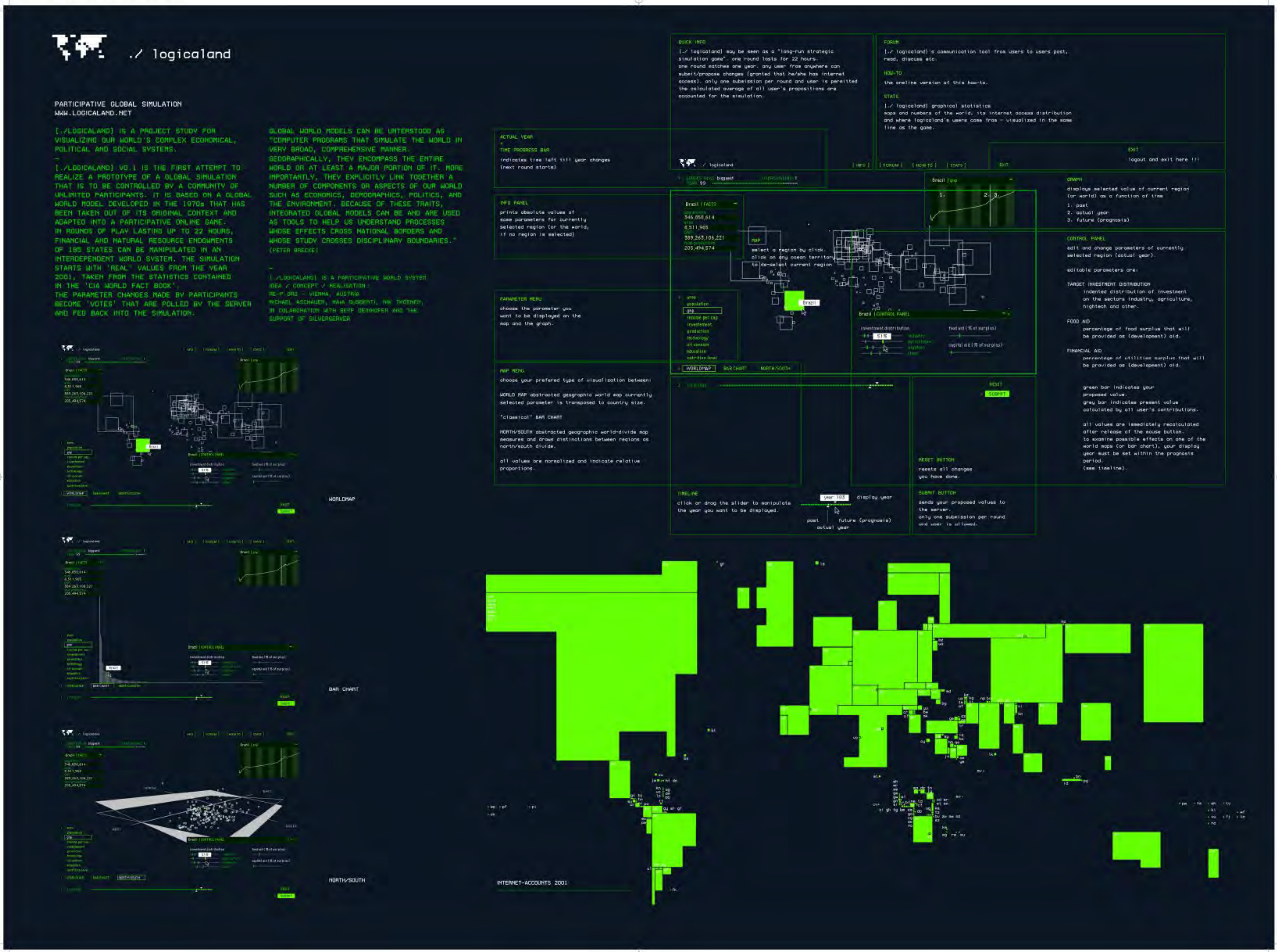
III.1 *Tectonic Movements and Earthquake Hazard Predictions* - Michael W. Hamburger, Chuck Meertens, and Elisha F. Hardy - 2007



III.2 *The Oil Age: World Oil Production 1859-2050* - Rob Bracken, Dave Menninger, Michael Poremba, and Richard Katz - 2006



III.3 *Impact of Air Travel on Global Spread of Infectious Diseases* - Vittoria Colizza, Alessandro Vespignani, and Elisha F. Hardy - 2007



III.4 *[.Logicland] Participative Global Simulation* - Michael Ashauer, Maia Gusberti, Nik Thoenen, and Sepp Deinhofer - 2002

INSTITUTE FOR THE FUTURE

Science & Technology Outlook: 2005–2055

Technology Horizons Program
Institute for the Future
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A map is a tool for navigating an unknown terrain. In the case of this map, **Science & Technology Outlook: 2005-2055**, the terrain we're navigating is the uncharted territory of science and technology (S&T) in the next 50 years. However, the map of the future is not a tool for prediction or, for that matter, the product of predictions. Nor is it comparable to modern navigation techniques in which we rely on a shrinking number of strong signals, like GPS coordinates, to show the right path. Rather, it's more akin to classical low-tech navigational techniques with their reliance on an array of weak signals such as wind direction, the look and feel of the water, and the shape of cloud formations. Taken together, these signals often prove more useful for navigation than high-tech methods because, in addition to aiding travelers in selecting the "right" path, the signals contextualize information and reveal interdependencies and connections between seemingly unrelated events, thus enriching our understanding of the landscape. That's precisely the intention of this map of the future of S&T—to give the reader a deeper contextual understanding of the landscape and to point to the intricacies and interdependencies between trends.

While developing the map, the **Institute for the Future (IFTF)** team listened for and connected a variety of weak signals, including those generated during interviews and workshop conversations involving more than 100 eminent U.K. and U.S. experts in S&T—academicians, policymakers, journalists, and corporate researchers. The IFTF team also compiled a database of outlooks on developments that are likely to impact the full range of S&T disciplines and practice areas over the next 50 years. We also relied on IFTF's 40 years of experience in forecasting S&T developments to create the map and an accompanying set of **S&T Perspectives** that discuss issues emerging on the S&T horizon and are important for organizations, policymakers, and society-at-large to understand.

On this map, six themes are woven together across the 50-year horizon, often resulting in important breakthroughs. These are supported by key technologies, innovations, and discoveries. In addition to the six themes, three meta-themes—democratized innovation, transdisciplinarity, and emergence—will overlay the future S&T landscape influencing how we think about, learn about, and practice science. Finally, S&T trends won't operate in a vacuum. Wider social, demographic, political, economic, and environmental trends will both influence S&T trends and will be influenced by them. Some of these wider trends surround the map to remind us of the larger picture.

MAP THEMES

Small World

After 20 years of basic research and development at the 100-nanometer scale, the importance of nanotechnology as a source of innovations and new capabilities in everything from materials science to medicine is already well-understood. Three trends, however, will define how nanotechnology will unfold, and what impacts it will have. First, nanotechnology is not a single field with a coherent intellectual program; it's an opportunistic hybrid, shaped by a combination of fundamental research questions, promising technical applications, and venture and state capital. Second, nanotechnology is moving away from the original vision of small-scale mechanical engineering—in which assemblers build mechanical systems from individual atoms—toward one in which molecular biology and biochemistry contribute essential tools (such as proteins that build nanowires). Finally, nanotechnology will also serve as a model for transdisciplinary science. It will support both fundamental research and commercially oriented innovation; and it will be conducted not within the boundaries of conventional academic or corporate research departments, but in institutional and social milieux that emphasize heterogeneity.

Intentional Biology

For 3.6 billion years, evolution has governed biology on this planet. But today, Mother Nature has a collaborator. Inexpensive tools to read and rewrite the genetic code of life will bootstrap our ability to manipulate biology from the bottom up. We'll not only genetically re-engineer existing life but actually create new life forms with purpose. Still, we will not be blind to what nature has to teach us. Evolution's elegant engineering at the smallest scales will be a rich source of inspiration as we build the bio-nanotechnology of the next 50 years.

Extended Self

In the next 50 years, we will be faced with broad opportunities to remake our minds and bodies in profoundly different ways. Advances in biotechnology, brain science, information technology, and robotics will result in an array of methods to dramatically alter, enhance, and extend the mental and physical hand that nature has dealt us. Wielding these tools on ourselves, humans will begin to define a variety of different "transhumanist" paths—that is, ways of being and living that extend beyond what we today consider natural for our species. In the very long term, following these paths could someday lead to an evolutionary leap for humanity.

Mathematical World

The ability to process, manipulate, and ultimately understand patterns in enormous amounts of data will allow decoding of previously mysterious processes in everything from biological to social systems. Scientists are learning that at the core of many biological phenomena—reproduction, growth, repair, and others—are computational processes that can be decoded and simulated. Using techniques of combinatorial science to uncover such patterns—whether these are physical, biological, or social—will likely occupy an increasing share of computing cycles in the next 50 years. Such massive computation will also make simulation widespread. Computer simulation will be used not only to help make decisions about large complex scientific and social problems but also to help individuals make better choices in their daily lives.

Sensory Transformation

In the next ten years, physical objects, places, and even human beings themselves will increasingly become embedded with computational devices that can sense, understand, and act upon their environment. They will be able to react to contextual clues about the physical, social, and even emotional state of people and things in their surroundings. As a result, increasing demands will be placed on our visual, auditory, and other sensory abilities. Information previously encoded as text and numbers will be displayed in richer sensory formats—as graphics, pictures, patterns, sounds, smells, and tactile experiences. This enriched sensory environment will coincide with major breakthroughs in our understanding of the brain—in how we process sensory information and connect various sensory functions. Humans will become much more sophisticated in their ability to understand, create, and manage sensory information and ability to perform such tasks will become keys to success.

Lightweight Infrastructure

A confluence of new materials and distributed intelligence is pointing the way toward a new kind of infrastructure that will dramatically reshape the economics of moving people, goods, energy, and information. From the molecular level to the macro-economic level, these new infrastructure designs will emphasize smaller, smarter, more independent components. These components will be organized into more efficient, more flexible, and more secure ways than the capital-intensive networks of the 20th century. These lightweight infrastructures have the potential to boost emerging economies, improve social connectivity, mitigate the environmental impacts of rapid global urbanization, and offer new future paths in energy.

META-THEMES

Democratized Innovation

Before the 20th century, many of the greatest scientific discoveries and technical inventions were made by amateur scientists and independent inventors. In the last 100 years, a professional class of scientists and engineers, supported by universities, industry, and the state, pushed amateurs aside as a creative force. At the national scale, the capital-intensive character of scientific research made world-class research the property of prosperous advanced nations. In the new century, a number of trends and technologies will lower the barriers to participation in science and technology again, both for individuals and for emerging countries. The result will be a renaissance of the serious amateurs, the growth of new scientific and technical centres of excellence in developing countries, and a more global distribution of world-class scientists and technologists.

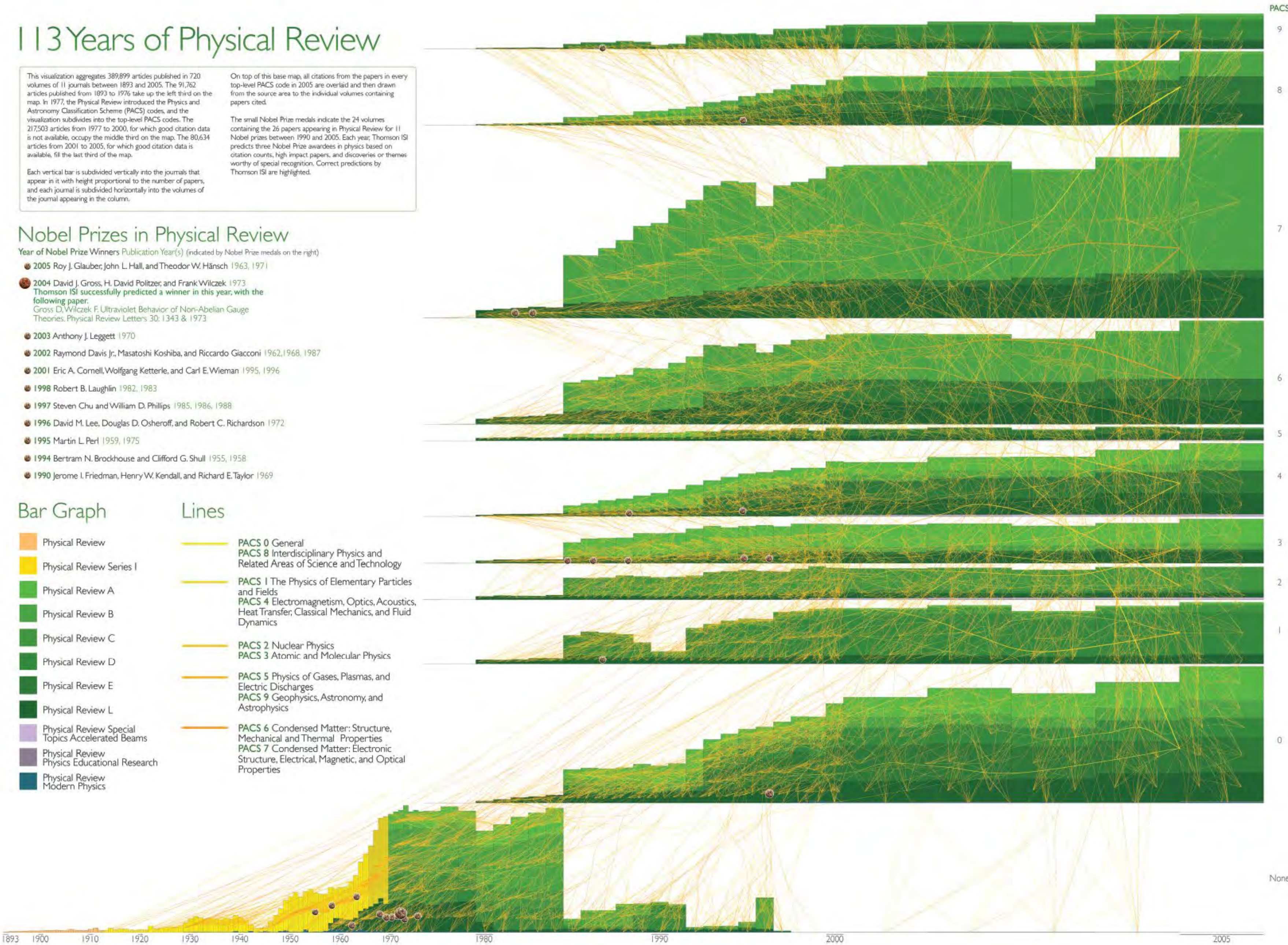
Transdisciplinarity

In the last two centuries, natural philosophy and natural history fractured into the now-familiar disciplines of physics, chemistry, biology, and so on. The sciences evolved into their current form in response to intellectual and professional opportunities, philanthropic priorities, and economic and state needs. Through most of the 20th century, the growth of the sciences, and academic and career pressures, encouraged ever-greater specialization. In the coming decades, transdisciplinary research will become an imperative. According to Howard Rheingold, a prominent forecaster and author, "transdisciplinarity goes beyond bringing together researchers from different disciplines to work in multidisciplinary teams. It means educating researchers who can speak languages of multiple disciplines—biologists who have understanding of mathematics, mathematicians who understand biology."

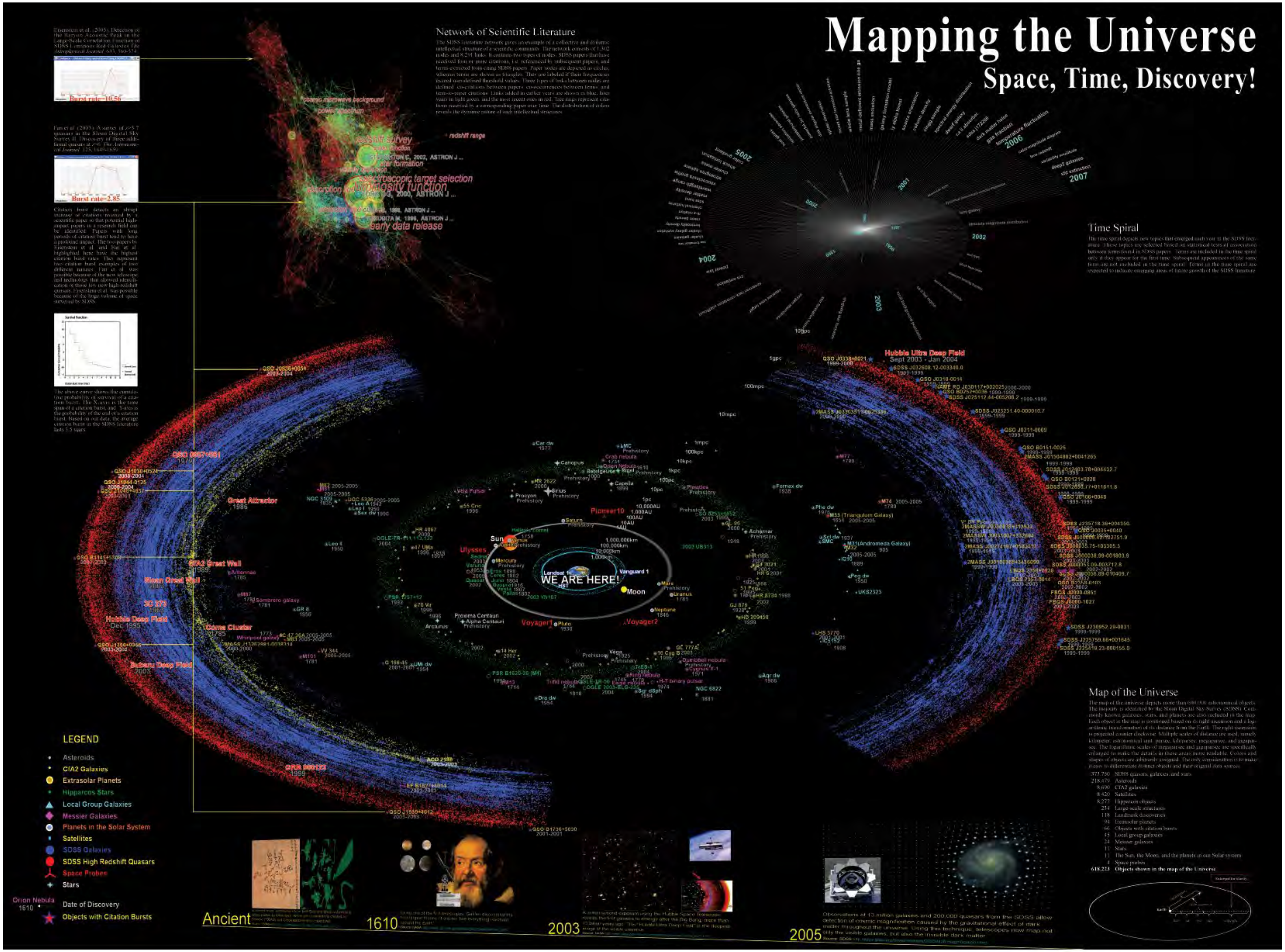
Emergence

The phenomenon of self-organizing swarms that generate complex behavior by following simple rules—will likely become an important research area, and an important model for understanding how the natural world works and how artificial worlds can be designed. Emergent phenomena have been observed across a variety of natural phenomena, from physics to biology to sociology. The concept has broad appeal due to the diversity of fields and problems to which it can be applied. It is proving useful for making sense of a very wide range of phenomena. Meanwhile, emergence can be modeled using relatively simple computational tools, although those models often require substantial processing power. More generally, it is a richly suggestive as a way of thinking about designing complex, robust technological systems. Finally, emergence is an accessible and vivid a metaphor for understanding nature. Just as classical physics profited from popular treatments of Newtonian mechanics, so too will scientific study and technical reproductions of emergent phenomena likely draw benefits from the popularization of its underlying concepts.

III.5 *Science & Technology Outlook: 2005-2055* – Marina Gorbis, Jean Hagan, Alex Soojung-Kim Pang, and David Pescovitz - 2006

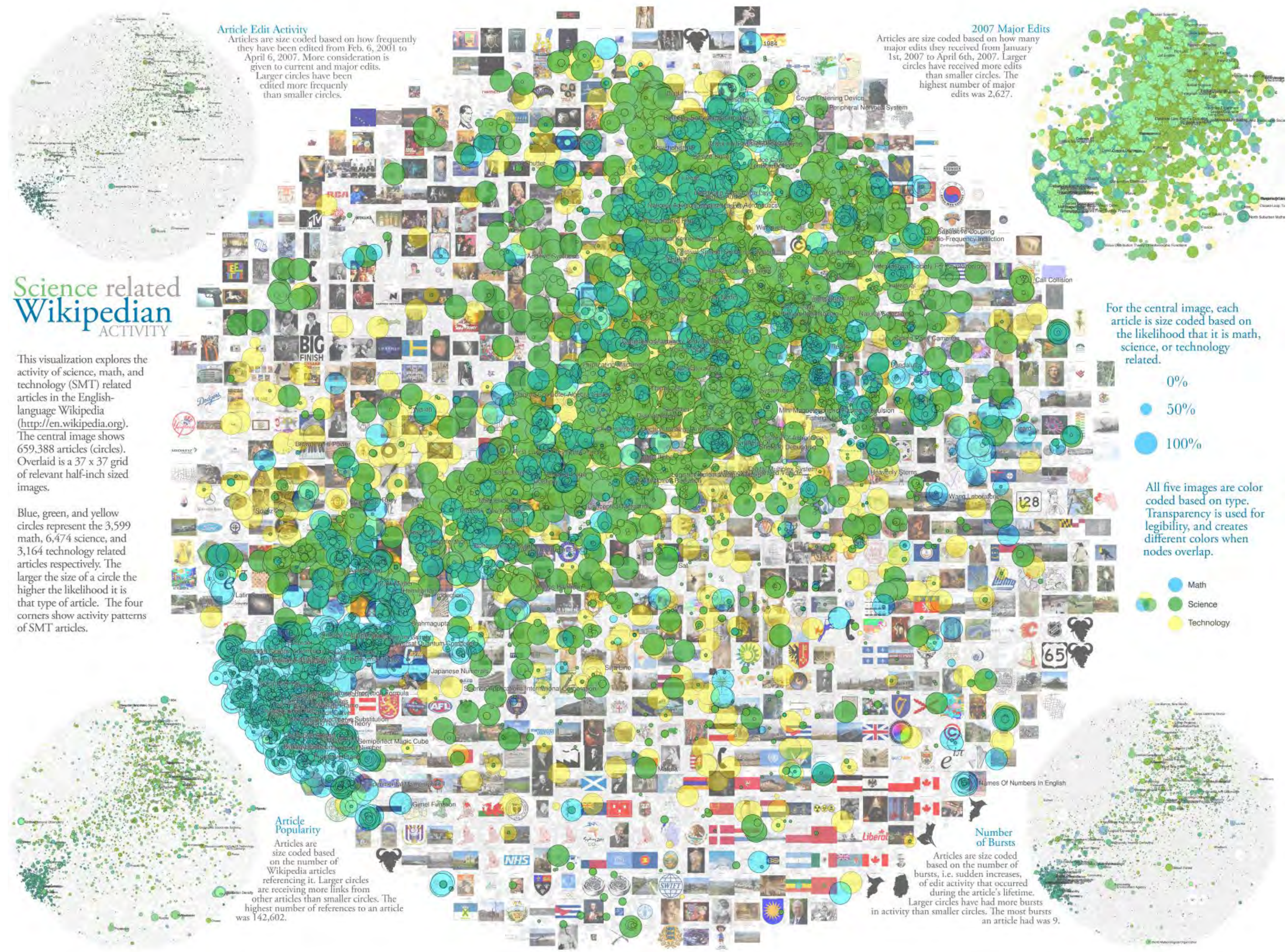


III.6 *113 Years of Physical Review* - Bruce W. Herr II, Russell J. Duhon, Elisha F. Hardy, Shashikant Penumarthy, and Katy Börner - 2006

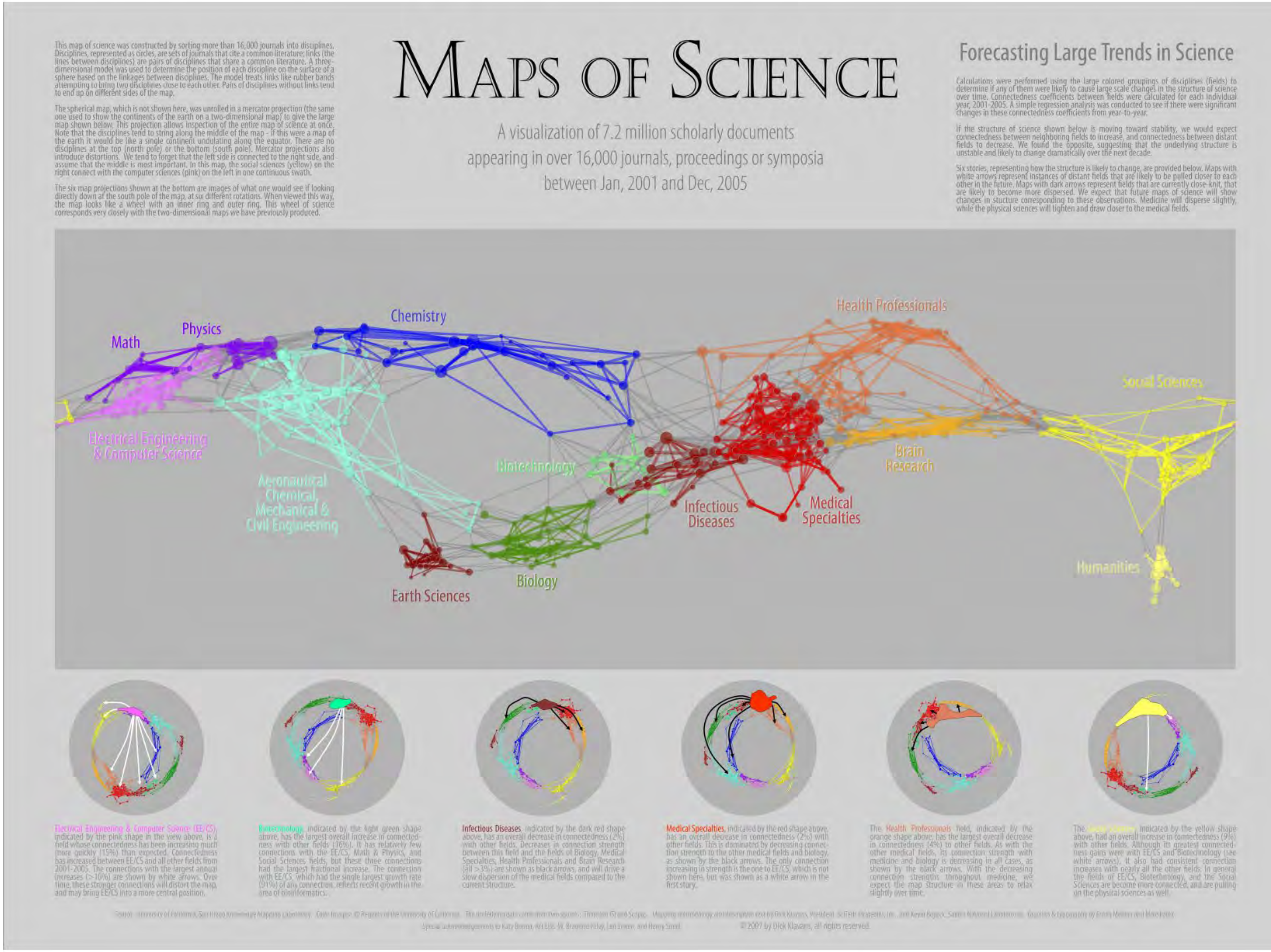


III.7 *Mapping the Universe: Space, Time, Discovery!*

Chaomei Chen, Jian Zhang, Lisa Kershner, Michael S. Vogeley, J. Richard Gott III, and Mario Juric - 2007



III.8 *Science-Related Wikipedian Activity* - Bruce W. Herr II, Todd M. Holloway, Elisha F. Hardy, Katy Börner, and Kevin Boyack - 2007



III.9 *Maps of Science: Forecasting Large Trends in Science* - Richard Klavans and Kevin Boyack - 2007

III.10 *Hypothetical Model of the Evolution and Structure of Science* - Daniel Zeller - 2007

Exhibit Venues

April 15 - 19, 2015, International Science Festival, Gothenburg, Sweden.

May 1 - October 30, Galter Health Sciences Library, Northwestern University, Chicago, IL.

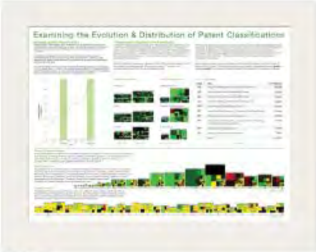
January 1 - June 1, 2013, National Academy of Sciences, Upstairs Gallery, Washington, D.C.

Iteration IV (2008)

Science Maps for Economic Decision Makers

IV.1

IV.3



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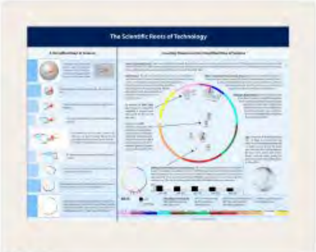

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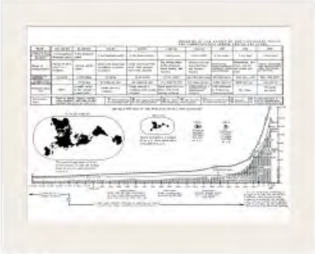

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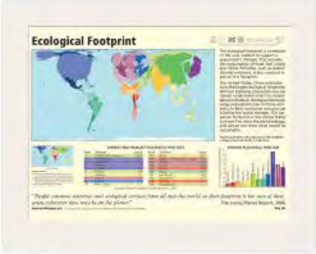

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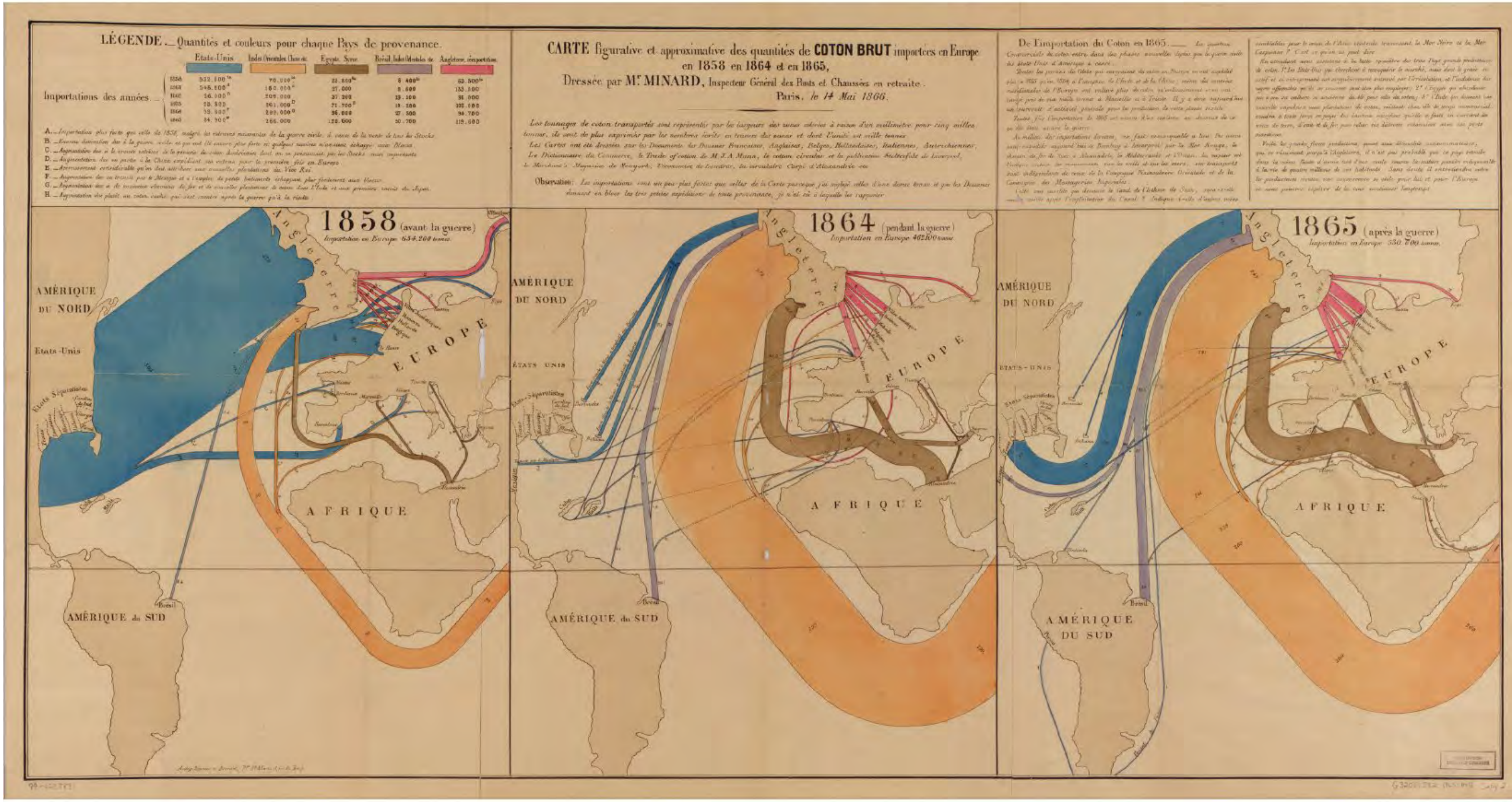


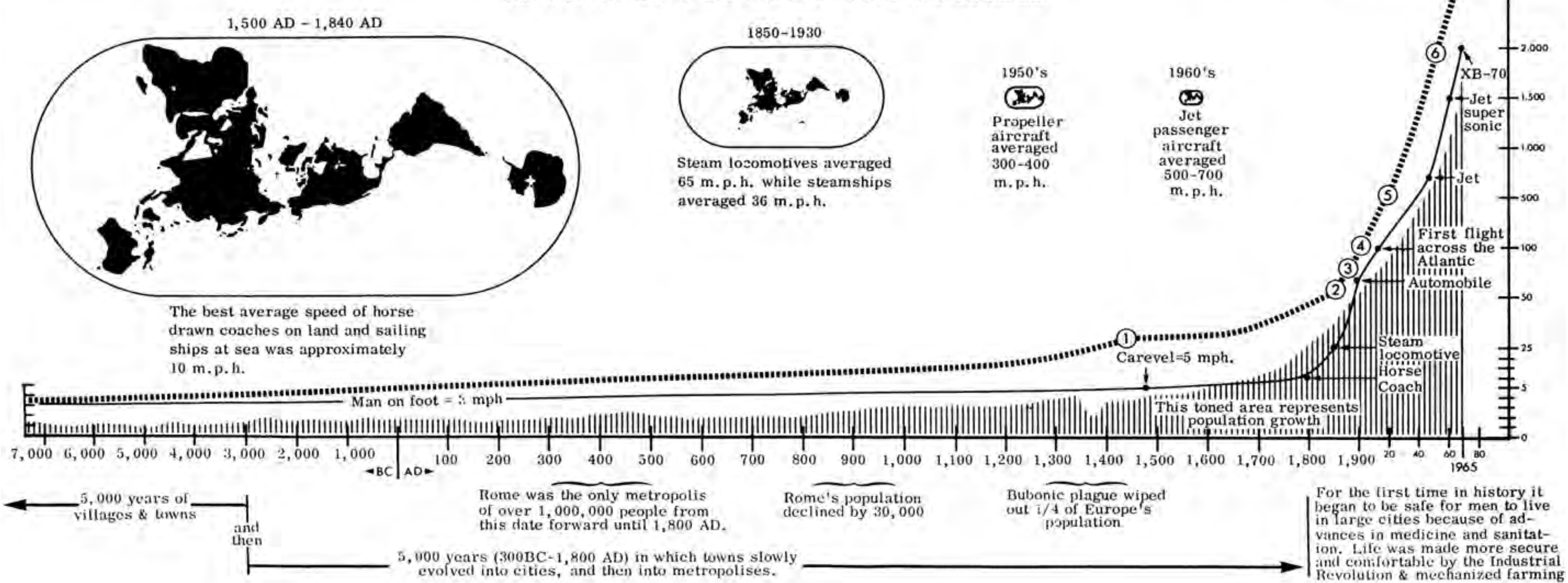
IV.1 *Europe Raw Cotton Imports in 1858, 1864 and 1865* - Charles Joseph Minard - 1866

SHRINKING OF OUR PLANET BY MAN'S INCREASED TRAVEL AND COMMUNICATION SPEEDS AROUND THE GLOBE

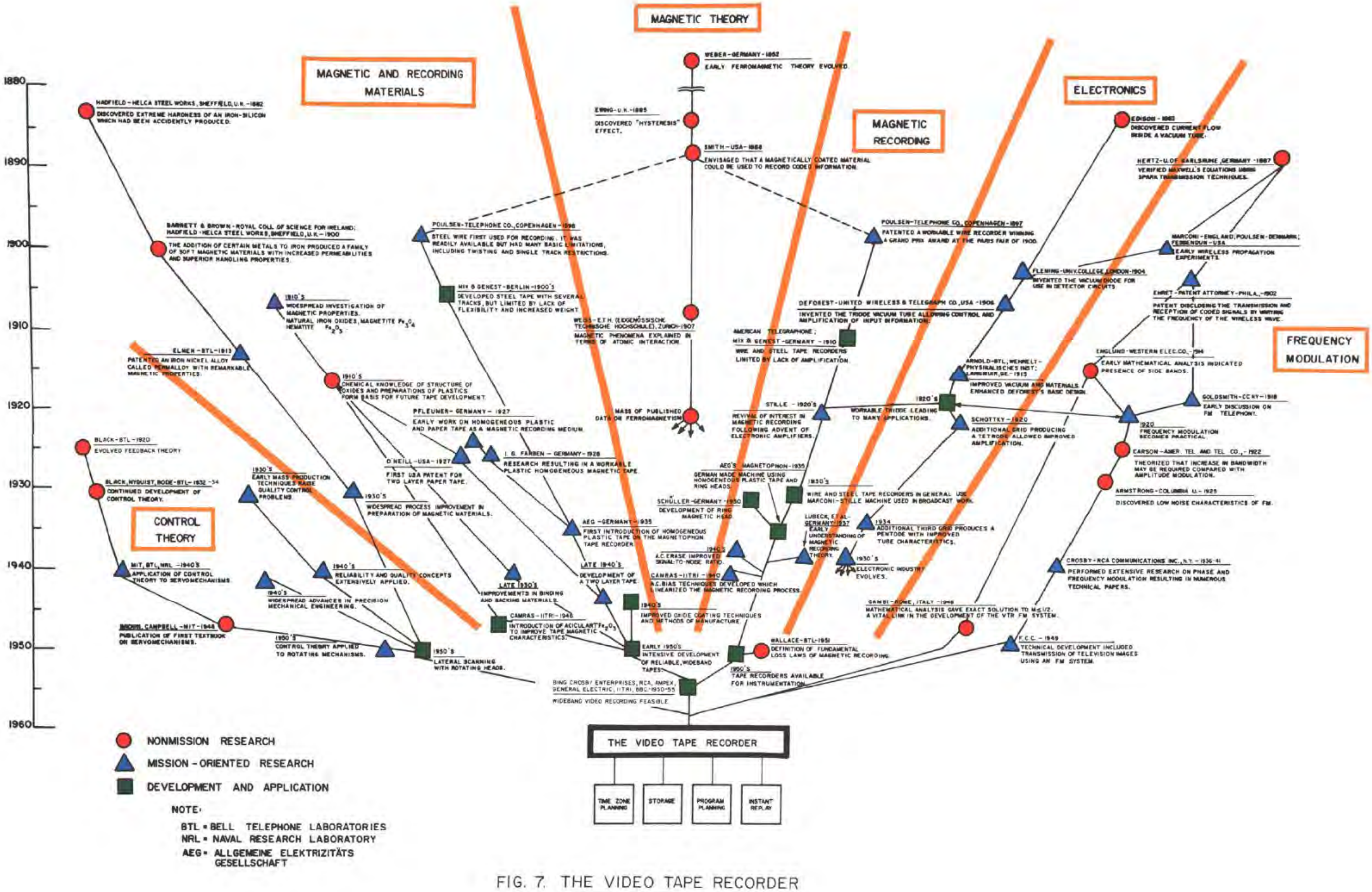
YEAR	500,000 BC	20,000 BC	300 BC	500 BC	1,500 AD	1,900 AD	1925	1950	1965
Required time to travel around the globe	A few hundred thousand years	A few thousand years	A few hundred years	A few tens of years	A few years	A few months	A few weeks	A few days	A few hours
Means of transportation	Human on foot (over, ice bridges)	On foot and by canoe	Canoe with small sail or paddles or relays of runners	Large sail boats with oars, pack animals, and horse chariots	Big sailing ships (with compass), horse teams, and coaches	Steam boats and railroads (Suez and Panama Canals)	Steamships, transcontinental railways, autos, and airplanes	Steamships, railways, auto, jet, and rocket aircraft	Atomic steamship, high speed railway, auto, and rocket-jet aircraft
Distance per day(land)	15 miles	15-20 miles	20 miles	15-25 miles	20-25 miles	Rail 300-900 miles	400-900 miles	Rail 500-1,500	Rail 1,000-2,000
Distance per day (sea or air)		20 by sea	40 miles by sea	135 miles by sea	175 miles by sea	250 miles by sea	3,000-6,000 air	6,000-9,500 air	408,000 air
Potential state size	None	A small valley in the vicinity of a small lake	Small part of a continent	Large area of a continent with coastal colonies	Great parts of a continent with trans-oceanic colonies	Large parts of a continent with transoceanic colonies	Full continents & Transocean Commonwealths	The Globe	The globe and more

Communications							
Word of mouth, drums, smoke, relay runners, and hand printed manuscripts prior to 1441 A.D.	① 1441 The Gutenberg printing press	② 1863 The rapid print Web newspaper press	③ 1876 The Bell telephone	④ 1895 The Marconi telegraph	⑤ 1920 First commercial radio broadcast	⑥ 1950 National Television	⑦ 1965 Transcontinental T. V. with the introduction of Early Bird satellite

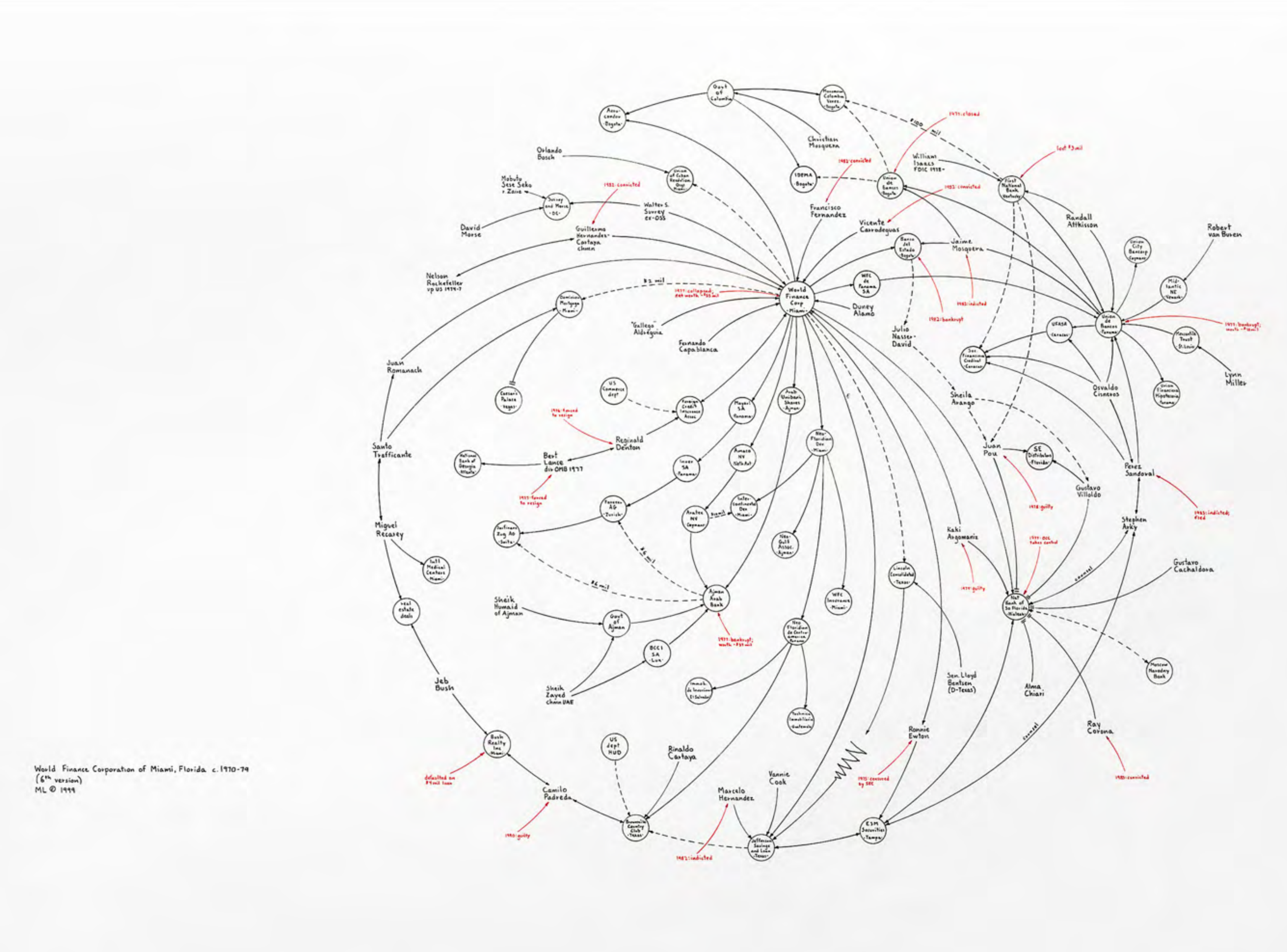
THE RELATIVE SIZE OF THE WORLD AS TRAVEL TIME DECREASES



IV.2 *Shrinking of Our Planet* - R. Buckminster Fuller and John McHale - 1965



IV.3 *Tracing of Key Events in the Development of the Video Tape Recorder* - George Benn and Francis Narin - 1968



IV.4 *World Finance Corporation, Miami, Florida, ca. 1970-79 (6th Version)* - Mark Lombardi - 1999

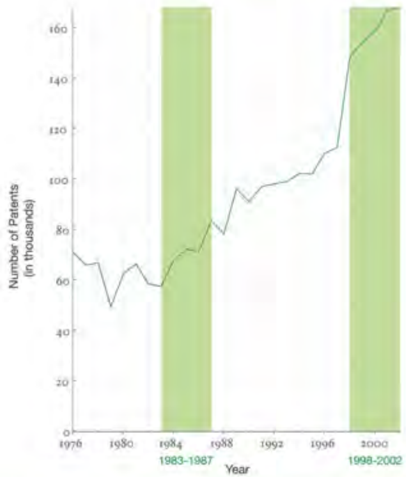
Examining the Evolution & Distribution of Patent Classifications

Managing Growing Patent Portfolios

Organizations, businesses, and individuals rely on patents to protect their intellectual property and business models. As market competition increases, patenting innovation and intellectual property rights becomes ever more important.

