

Mapping Science

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60 Engineering and Architecture High School Students Encounter
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Mapping Science Exhibit – 10 Iterations in 10 years

<http://scimaps.org/>

The Power of Maps (2005)



The Power of Reference Systems (2006)



The Power of Forecasts (2007)



Science Maps for Economic Decision Makers (2008)



Science Maps for Science Policy Makers (2009)



Science Maps for Scholars (2010)

Science Maps as Visual Interfaces to Digital Libraries (2011)

Science Maps for Kids (2012)