Managing the staggering number of patents demands new tools and methodologies. Grouping patents by their classifications offers an ideal resolution for better understanding how intellectual borders are established and change over time.

The charts below show the annual number of patents granted from January 1, 1976 to December 31, 2002 in the United States Patent and Trademark Office (USPTO) patent archive; slow and fast growing patent classes; the top 10 fast growing patent subclasses; and two evolving patent portfolios.



The Structure and Evolution of the Patent Space

The United States Patent and Trademark Office assigns each patent to one of more than 450 classes covering broad application domains. For example, class 514 encompasses all patents dealing with 'Drug, Bio-Affecting and Body Treating Compositions.' Classes are further broken down by subclasses that have hierarchical associations. As one example, class 455 features subclass 99 entitled "with vehicle."

The top 10 fast growing patent classes for 1998–2002 are listed together with the number of patents granted. Most come from the 'Computer and Communications' and the 'Drugs and Medical' area.

The evolving hierarchical structure of patent classes and their sizes is represented using treemaps, a space-filling visualization technique developed by Ben Shneiderman at the University of Maryland. A treemap presents a hierarchy as a collection of nested rectangles—demarcating a parent-child relationship between nodes by nesting the child within the parent rectangle. The size and color of each rectangle represent certain attributes of the nodes.

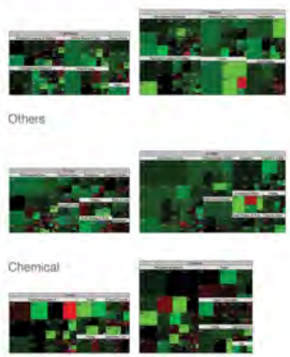
Here, each rectangle represents a class and the area size denotes the total number of patents in that class. The rectangle's color corresponds to percentage increase (**green**) or decrease (**red**) in the number of patents granted in that class from the previous interval.

Slow Growing Classes

Mechanical

Others

Chemical



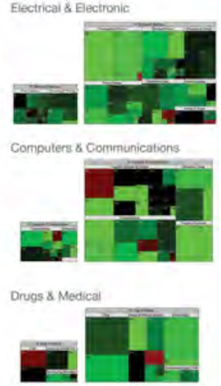
1983 - 1987 1998 - 2002

Fast Growing Classes

Electrical & Electronic

Computers & Communications

Drugs & Medical



1983 - 1987 1998 - 2002

Top-10 Subclasses

Class	Title	# of Patents
514	Drug, Bio-Affecting and Body Treating Compositions	18,778
438	Semiconductor Device Manufacturing:Process	17,775
435	Chemistry: Molecular Biology and Microbiology	17,474
424	Drug, Bio-Affecting and Body Treating Compositions	13,637
428	Stock Material or Miscellaneous Articles	13,314
257	Active Solid-State Devices (e.g., Transistors, Solid-State Diodes)	12,924
395	Information Processing System Organization	9,955
345	Computer Graphics Processing, Operator Interface Processing, and Selective Visual Display Systems	9,510
359	Optical: Systems and Elements	9,151
365	Static Information Storage and Retrieval	8,392
	Total	130,910

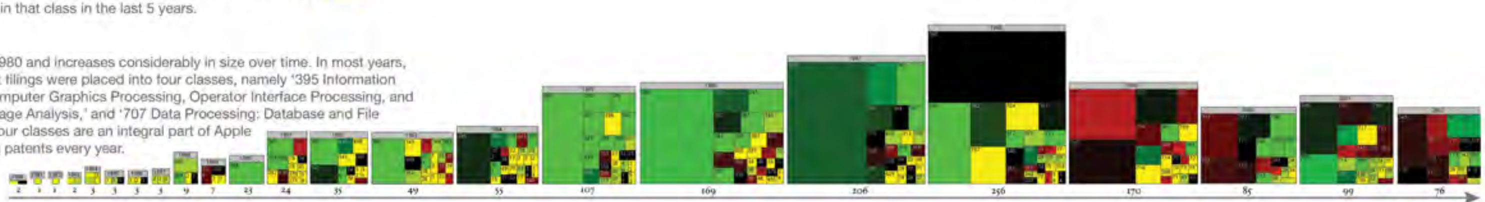
1998 - 2002

Patent Portfolio Analysis

A longitudinal analysis of portfolios reveals different patenting strategies. For each year (given in gray above each treemap), a treemap of all new patents granted to the assignee is shown. The number of patents is given below each treemap. The same size and color coding as above was used. In addition, yellow indicates that no patent has been granted in that class in the last 5 years.

Apple Computer, Inc.

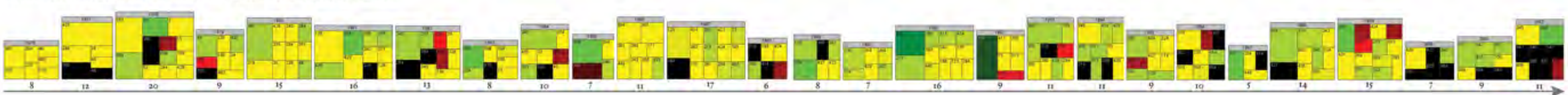
Apple Computer, Inc.'s portfolio starts in 1980 and increases considerably in size over time. In most years, more than half of Apple Computer's patent filings were placed into four classes, namely '395 Information Processing System Organization,' '345 Computer Graphics Processing, Operator Interface Processing, and Selective Visual Display Systems,' '382 Image Analysis,' and '707 Data Processing: Database and File Management or Data Structures.' These four classes are an integral part of Apple Computer, Inc.'s patent portfolio, receiving patents every year.



1980 - 2002

Jerome Lemelson

The patent portfolio of Jerome Lemelson shows a very different activity pattern. Starting in 1976, he publishes between 6–20 patents each year. However, the predominance of yellow shows that there is little continuity from previous years in regards to the classes into which patents are filed. No class dominates. Instead, more and more new intellectual space is claimed.

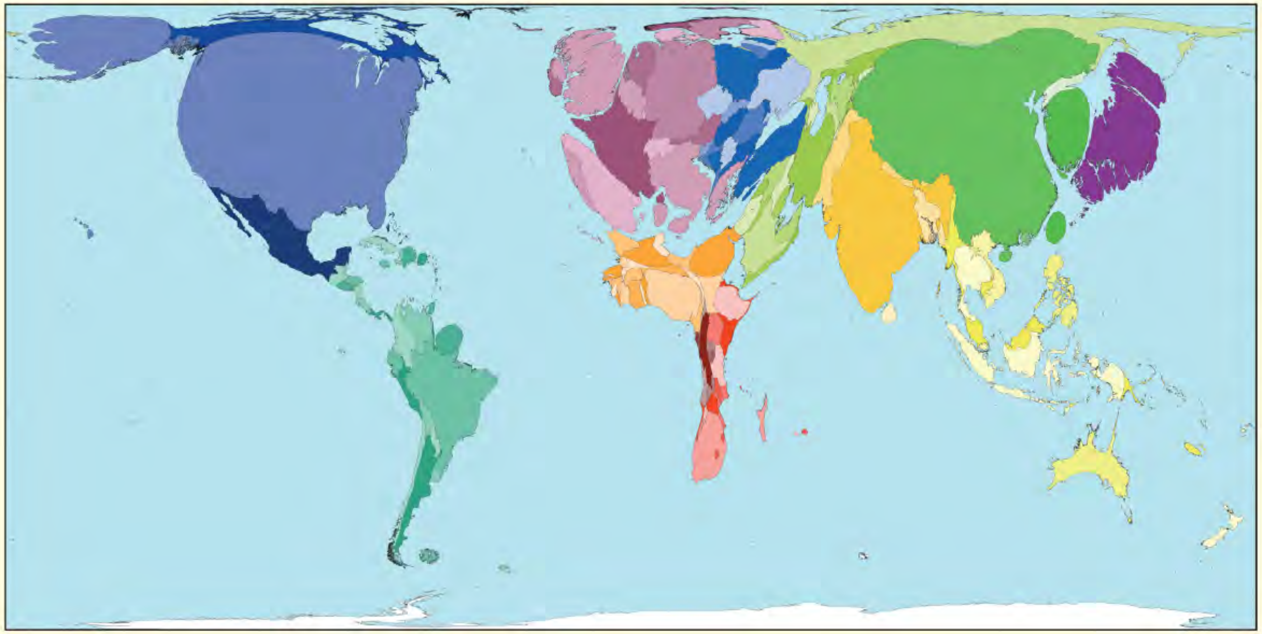


1976 - 2002

IV.5 *Examining the Evolution & Distribution of Patent Classifications* - Daniel O. Kutz, Katy Borner, and Elisha F. Hardy - 2004

Ecological Footprint

Produced by the SASI group (Sheffield) and Mark Newman (Michigan)



The ecological footprint is a measure of the area needed to support a population's lifestyle. This includes the consumption of food, fuel, wood, and fibres. Pollution, such as carbon dioxide emissions, is also counted as part of the footprint.

The United States, China and India have the largest ecological footprints. Without knowing population size we cannot understand what this means about individuals' ecological demands. Large populations live in China and India. In both territories resource use is below the world average. The per person footprint in the United States is almost five times the world average, and almost ten times what would be sustainable.

Territory size shows the proportion of the worldwide ecological footprint which is made there.

Land area

Technical notes

- Data are from the WWF (Worldwide Fund for Nature) International and Institute of Zoology.
- Ecological footprint is measured in global hectares. One global hectare is an area that has the world average biological productivity of one hectare.
- See website for further information.

LARGEST AND SMALLEST ECOLOGICAL SHOE SIZES

Rank	Territory	Value
1	United Arab Emirates	10.6
2	United States	9.7
3	Greenland	7.7
3	Bahamas	7.7
5	Canada	7.5
6	Kuwait	7.4
7	Australia	7.0
8	Finland	6.8
9	Estonia	6.1
10	New Zealand	6.1

Rank	Territory	Value
191	Nepal	0.61
192	Democratic Republic of Congo	0.58
193	Zambia	0.58
194	Congo	0.58
195	Malawi	0.57
196	Haiti	0.57
197	Cambodia	0.55
198	Bangladesh	0.47
199	Somalia	0.23
200	Afghanistan	0.11

*ecological footprint in global hectares per person, 2002**

AVERAGE ECOLOGICAL SHOE SIZE

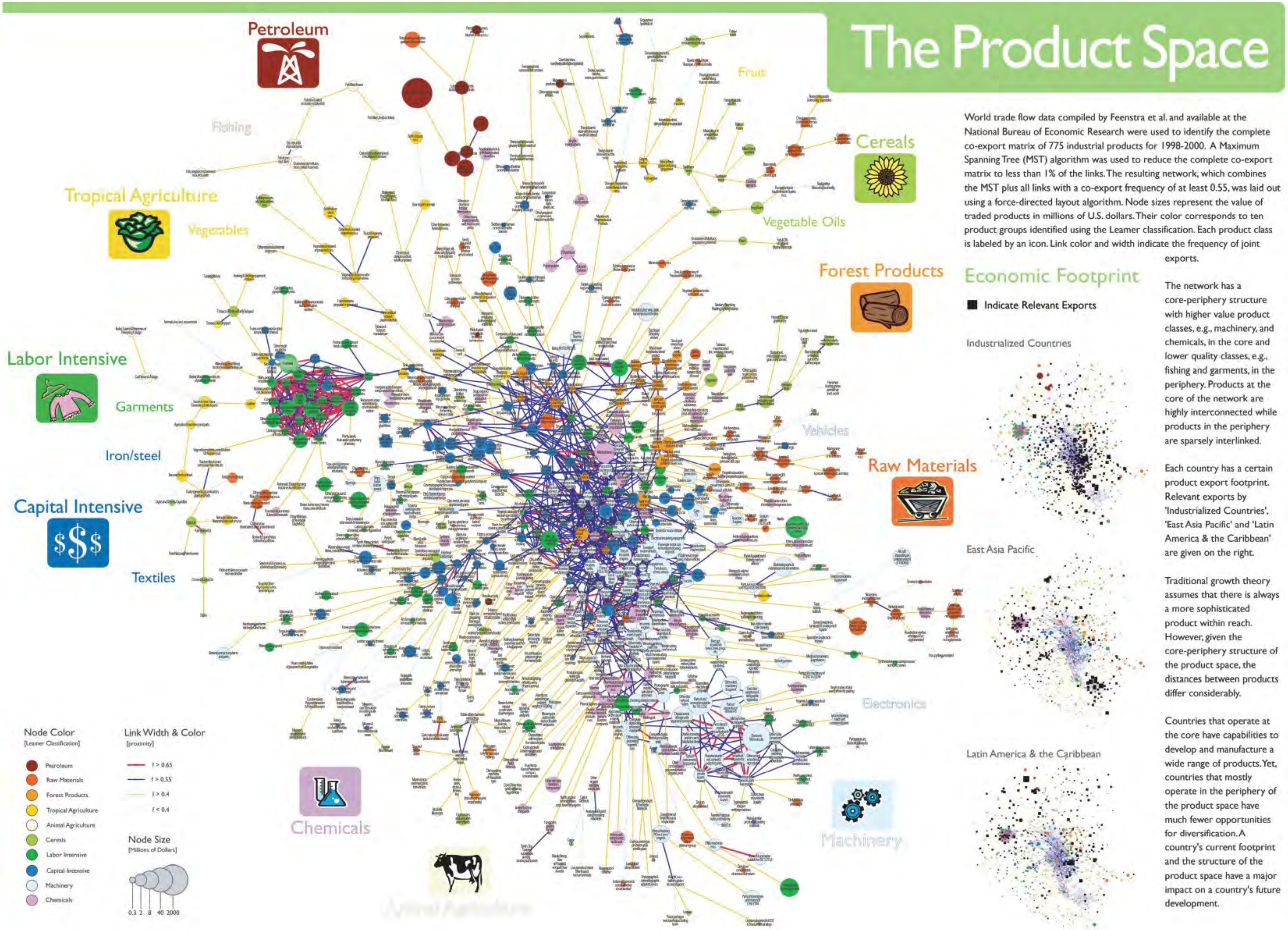
"People consume resources and ecological services from all over the world, so their footprint is the sum of these areas, wherever they may be on the planet."

The Living Planet Report, 2006

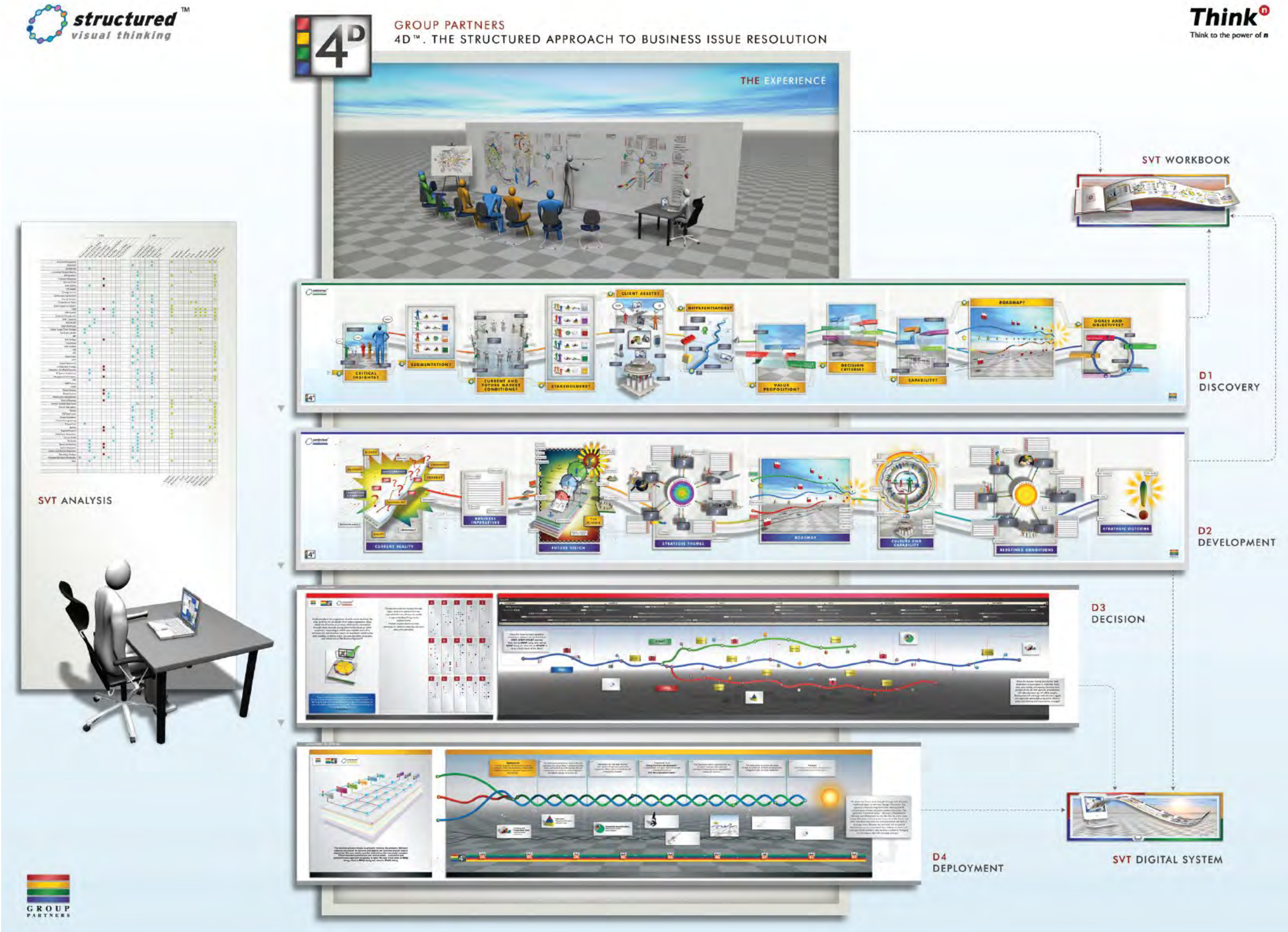
www.worldmapper.org © Copyright 2006 SASI Group (University of Sheffield) and Mark Newman (University of Michigan)

Map 322

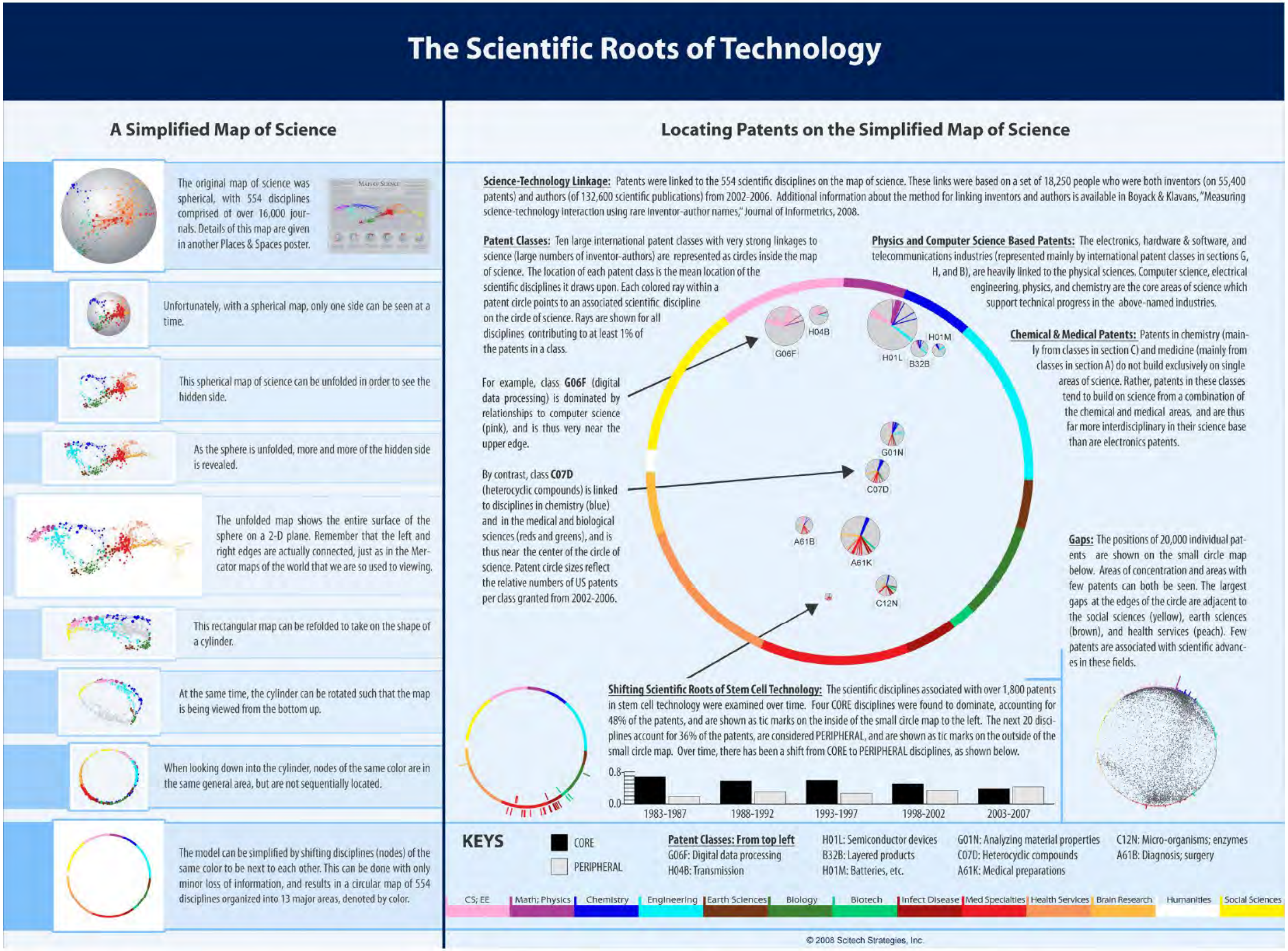
IV.6 *Ecological Footprint* - Danny Dorling, Mark E.J. Newman, Graham Allsopp, Anna Barford, Ben Wheeler, John Pritchard, and David Dorling - 2006



IV.7 *The Product Space* - César A. Hidalgo, Bailey Klinger, Albert-László Barabási, Ricardo Hausmann - 2007



IV.8 *4D™. The Structured Visual Approach to Business-Issue Resolution* - Jon Caswell, Hazel Tiffany, and Ian Francis - 2008



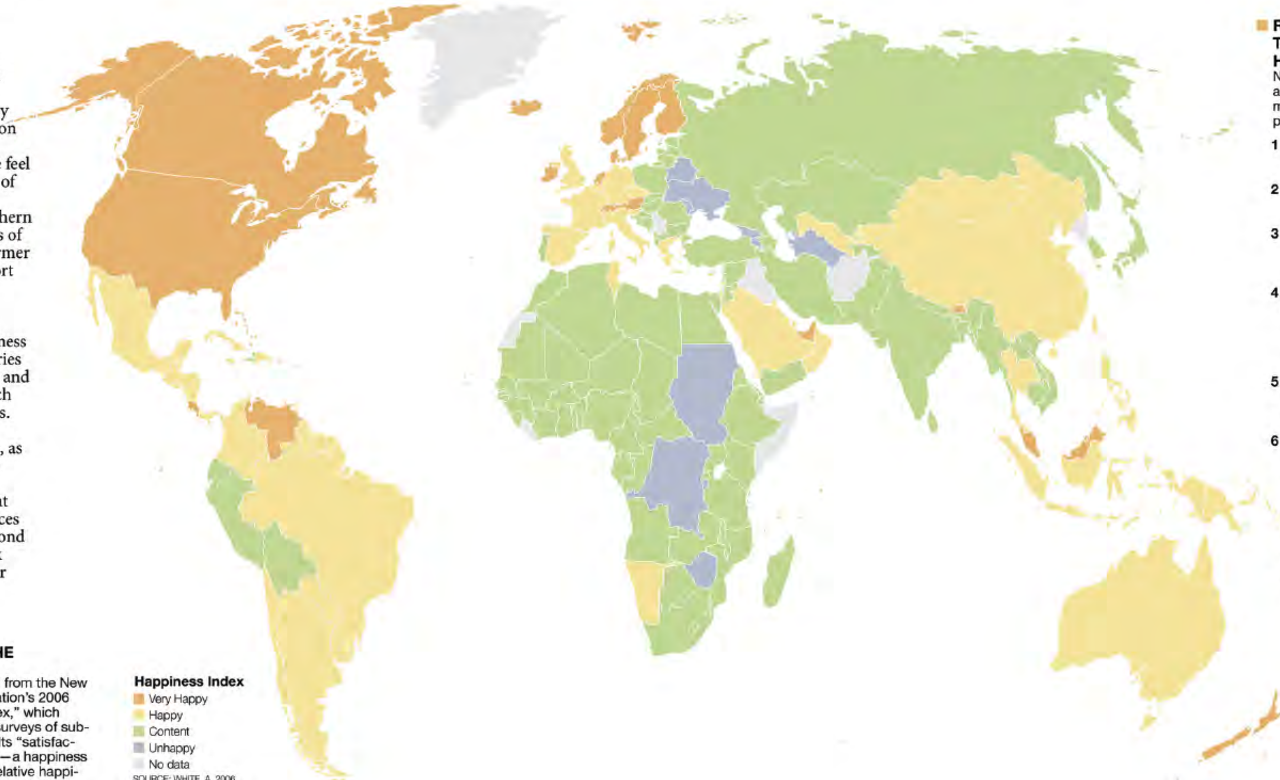
IV.9 *The Scientific Roots of Technology* - Kevin W. Boyack and Richard Klavans - 2007

Happiness Depends on Various Factors

Social scientists are starting to include relative happiness with hard data on economic status, health, and other factors as they assess quality of life. They rely on surveys of "subjective well-being"—how good people feel about their lives. A world map of one "happiness index" shows many, but not all, wealthy northern countries faring well. Residents of sub-Saharan Africa and the former Soviet Union, meanwhile, report particularly low levels of contentment.

Any attempt to measure happiness will fall short—each life is a series of joys, struggles, and sorrows, and satisfaction can depend as much on outlook as on circumstances. Averages obscure the happy moments in struggling nations, as well as people who suffer from poor health, poverty, or discrimination in countries that rank high. Still, happiness indices can help researchers move beyond simple economics as they track progress—or backsliding—over time.

"It's time we admitted there's more to life than money."
- David Cameron, U.K. leader of the opposition, 2006



MEASURING THE INTANGIBLE
The map is derived from the New Economics Foundation's 2006 "Happy Planet Index," which drew on over 100 surveys of subjective well-being. Its "satisfaction with life scale"—a happiness index—ranks the relative happiness of nations, from a high of 273 (Denmark and Switzerland) to a low of 100 (Burundi).

RANKING THE WORLD'S HAPPIEST PLACES
Northern Europe, North America, and several wealthy countries make the list, but so do many less prosperous island nations.

1 DENMARK
SWITZERLAND

2 AUSTRIA
ICELAND

3 BAHAMAS
FINLAND
SWEDEN

4 BHUTAN
BRUNEI
CANADA
IRELAND
LUXEMBOURG

5 COSTA RICA
MALTA
NETHERLANDS

6 ANTIGUA AND BARBUDA
MALAYSIA
NEW ZEALAND
NORWAY
SEYCHELLES
ST. KITTS AND NEVIS
UNITED ARAB EMIRATES
UNITED STATES
VANUATU
VENEZUELA

DEFINING WELL-BEING
By comparing the happiness index to data from the UN, the CIA, and other sources, a U.K. psychologist determined that good health and health care, enough money for fundamental needs, and access to basic education are the most important factors for subjective well-being. European countries top all three measures.

HEALTH
Japan boasts the world's longest life expectancy—one measure of overall health. Swaziland, at the other end of the scale, is plagued by poverty, disease, and violence. Disparities in access to health care divide many countries into haves and have-nots.

WEALTH
Money still can't buy love, or happiness, and wealthier people aren't always more content. Still, tiny Luxembourg, which takes top rank in per capita Gross Domestic Product (GDP), also rates a 253 on the happiness index. Real poverty means real misery, a fate shared by billions.

EDUCATION
Residents of Australia can expect to spend more time in school—an average of almost 21 years—than citizens of any other country. But only a basic education is needed to see a significant jump in overall happiness. Around the world, hundreds of millions lack even that.

*Photos different than those used in EarthPulse publication

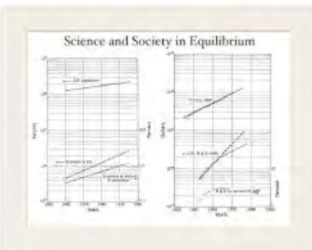
IV.10 *A Global Projection of Subjective Well-Being* - Adrian White and the National Geographic EarthPulse Team - 2008

Check out our Zoom Maps online!

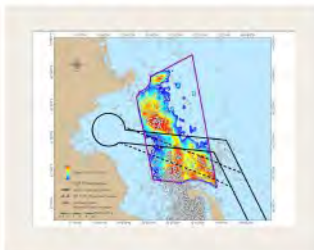
Visit scimaps.org and check out all our maps in stunning detail!

Iteration V (2009)

Science Maps for Science Policy Makers



V.1



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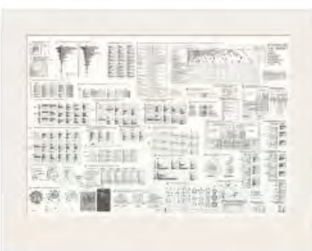

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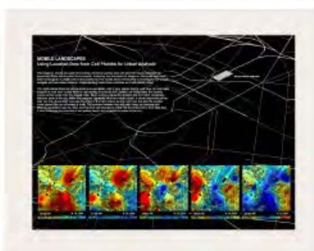

V.4

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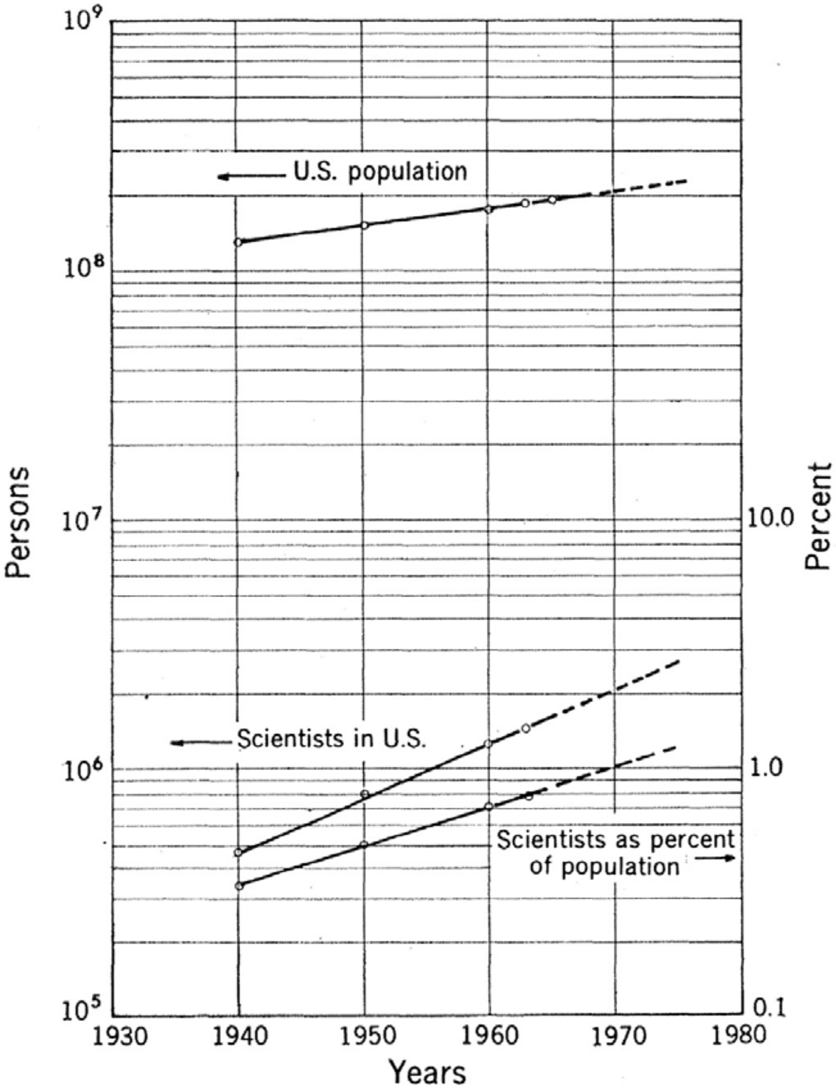
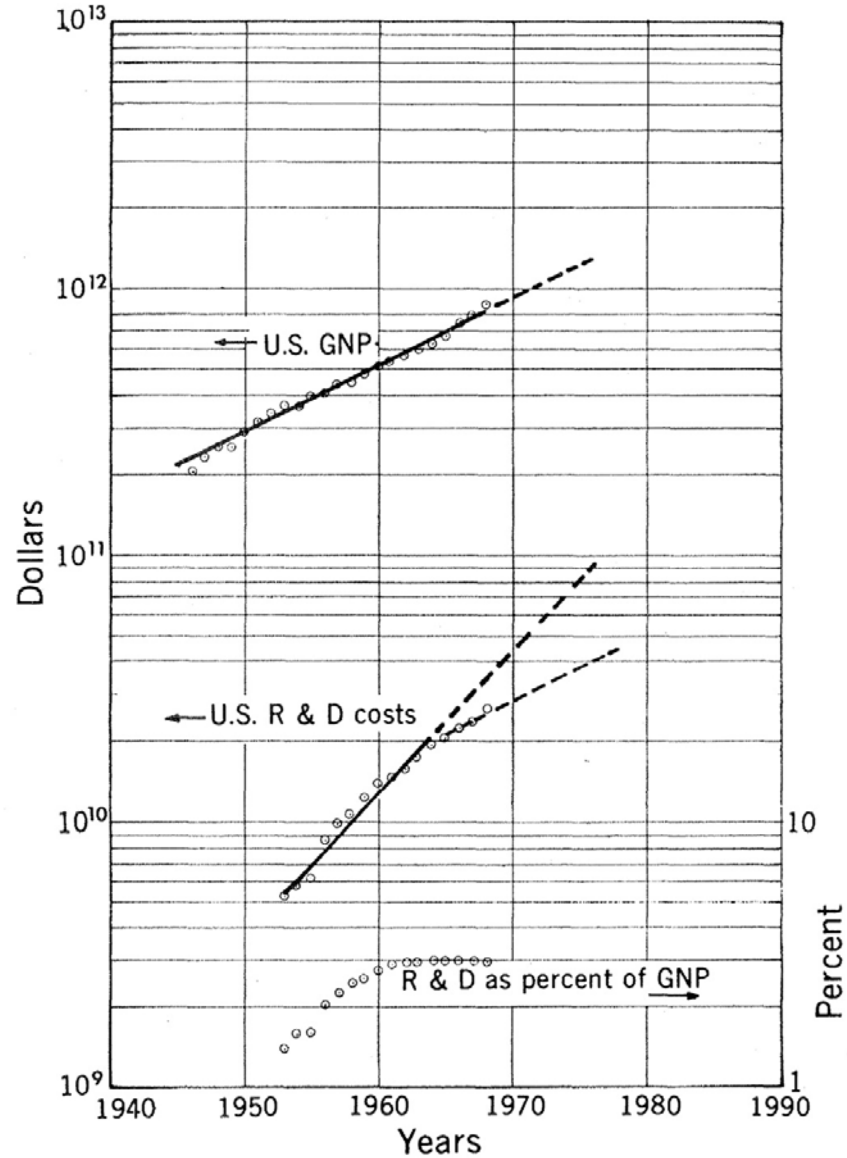
V.8

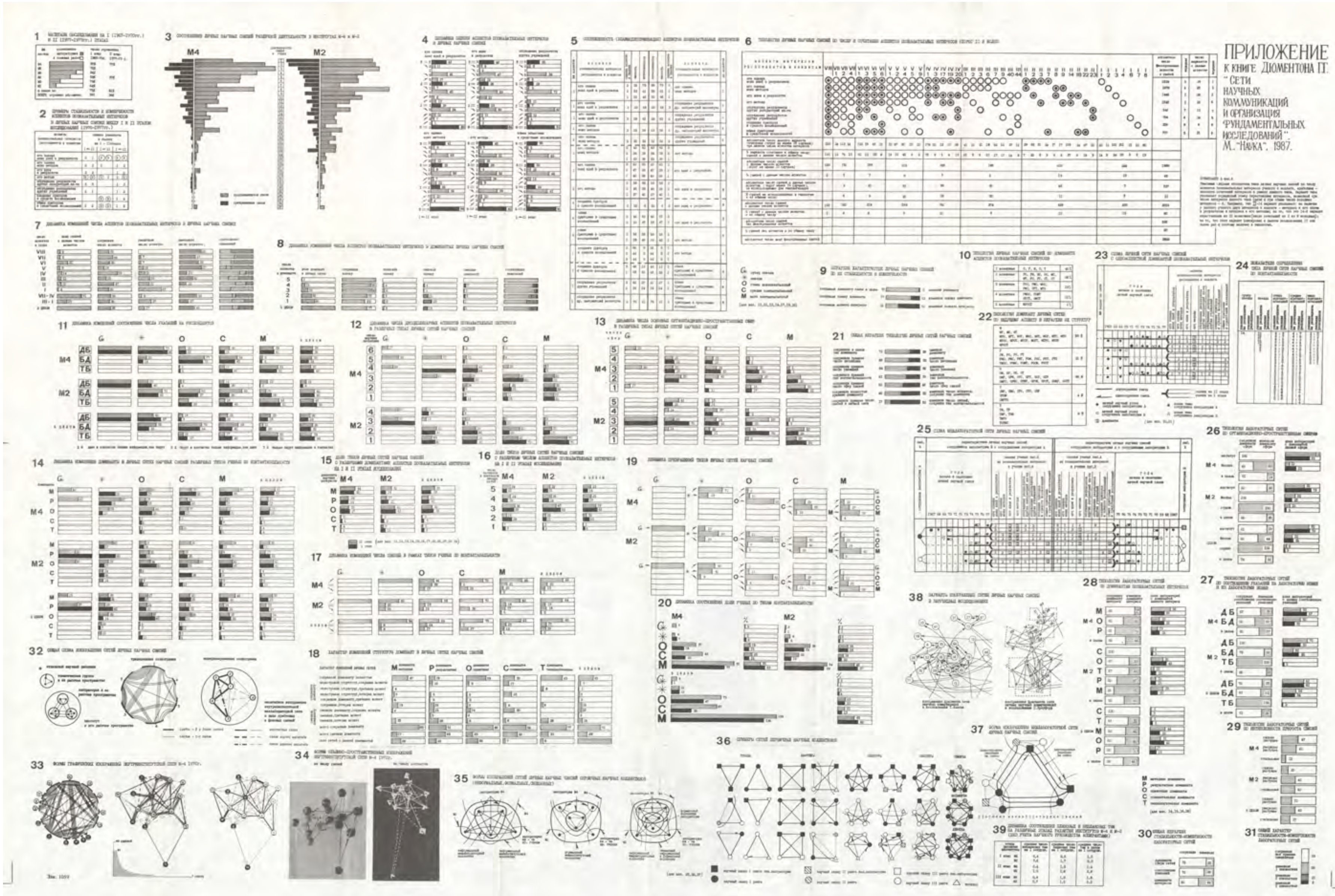
V.10

Science and Society in Equilibrium

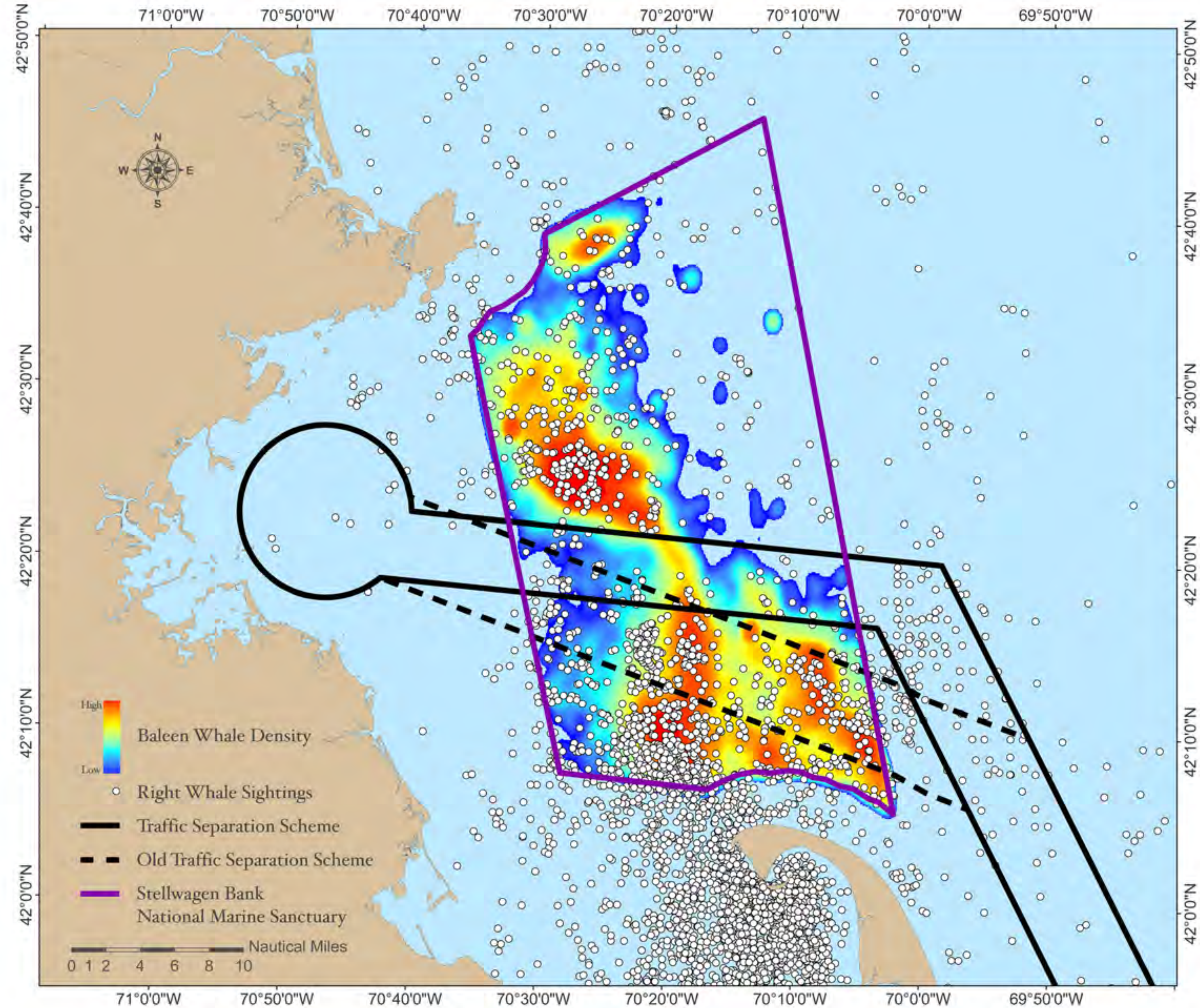




V.1 *Science and Society in Equilibrium* - Joseph P. Martino - 1969

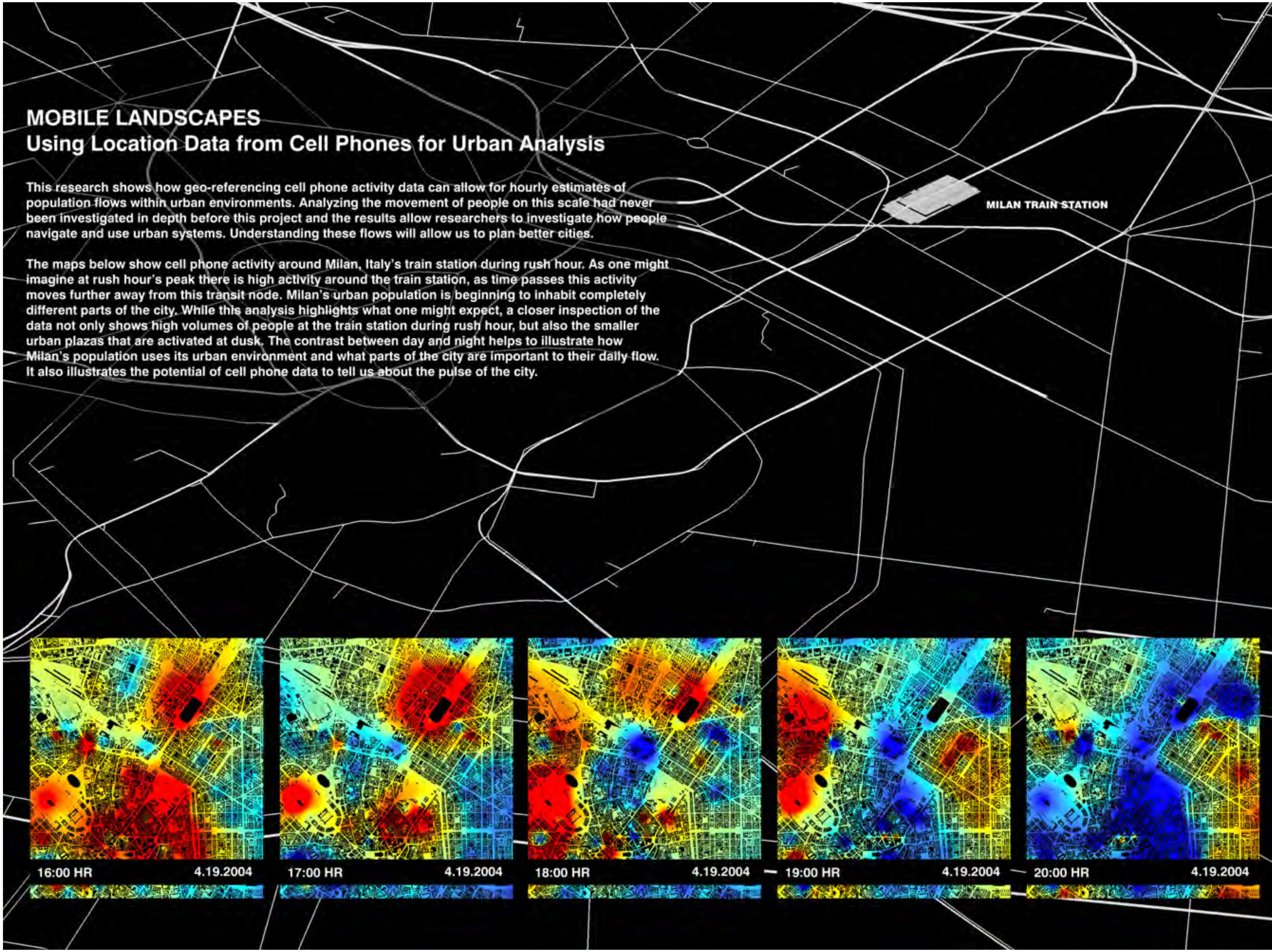


V.2 *Networks of Scientific Communications* - Georgiy G. Dumenton - 1987

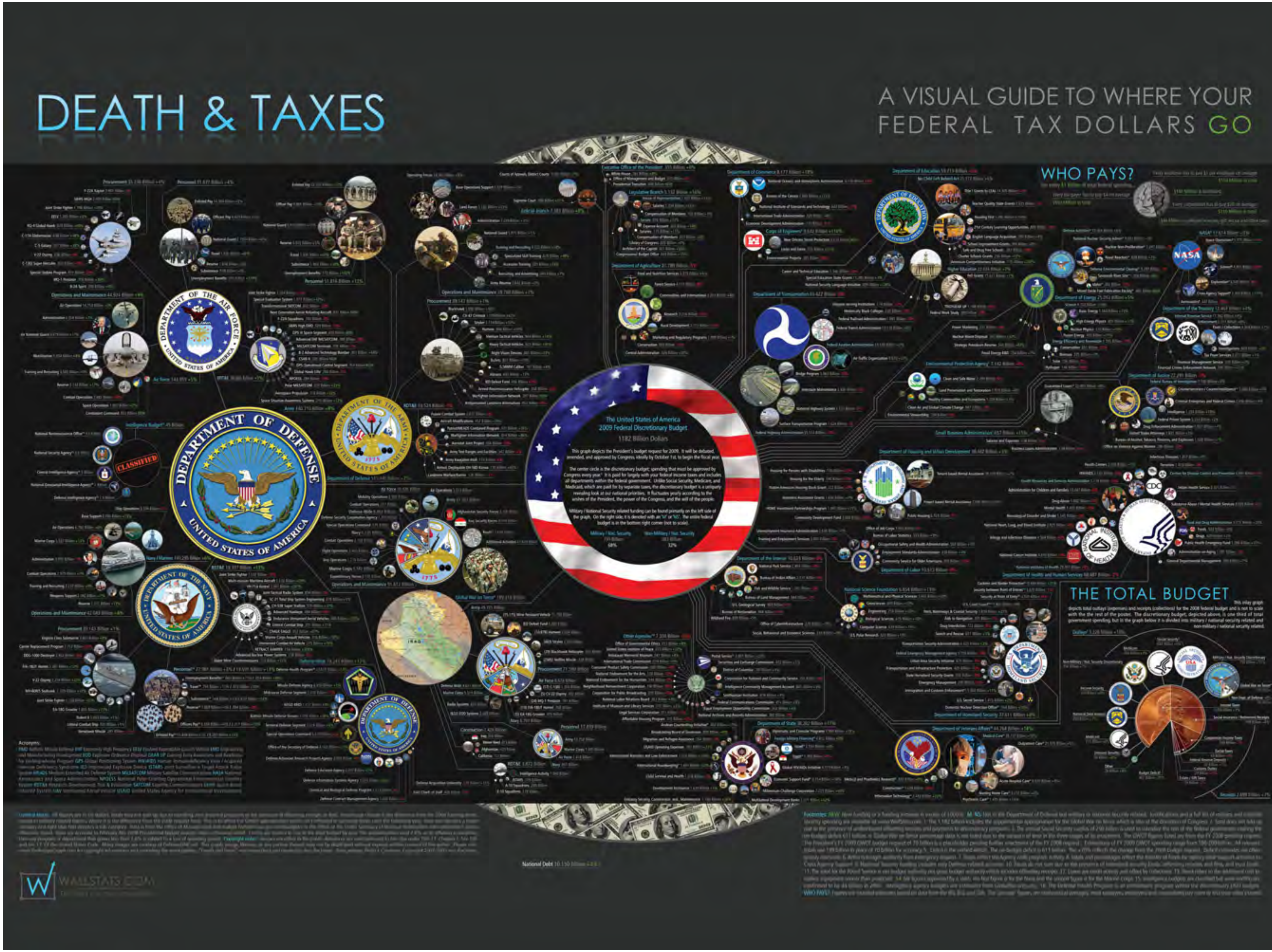


V.3 *Realigning the Boston Traffic Separation Scheme to Reduce the Risk of Ship Strike to Right and Other Baleen Whales*

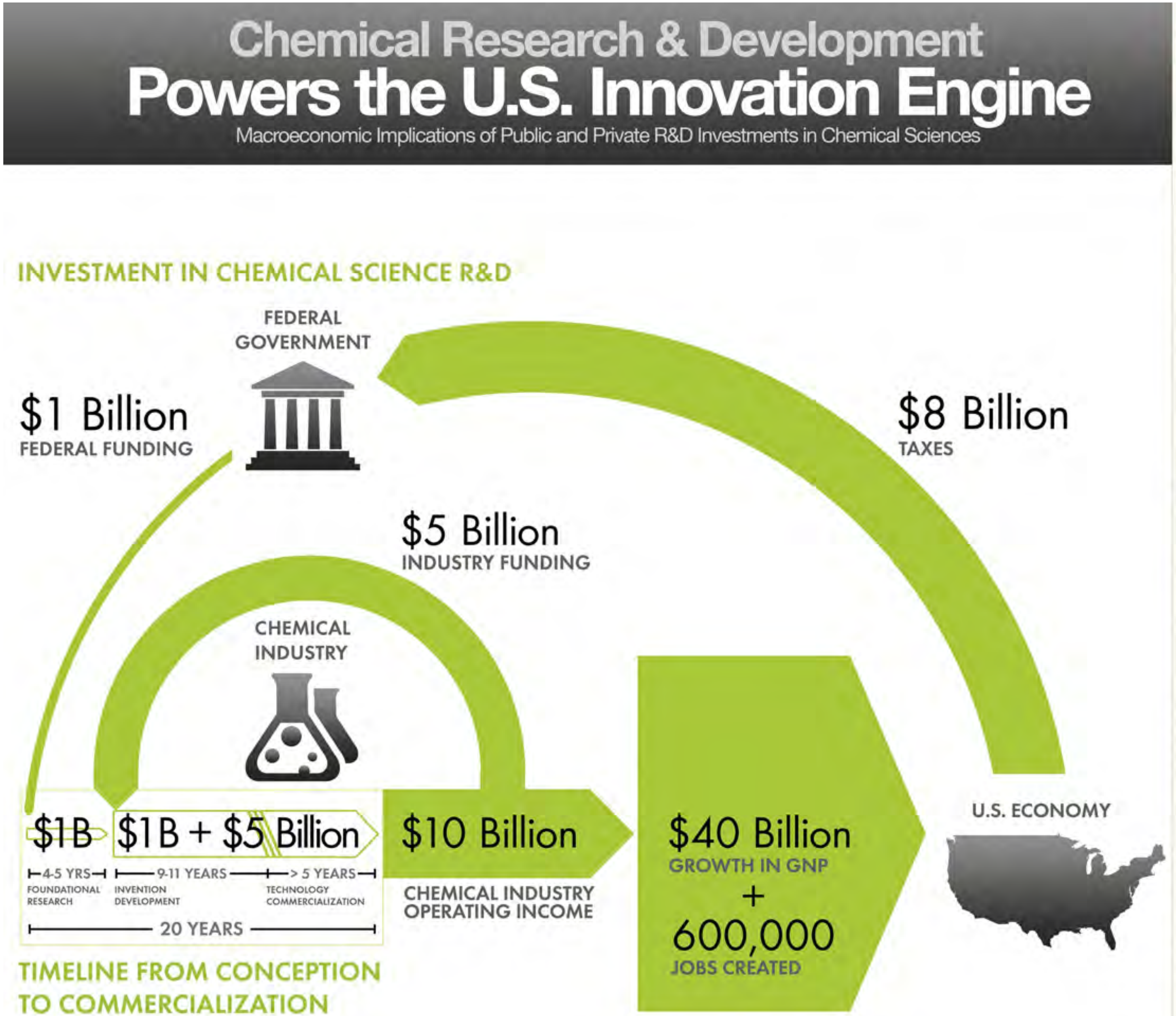
David N. Wiley, Michael A. Thompson, and Richard Merrick - 2006



V.4 *Mobile Landscapes: Using Location Data from Cell Phones for Urban Analysis* - Sarah Williams, Carlo Ratti, and Riccardo Maria Pulselli - 2006



V.5 *Death and Taxes 2009* - Jess Bachman - 2009



The Council for Chemical Research (CCR) 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.

The design shows that an input of $1B in federal investment, leveraged by $5B in industry investment, brings new technologies to market and results in $10B of operating income for the chemical industry, $40B of 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 in tax base that in turn is available for investment in basic research.

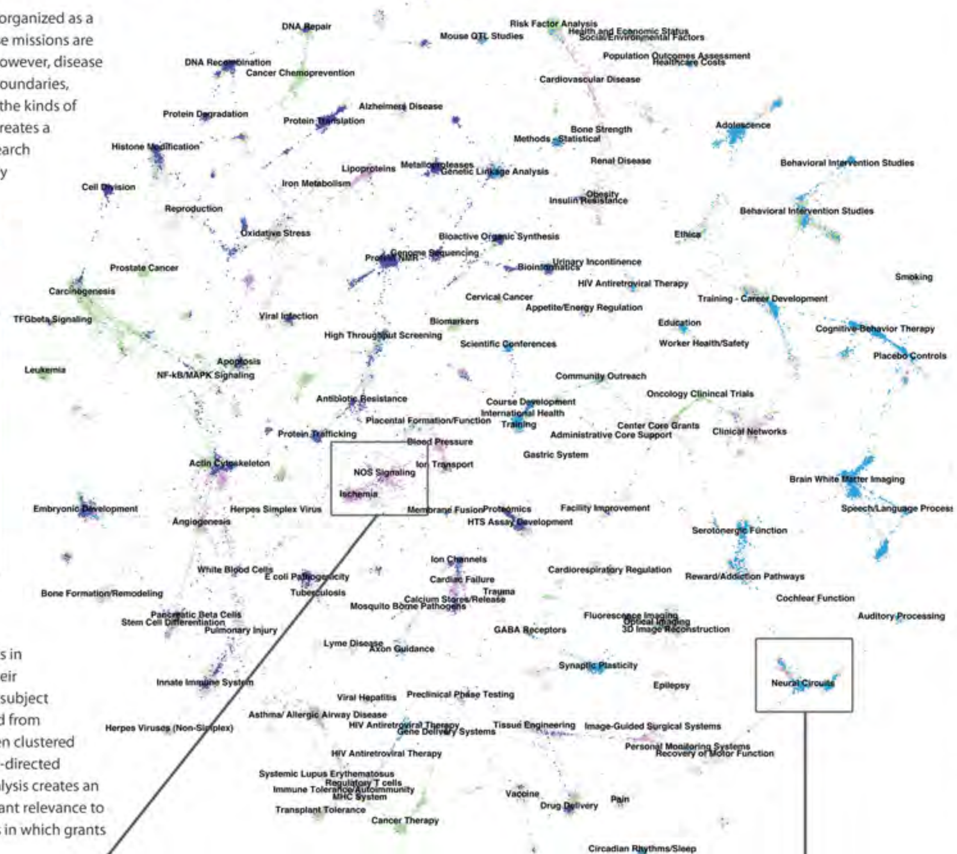
V.6 *Chemical R&D Powers the U.S. Innovation Engine* - The Council for Chemical Research - 2009

A Topic Map of NIH Grants 2007

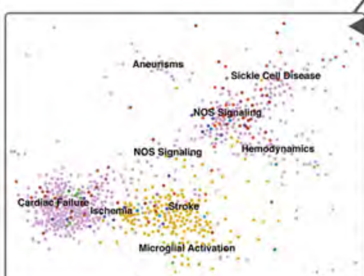
ChalkLabs ISI UCIrvine

Bruce W. Herr II (Chalklabs & IU), Gully Burns (ISI), David Newman (UCI), Edmund Talley (NIH)

The National Institutes of Health (NIH) is organized as a multitude of Institutes and Centers whose missions are primarily focused on distinct diseases. However, disease etiologies and therapies flout scientific boundaries, and thus there is tremendous overlap in the kinds of research funded by each Institute. This creates a daunting landscape for decisions on research directions, funding allocations, and policy formulations. Shown here is devised an interactive topic map for navigating this landscape, online at www.nihmaps.org. Institute abbreviations can be found at www.nih.gov/icd.



Topic modeling, a statistical technique that automatically learns semantic categories, was applied to assess projects in terms used by researchers to describe their work, without the biases of keywords or subject headings. Grant similarities were derived from their topic mixtures, and grants were then clustered on a two-dimensional map using a force-directed simulated annealing algorithm. This analysis creates an interactive environment for assessing grant relevance to research categories and to NIH Institutes in which grants are localized.

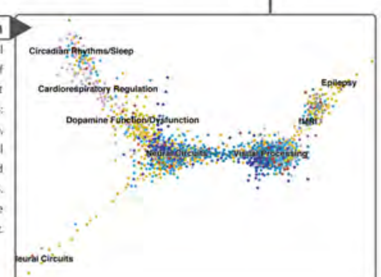


Cardiac Diseases Research

An area of the map focused on cardiovascular function and dysfunction. Cardiac Failure (primarily funded by NHLBI) is topically clustered next to Stroke (NINDS), since these are the two major medical emergencies associated with ischemia, which results from a restricted blood supply. Also localized in this area are grants focused on Nitric Oxide (NOS) Signaling, a major biochemical pathway for vasodilation, and grants on Hemodynamics, Sickle Cell Disease, and Aneurysms.

Neural Circuits Research

An area of the map focused on neural circuits, which shows the diversity of topics and NIH Institutes that fund research in this area, such as: Cardiorespiratory Regulation, primarily funded by NHLBI; Visual Processing, primarily funded by NEI; and Epilepsy, primarily funded by NINDS. For color coding, see legend in the upper-left inset.



National Cancer Institute (NCI)

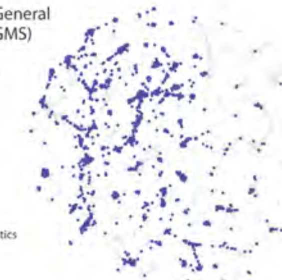
TOP 10 TOPICS

1. Oncology Clinical Trials
2. Cancer Treatment
3. Cancer Therapy
4. Carcinogenesis
5. Risk Factor Analysis
6. Cancer Chemotherapy
7. Metastasis
8. Leukemia
9. Prediction/Prognosis
10. Cancer Chemoprevention

National Institute of General Medical Sciences (NIGMS)

TOP 10 TOPICS

1. Bioactive Organic Synthesis
2. X-ray Crystallography
3. Protein NMR
4. Computational Models
5. Yeast Biology
6. Metalloproteases
7. Enzymatic Mechanisms
8. Protein Complexes
9. Invertebrate/Zebrafish Genetics
10. Cell Division



National Heart, Lung, and Blood Institute (NHLBI)

TOP 10 TOPICS

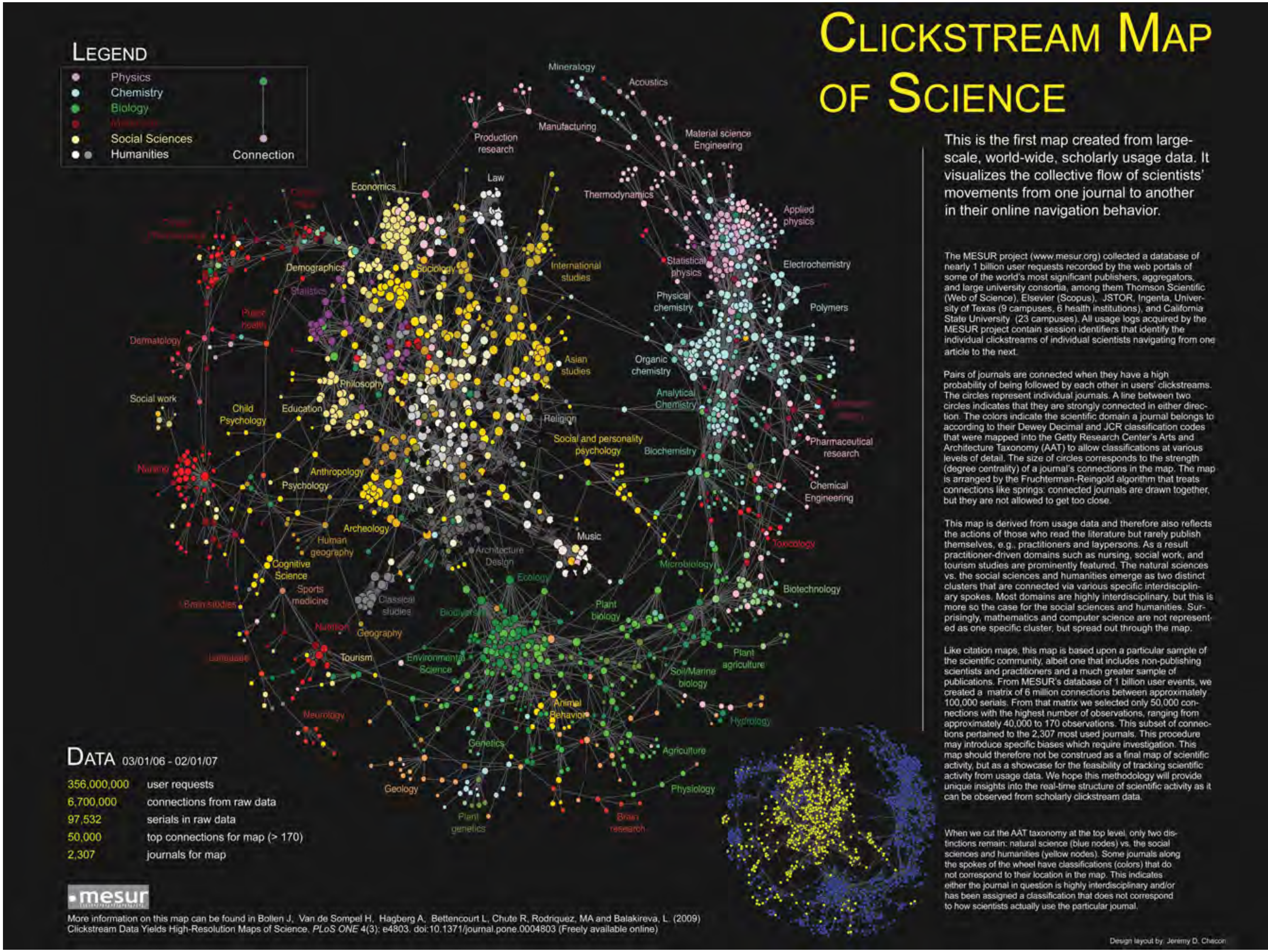
1. Cardiac Failure
2. Pulmonary Injury
3. Genetic Linkage Analysis
4. Cardiovascular Disease
5. Atherosclerosis
6. Hemostasis
7. Blood Pressure
8. Asthma/ Allergic Airway Disease
9. Gene Association
10. Lipoproteins

National Institute of Mental Health (NIMH)

TOP 10 TOPICS

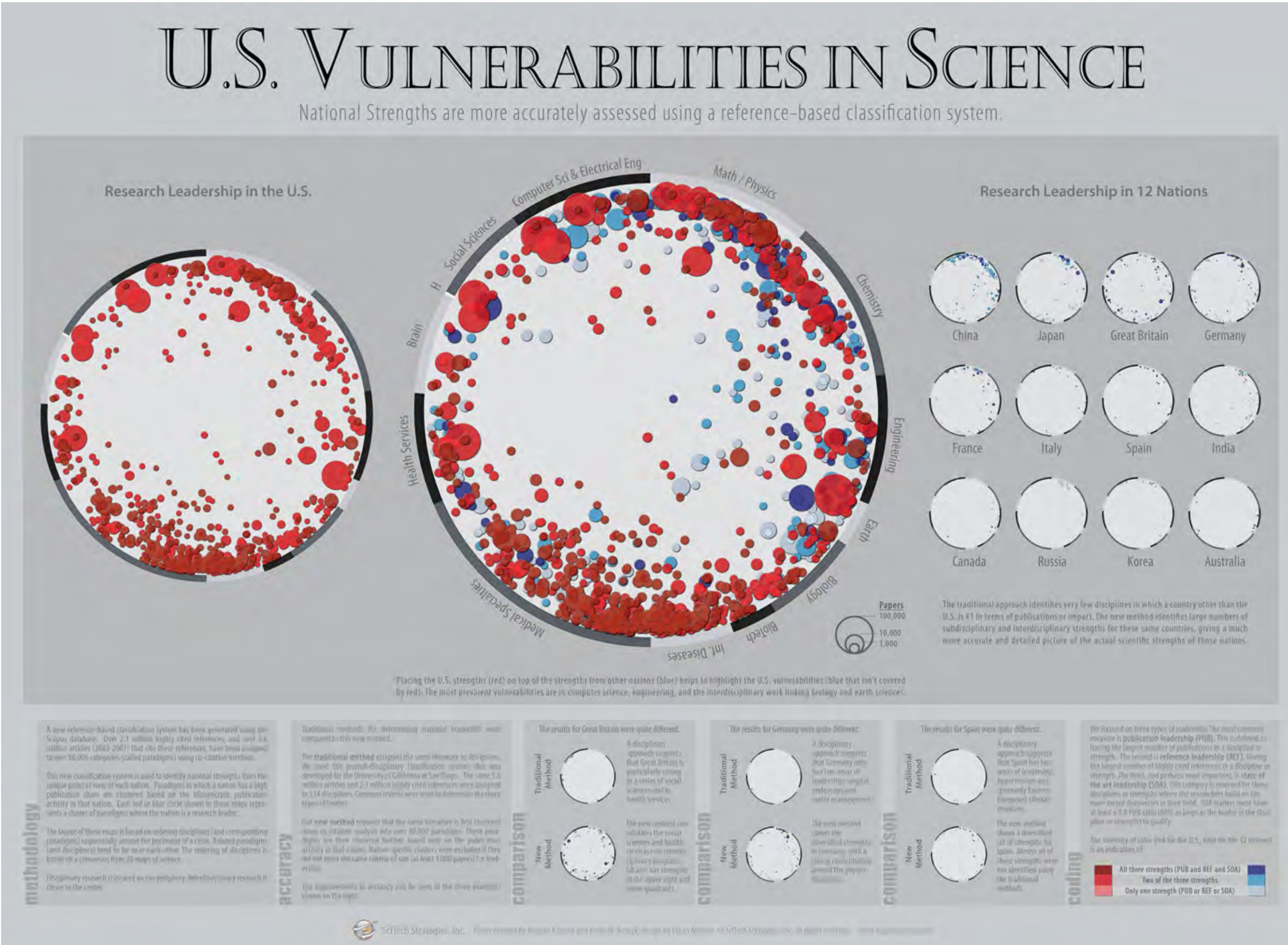
1. Mood Disorders
2. Schizophrenia
3. Behavioral Intervention Studies
4. Mental Health
5. Depression
6. Cognitive-Behavior Therapy
7. AIDS Prevention
8. Genetic Linkage Analysis
9. Adolescence
10. Childhood

V.7 *A Topic Map of NIH Grants 2007* - Bruce W. Herr II, Gully A.P.C. Burns, David Newman, and Edmund Talley - 2009



V.8 *A Clickstream Map of Science*

Johan Bollen, Herbert Van de Sompel, Aric Hagberg, Luís M. A. Bettencourt, Ryan Chute, Marko A. Rodriguez, and Lyudmila Balakireva - 2008



V.9 *U.S. Vulnerabilities in Science* - Kevin W. Boyack and Richard Klavans - 2008

V.10 *The Millennium Development Goals Map* - The World Bank and National Geographic - 2006

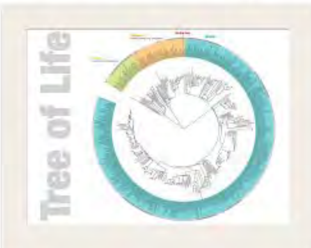
Exhibit Venues

April 15 - 19, 2015, International Science Festival, Gothenburg, Sweden.

May 1 - October 30, Galter Health Sciences Library, Northwestern University, Chicago, IL.

January 1 - June 1, 2013, National Academy of Sciences, Upstairs Gallery, Washington, D.C.

Iteration VI (2010)
Science Maps for Scholars



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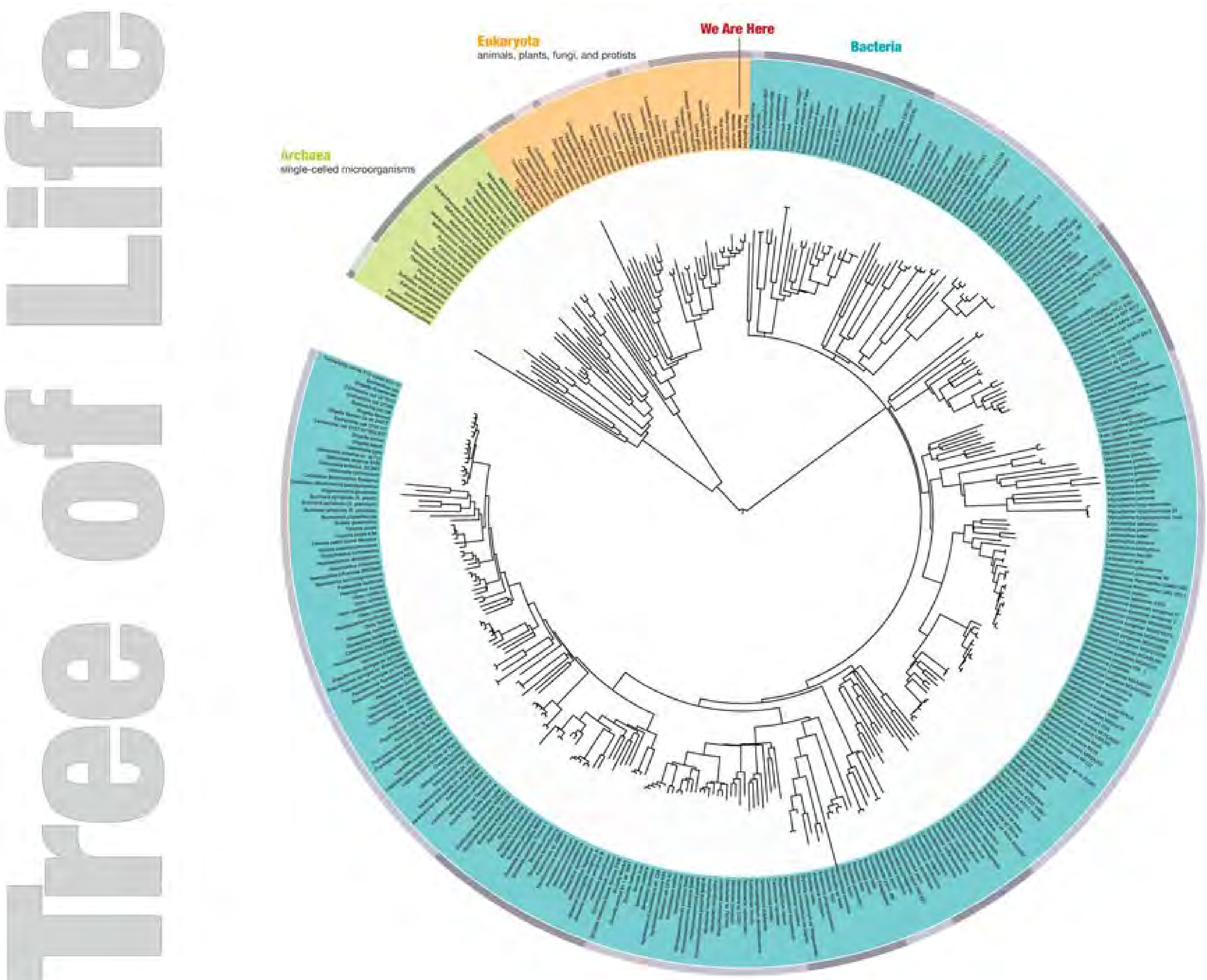
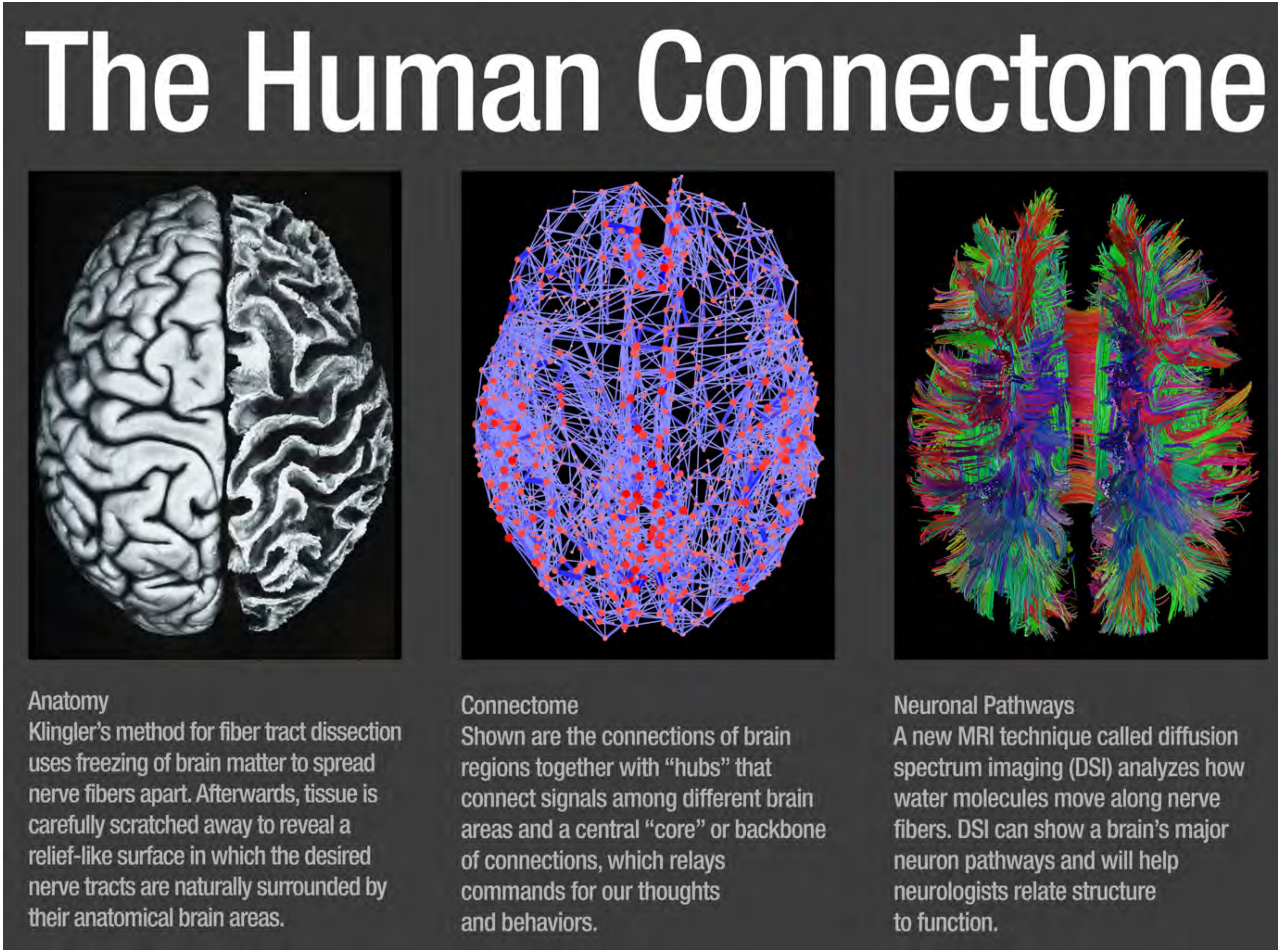
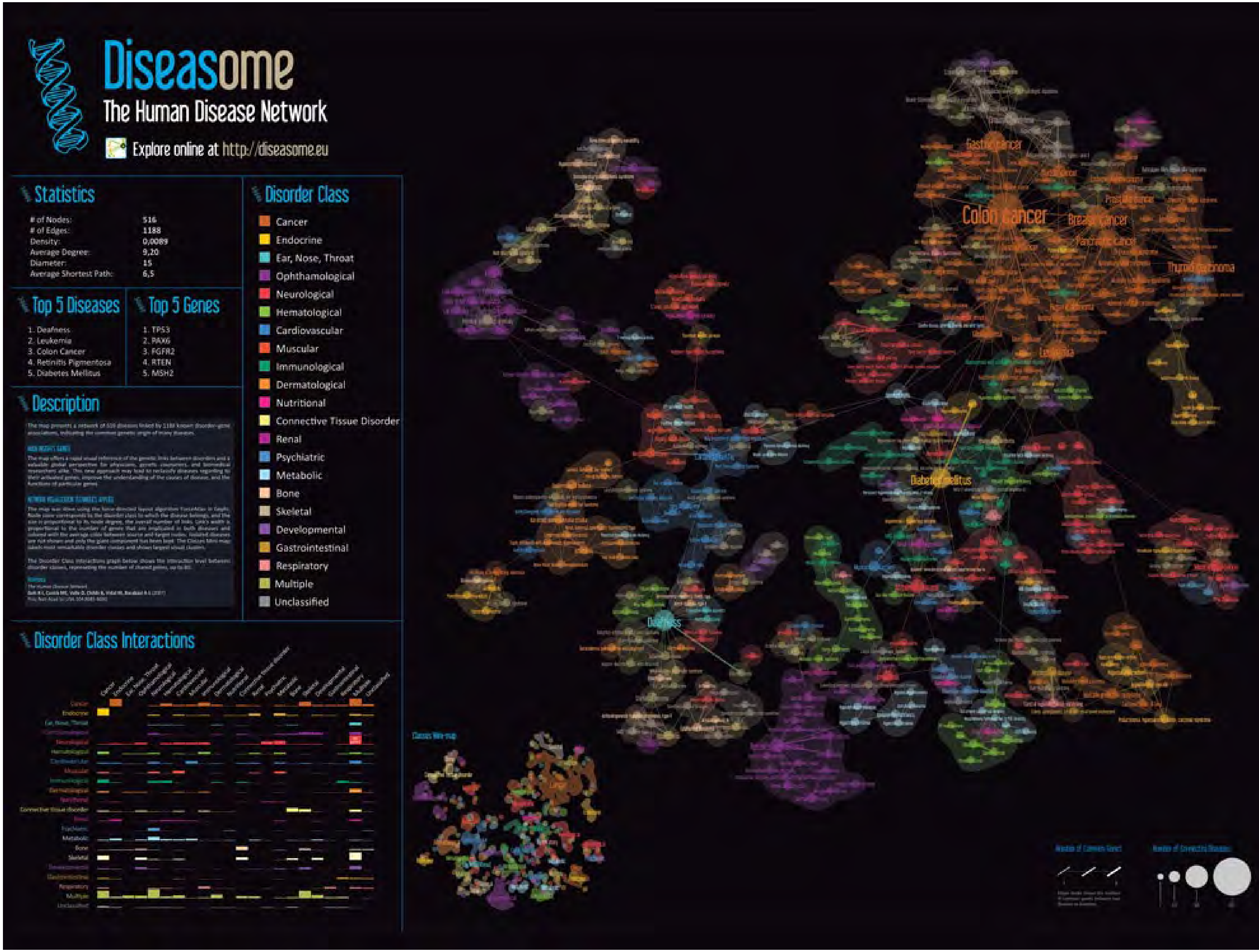


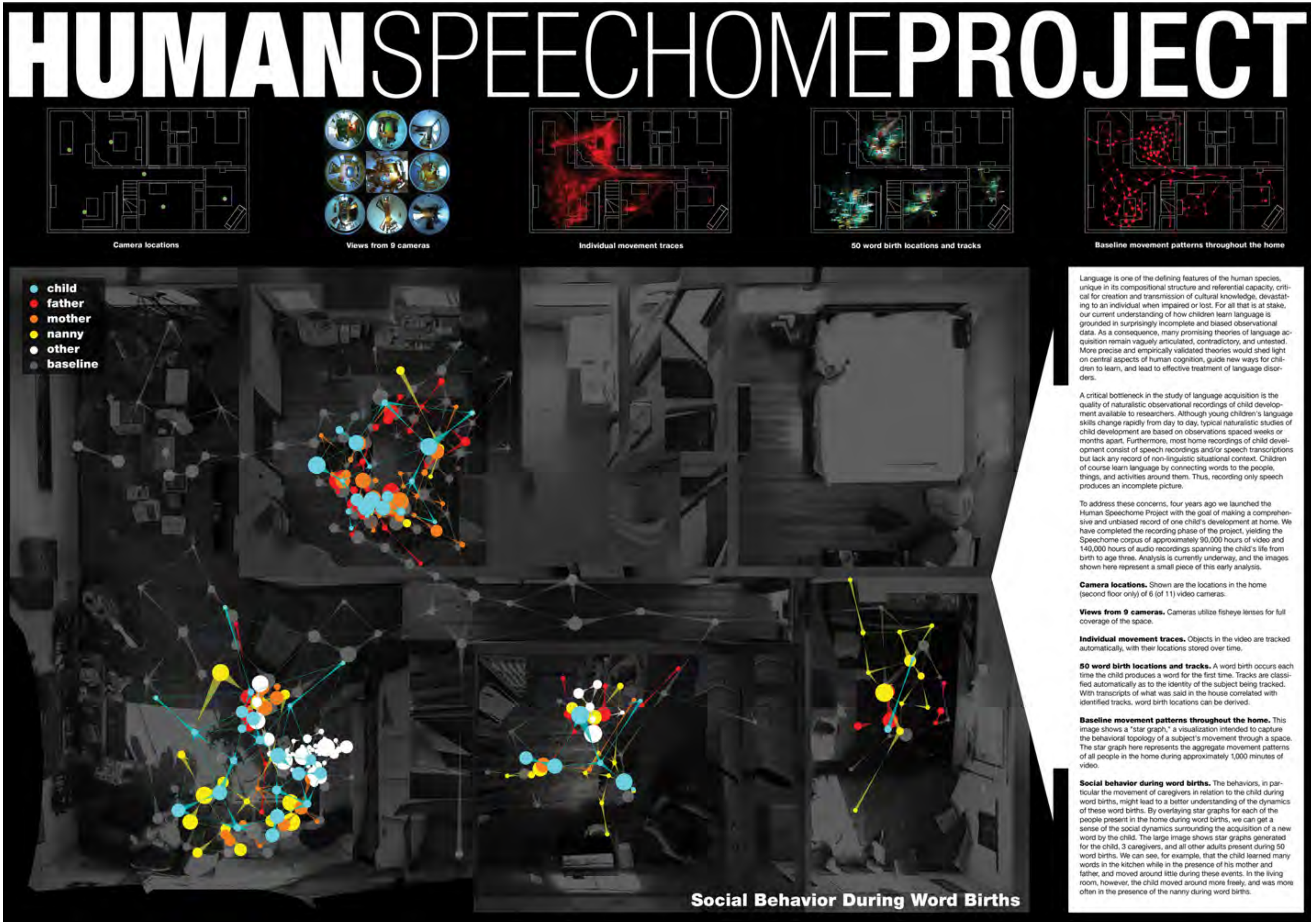
VI.1 *Tree of Life* - Peer Bork, Francesca Ciccarelli, Chris Creevey, Berend Snel, and Christian von Mering - 2006



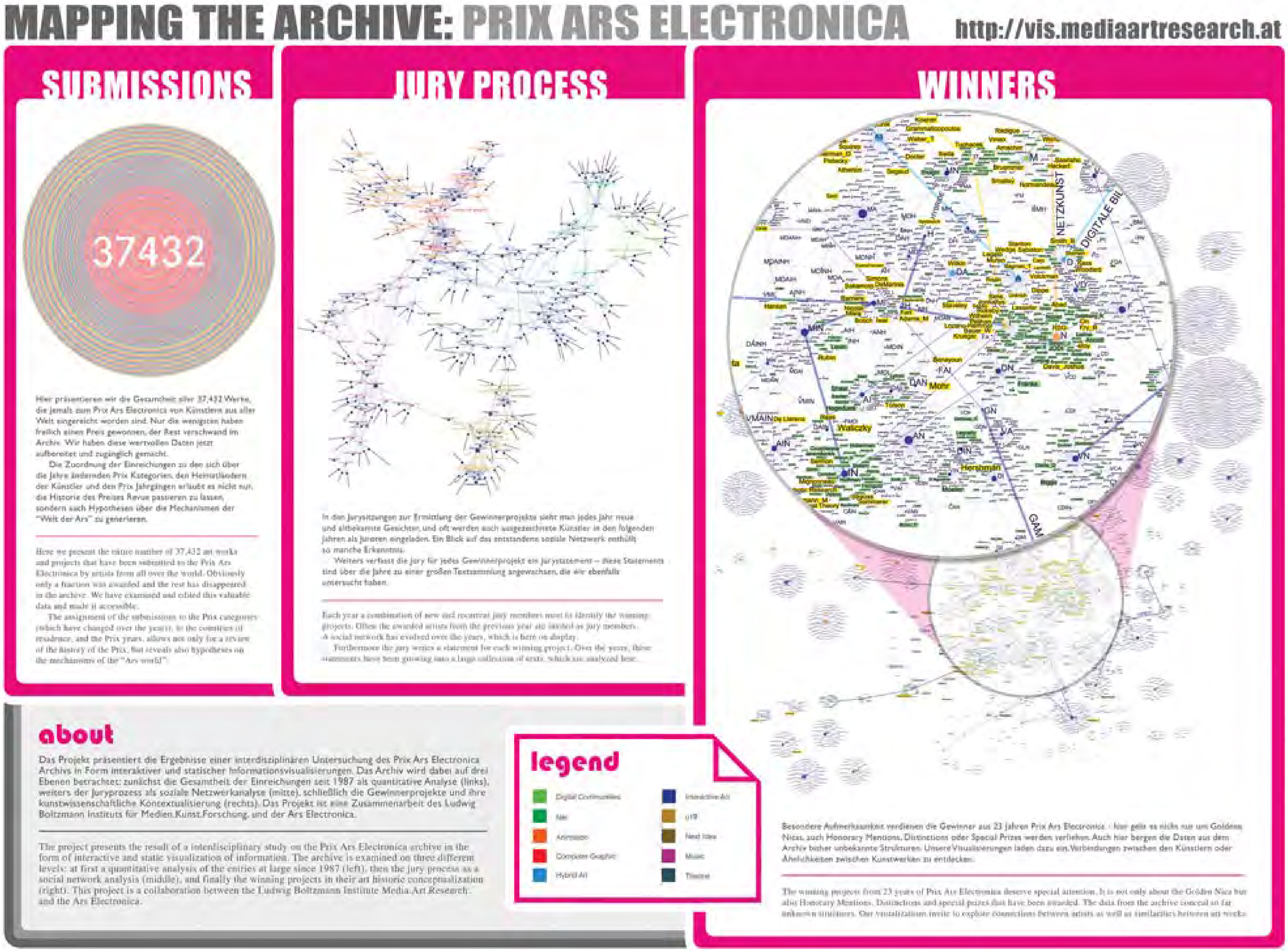
VI.2 *The Human Connectome* - Patric Hagmann and Olaf Sporns - 2008



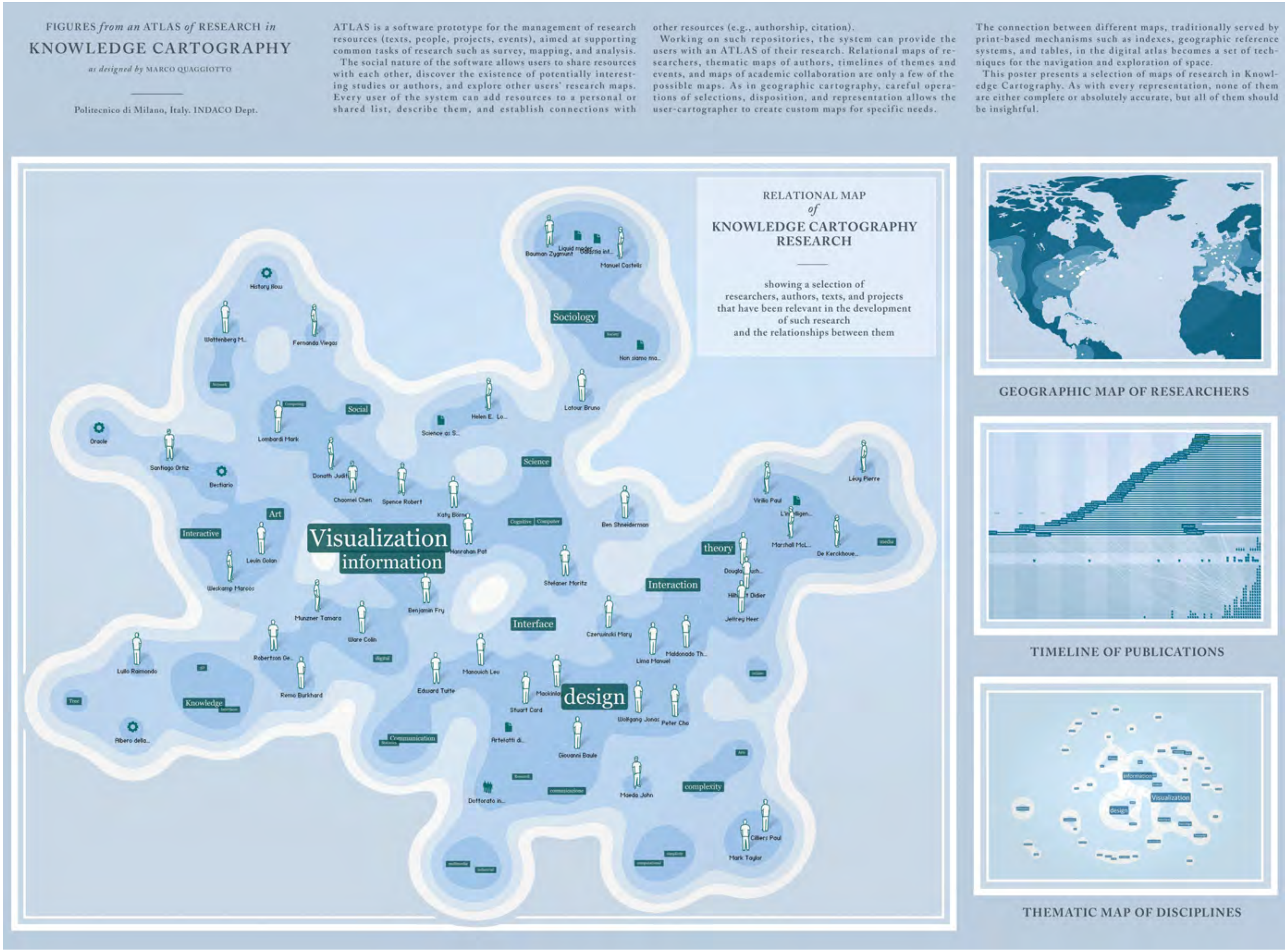
VI.3 *Diseasome: The Human Disease Network* - Mathieu Bastian and Sébastien Heymann - 2009



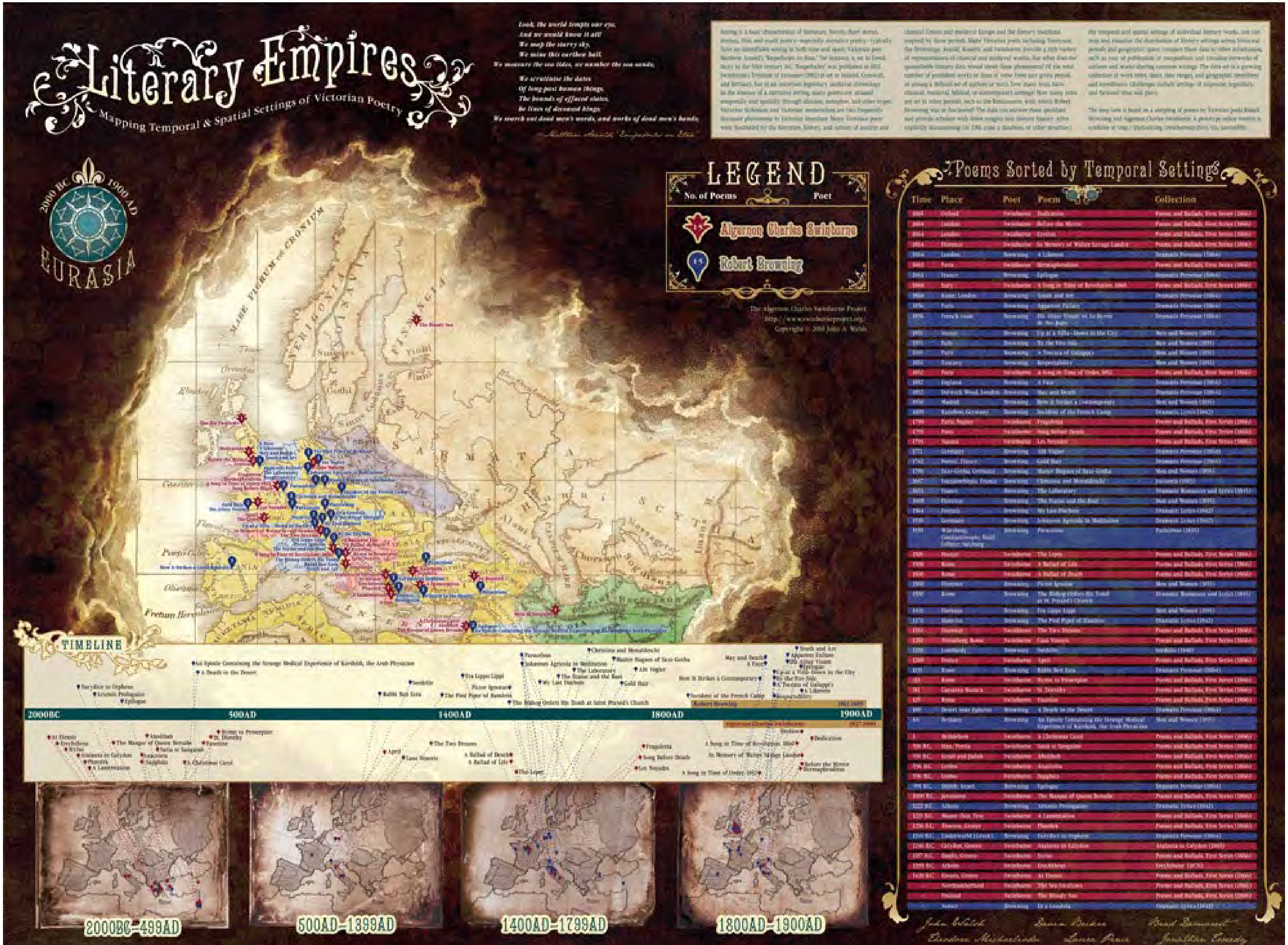
VI.4 *Human Speechome Project* - George Shaw, Philip James DeCamp, and Deb Roy - 2009



VI.5 *Mapping the Archive: Prix Ars Electronica* - Dietmar Offenhuber, Moritz Stefaner, Evelyn Münster, Jaume Nualart, and Gerhard Dirmoser - 2008

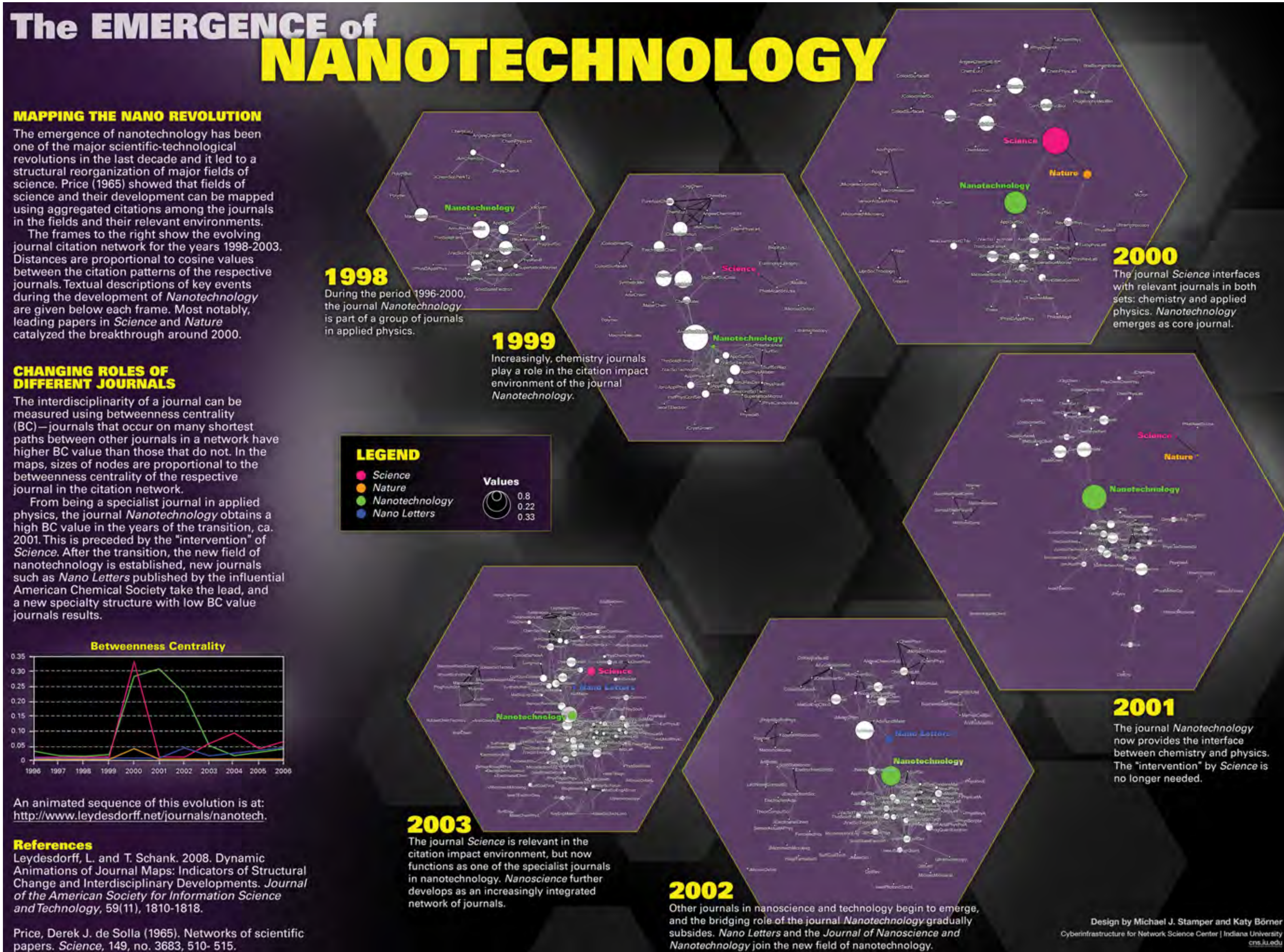


VI.6 *Knowledge Cartography* - Marco Quaggiotto - 2008

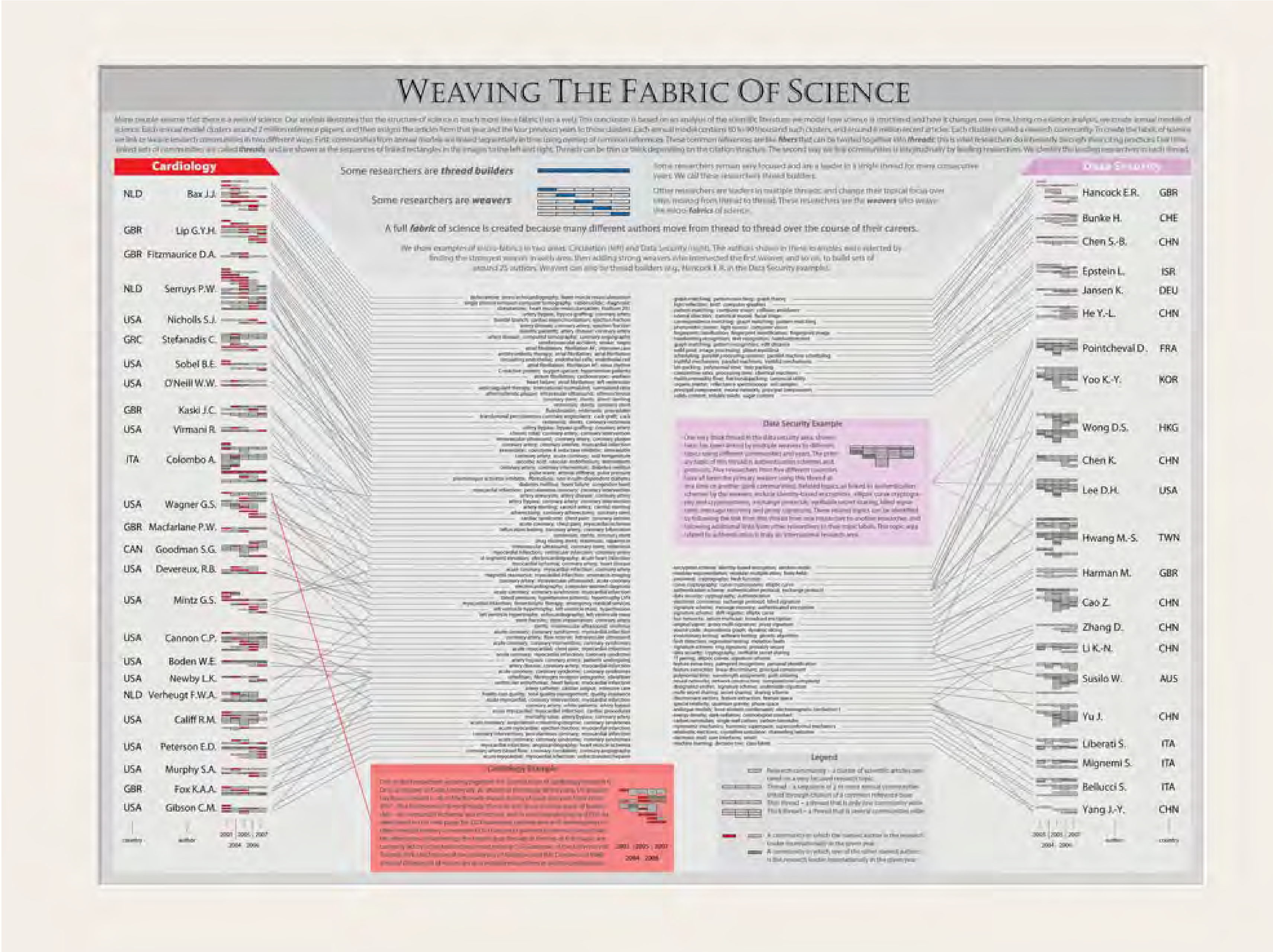


VI.7 *Literary Empires: Mapping Temporal and Spatial Settings of Victorian Poetry*

John A. Walsh, Devin Becker, Bradford Demarest, Jonathan Tweedy, Theodora Michaelidou, and Laura Pence - 2010



VI.8 *The Emergence of Nanoscience & Technology* - Loet Leydesdorff - 2010



VI.9 *Weaving the Fabric of Science* - Richard Klavans and Kevin W. Boyack, SciTech Strategies, Inc. - 2010

U.S. Job Market: Where are the Academic Jobs?

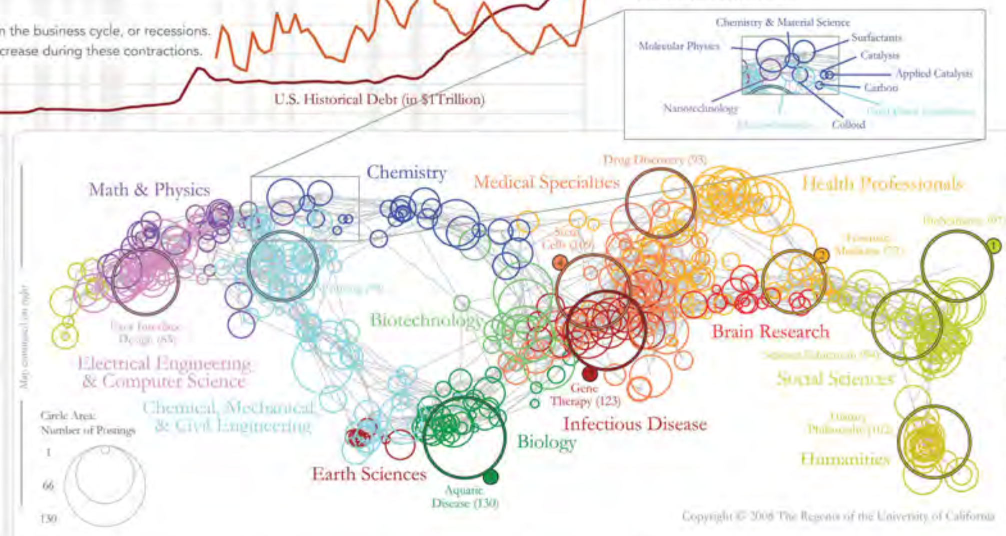
Labor Statistics

From the start of the recession in December 2007 through the end of 2009, more than 8 million jobs were lost in the United States. In October 2009, the U.S. unemployment rate peaked at 10.1 percent (after adjustment for seasonal variations). In April 2010, unemployment was still at 9.9 percent. In May 2010, about 6.8 million individuals, or 46 percent of those unemployed, had been unemployed for at least 27 weeks. Each month, 100,000 people enter the U.S. labor market—including high school and college graduates. They join 15 million Americans looking for work.

Unemployment rates are calculated and adjusted by the Bureau of Labor Statistics within the U.S. Department of Labor and reported in their monthly Economic News Release on the Employment Situation. Historical employment data, including unemployment rates with and without seasonal adjustment and divided by individual characteristics and employment sectors, are also available from the Bureau of Labor Statistics.

General Trends

The charts to the left show annual national economic indicators. These indicators serve as background data; they flow beneath and around more specific analyses of the job market. Business cycle data come from the National Bureau of Economic Research. Historical debt data come from the U.S. Department of Treasury. Unemployment rates come from the Bureau of Labor Statistics. GDP data come from the Bureau of Economic Analysis. Stock Price Index data come from the research of Dr. Robert Shiller at Yale University Department of Economics. Individual conversion factors (compiled from Bureau of Labor Statistics Consumer Price Indices by the Oregon State University Political Science Department) were applied where appropriate.



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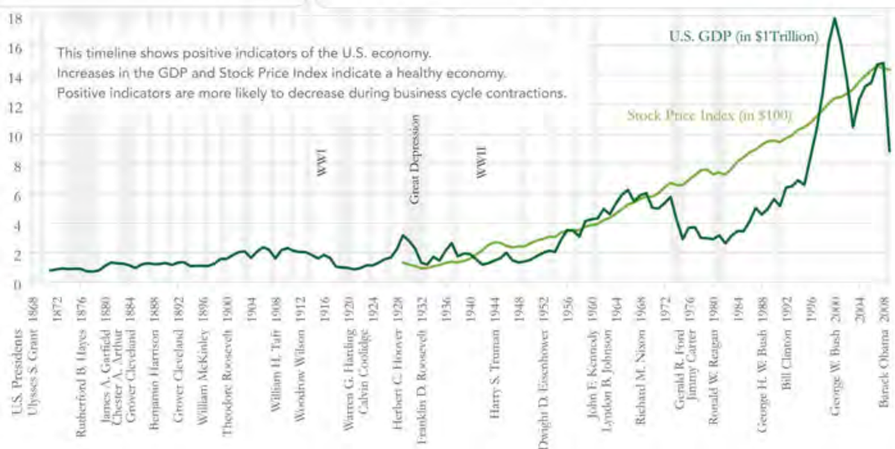
Sample Jobs

Geospatial Map

Using U.S. city and state information, circles are placed over the location of the job postings and are sized in relation to the number of postings listed for that location. The top 10 cities with the highest number of postings are labeled, and the number of postings is given in parentheses.

Where are the Academic Jobs?

Over 3,500 jobs posted between July 2008 and February 2009 on Nature Jobs were collected and analyzed. The two maps above show the 1,037 job postings located in the U.S. and represent a directed study of the job market that sits on top of larger trends over time.



Topic Map

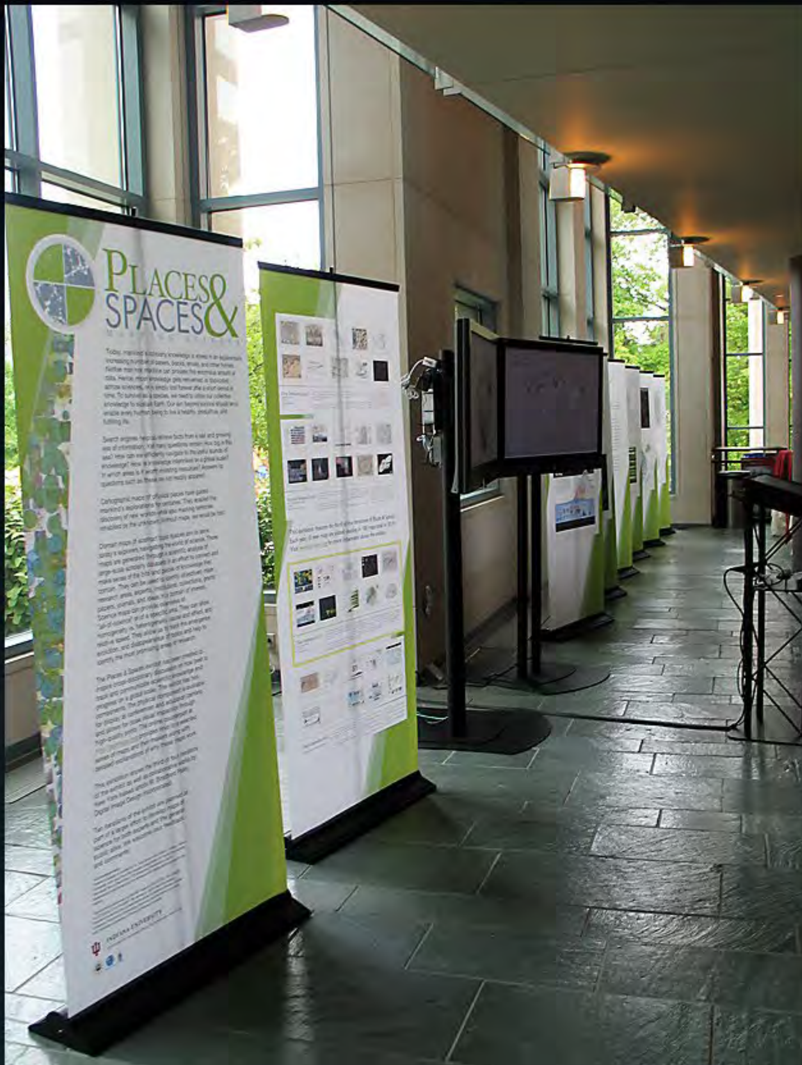
How many and what jobs are available in which scientific area? The UCSD Map of Science used here was created by analyzing 7.2 million papers published in over 16,000 separate journals, proceedings, and series from Thomson Scientific and Scopus over the five-year period from 2001 to 2005.

Using a hierarchical, multi-step clustering procedure, journals were grouped into 554 clusters based on common word usage and shared references (bibliographic coupling). In the map, each cluster is represented by a node, and links denote strong bibliographic coupling relations. The 554 clusters are further grouped into 13 color-coded scientific disciplines.

The 1,037 jobs were overlaid based on word matches in their description and keywords associated with each of the 554 nodes. Like in the geospatial map, circle area sizes correspond to the number of jobs posted.

VI.10 *U.S. Job Market: Where are the Academic Jobs?* - Angela M. Zoss and Katy Börner - 2010

Want to host the Places & Spaces Exhibit?



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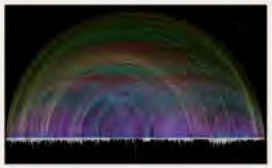
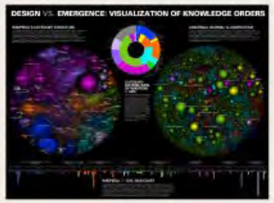
Iteration VII (2011)
Science Maps as Visual Interfaces to Digital Libraries

VII.1



VII.3



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MONDOTHÈQUE

A MULTIMEDIA DESK IN A GLOBAL INTERNET

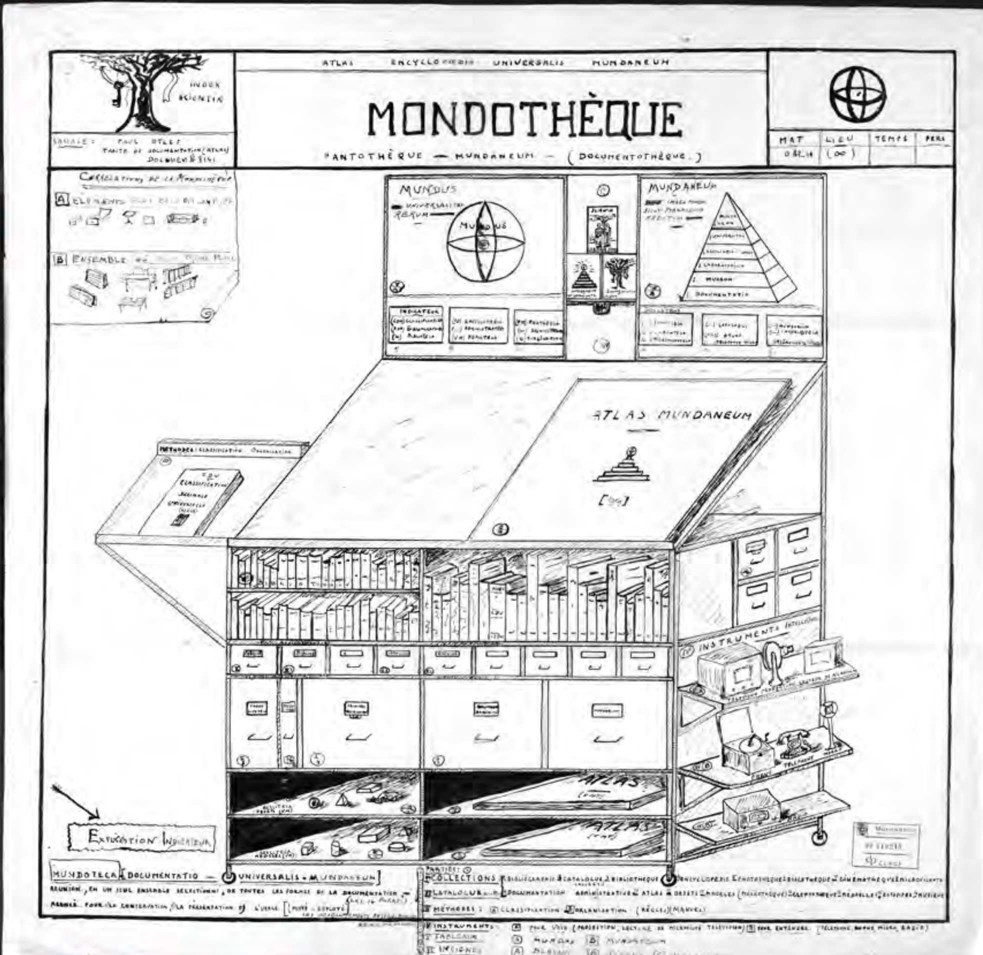
Paul Otlet (1868-1944), visionary Belgian lawyer fascinated by the problems of access to global knowledge, is often acknowledged as a pioneer of the Internet. His design of 1936 for a multimedia desk for home use, the Mondothèque, integrated access to new documentary formats including multimedia substitutes for traditional books involving all available communications technologies such as microfilm, gramophone, radio and TV. A major resource was a new form of visual encyclopedia, the Encyclopedia Universalis Mundaneum. Connected by the Mondothèque to a network of global collections (Species Mundaneum), the user could access and engage in the international production and dissemination of knowledge.

Paul Otlet
Mondothèque
June 8, 1936 | 64 x 67 cm
Pen and ink on transparent paper*
EUM Affiches 8141
© Mundaneum Mons Belgium

The Mondothèque is a multimedia desk with spaces for essential books, with atlases in the form of visual encyclopedia, for small (museum) objects and with drawers for bibliographical cards and microfilms ordered according to the rules of his Universal Decimal Classification system. On its shelves sit communication and broadcasting instruments, such as radio, telephone, television and film equipment.

*Otlet's original drawing is on light grey tracing paper. It has been lightened here for legibility and printing purposes.

Paul Otlet
Species Mundaneum
January 16, 1937 | 21 x 28 cm
pen and ink on transparent paper
EUM 8504
© Mundaneum Mons Belgium



MUNDOTECA [Documentatio-Universalis-Mundaneum]

BRINGING TOGETHER OF ALL KINDS OF DOCUMENTATION - (THE 16 KINDS) IN A SINGLE ORDERED GROUPING

An agency for a) conservation, b) presentation, c) use (specific or general) – systematic developments in furniture, buildings, galleries.

COMPONENTS

1 Bibliography · 2 Union Catalogue · 3 Library · 4 Encyclopedia · 5 Photographic library · 6 Music library · 7 Film library · 8 Microfilm library · 9 Administrative Documentation · 10 Atlas [collection of maps, engravings, charts, graphic representations] · 11 Objects · 12 Models [library of museum objects] · 13 Sculpture collection · 14 Medals · 15 Prints · 16 Music

of the Mundaneum for all 16 kinds of documentation

A Classification B Organisation (Rules, Manual)

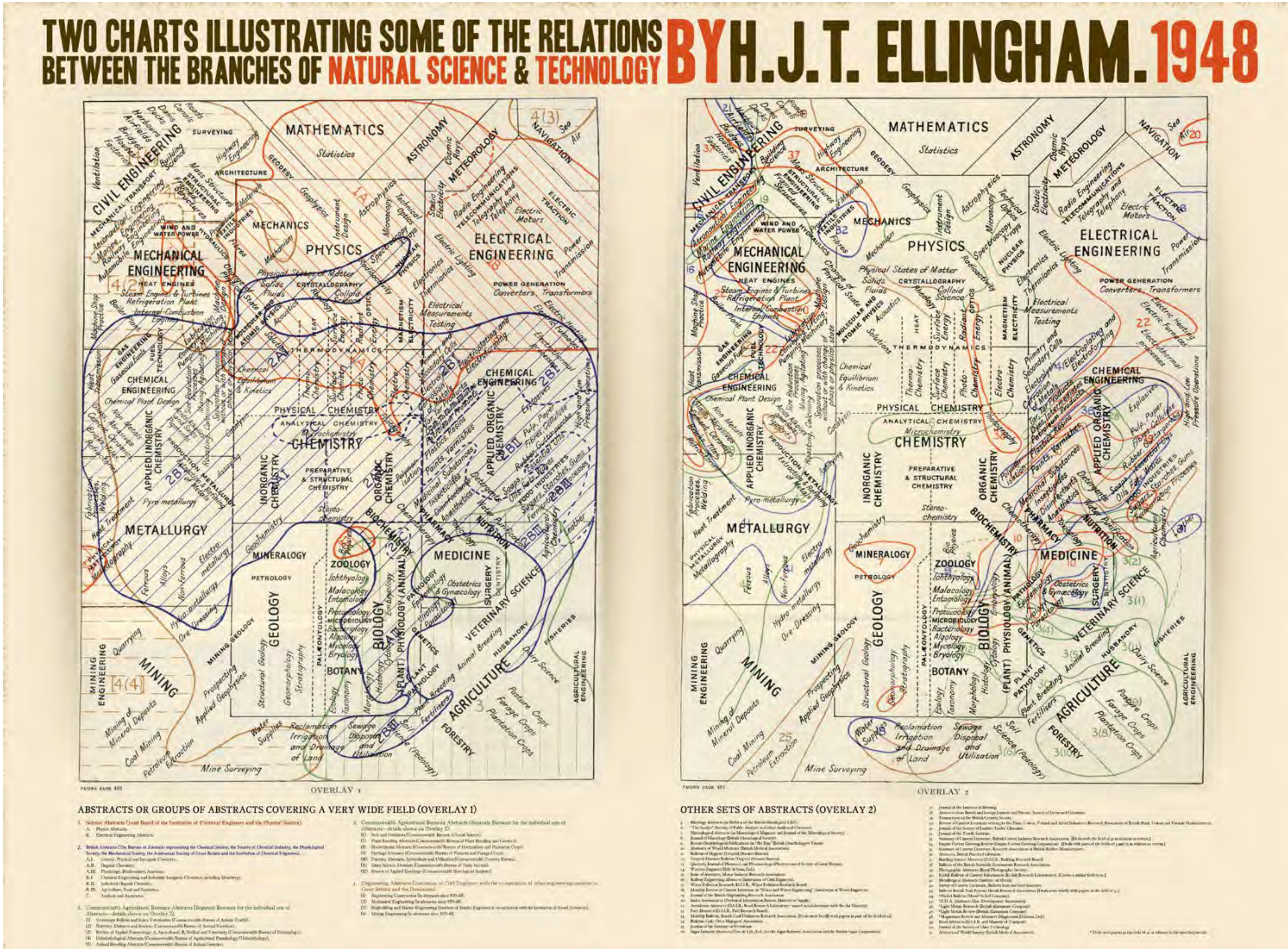
A To see with (Projection, Microfilm reader, Television) B To hear with (Telephone, Phonograph, Microphone, Radio)

A Mundus B Mundaneum

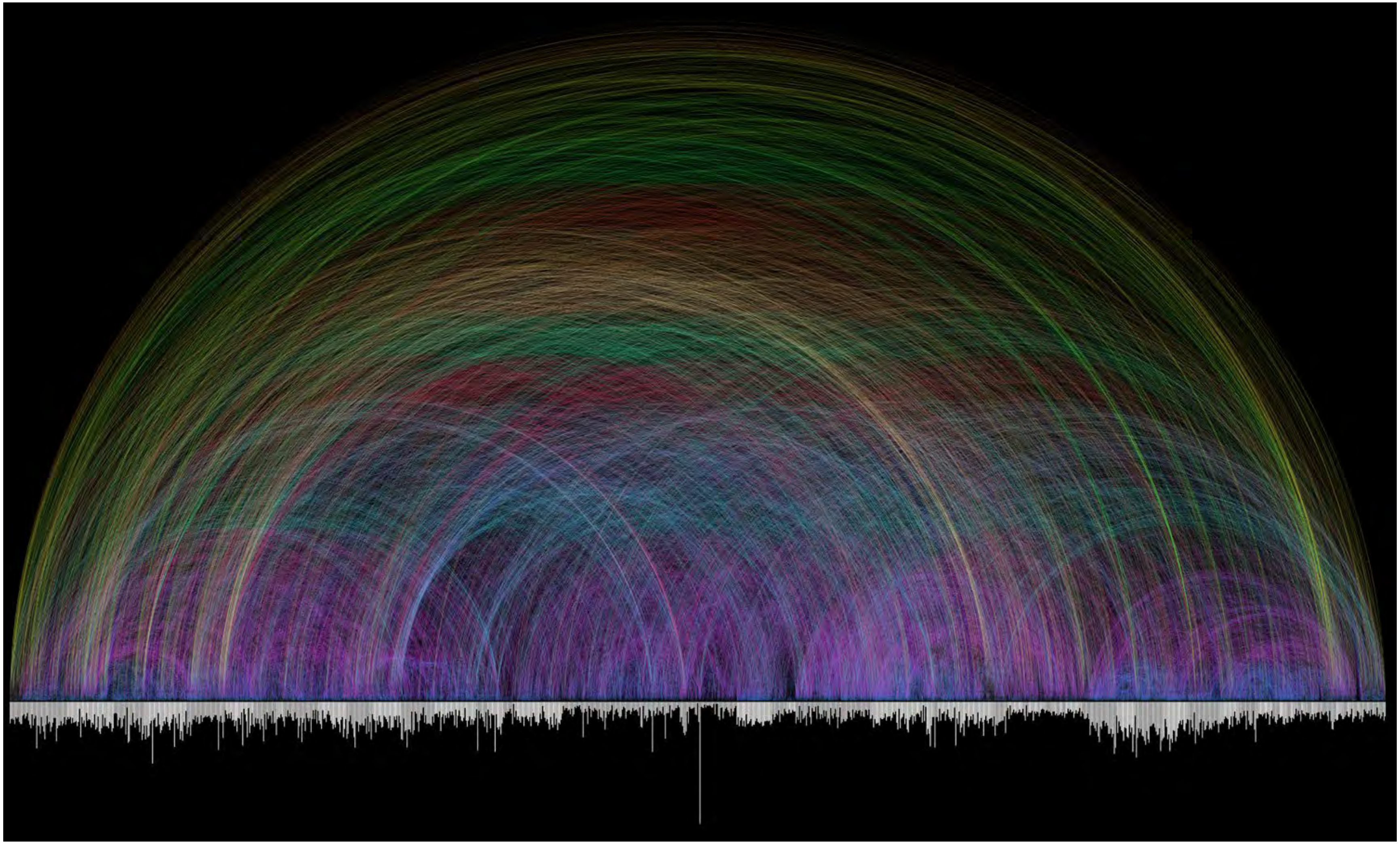
A Coats of Arms B Stele [Stone monuments] C Coins

Text: Mondothèque. A multimedia desk in a global internet
Charles van den Heuvel, Huygens ING (KNAW), The Hague & W. Boyd Rayward, University of Illinois, Urbana-Champaign
Acknowledgment: Stéphanie Manfroid, Mundaneum, Mons
Graphic Design: Janet Armstrong BNO| Armstrong Design, Maastricht, NL with the collaboration of Michael J. Stamper

VII.1 *Mondothèque. Multimedia Desk in a Global Internet* - Paul Otlet - 1936/37



VII.2 *Two Charts Illustrating Some of the Relations between the Branches of Natural Science & Technology* - H.J.T. Ellingham - 1948



VII.3 *Visualizing Bible Cross-References* - Chris Harrison and Christoph Römhild - 2008

Finding RESEARCH LITERATURE on Autism

A Comparison of Four Bibliographic Databases

PubMed® (PM)
Records: 19 million
Scope: Emphasis on biomedicine and health journals. Primarily MEDLINE database plus selected other records. 1949–present.
Producer: National Center for Biotechnology Information, National Library of Medicine, NIH
Selected features: Free. Links to other NCBI resources (e.g., Entrez Gene). MeSH indexing. Automatic mapping of queries to MeSH terms and narrower concepts.

Scopus™ (SCO)
Records: 38 million
Scope: Multi-disciplinary, primarily life, health, social, and physical sciences. Journals, books, conferences, et al. back to 1823.
Producer: Elsevier
Selected features: References and citation counts (post-1996). Searches scientific web sites and patents. Proximity search. Author and affiliation identifier tools. Author details page with citations, affiliations, h-index, etc.

Web of Science® (WOS)
Records: 39 million*
Scope: Wide variety of sciences and social sciences*. Journals, book reviews, meeting abstracts, etc.
Producer: Thomson Reuters
Selected features: References and citation counts and h-index. Integration with EndNote Web, ResearcherID, and search of scientific web sites. Proximity searching. Author Finder and Cited Reference searching.
** Sci. Cit. Index Expanded (1900–) and Social Sci. Cit. Index (1956–)*

PsycINFO® (PSY)
Records: 2.7 million
Scope: Psychological literature. Journals, books, dissertations, et al. 1806 to present.
Producer: American Psychological Association produces the database and Wolters Kluwer Health produces the Ovid interface.
Selected features: Mapping to thesaurus of terms. Specialized fields: test names, methods, population. Proximity search.
NB: PsycINFO is available through several vendors. The OvidSP platform was used for this analysis.

1. Overlap in Database Coverage

Search results for "autism" or "autistic" in the title

Year	Database	Hits in each database	Total hits for year	Hits lost if searching only this database
1969 (–40 years)	PM	39	70	31
	SCO	40		30
	WOS	41		29
	PSY	43		27
1989 (–20 years)	PM	153	345	192
	SCO	180		165
	WOS	178		167
	PSY	249		96
1999 (–10 years)	PM	220	605	385
	SCO	340		265
	WOS	406		199
	PSY	329		276
2004 (–5 years)	PM	482	1171	689
	SCO	632		539
	WOS	827		344
	PSY	557		614
2009 (As of July 1)	PM	644	932	288
	SCO	646		286
	WOS	609		323
	PSY	148		784

2. Differences in Journal Coverage

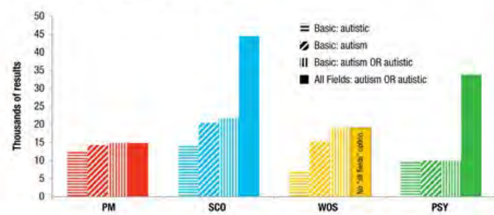
Portion of journals' autism publications in each database. Journals ≥ 1% of the total research publications

Journal	Articles	PM (%)	SCO (%)	WOS (%)	PSY (%)
Journal of autism & developmental disorders (1979–)	151	92	98	91	85
Journal of child psychology & psychiatry, & allied disciplines (1960–)	54	96	94	98	96
Autism (1997–)	48	52	94	52	85
Focus on autism & other developmental disabilities (1996–)	31	0	0	0	100
Journal of the American Academy of Child & Adolescent Psychiatry (1987–)	27	92	96	96	85
Mental retardation & developmental disabilities research reviews (1995–2007)	21	90	100	95	90
Developmental medicine & child neurology (1962–)	21	100	100	100	76
The American journal of psychiatry (1921–)	18	94	100	100	94
American journal of medical genetics. Part B, Neuropsychiatric genetics (2003–)	15	100	93	100	0
European child & adolescent psychiatry (1992–)	14	100	100	100	86
Infants & young children (1992–)	14	0	100	100	0

The four databases were compared in their coverage of the 11 journals with the most publications in Part 1. Although each database had most of the publications in these journals, there were gaps. Databases may exclude some types of publications (e.g., editorials, letters) or may have indexed the journal in different years.

3. How Search Terms Are Processed

Word variants and "Basic search"

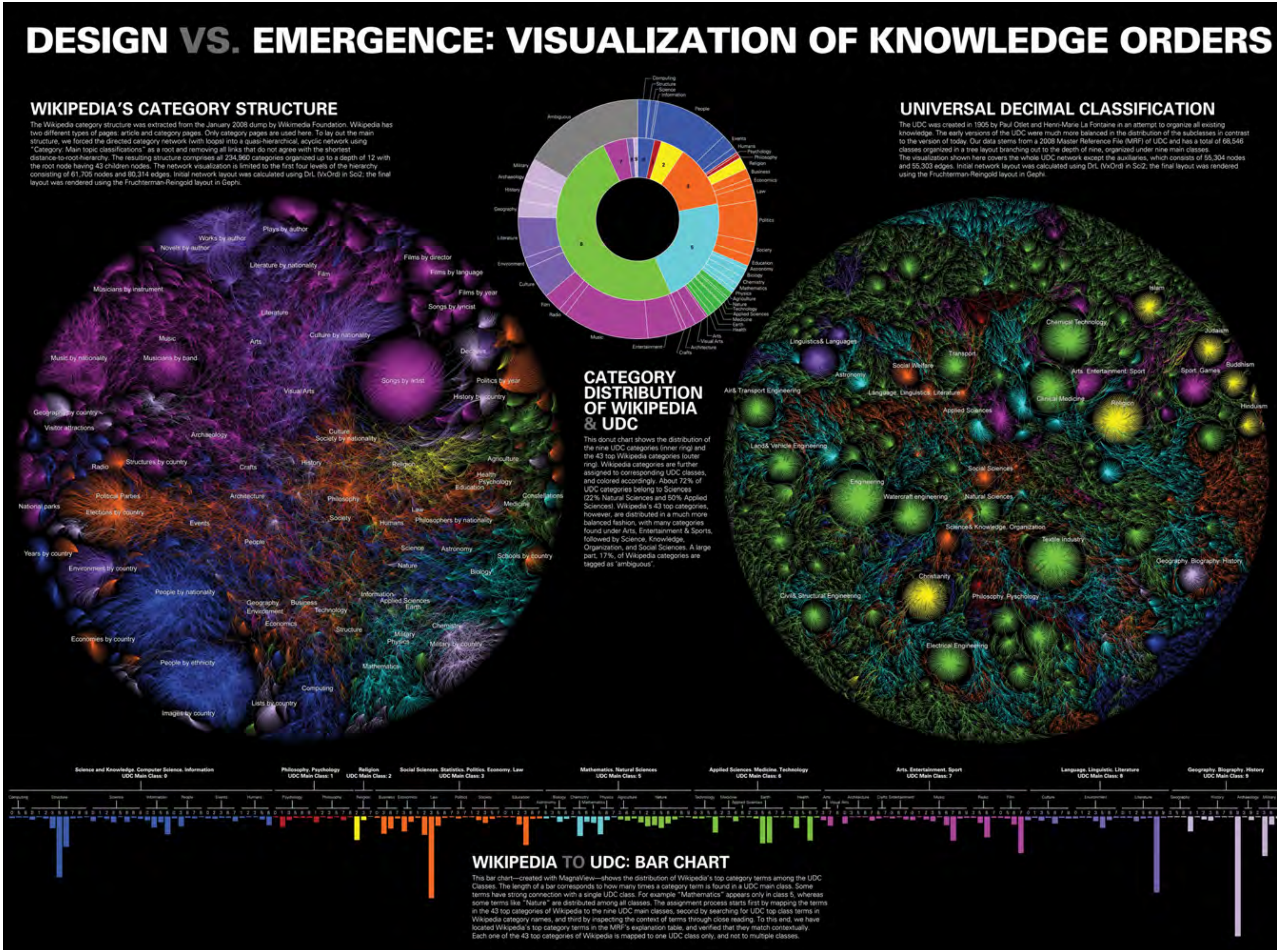


The basic, default search in each database was used for the terms *autistic, autism,* and *autism OR autistic.* The latter search was repeated in all searchable fields. Some databases search for word variations but others do not. The default search may not include all possible fields though not all fields may be relevant.

4. Conclusions

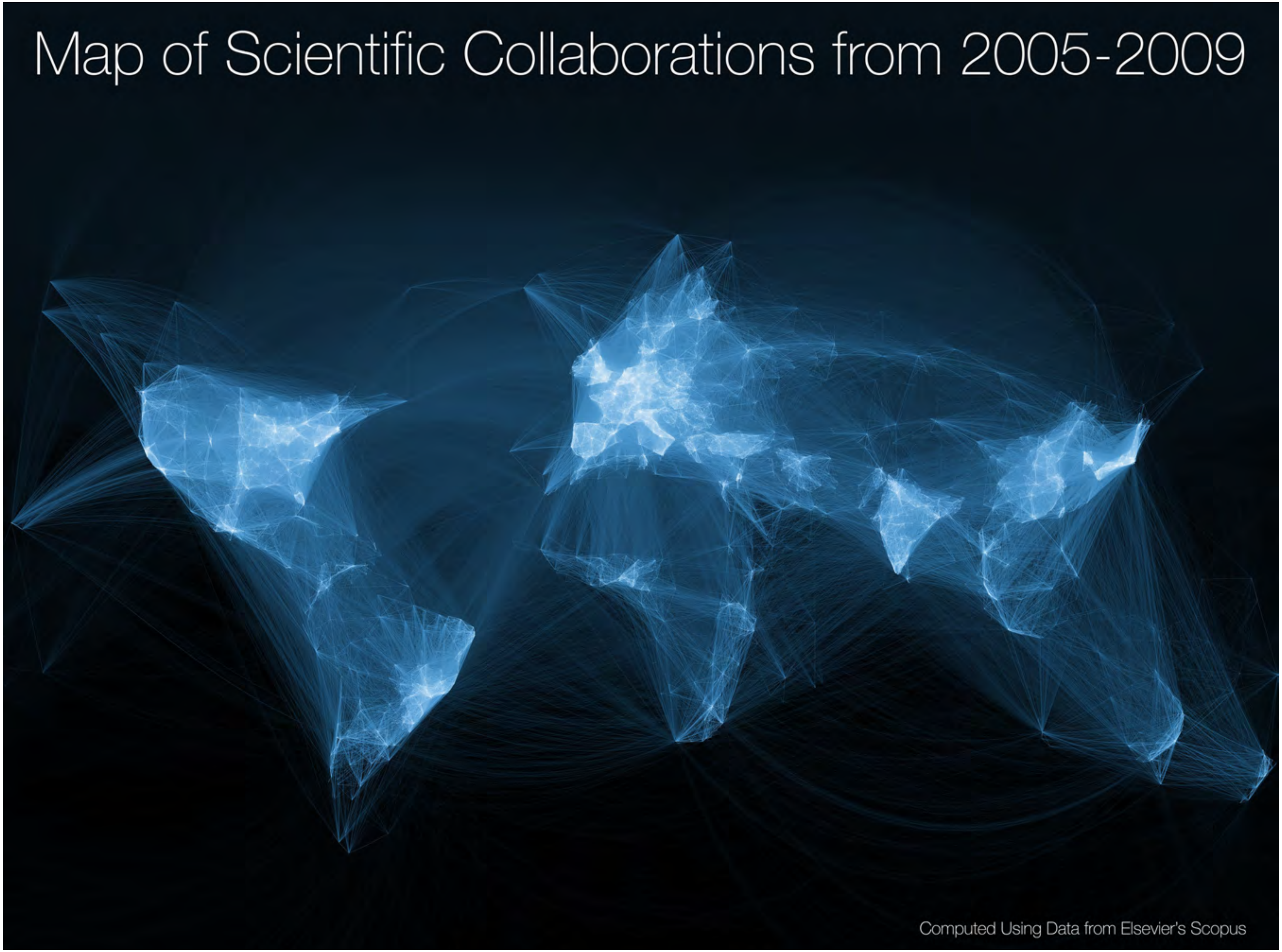
- No one database contains everything. Similar numbers of results is no indication of how similar the search results themselves are. Using multiple databases is important for doing a comprehensive search.
- Databases have different results because they include different journals, different years, and different types of publications.
- They also process a search differently, by looking in different fields or whether they automatically search for word variations and synonyms.
- Despite their differences, each database includes nearly all the journals that publish the most autism publications.
- This comparison is merely a broad overview of the content and one aspect of functionality of the databases. It cannot say which one is "best" for all purposes. Learn which resources are available to you, which tool fits which job, and how to use them.

VII.4 *Finding Research Literature on Autism* - Rex Robison - 2009

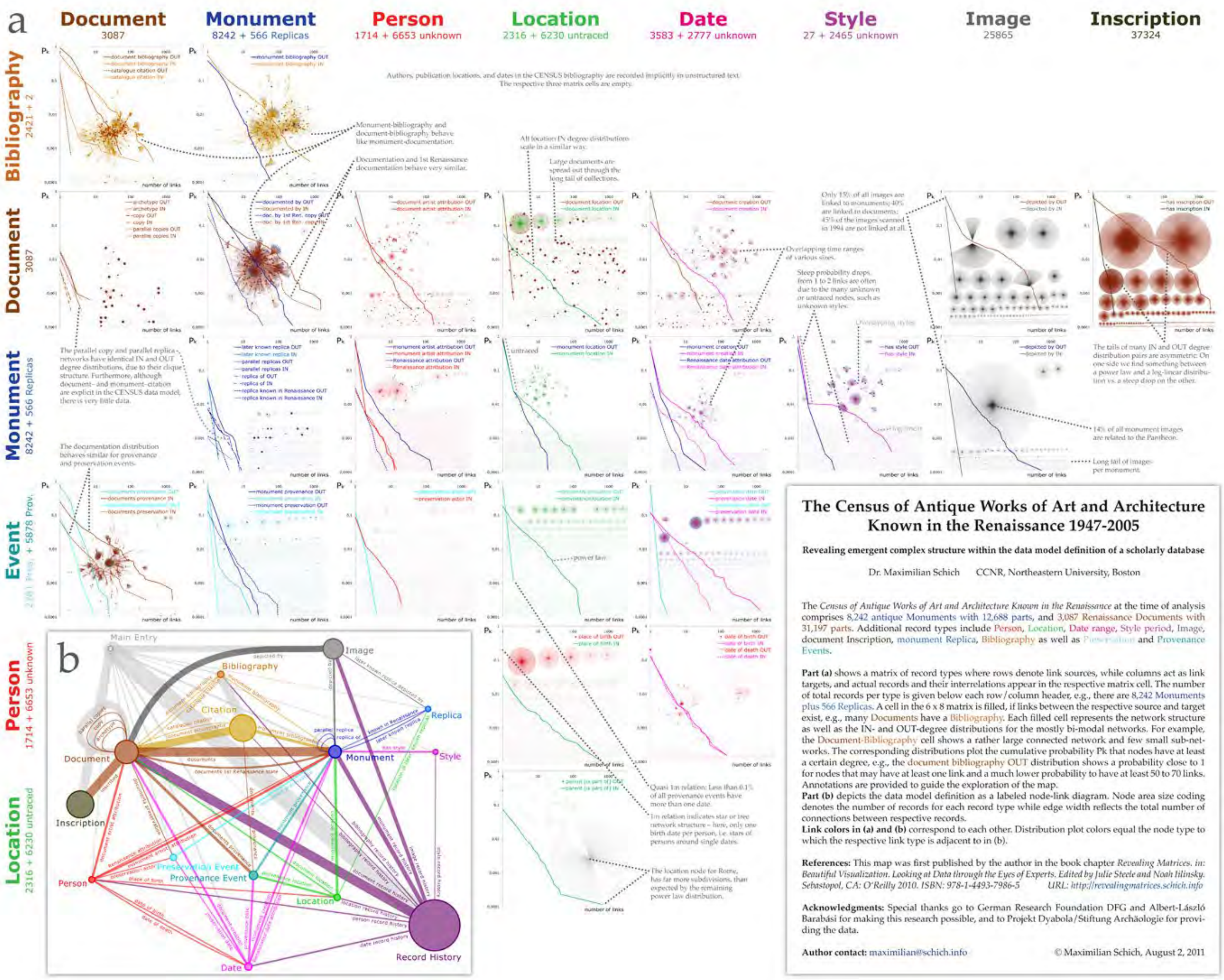


VII.5 *Design vs. Emergence: Visualization of Knowledge Orders*

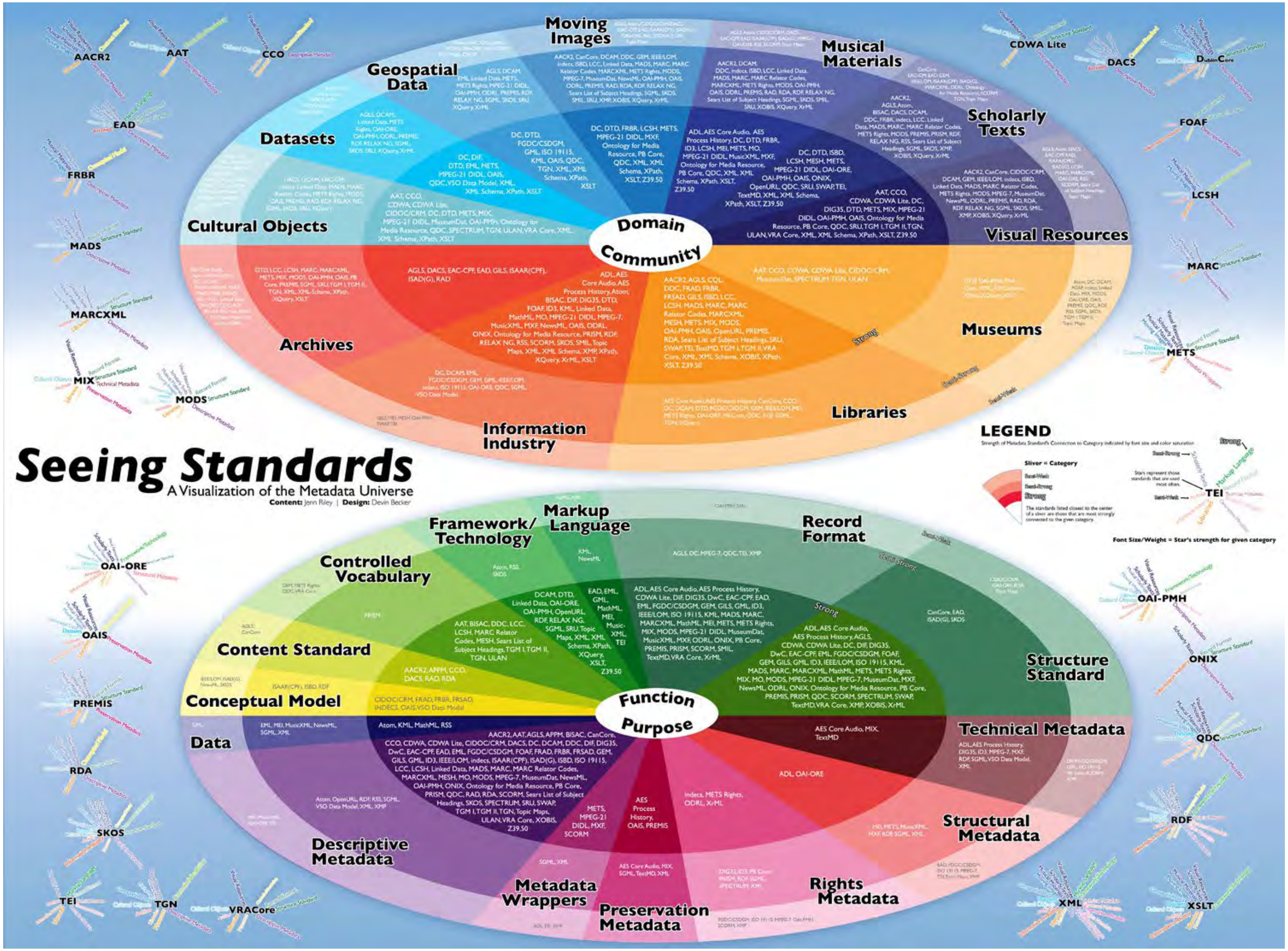
Alkim Almila Akdag Salah, Cheng Gao, Krzysztof Suchecki, and Andrea Scharnhorst - 2011



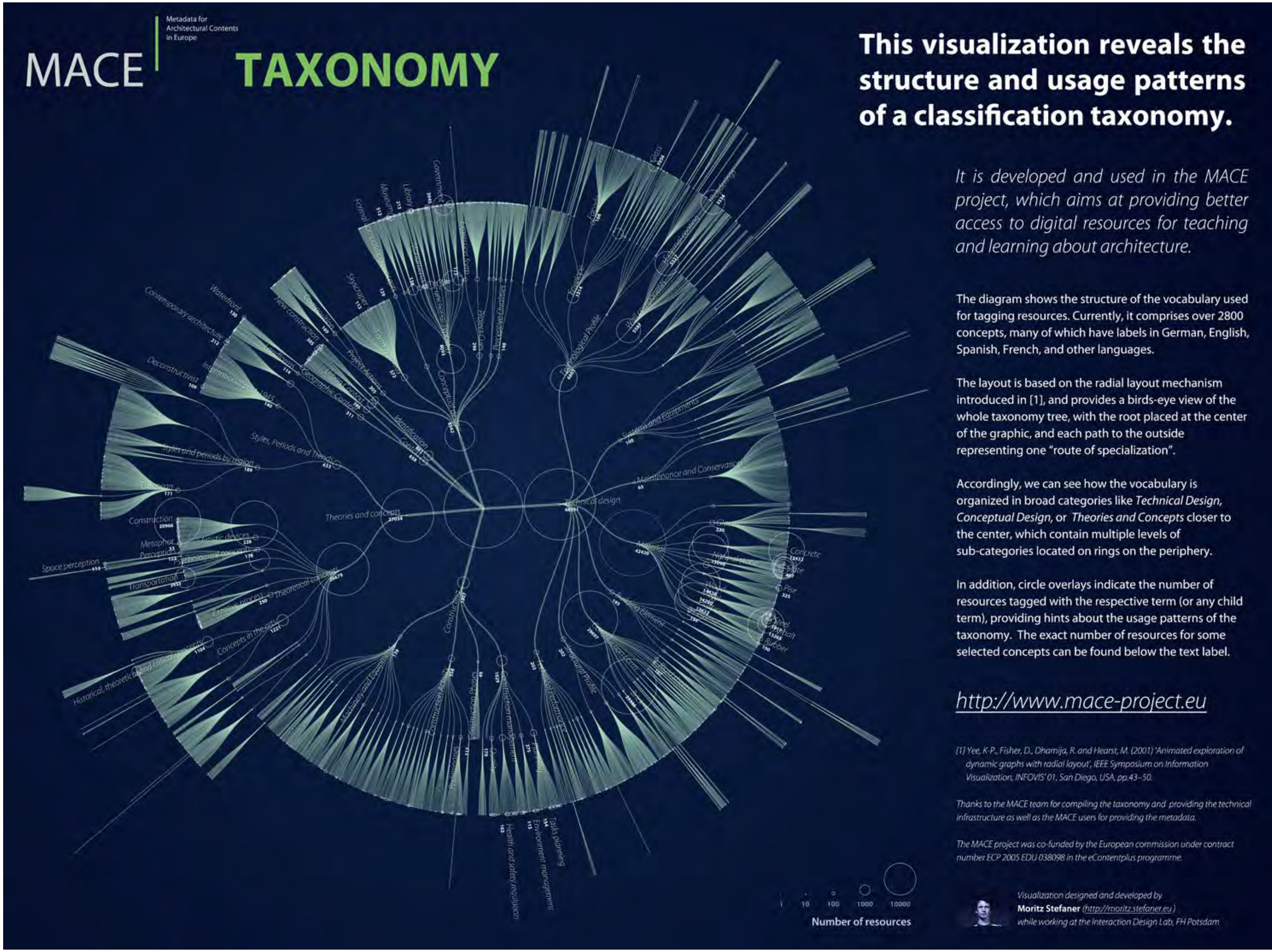
VII.6 *Map of Scientific Collaborations from 2005-2009* - Olivier H. Beauchesne - 2012



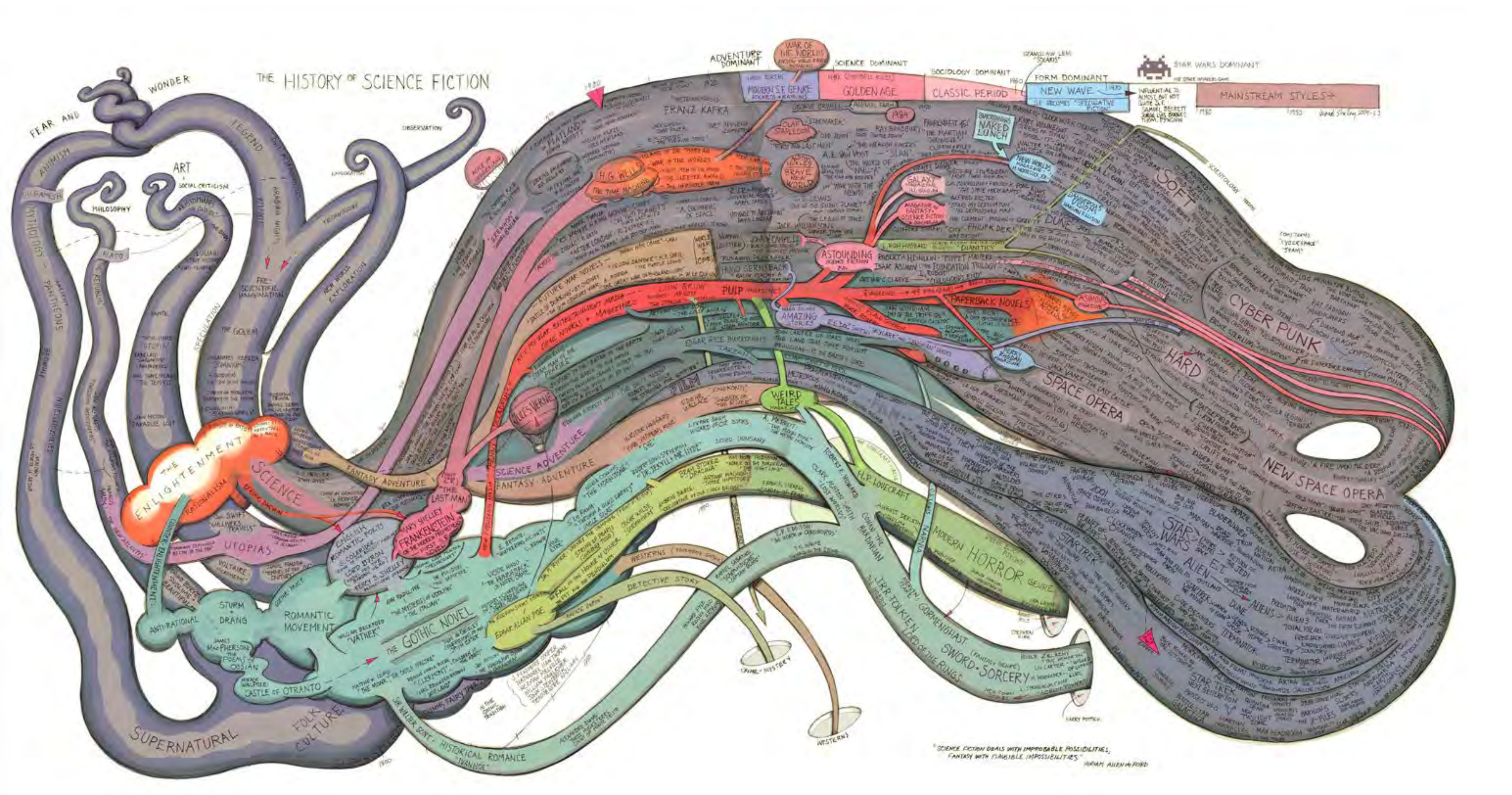
VII.7 *The Census of Antique Works of Art and Architecture Known in the Renaissance, 1947-2005* - Maximilian Schich - 2011



VII.8 *Seeing Standards: A Visualization of the Metadata Universe* - Devin Becker and Jenn Riley - 2009-2010



VII.9 *MACE Classification Taxonomy* - Moritz Stefaner - 2011



VII.10 *History of Science Fiction* - Ward Shelley - 2011

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facebook.com/mappingscience

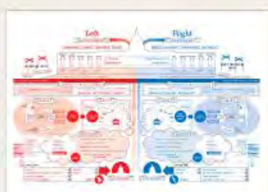
Iteration VIII (2012)

Science Maps for Kids

VIII.1

VIII.2

VIII.3



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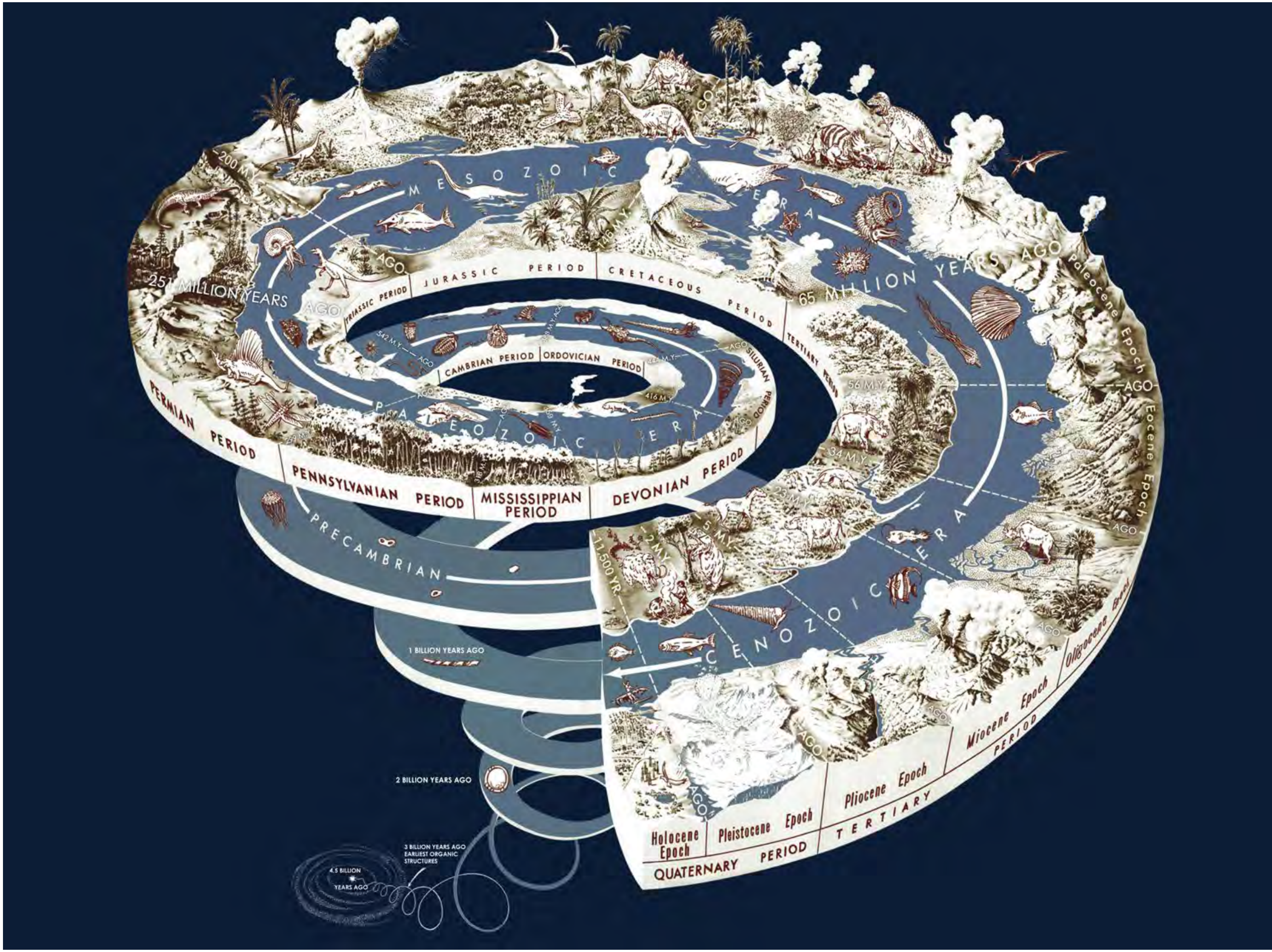
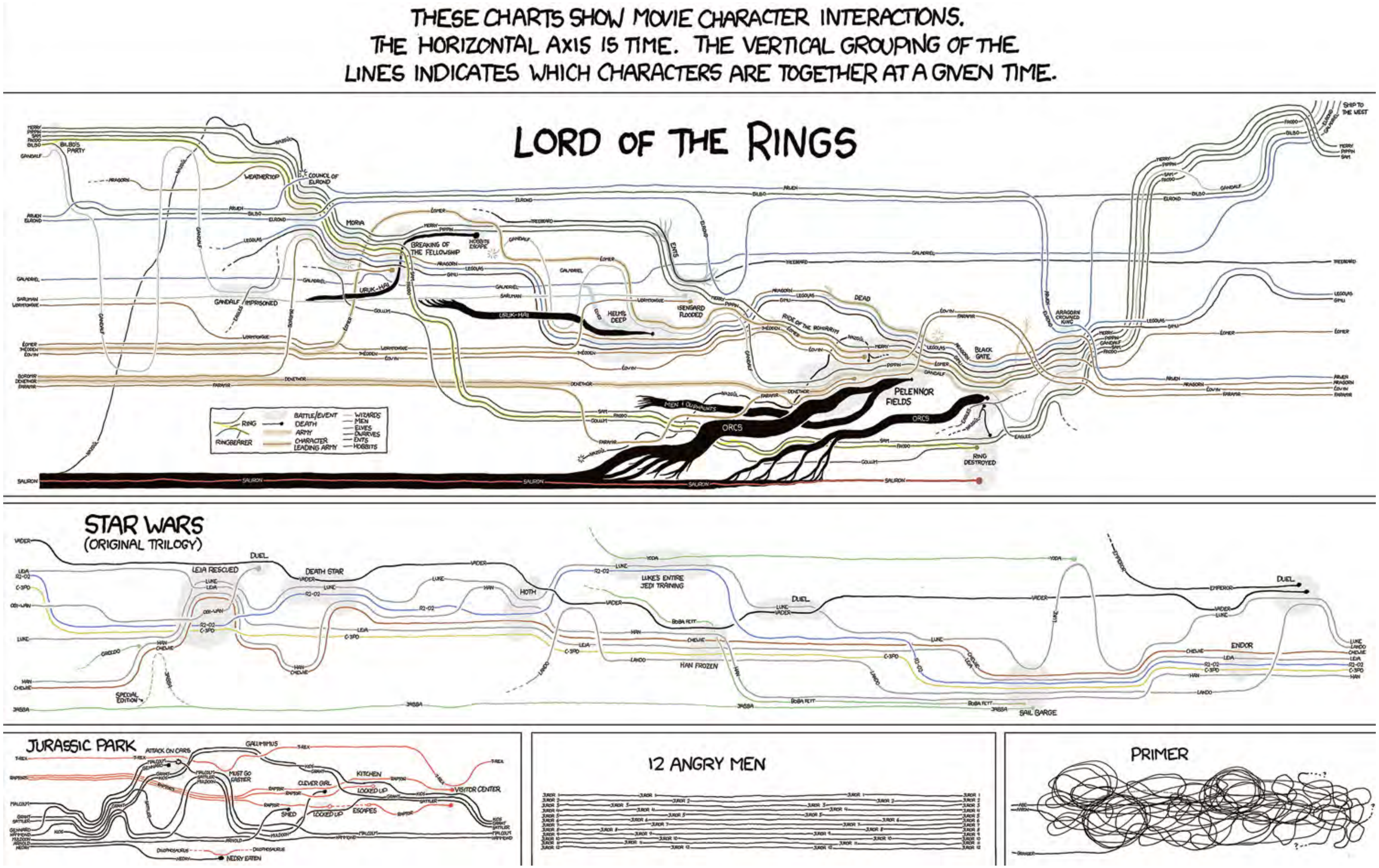
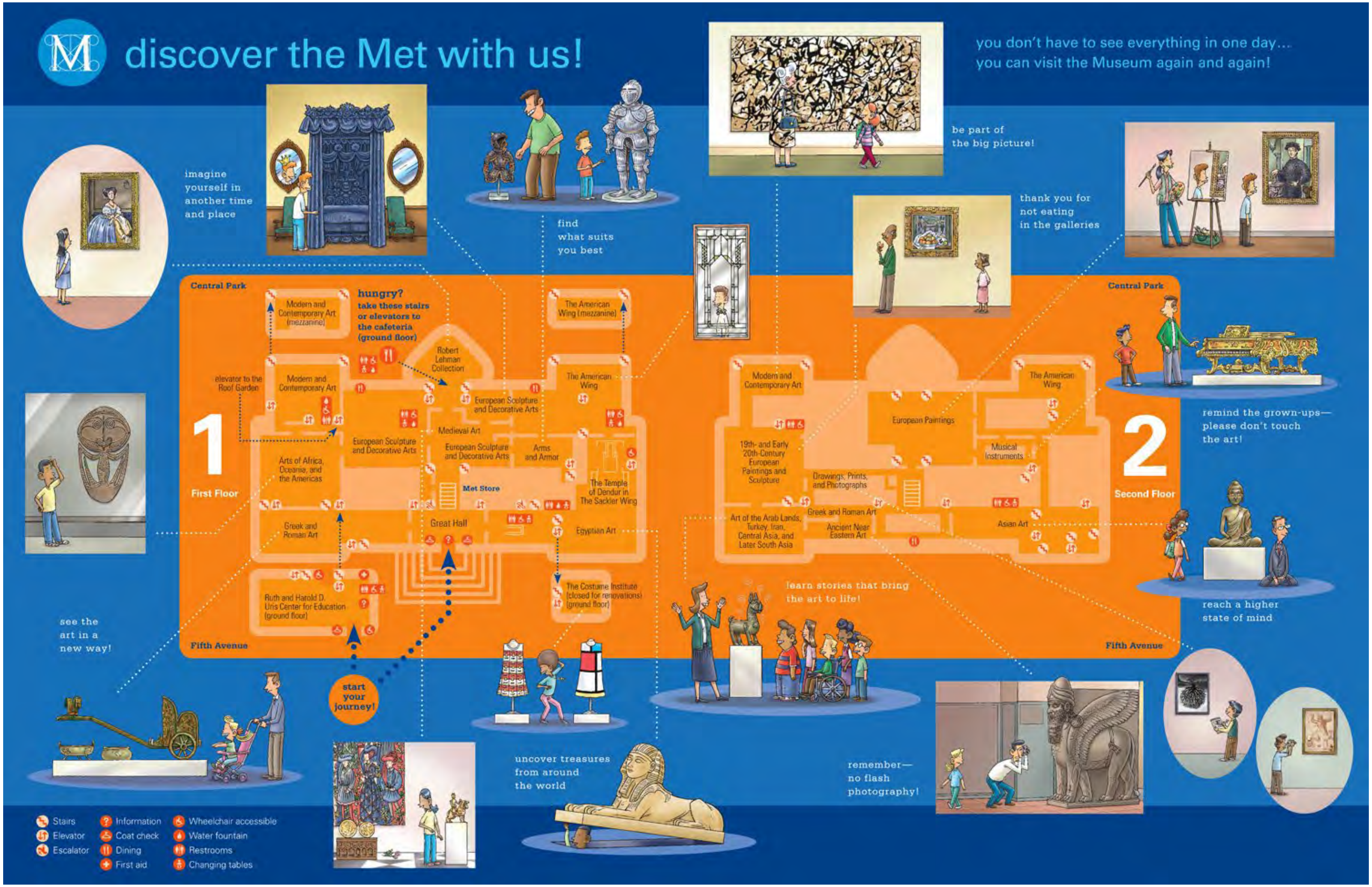


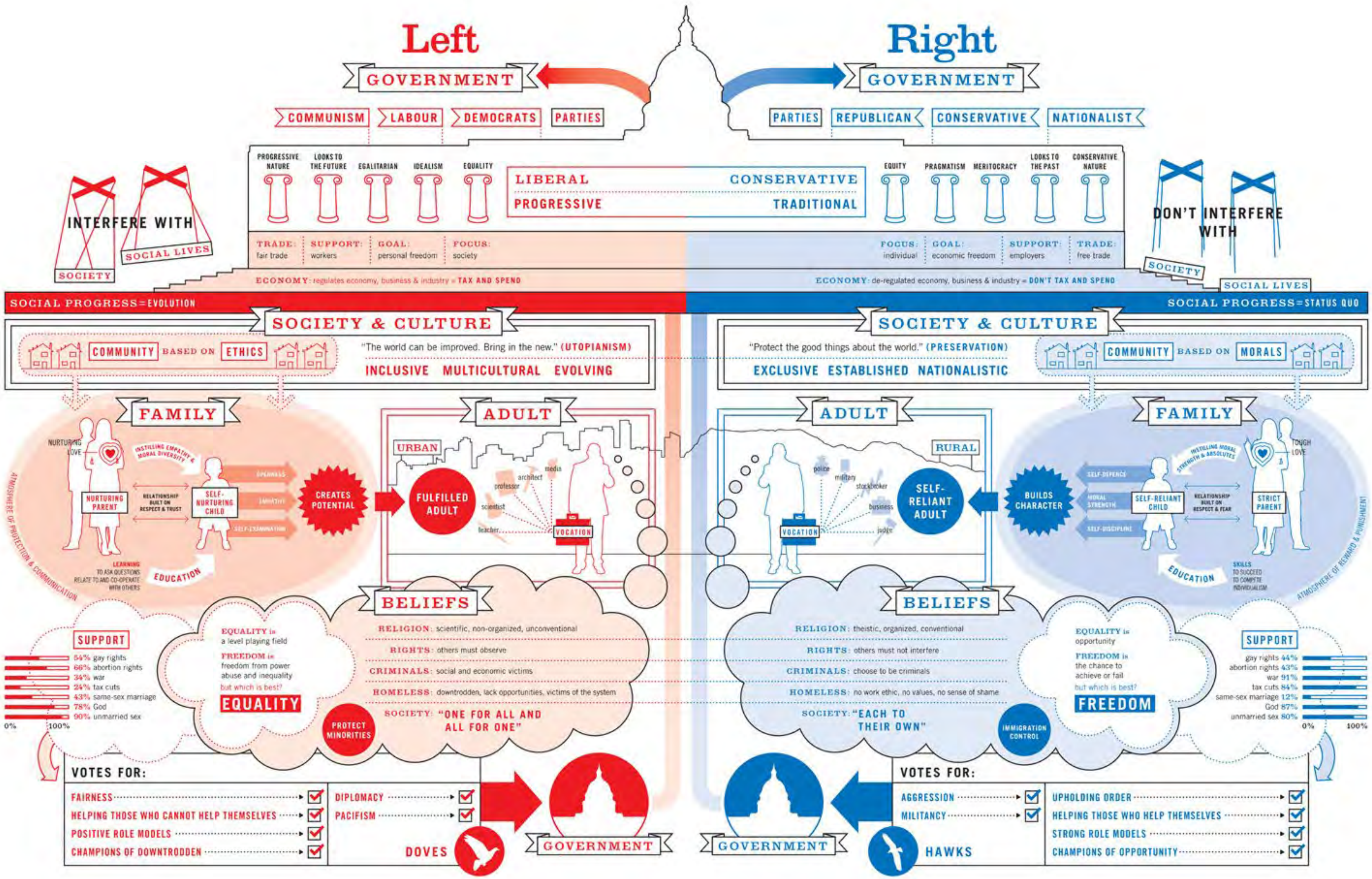
VIII.1 *Geologic Time Spiral: A Path to the Past* - Joseph Graham, William Newman, and John Stacy - 2008



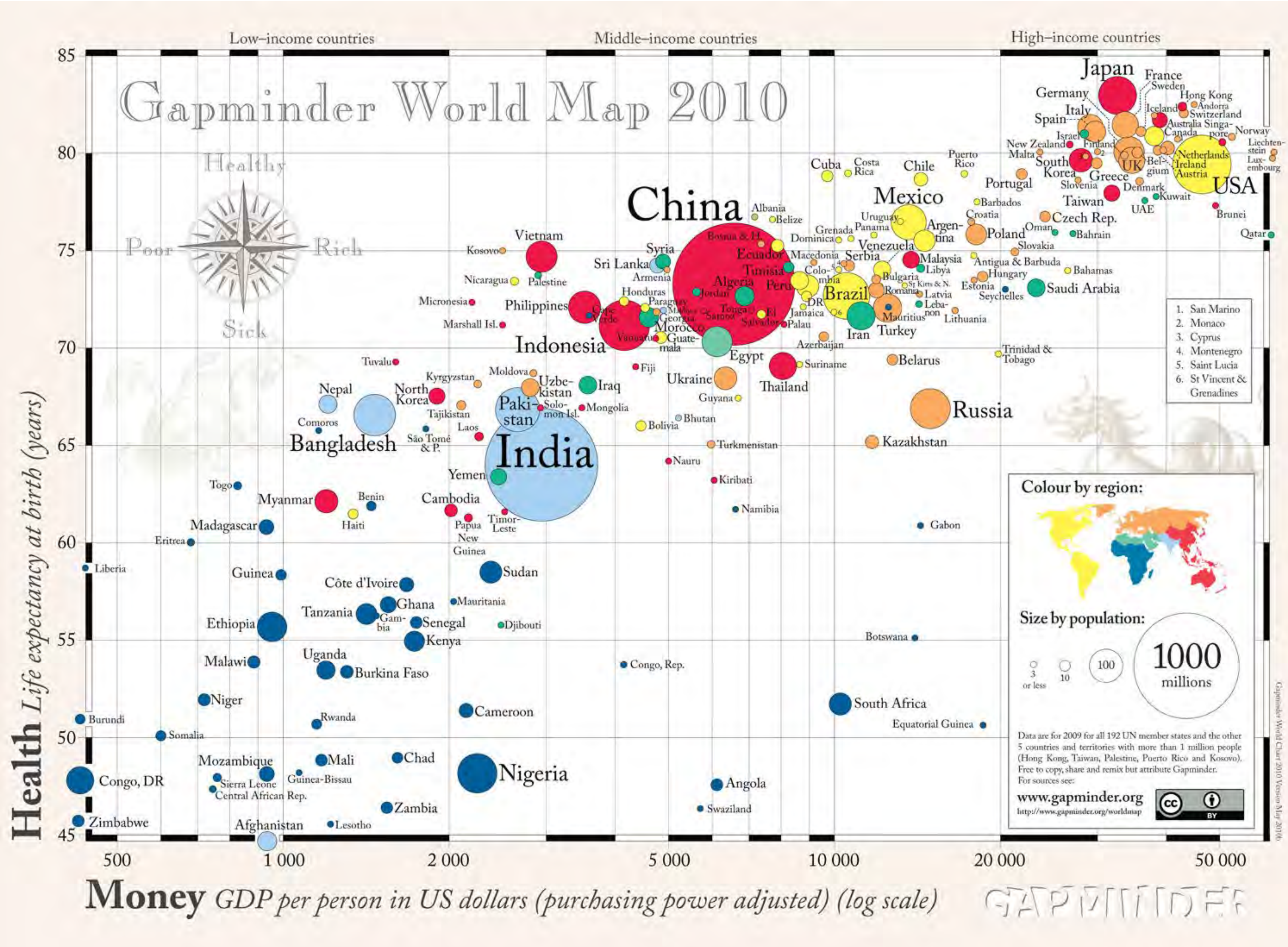
VIII.2 *Movie Narrative Charts (Comic #657)* - Randall Munroe - 2009



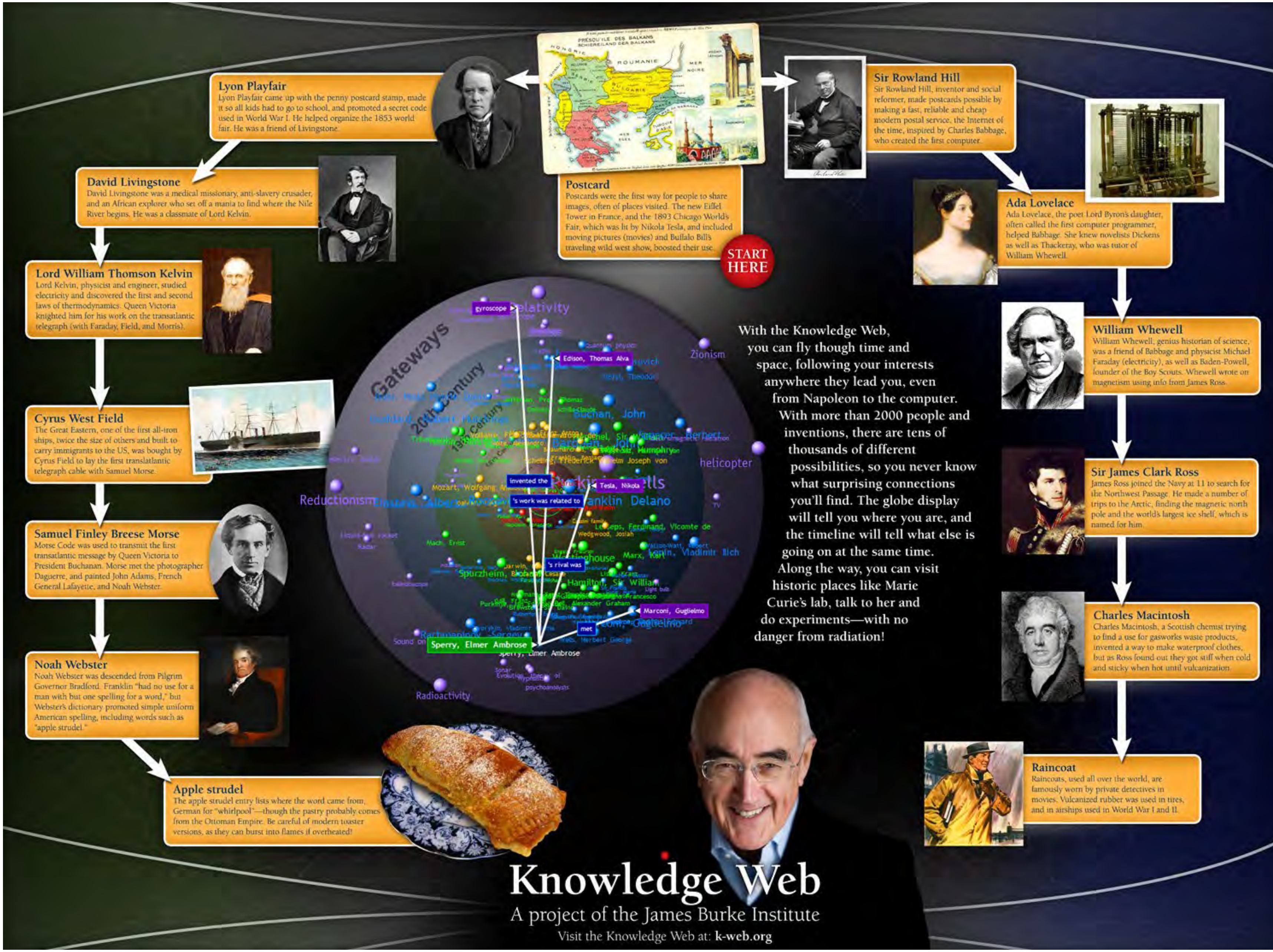
VIII.3 *Metropolitan Museum of Art Family Map* - Masha Turchinsky and John Kerschbaum - 2008



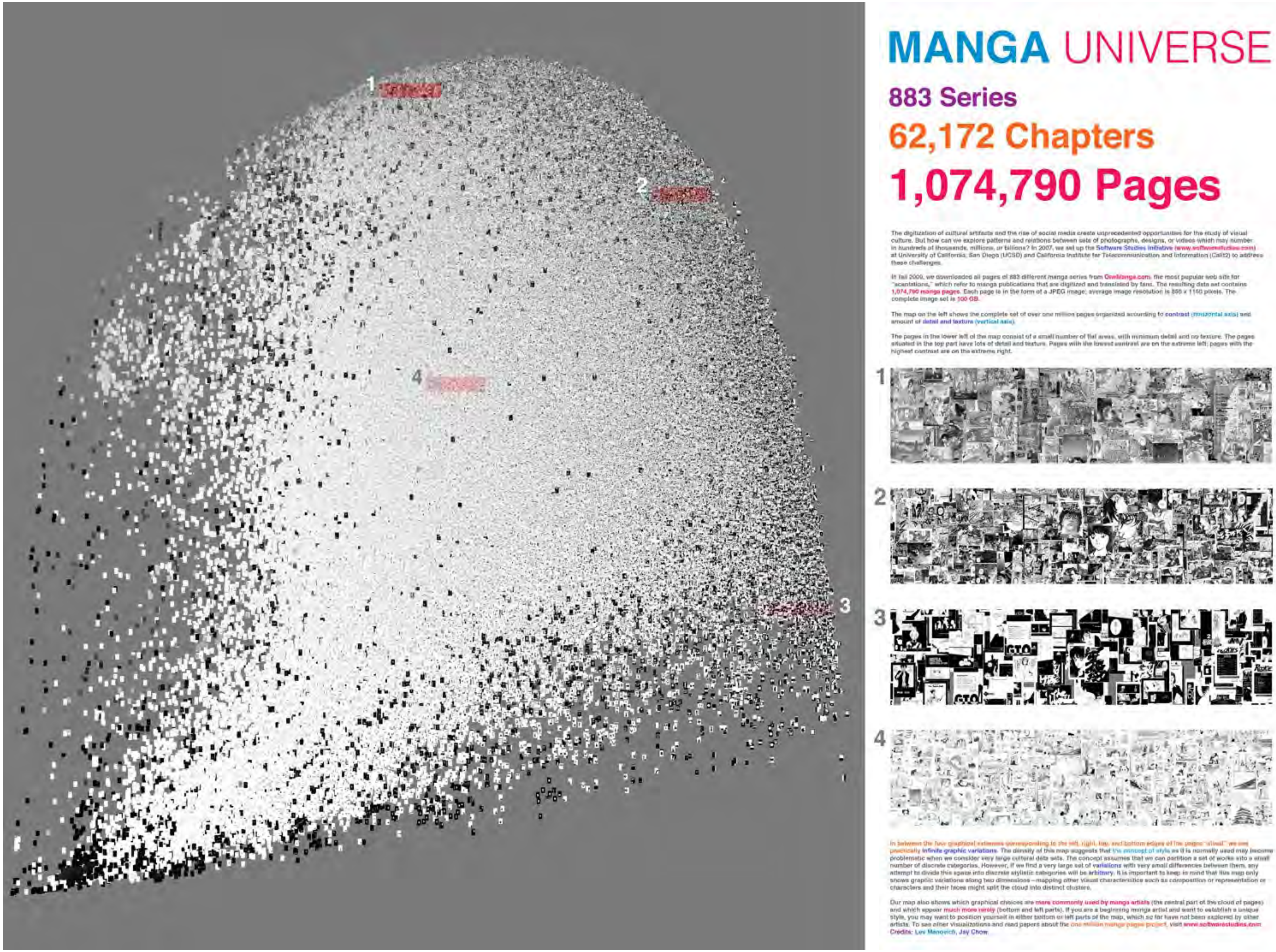
VIII.4 *Left vs. Right Political Spectrum* - David McCandless and Stefanie Posavec - 2009



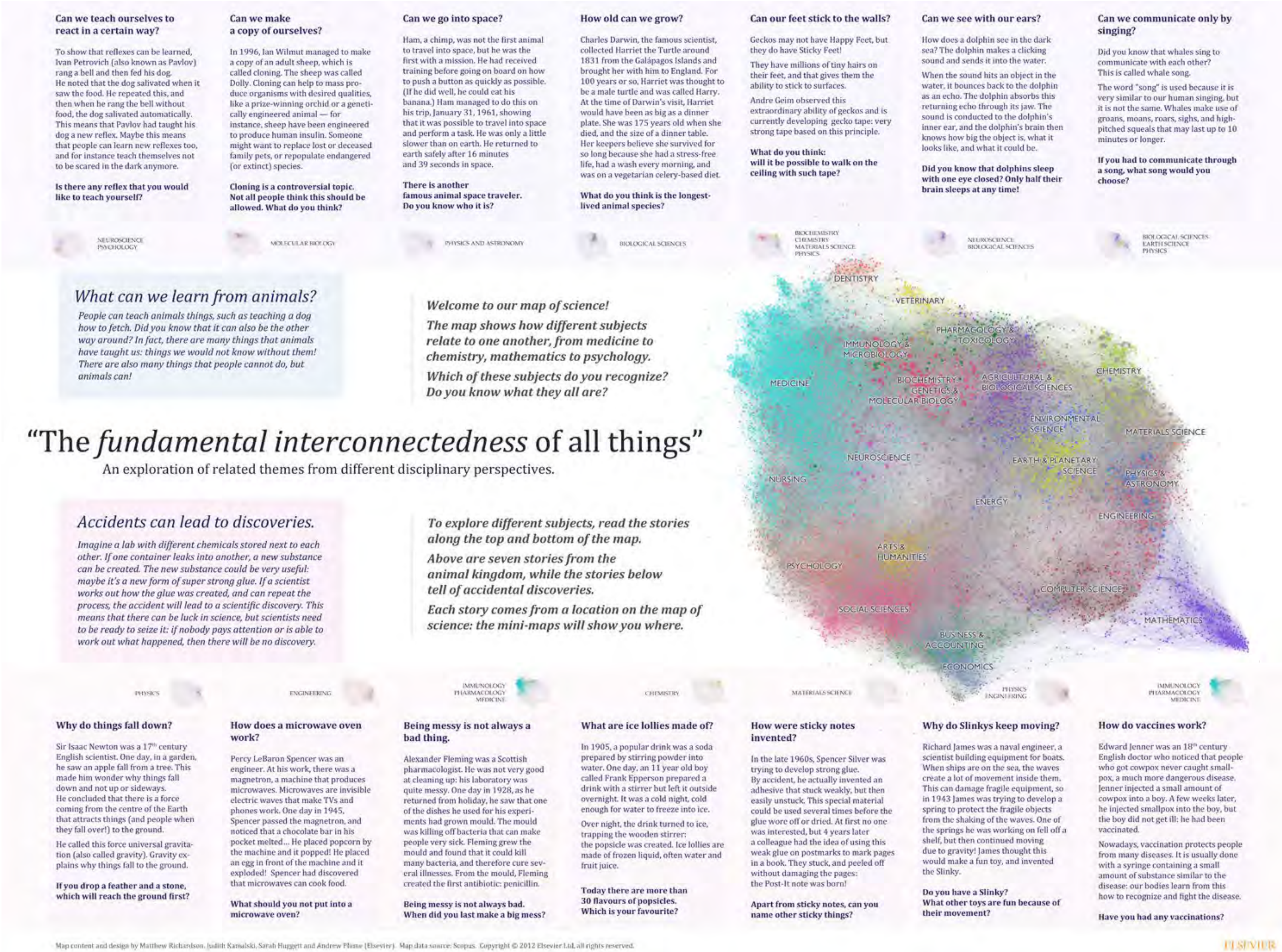
VIII.5 *Gapminder World Map* – Ola Rosling and Anna Rosling Rönnlund - 2010



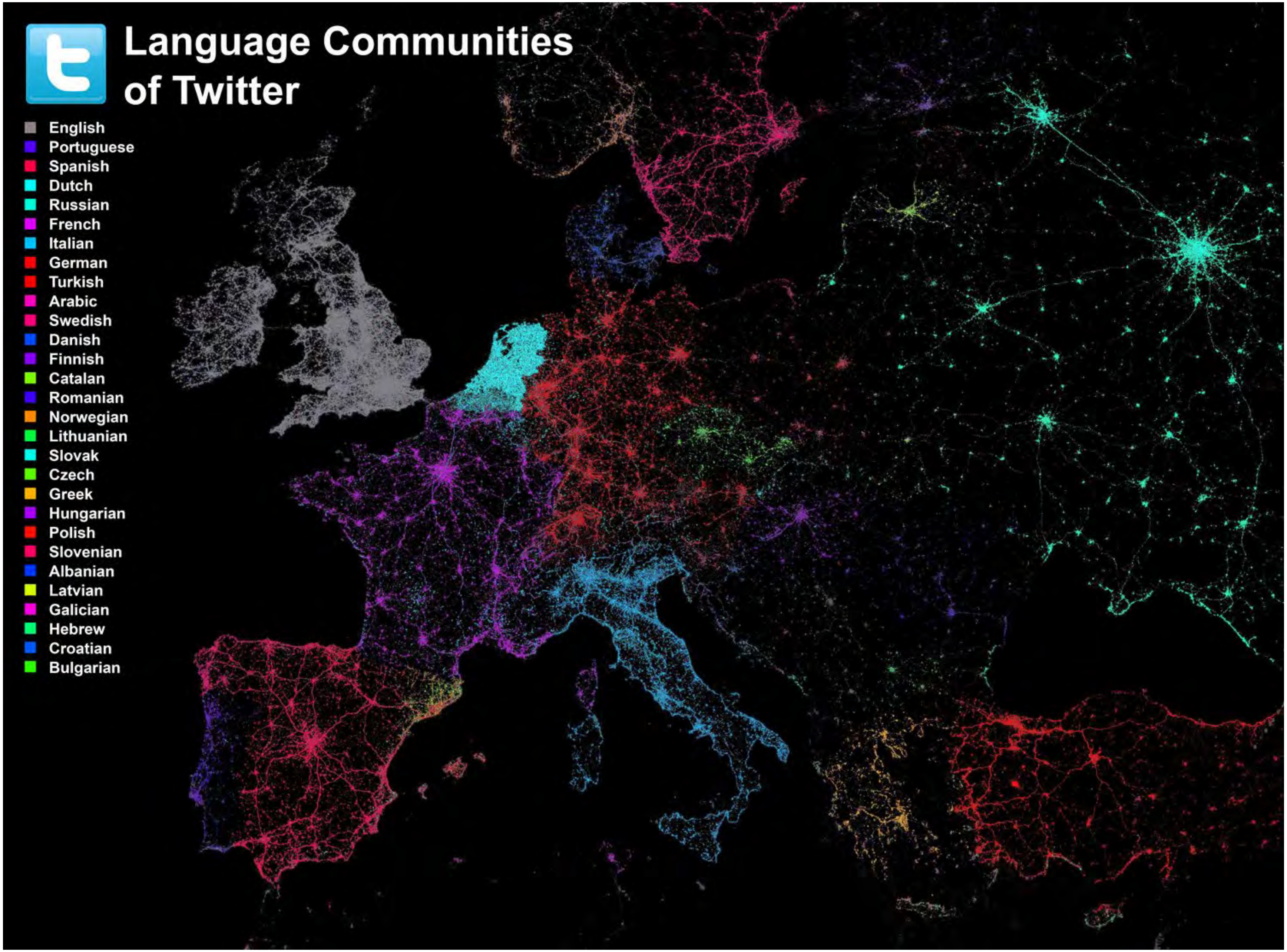
VIII.6 *Knowledge Web* - James Burke, Patrick McKercher, and Michael J. Stamper - 2012



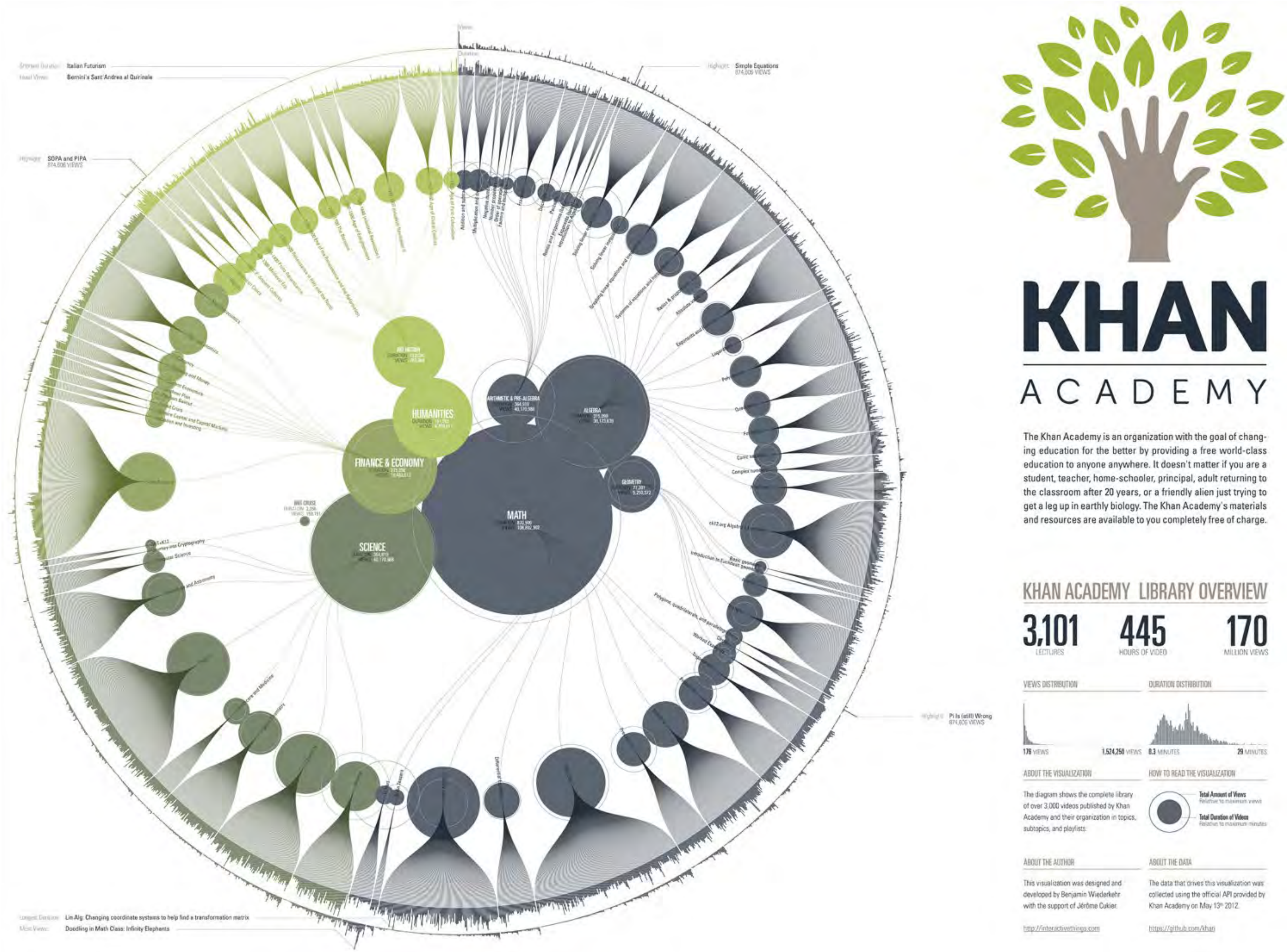
VIII.7 *Manga Universe* - Lev Manovich, Jeremy Douglass, and Jay Chow - 2012



VIII.8 *The Fundamental Interconnectedness of All Things* - Matthew Richardson, Judith Kamalski, Sarah Huggett, and Andrew Plume - 2012



VIII.9 *Language Communities of Twitter* - Eric Fischer - 2012

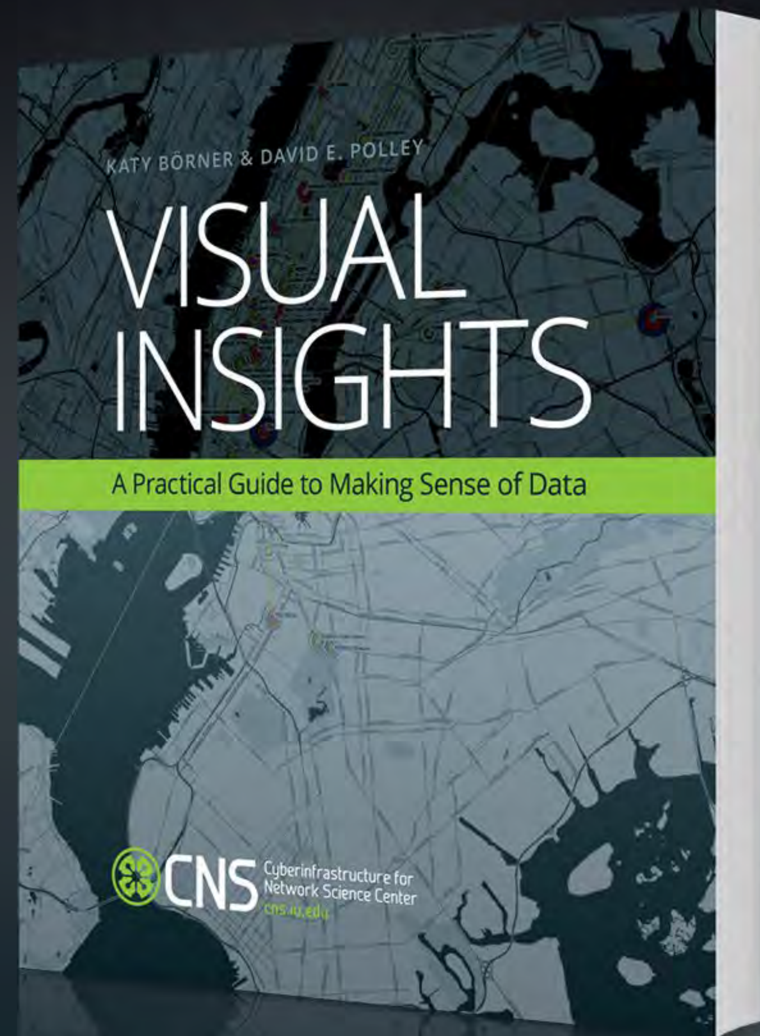


VIII.10 *Khan Academy Library Overview* - Benjamin Wiederkehr and Jérôme Cukier - 2012

The IVMOOC Companion Textbook

This textbook offers a gentle introduction to the design of insightful visualizations.
It seamlessly blends theory and practice, giving readers both the theoretical foundation and the practical skills necessary to render data into insights.

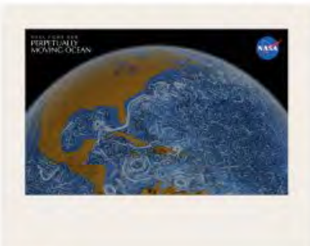
The book accompanies the Information Visualization MOOC that attracted students, scholars, and practitioners from many fields of science and more than 100 different countries.



cns.iu.edu/ivmoocbook14.html

Iteration IX (2013)

Science Maps Showing Trends and Dynamics



IX.1

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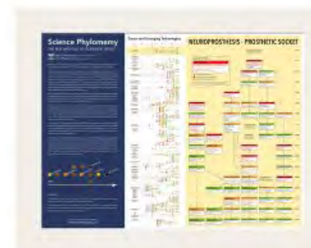
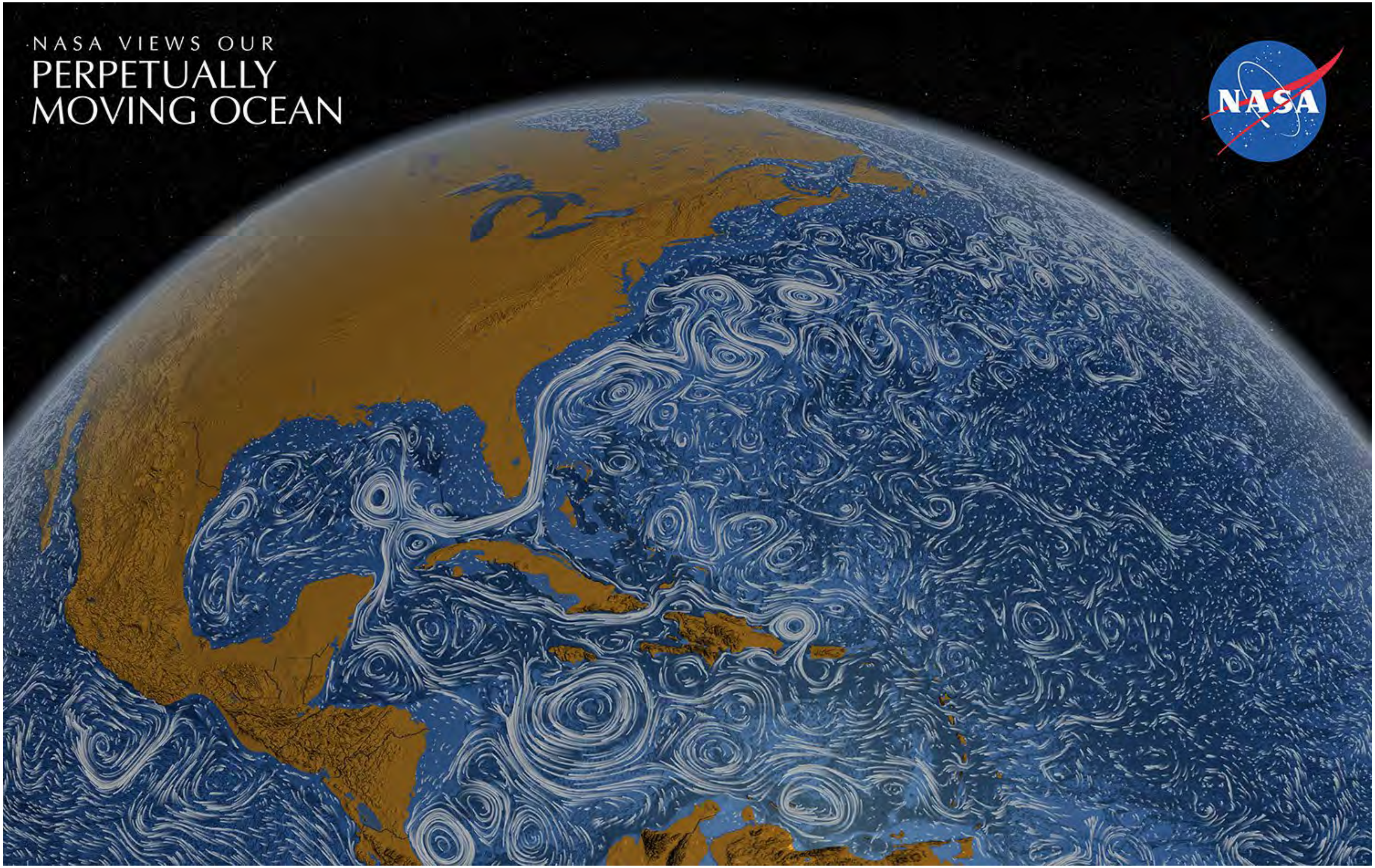
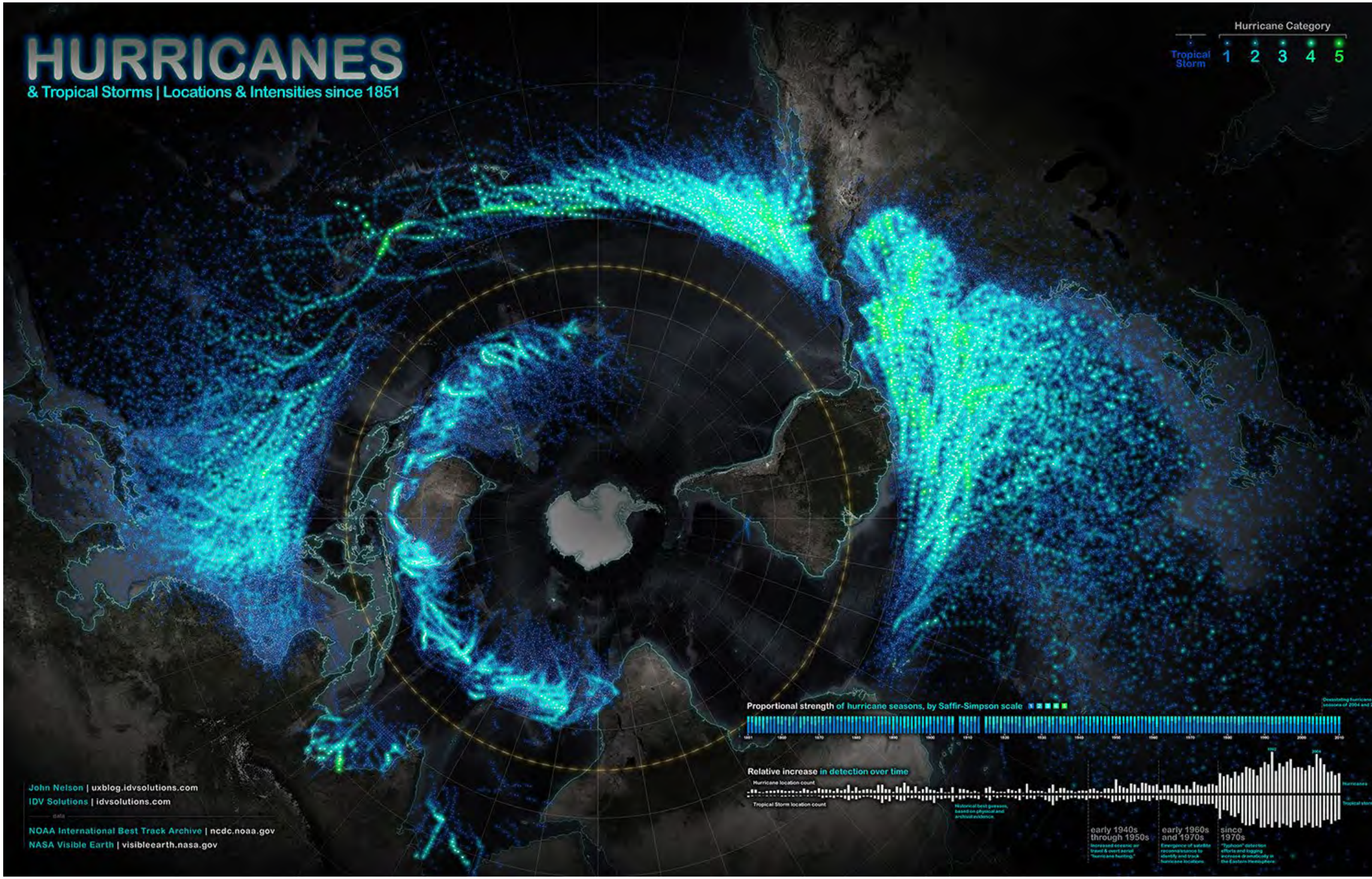
IX.9



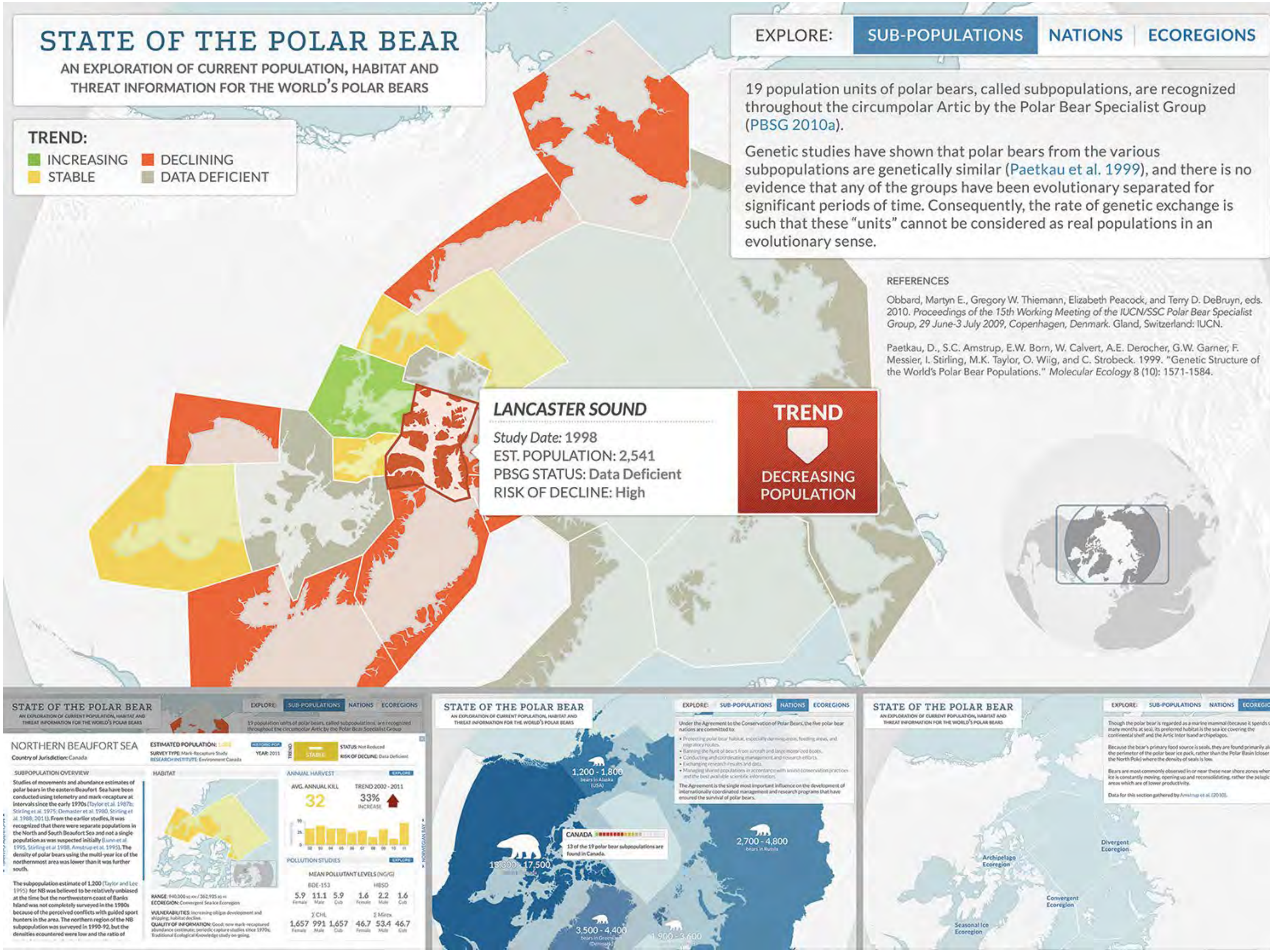
IX.10



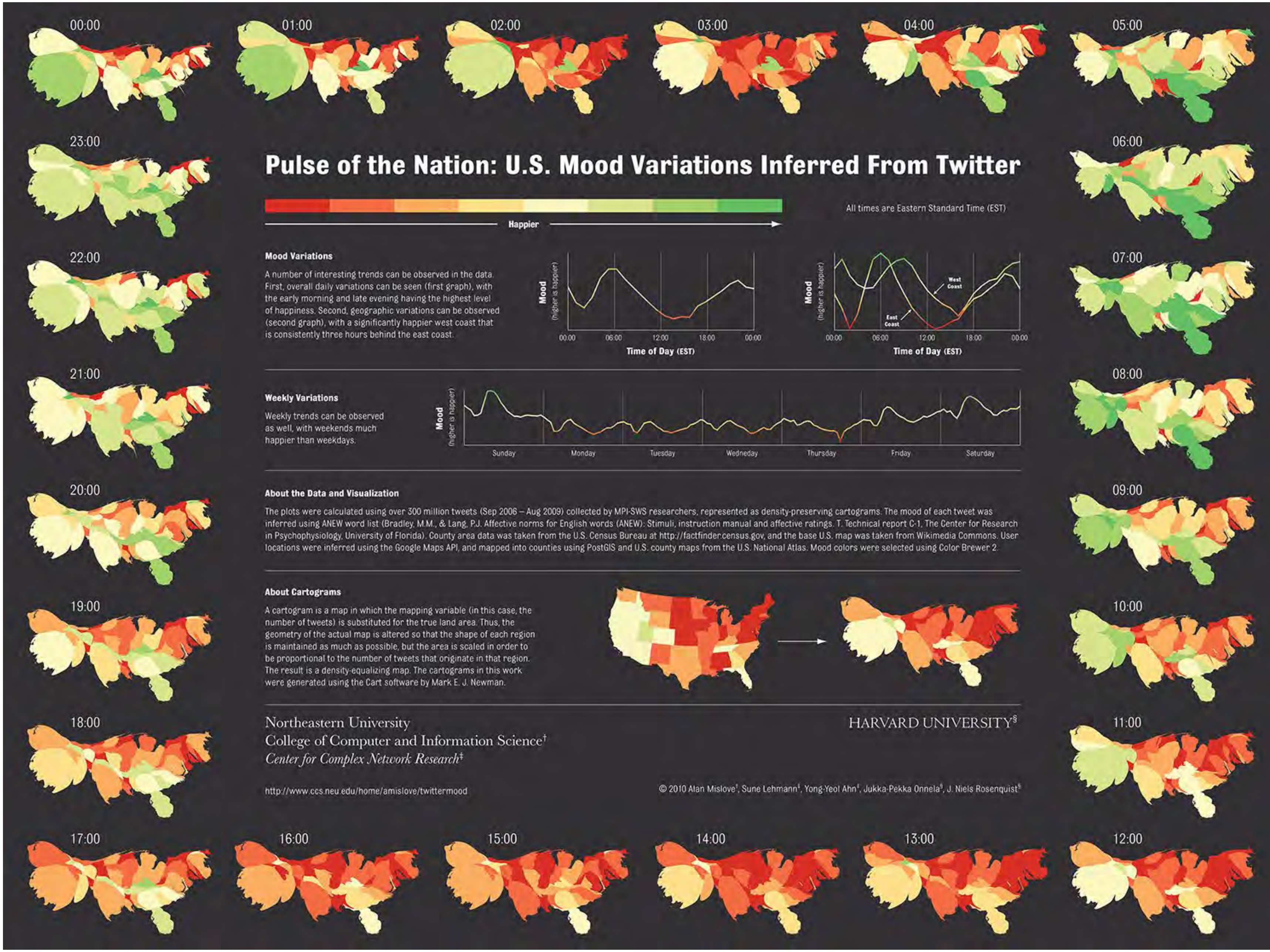
IX.1 *NASA Views Our Perpetually Moving Ocean* - Dimitris Menemenlis, Horace G. Mitchell, Christopher N. Hill, and Gregory W. Shirah - 2011



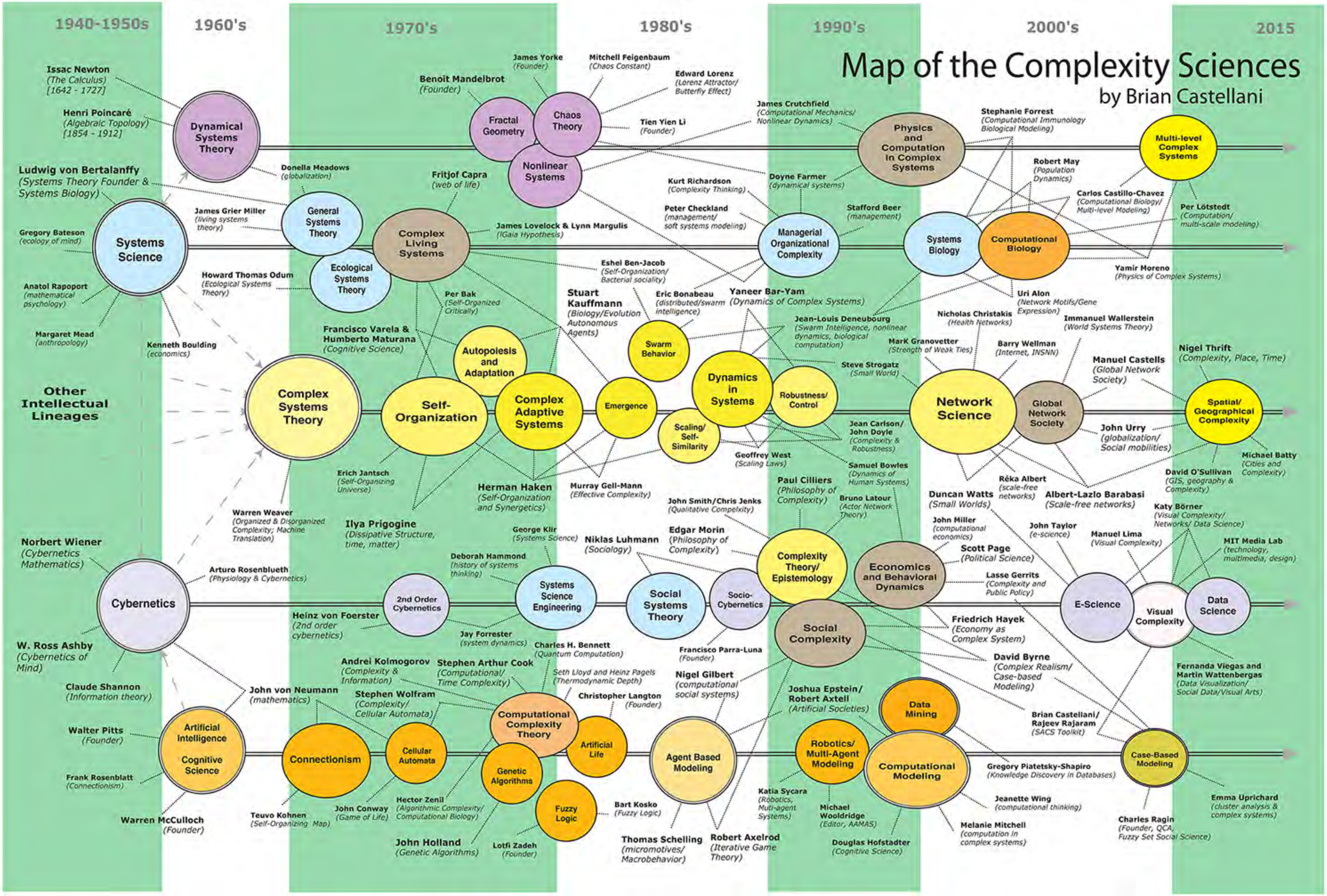
IX.2 *Hurricanes & Tropical Storms—Locations and Intensities since 1851* - John Nelson - 2012



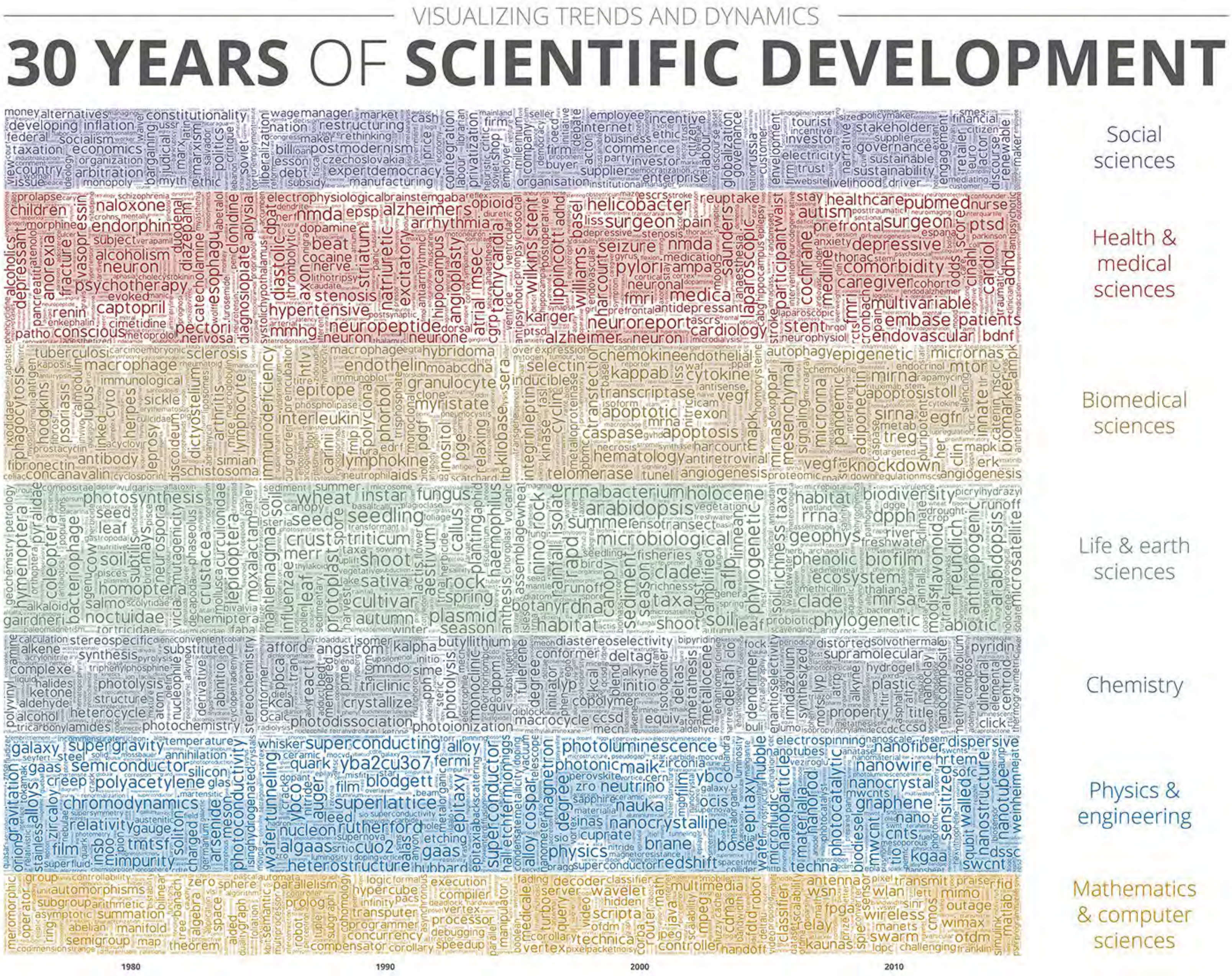
IX.3 *State of the Polar Bear* - Dino Citraro, Kim Rees, Jacob O'Brien, Brett Johnson, Domanique Alicia, and Andrew Winterman - 2013



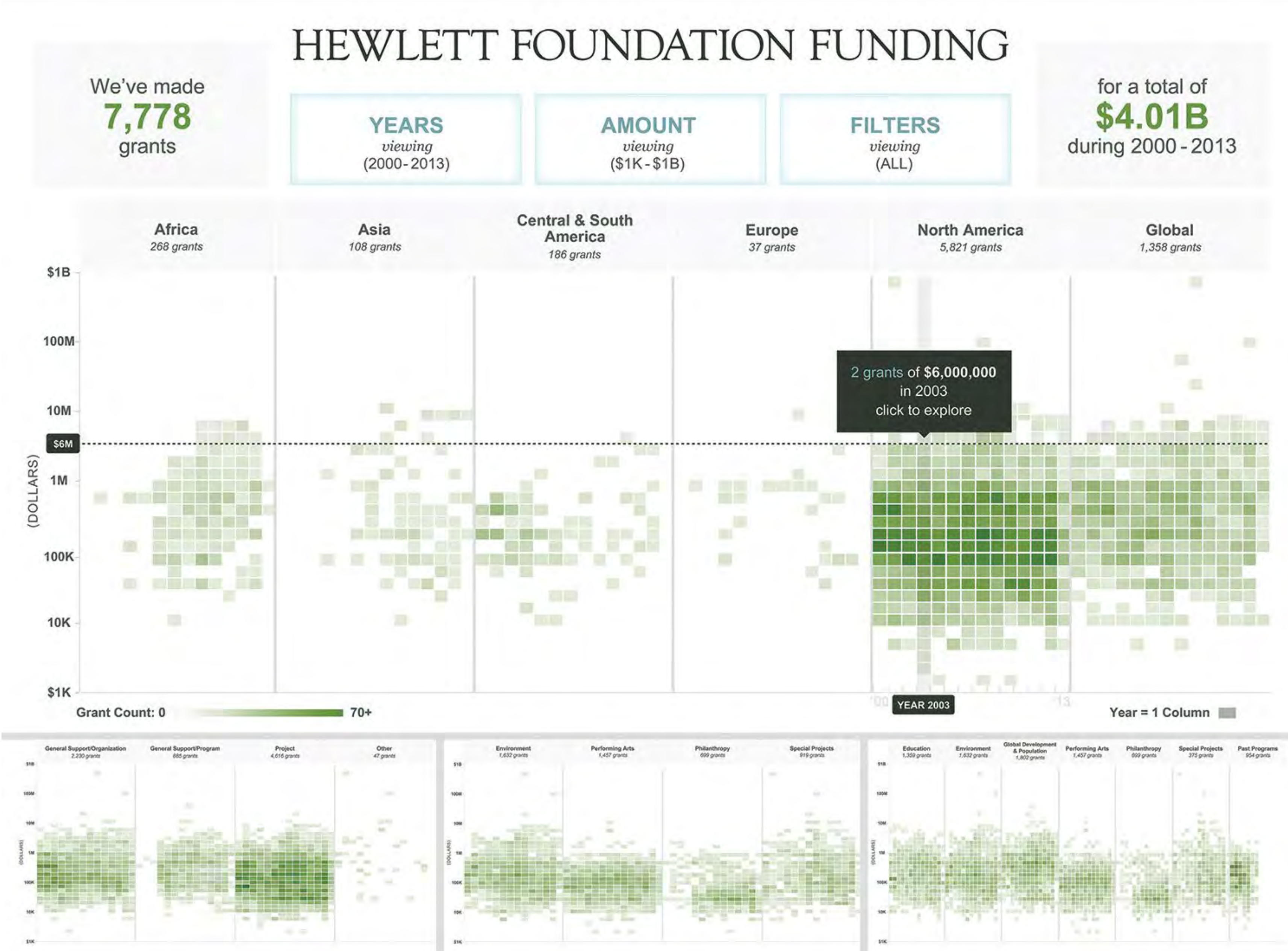
IX.4 *Pulse of the Nation* - Alan Mislove, Sune Lehmann, Yong-Yeol Ahn, Jukka-Pekka Onnela, and James Niels Rosenquist - 2010



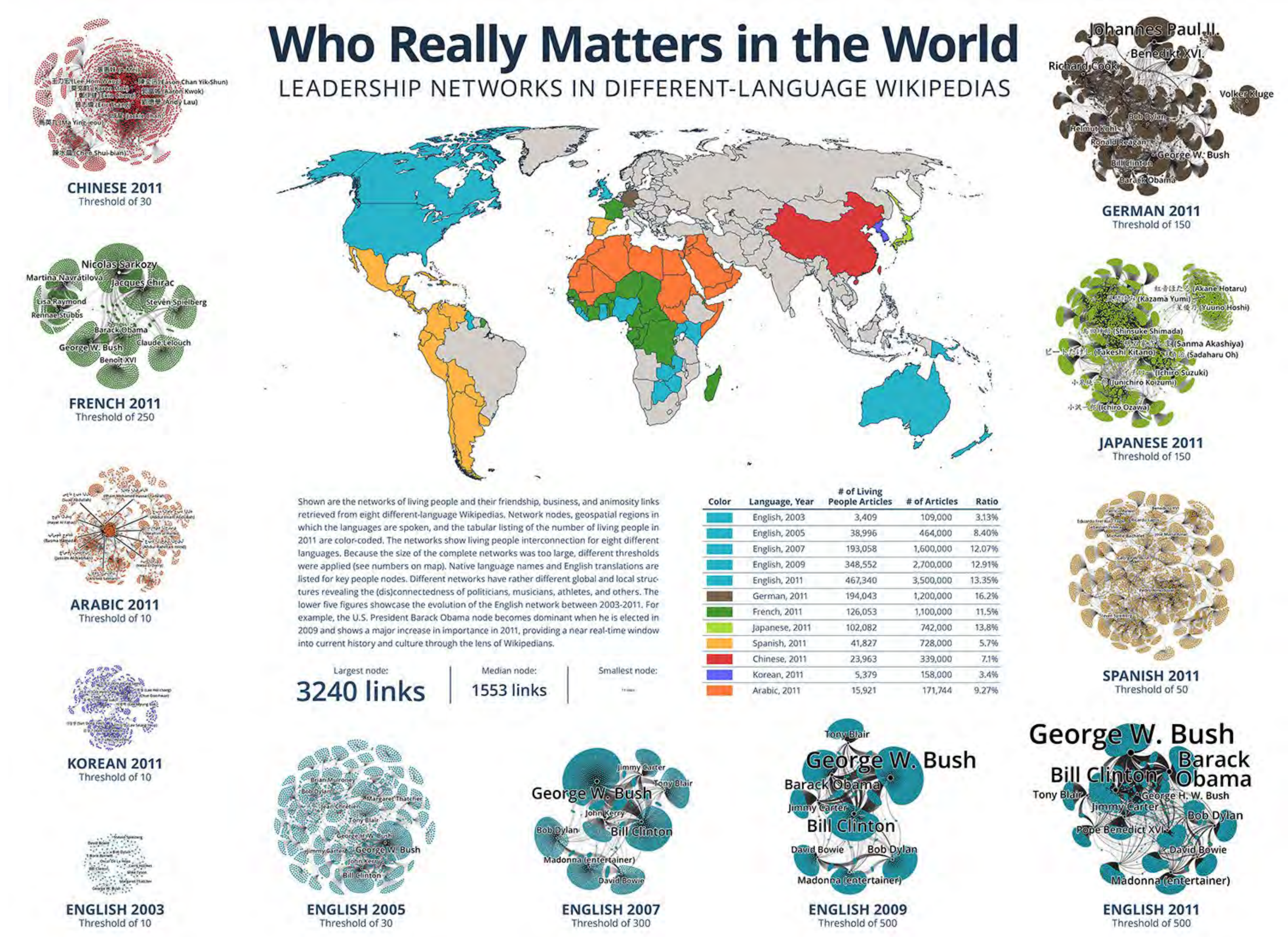
IX.5 *Map of Complexity Science* - Brian Castellani - 2013



IX.6 *Visualizing Trends and Dynamics: 30 Years of Scientific Development* - Nees Jan van Eck, Ludo Waltman, and Ferdy van Gool - 2013

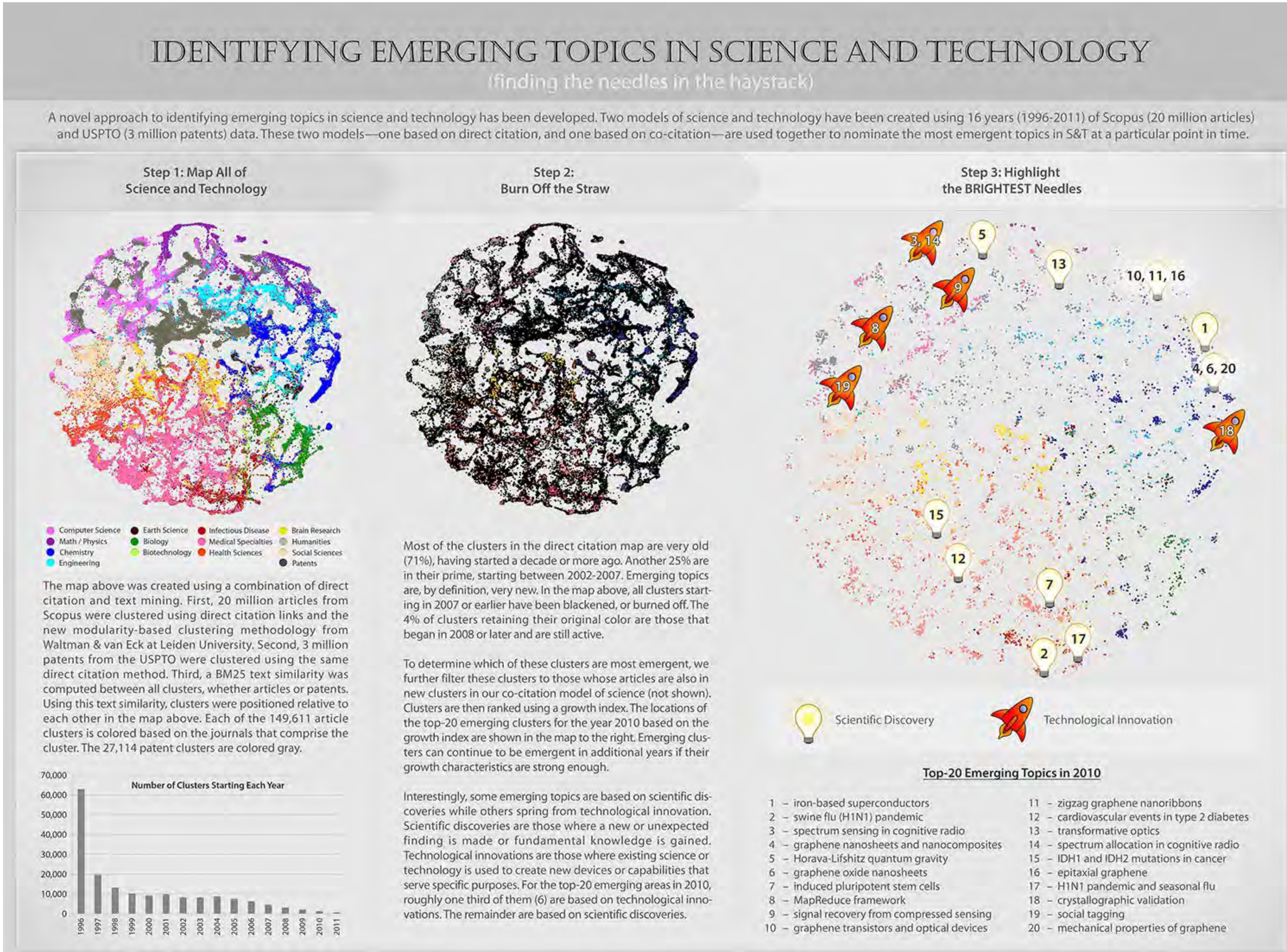


IX.7 *The Hewlett Foundation Grant Visualizer*
Dino Citraro, Kim Rees, Jacob O'Brien, Brett Johnson, Andrew Winterman, and Andrew Witherspoon - 2013

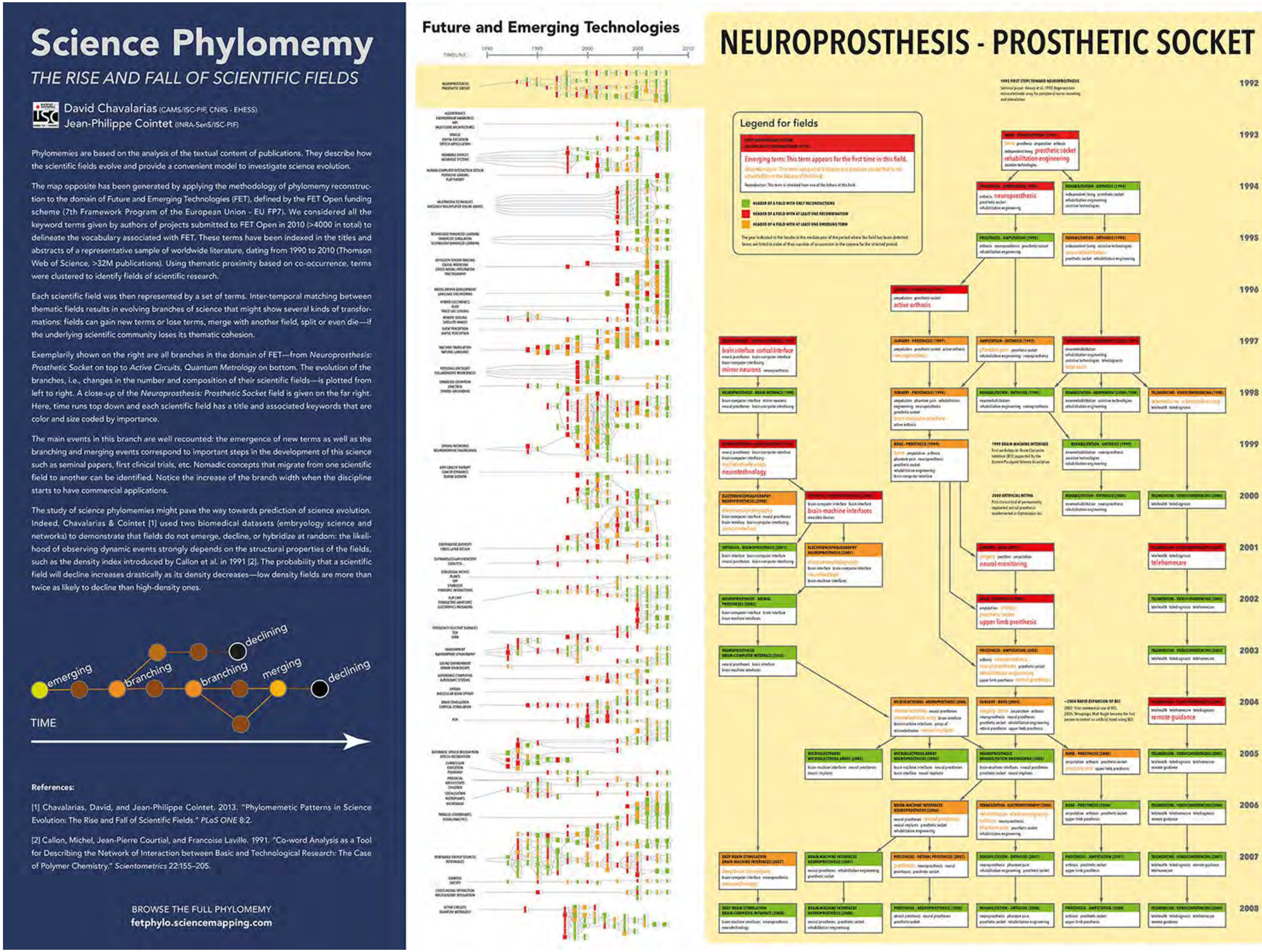


Color	Language, Year	# of Living People Articles	# of Articles	Ratio
	English, 2003	3,409	109,000	3.13%
	English, 2005	38,996	464,000	8.40%
	English, 2007	193,058	1,600,000	12.07%
	English, 2009	348,552	2,700,000	12.91%
	English, 2011	467,340	3,500,000	13.35%
	German, 2011	194,043	1,200,000	16.2%
	French, 2011	126,053	1,100,000	11.5%
	Japanese, 2011	102,082	742,000	13.8%
	Spanish, 2011	41,827	728,000	5.7%
	Chinese, 2011	23,963	339,000	7.1%
	Korean, 2011	5,379	158,000	3.4%
	Arabic, 2011	15,921	171,744	9.27%

IX.8 *Who Really Matters in the World—Leadership Networks in Different-Language Wikipedias*
Peter A. Gloor, Keiichi Nemoto, Samuel T. Mills, and David E. Polley - 2013



IX.9 *Identifying Emerging Topics in Science and Technology* - Kevin W. Boyack, Richard Klavans, and Henry G. Small - 2013



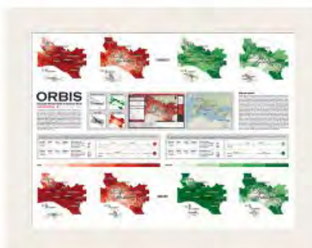
IX.10 *Science Phylomemy* - David Chavalarias and Jean-Philippe Cointet - 2013

Iteration X (2014)
The Future of Science Mapping

X.1

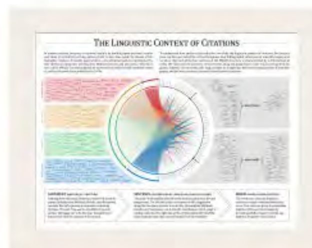
X.2

X.3



X.4

X.5



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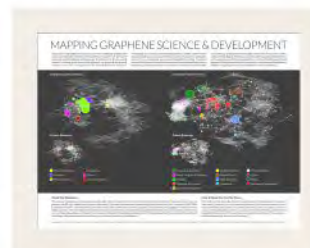
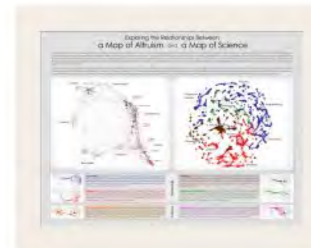


X.8



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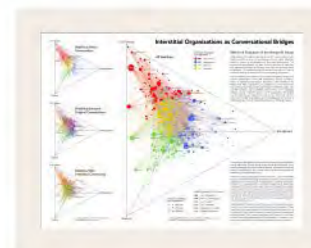
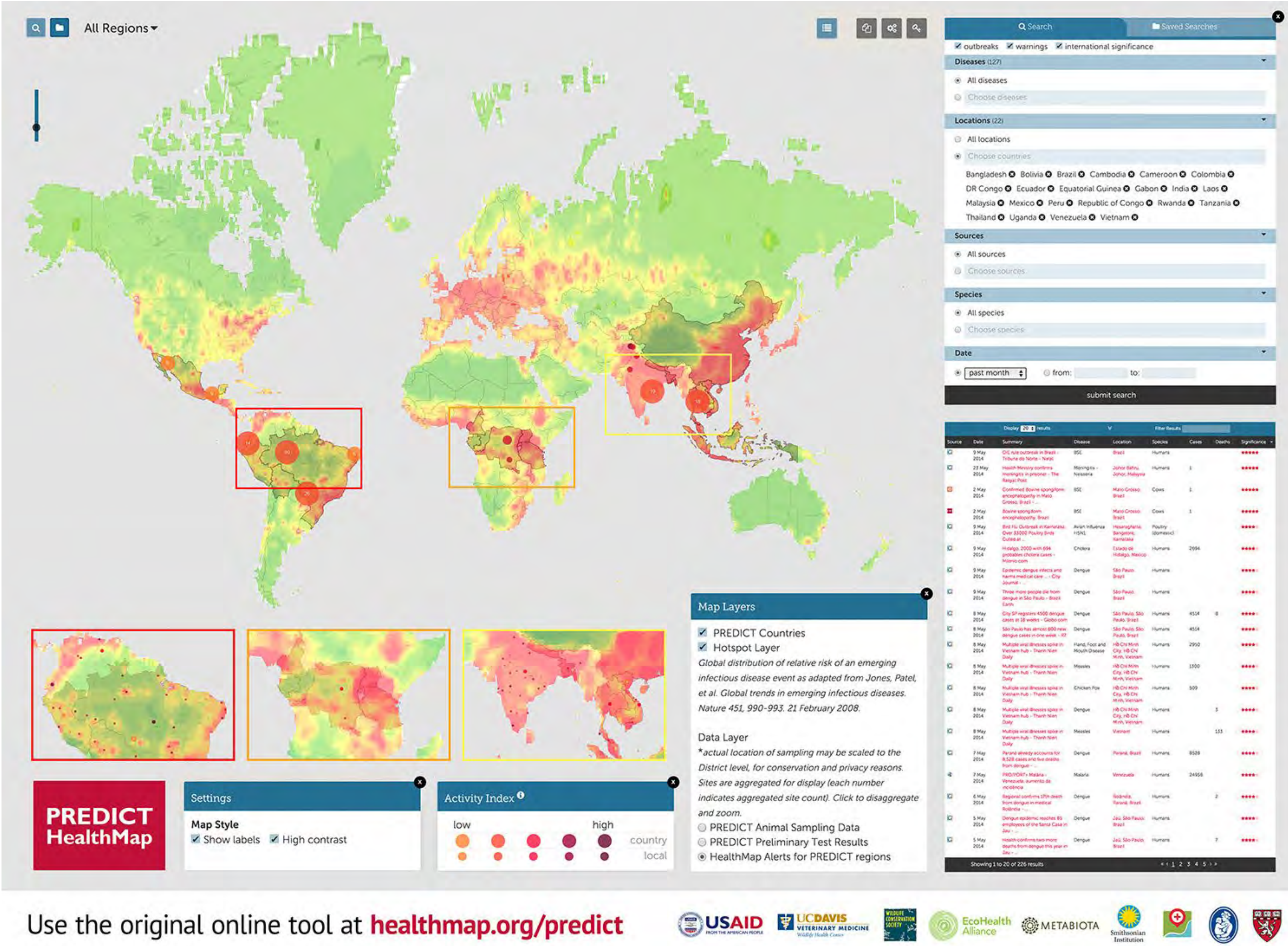


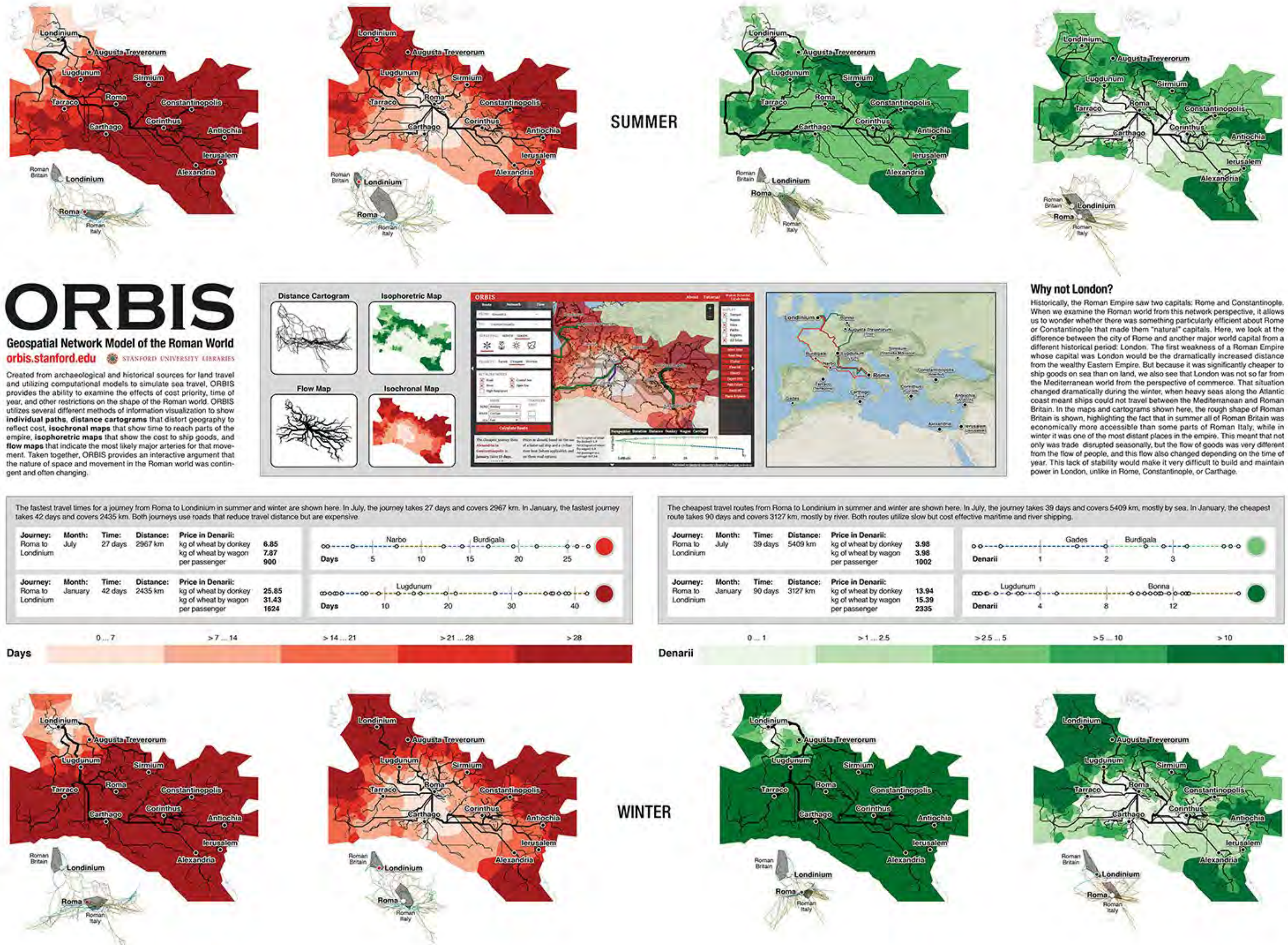
X.10

X.1 *Being a Map of Physics* - Bernard H. Porter - 1939

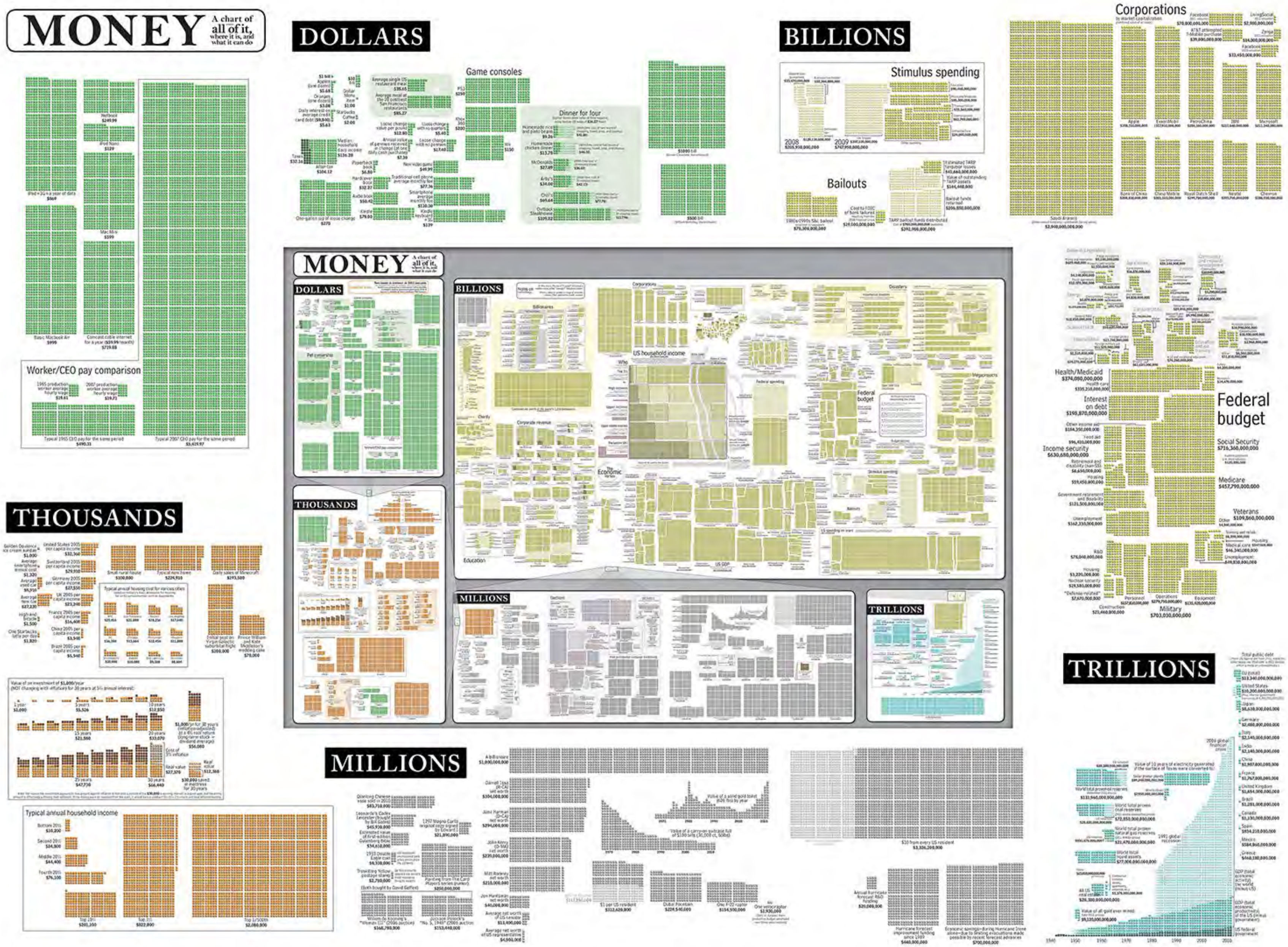
X.2 *Map of the Internet* - Martin Vargic - 2014



X.3 *PREDICT: HealthMap* - John Brownstein, Damien Joly, William Karesh, Peter Daszak, Nathan Wolfe, Tracey Goldstein, Susan Aman, Clark Freifeld, Sumiko Mekaru, Tammie O'Rourke, Stephen Morse, Christine Kreuder Johnson, Jonna Mazet, and the PREDICT Consortium - 2014



X.4 *ORBIS* - Elijah Meeks and Walter Scheidel - 2014

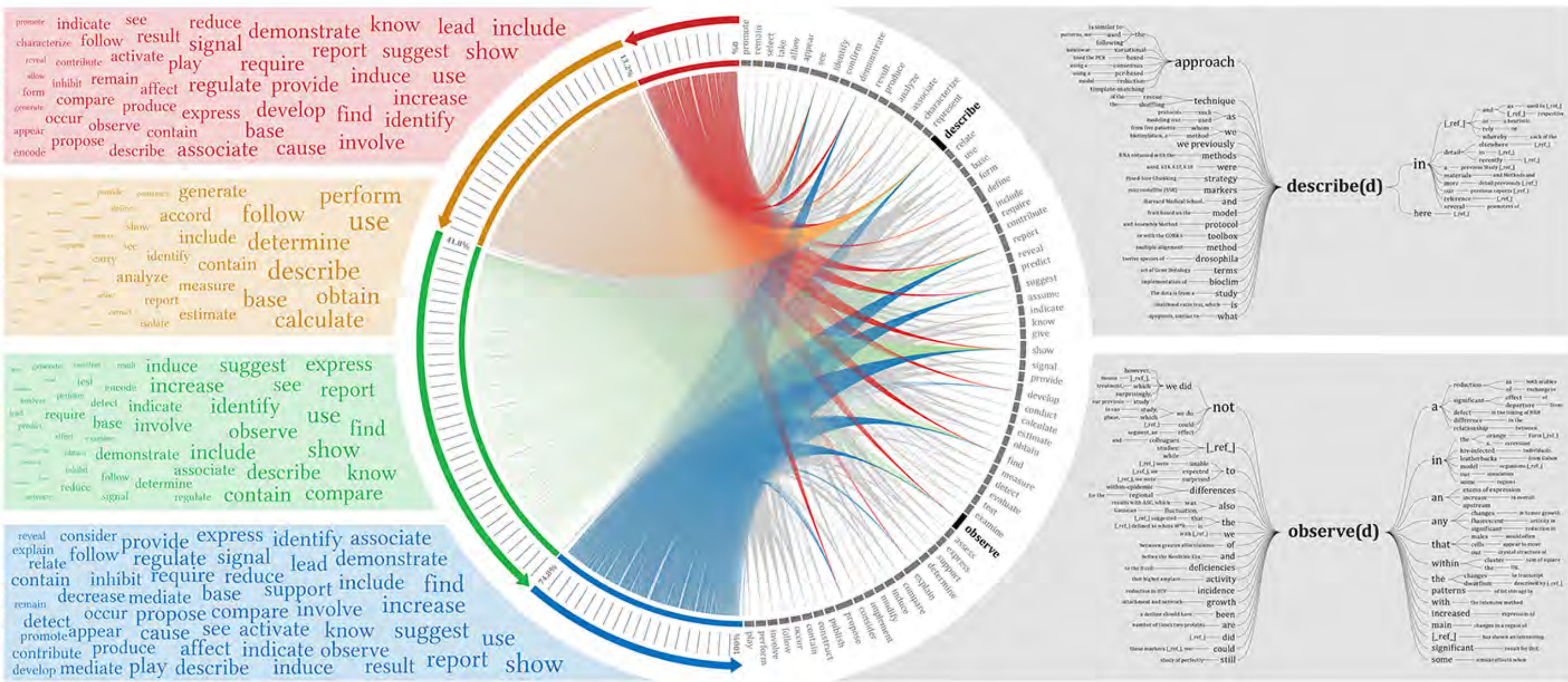


X.5 *Money* - Randall Munroe - 2009

THE LINGUISTIC CONTEXT OF CITATIONS

In modern science, progress is achieved mainly by building upon previous results and ideas. In scientific writing, authors refer to previous works by means of bibliographic citations. Scientific papers follow a standardized pattern represented by four rhetorical categories: Introduction, Methods, Results and Discussion. This structure, called IMRaD, has been adopted by most journals since the mid-twentieth century, and has become the standard in the 1970s.

To understand how authors cite each other, we study the linguistic context of citations. For this purpose, we have extracted the verbs that appear near bibliographic references in scientific papers and we show that each of the four sections of the IMRaD structure is characterized by a different set of verbs. We represent the positions of these verbs along the progression of the text as well as their linguistic contexts. On the whole, this map provides an insight into the internal organization of scientific papers and the way citations are made in the rhetorical sections.



DOCUMENT (RHETORICAL STRUCTURE)

Looking at the four main rhetorical sections of scientific papers (Introduction, Methods, Results, and discussion), we show the verbs present in sentences containing citations. The verb frequencies are different in each section: the bigger the verb, the more frequently it is found in the citation contexts of the section.

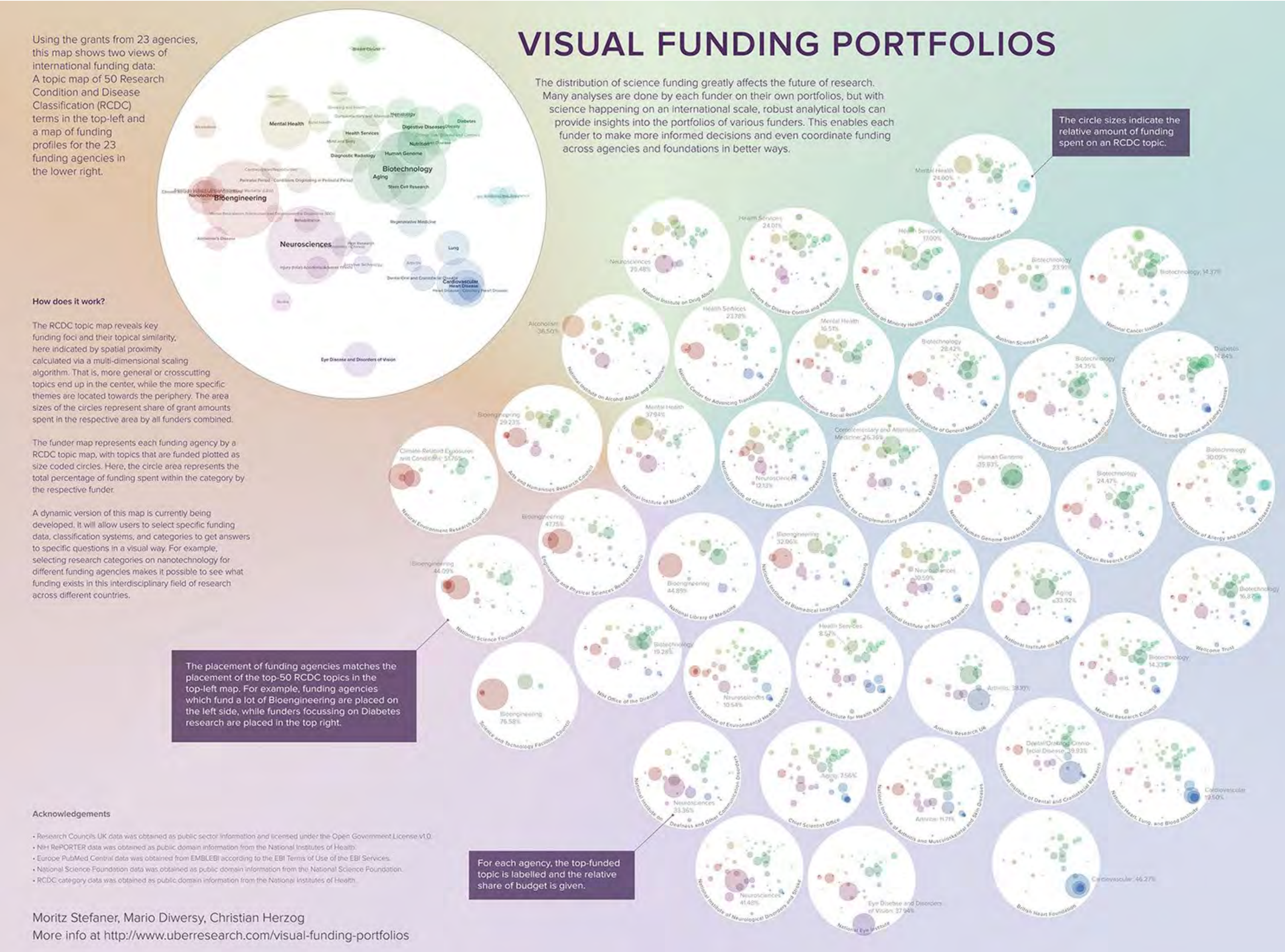
SENTENCE (DISTRIBUTION OF VERBS ALONG SCIENTIFIC PAPERS)

The circle in the middle links the verbs to their positions in the text progression. The left side of the circle presents the progression along the four main sections in an article: Introduction, Methods, Results, and Discussion, and shows the distribution of verb usage in citation contexts. The right side of the circle presents the list of the most frequent verbs that were extracted from the sentences.

WORD (VERBS IN THEIR CONTEXTS)

The word trees show the linguistic contexts in which verbs and references occur. Two verbs are given as an example together with texts that commonly precede and follow them. Type font size indicates frequency of occurence.

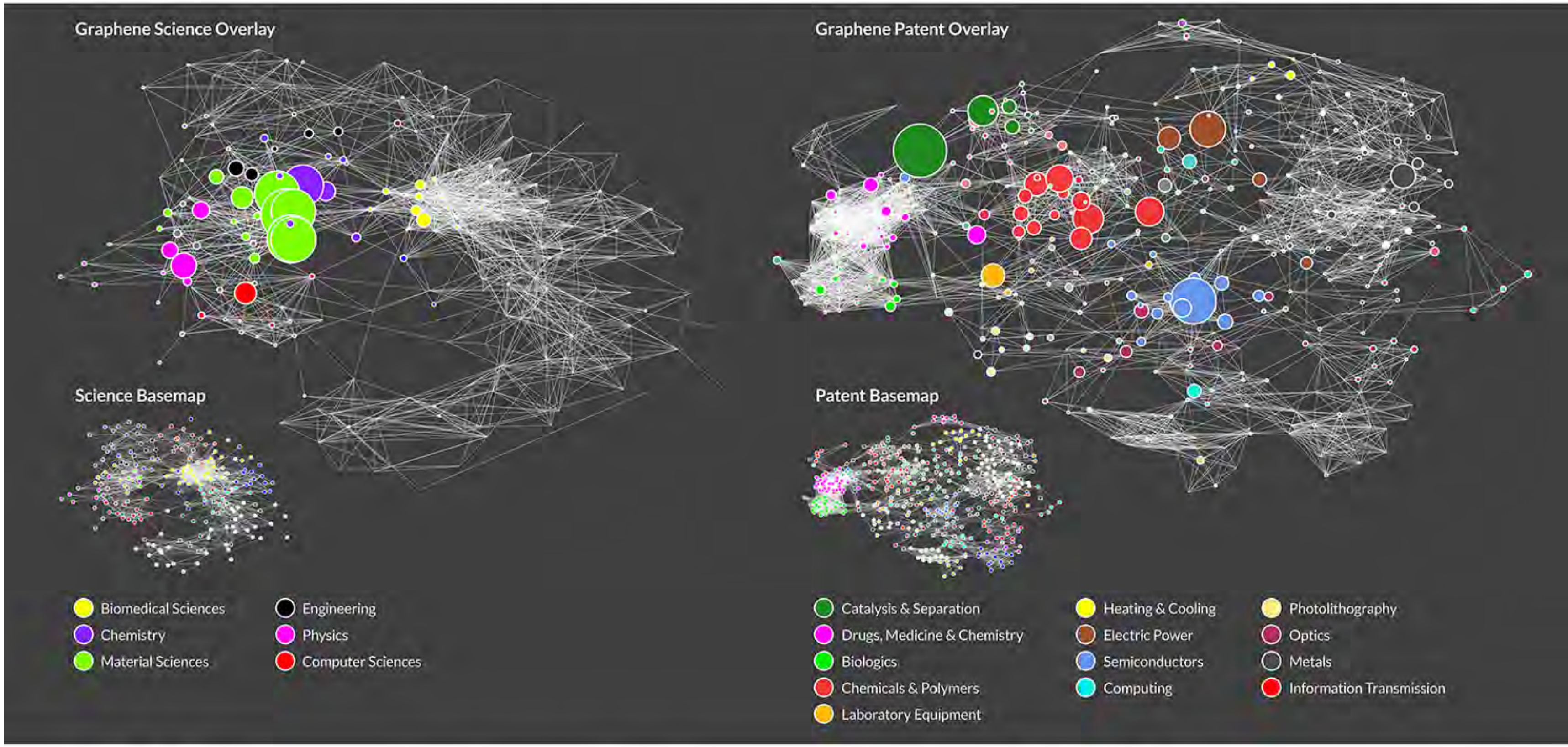
X.6 *The Linguistic Context of Citations* - Marc Bertin, Iana Atanassova, Vincent Larivière, and Yves Gingras - 2014



X.7 *Visual Funding Portfolios* - Moritz Stefaner, Mario Diwersy, and Christian Herzog - 2014

MAPPING GRAPHENE SCIENCE & DEVELOPMENT

These science and patent overlay maps show the unfolding of graphene discovery and exploitation between 2000 and 2013. Graphene is a new two-dimensional material made out of a single layer of carbon atoms. Its very special features—including great strength yet lightness, and electrical and thermal conductivities—were recognized in the 2010 Nobel Prize in physics. Interestingly, its research and development follows a "funnel" pattern where scholarly publications are primarily focused in one area of science, and patenting activity is widespread across multiple application areas. Graphene research (left), focuses on material sciences and closely related fields such as engineering and physical chemistry. There is very little activity in other fields such as biology. Graphene invention (right), on the other hand, covers a wider variety of technologies with focus on catalysis and separation, semiconductor parts and devices, batteries and capacitors, and the chemical properties of graphene. Other inventive activity focuses on a small amount of applications related to computing and pharmaceutical uses such as drug delivery.



About the Basemaps

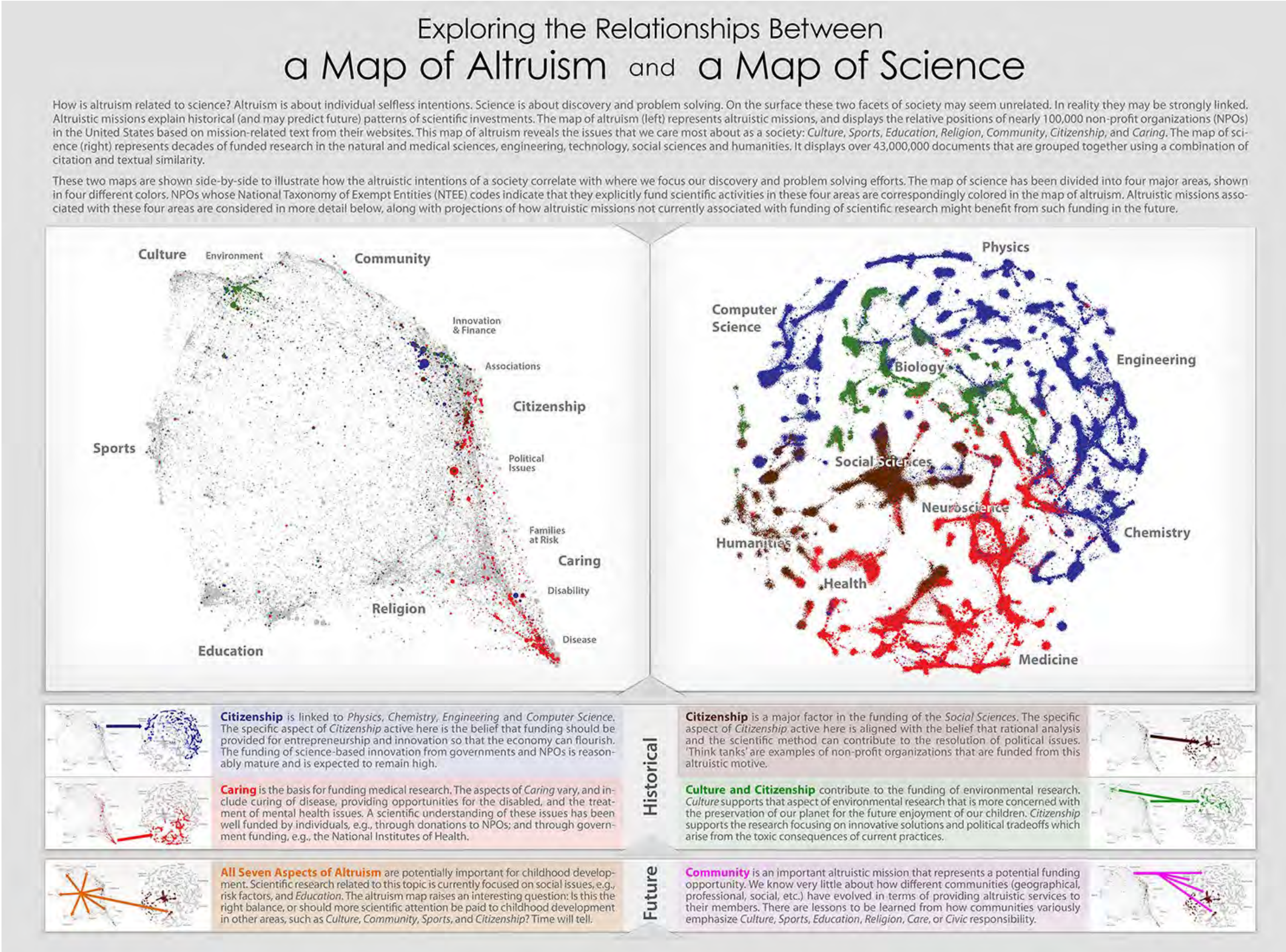
The science basemap was created using publication citation index data for 2009. It features 222 Web of Science category nodes that are grouped into 18 color-coded macro-science disciplines. The patent basemap was computed by mining patents for the time period 2000-2006. It consists of 466 IPC technology nodes grouped into 35 color-coded macro-patent categories. In each network map, edges are drawn between nodes that have a threshold above the median similarity value. The Kamada & Kawai layout algorithm in Pajek was used to layout the networks in a two-dimensional space—the closer two nodes are the higher the similarity between them. The basemaps show the structure of science and technology landscape respectively and serve as a reference system for data overlays.

How to Read the Overlay Maps

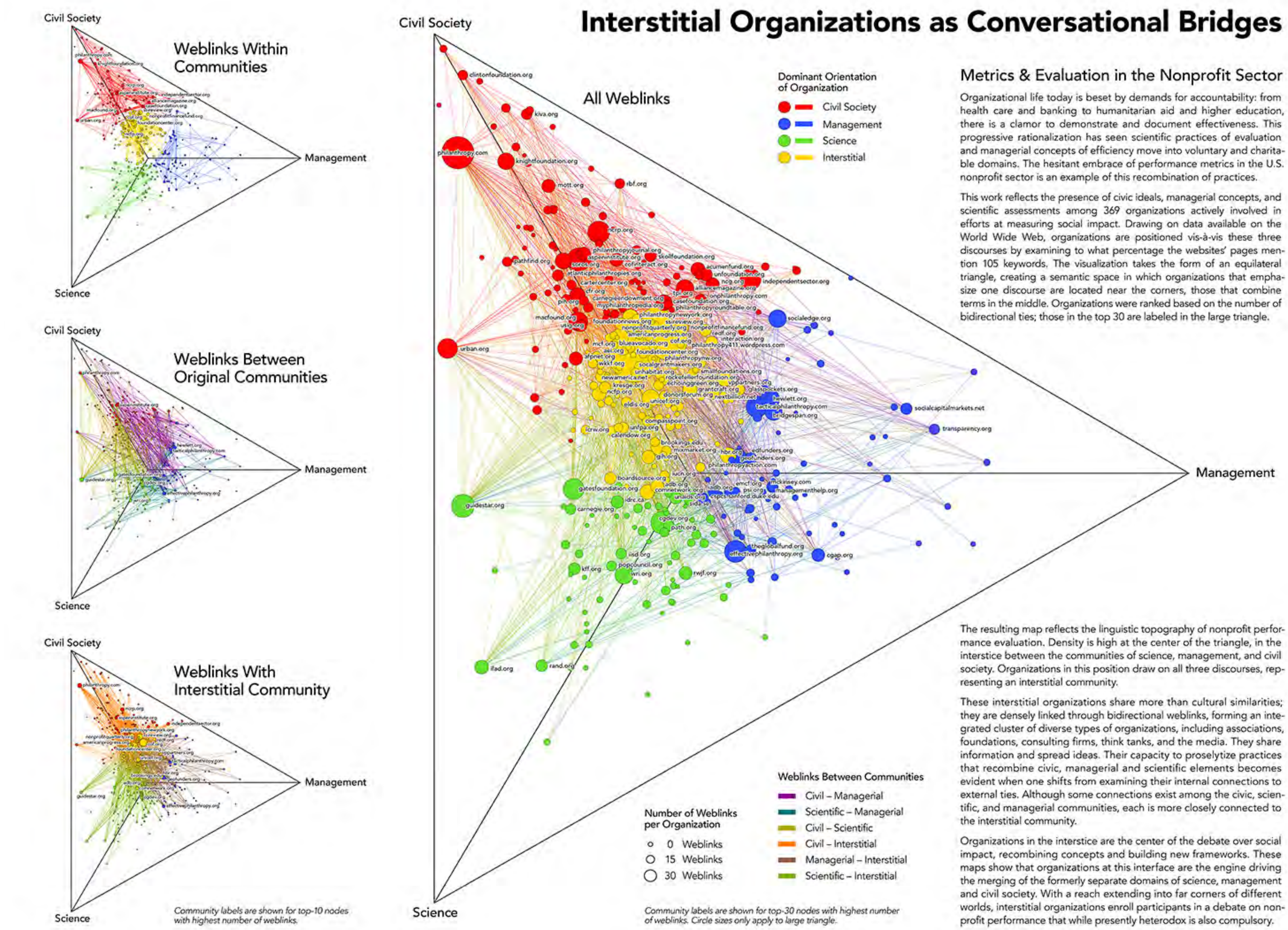
The data overlays show the number and placement of publications and patents that match "graphene" on the respective basemap. Node size indicates the number of matching publications or patents per node. Labels and colors of the six macro-science disciplines and the 13 macro-patent categories that contain matching publications and patents are given below the network maps. There exists no relation between the colors in the two maps.

Acknowledgments: This work is based on research undertaken largely at Georgia Tech drawing on support from the U.S. National Science Foundation (NSF) through the Center for Nanotechnology in Society, Arizona State University (Award No. 0531194) and the NSF project "Revealing Innovation Pathways: Hybrid Science Maps for Technology Assessment and Foresight" (Award No. 1064146). Part of this research was also undertaken in collaboration with SPRU, University of Sussex, and the Center for Nanotechnology in Society, University of California Santa Barbara (NSF Awards No. 0938099 and No. 0531184). The observations contained in this work are those of the authors and do not necessarily reflect the views of NSF.

X.8 *Mapping Graphene Science and Development: Focused Research with Multiple Application Areas* - by Luciano Kay, Alan L. Porter, Ismael Rafols, Nils Newman, and Jan L. Youtie - 2014



X.9 *Exploring the Relationships between a Map of Altruism and a Map of Science* - Richard Klavans and Kevin W. Boyack - 2014



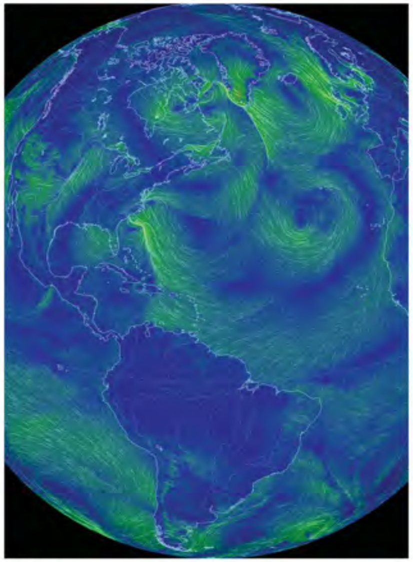
X.10 *Interstitial Organizations as Conversational Bridges* - Walter W. Powell, Achim Oberg, and Valeska P. Korff - 2014

Check out our Zoom Maps online!

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

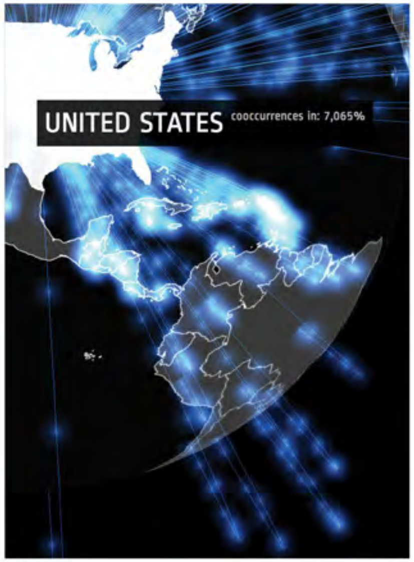
Iteration XI (2015)

Macroscopes for Interacting with Science



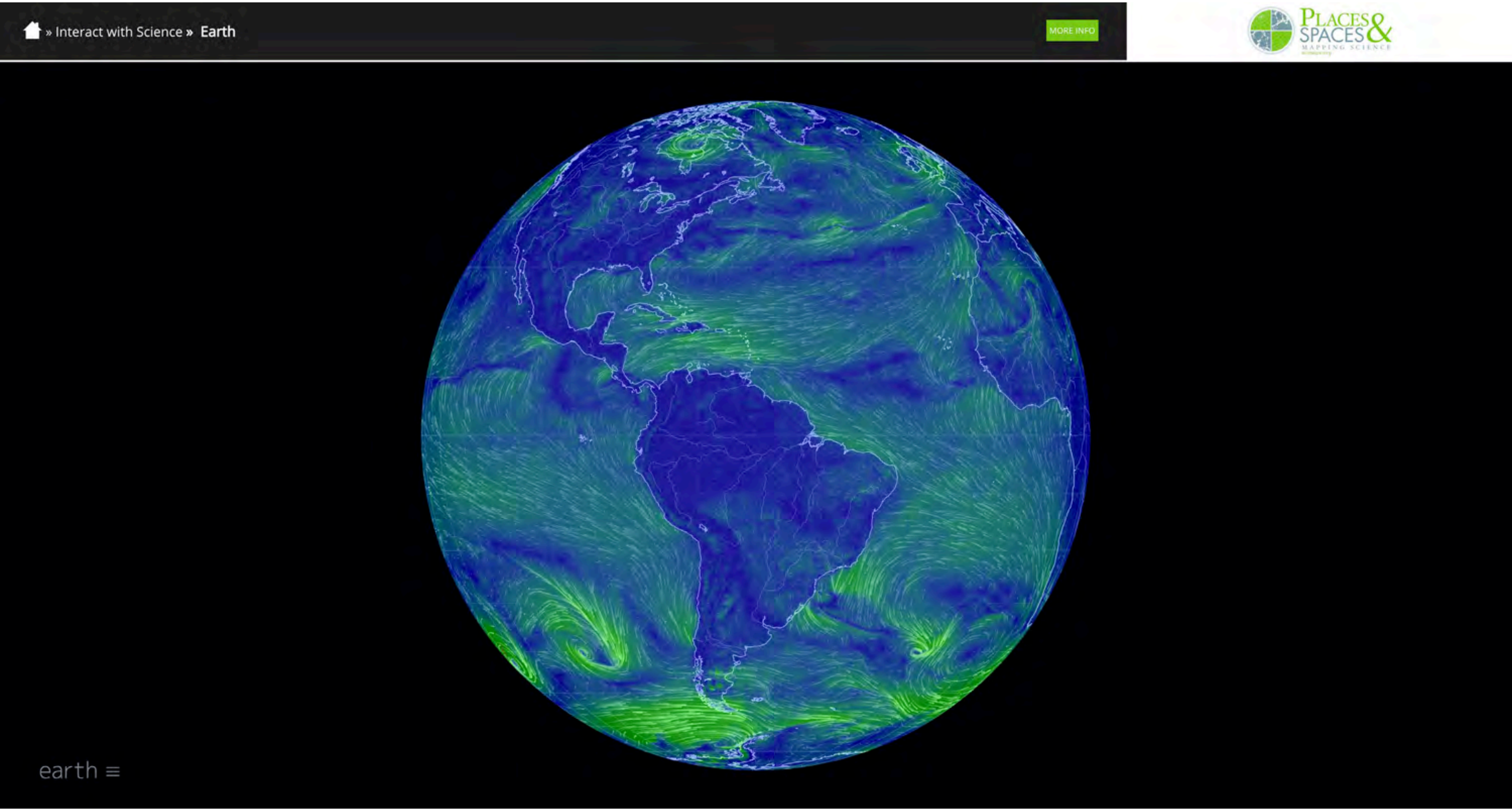
XI.1

XI.2

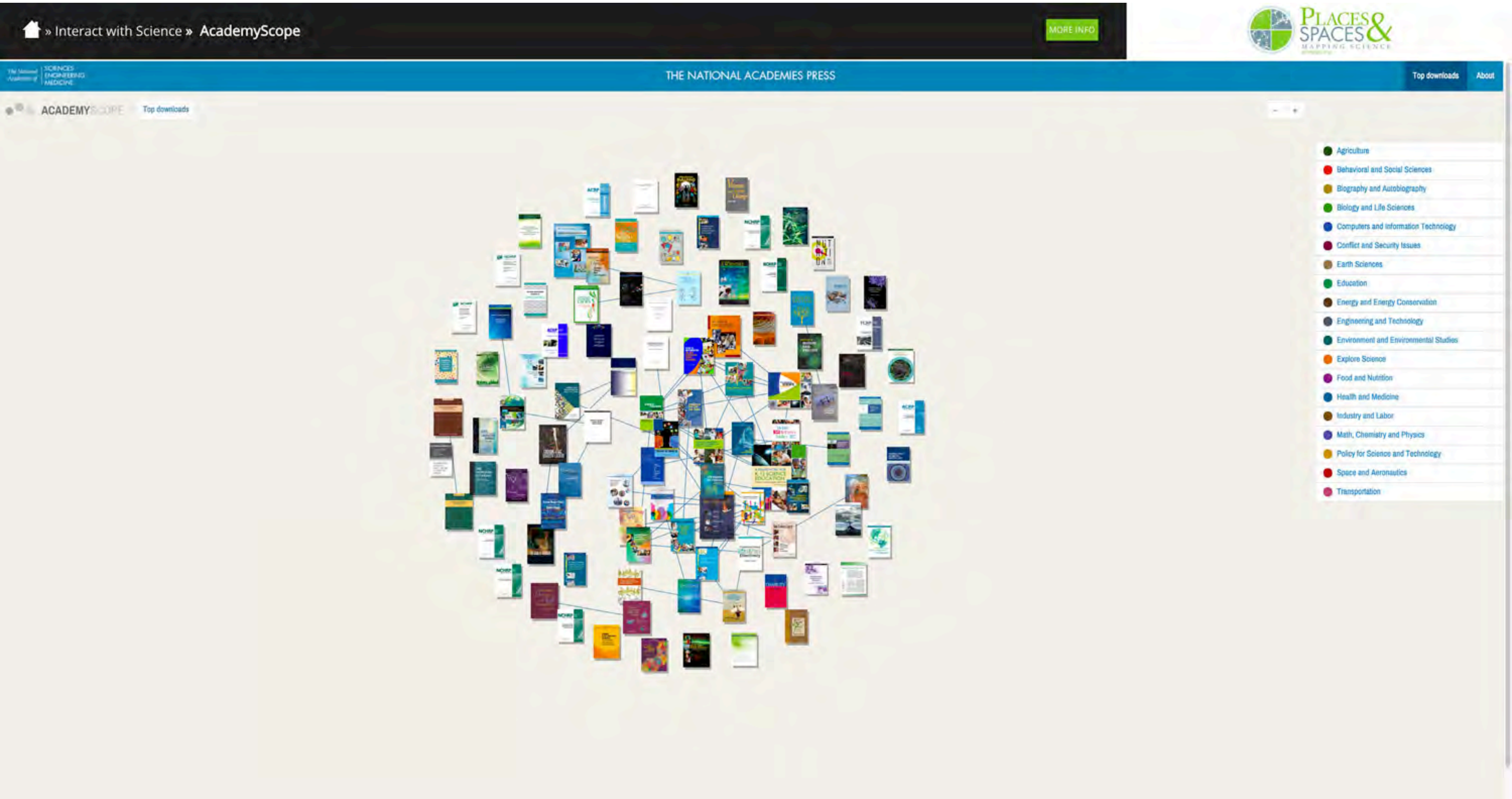


XI.3

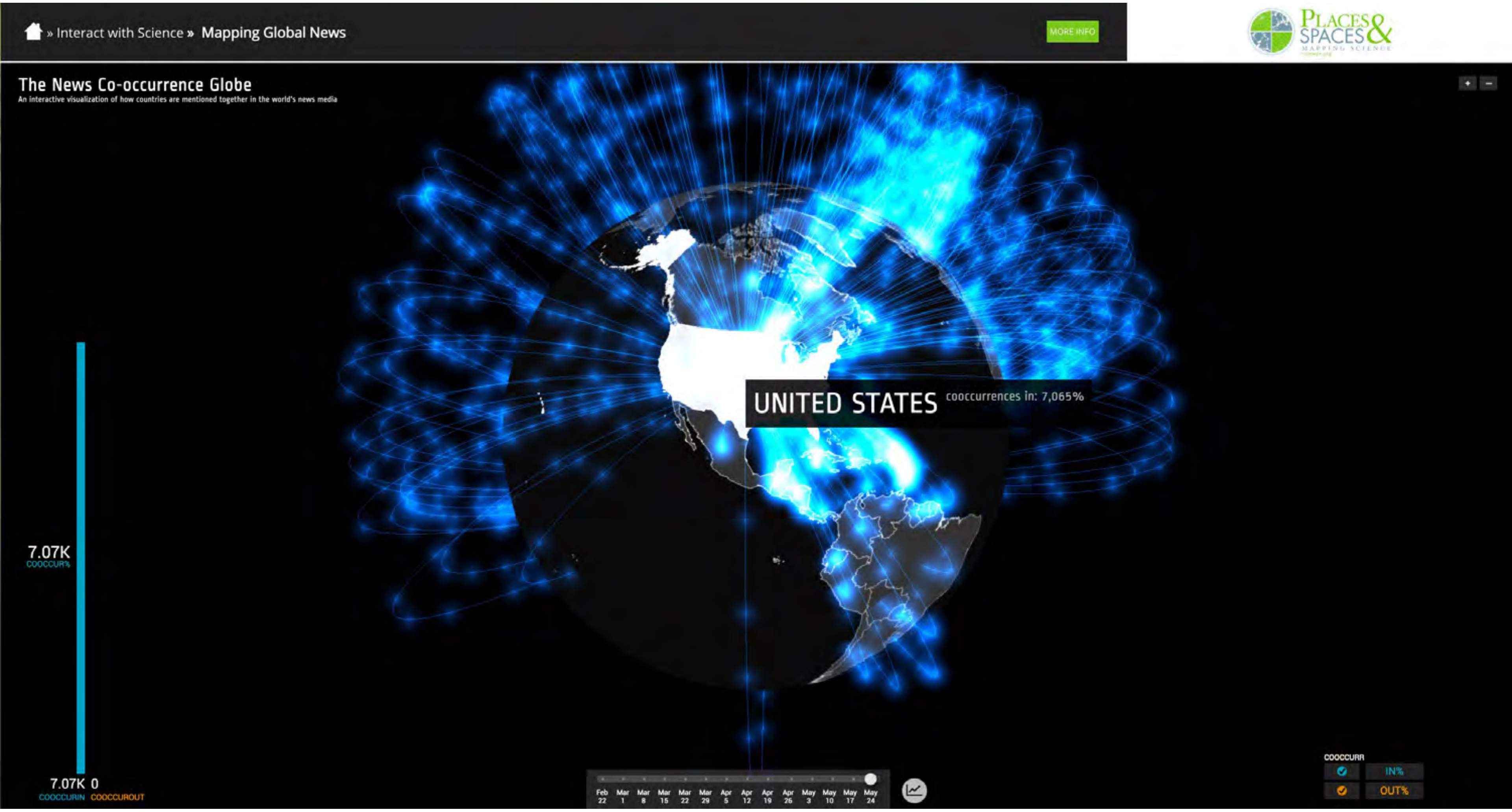
XI.4



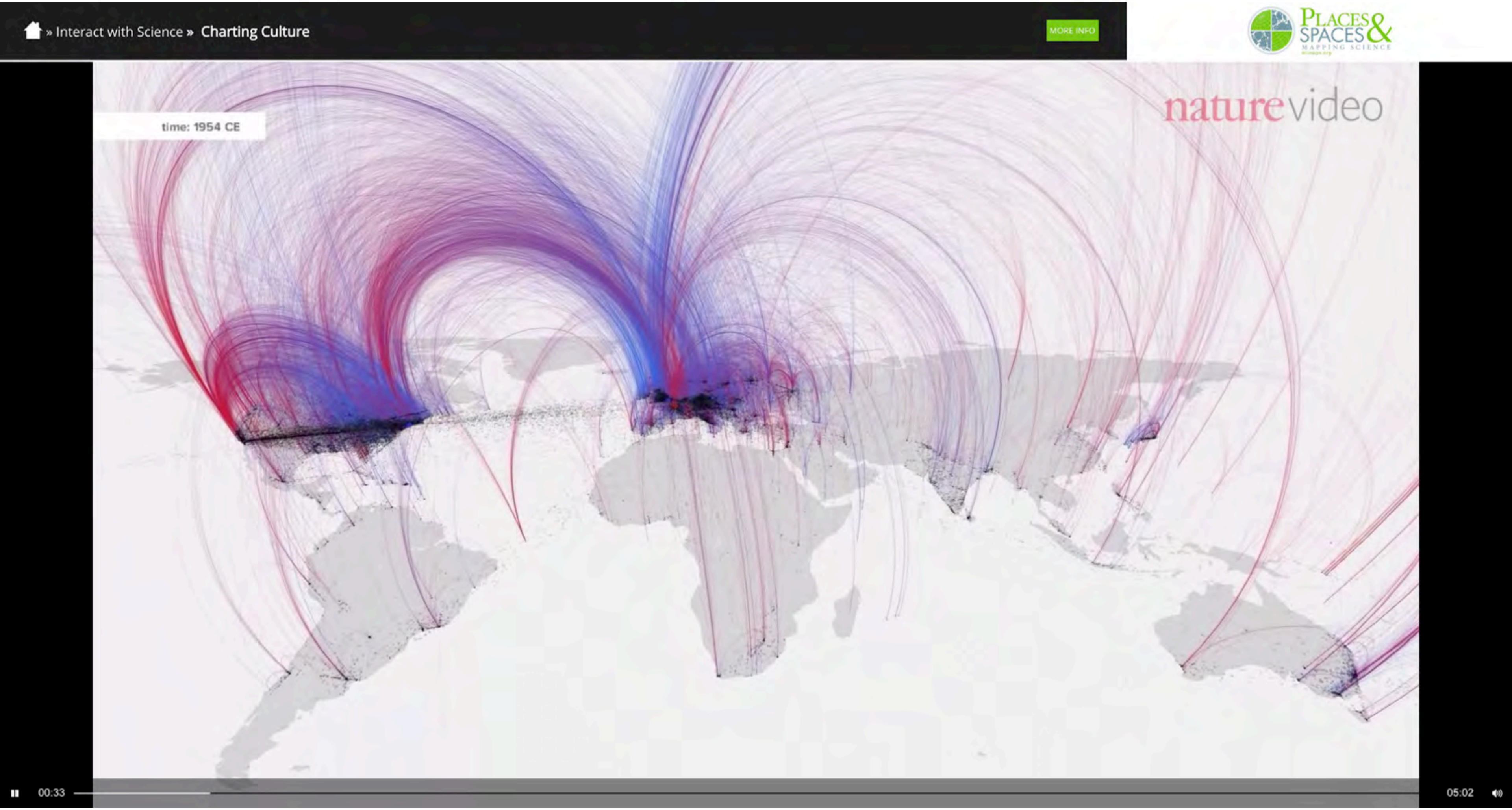
XI.1 *Earth* – Cameron Becarrio – 2015



XI.2 *AcademyScope* – Stephen Mautner, Barbara Kline Pope, Alphonse MacDonald, JD Talasek, Juan Thomassie, Jeff Colosino, Chin Hua Kong, Adam Simpson, Samuel Mills, and Katy Börner – 2013



XI.3 *Mapping Global News* – Kalev Leetaru – 2015



XI.4 *Charting Culture*– Maximillian Schich and Mauro Martino – 2014

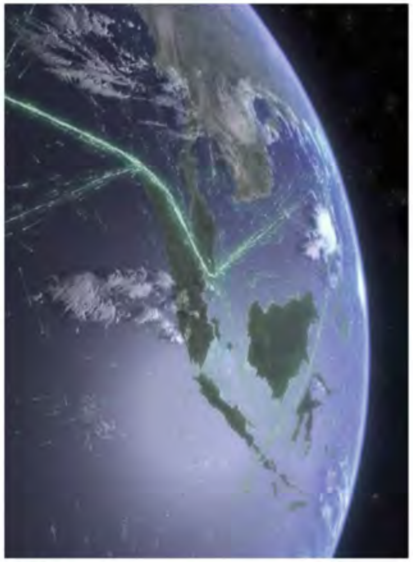
Iteration XII (2016)

Macroscopes for Making Sense of Science

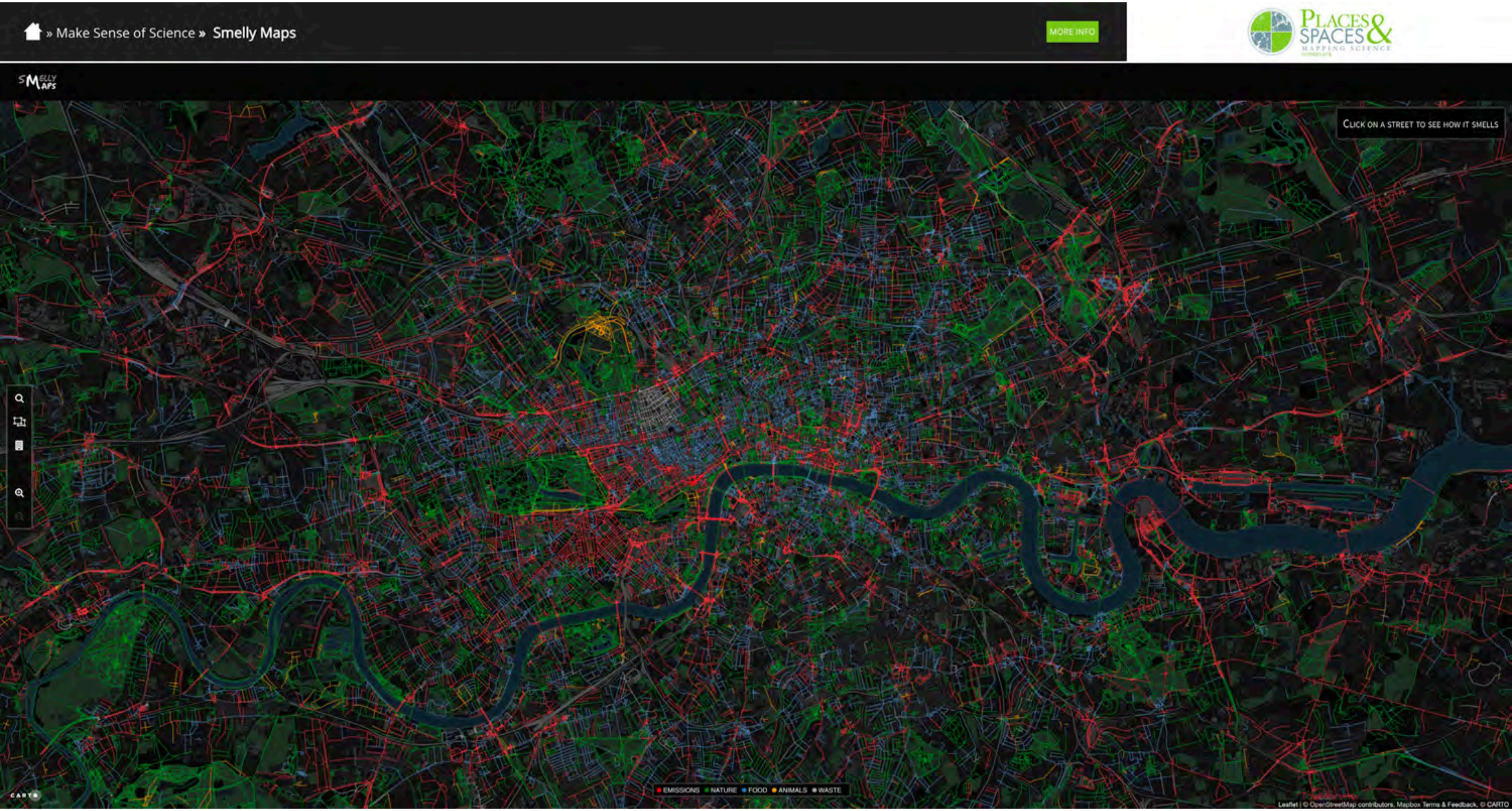
XII.1

XII.2

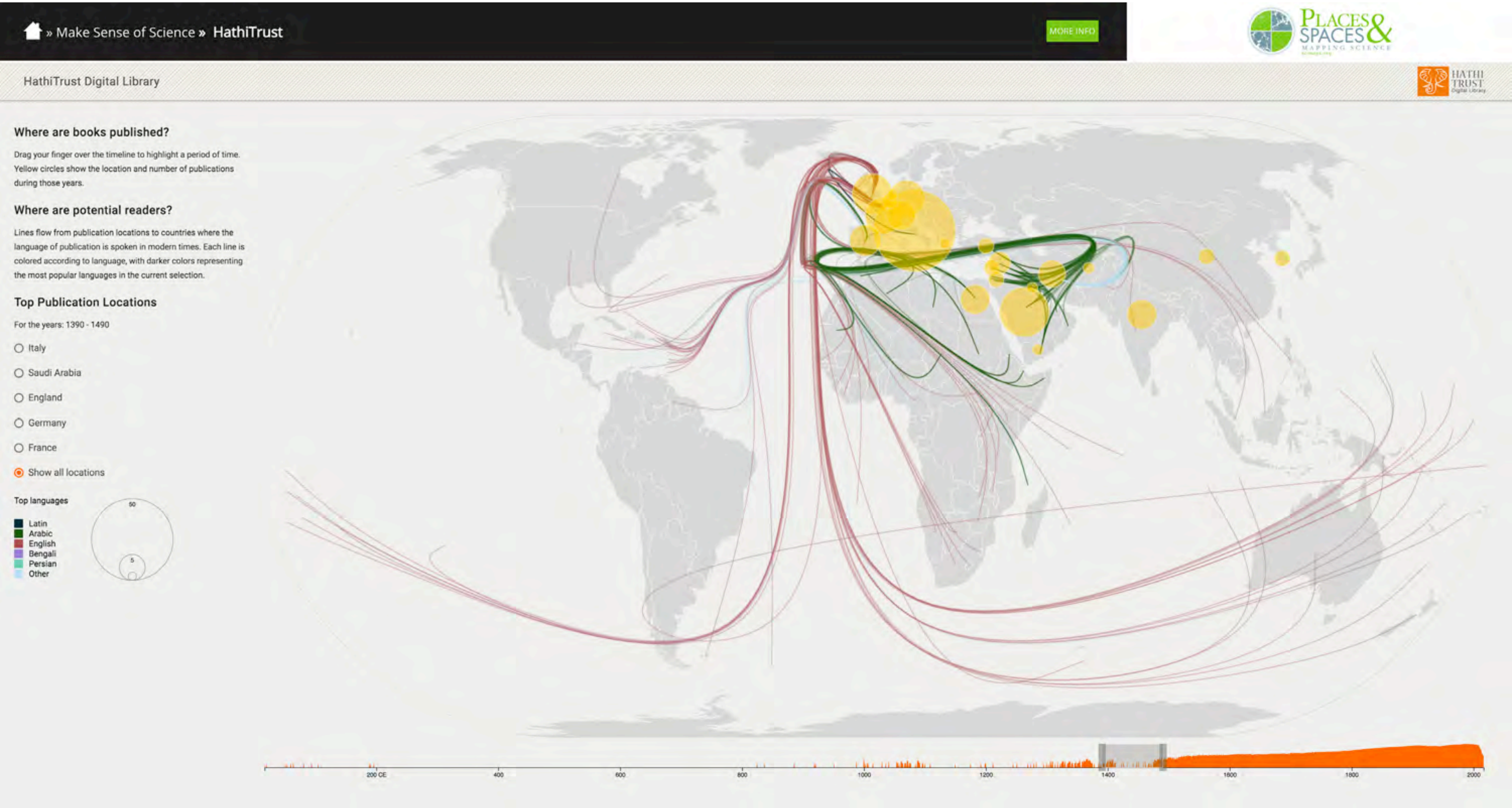
XII.3



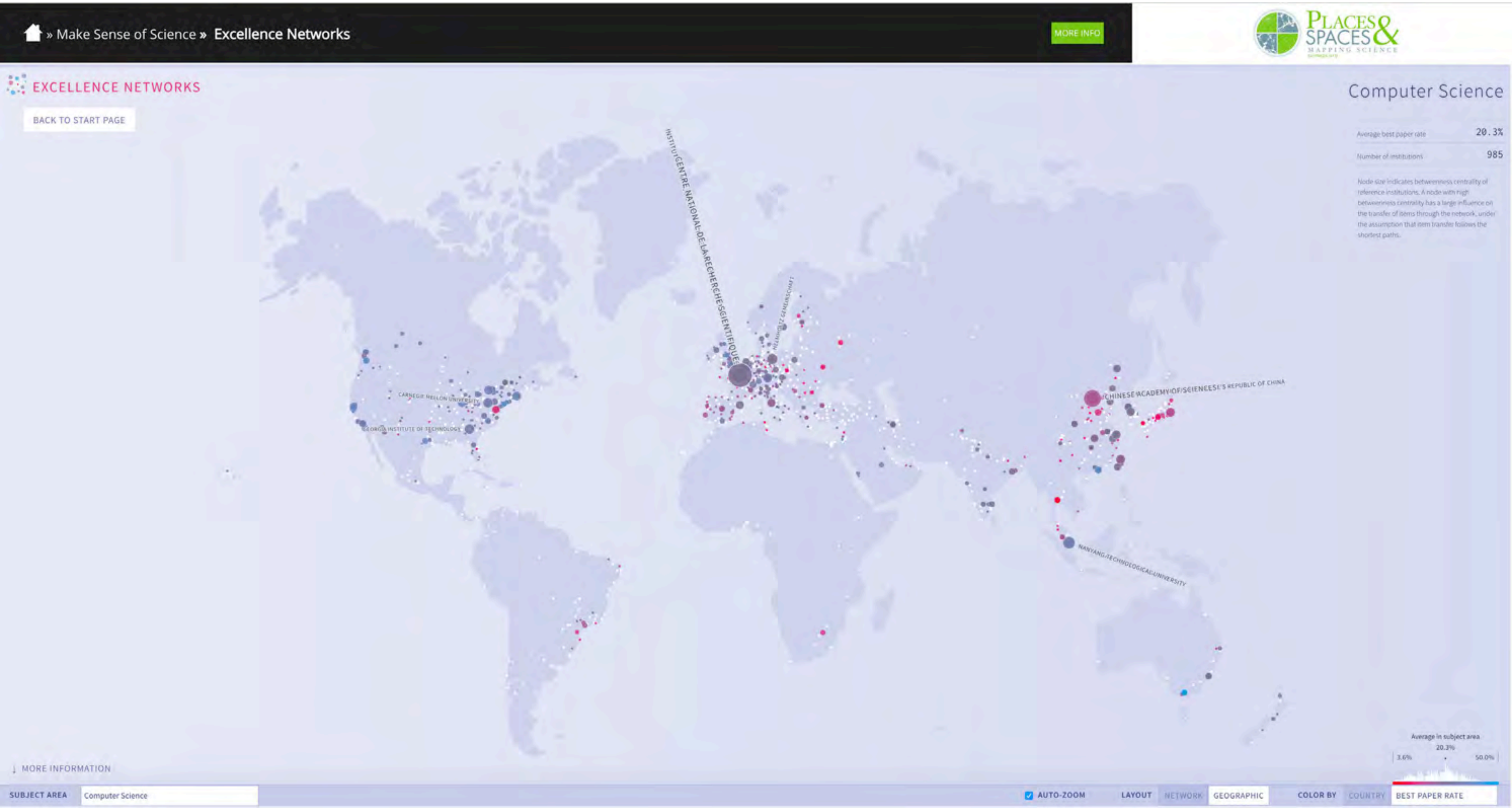
XII.4



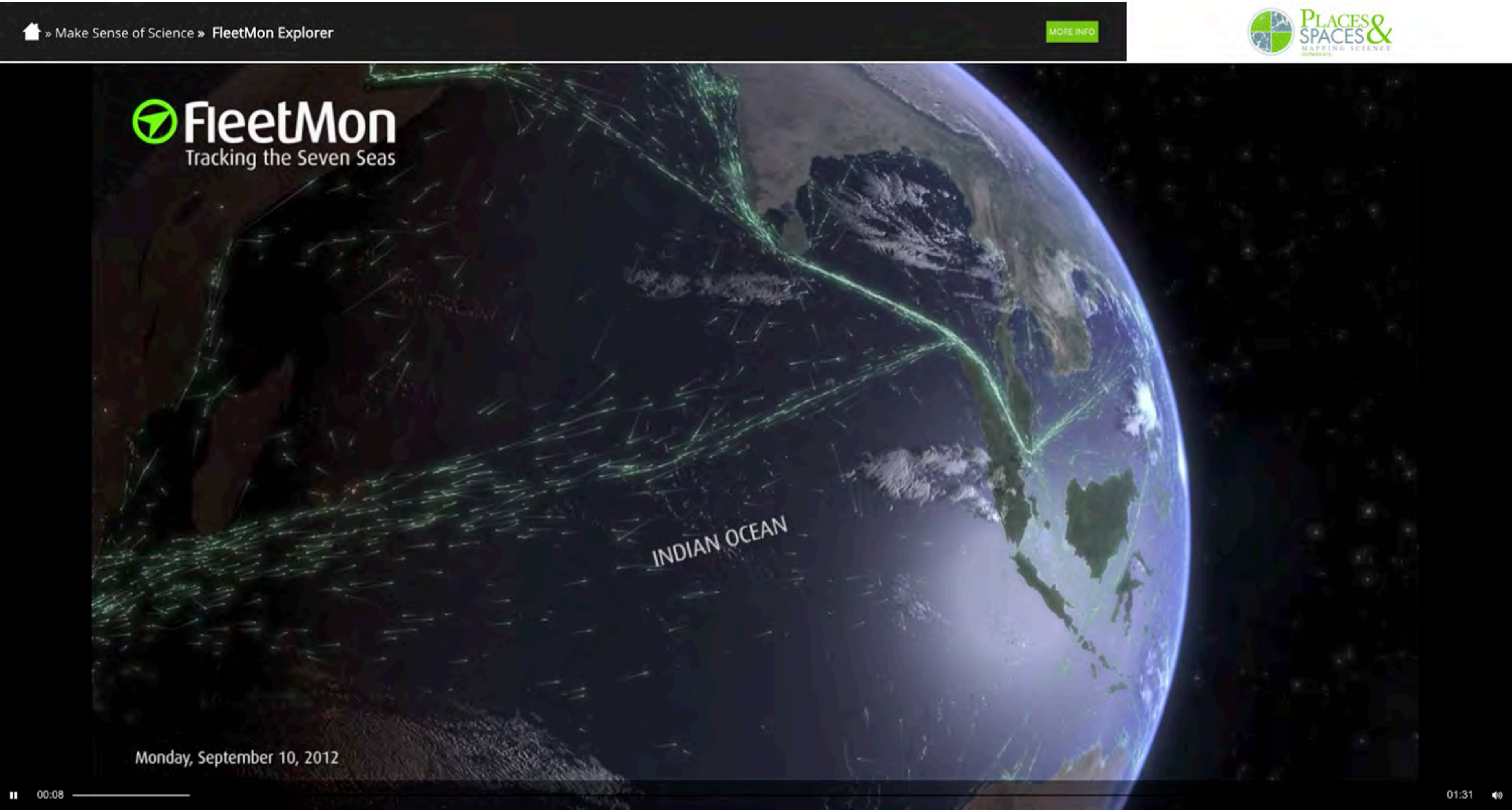
XII.1 *Smelly Maps*– Daniele Quercia, Rossano Schifanella, and Luca Maria Aiello – 2015



XII.1 *HathiTrust Digital Library* – David Reagan, Lisel Record, and Katy Börner – 2016



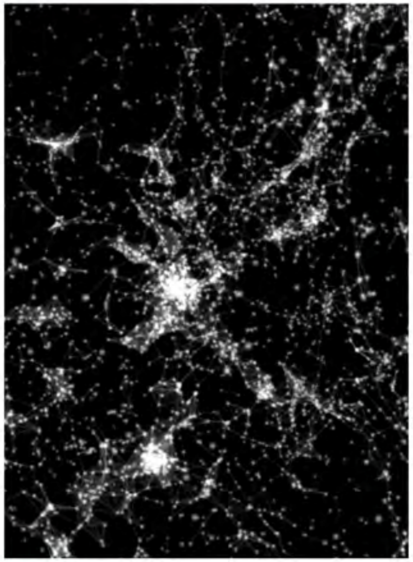
XII.3 *Excellence Networks* – Lutz Bornmann, Rüdiger Mutz, Moritz Stefaner, and Félix de Moya Anegón – 2015



XII.4 *FleetMon Explorer* –FleetMon– 2012

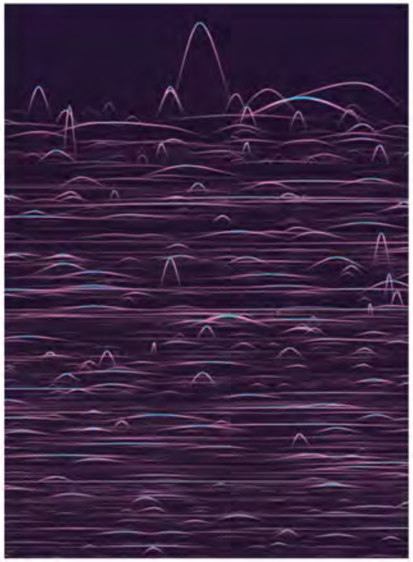
Iteration XIII (2017)

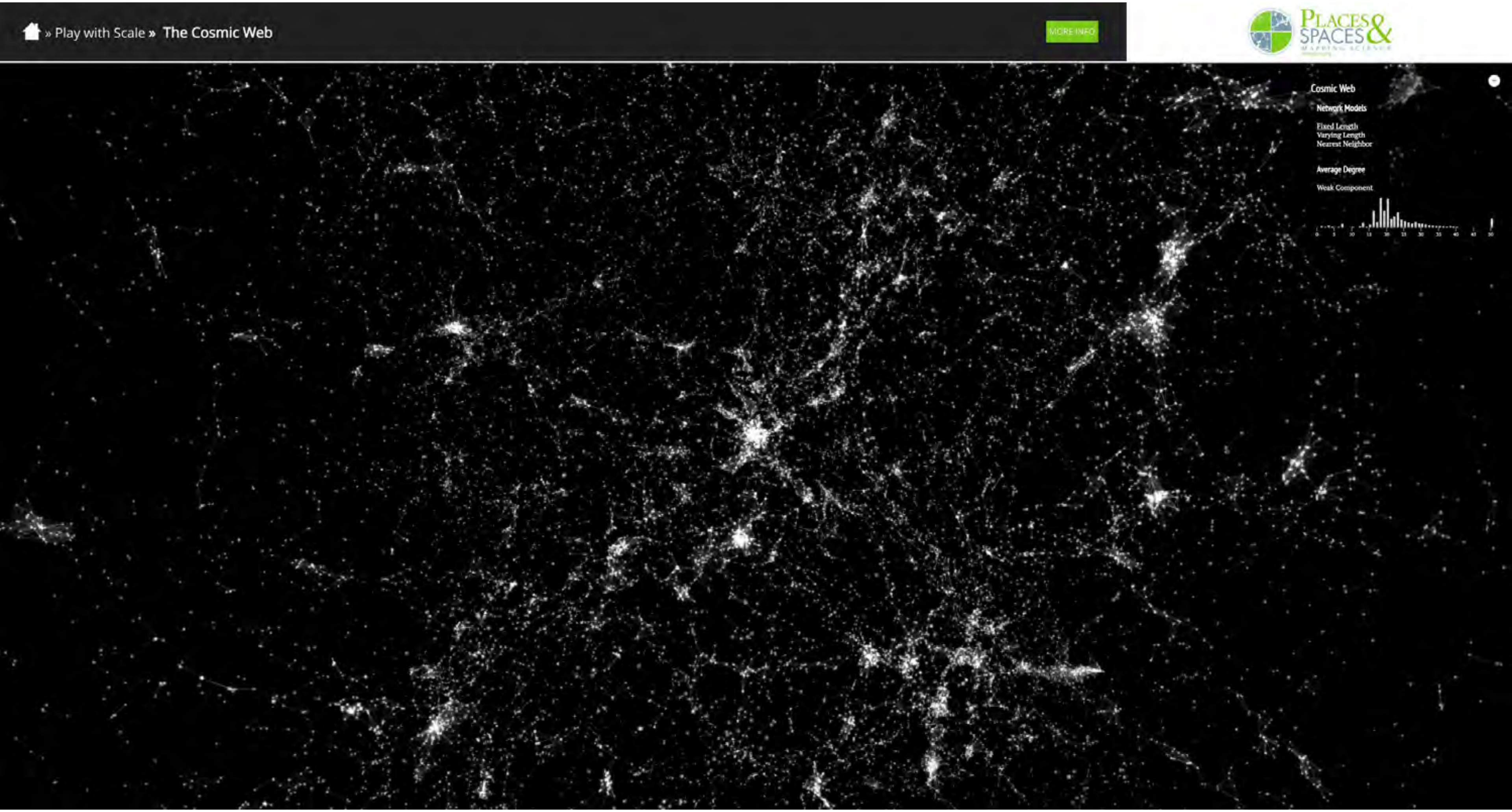
Macroscopes for Playing with Scale


XIII.1

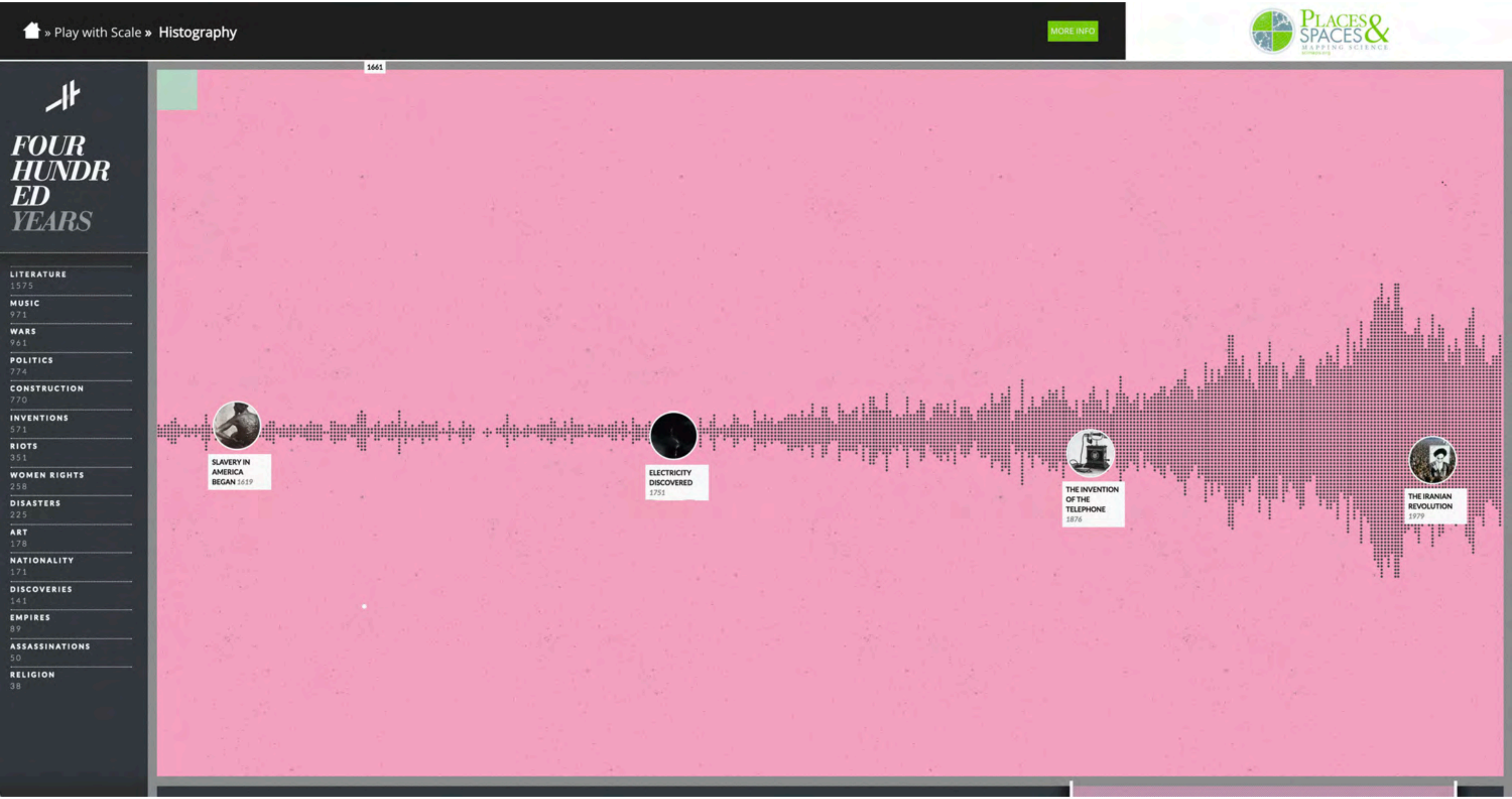
XIII.2


XIII.3

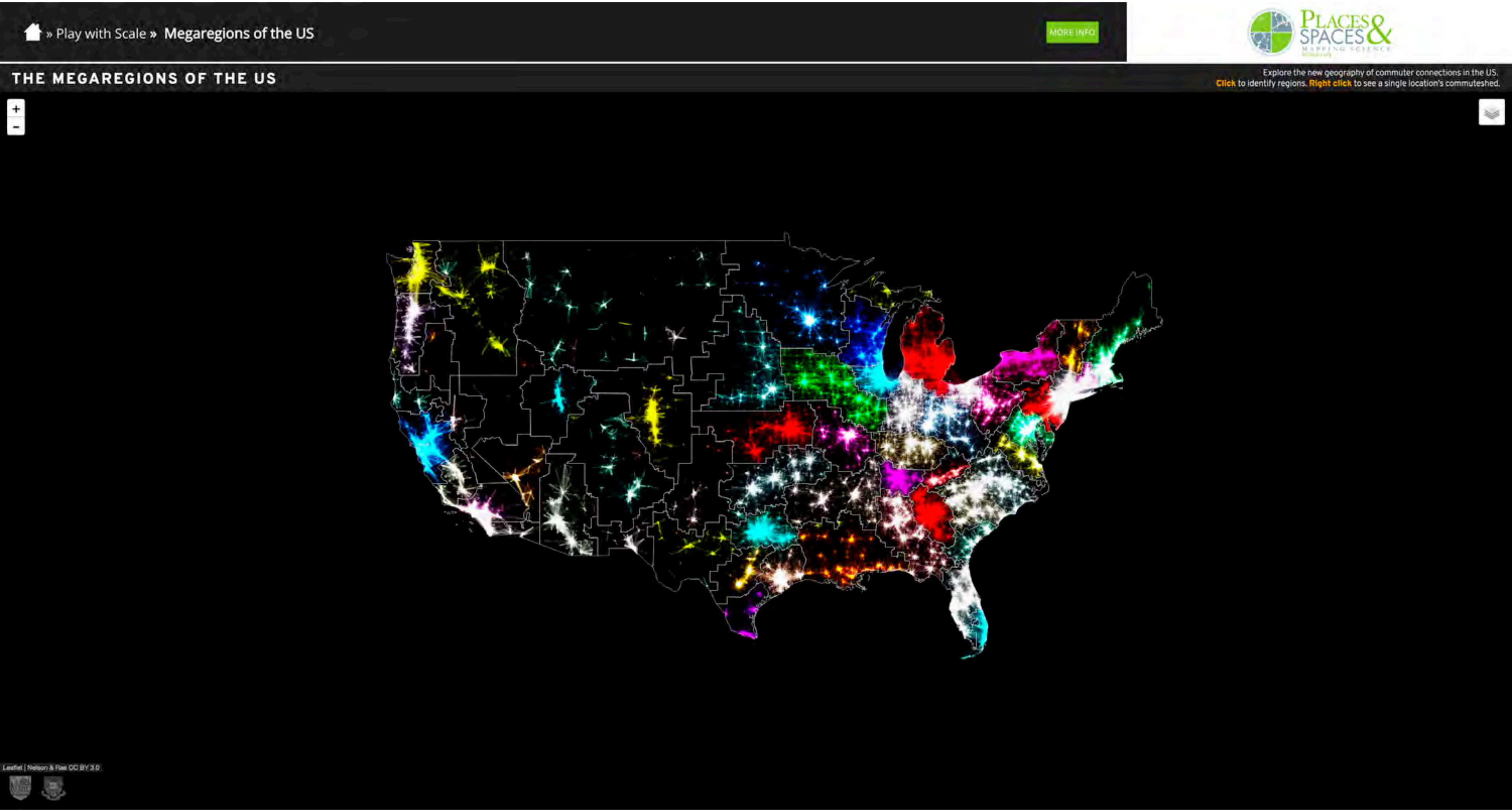

XIII.4



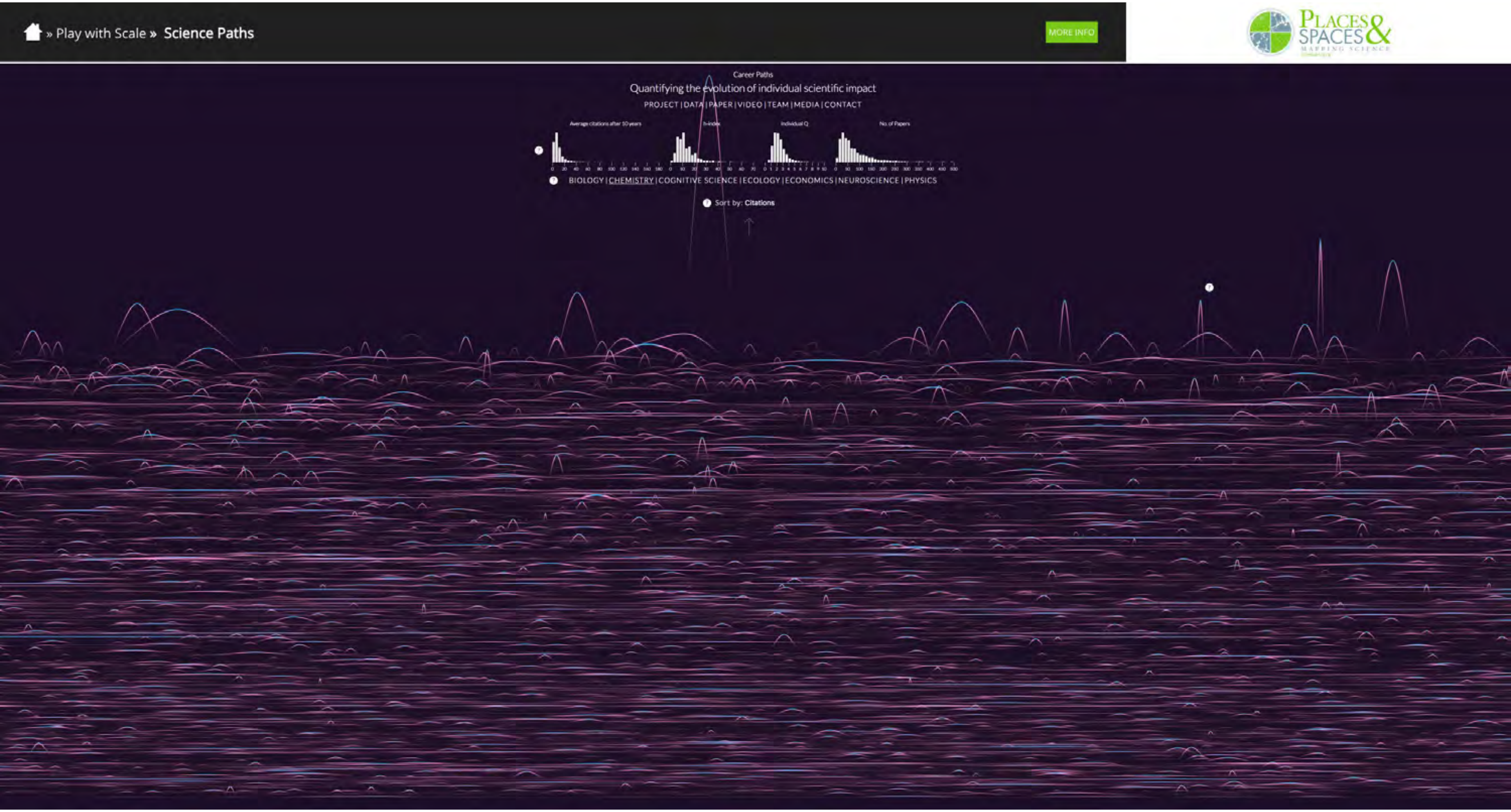
XIII.1 *The Cosmic Web* – Kim Albrecht and Albert-László Barabási – 2016



XIII.2 *Histography* – Matan Stauber – 2015



XIII.3 *Megaregions of the US* – Garrett Dash Nelson and Alasdair Rae – 2016



XIII.4 *Science Paths* – Kim Albrecht, Albert-László Barabási, and Roberta Sinatra – 2016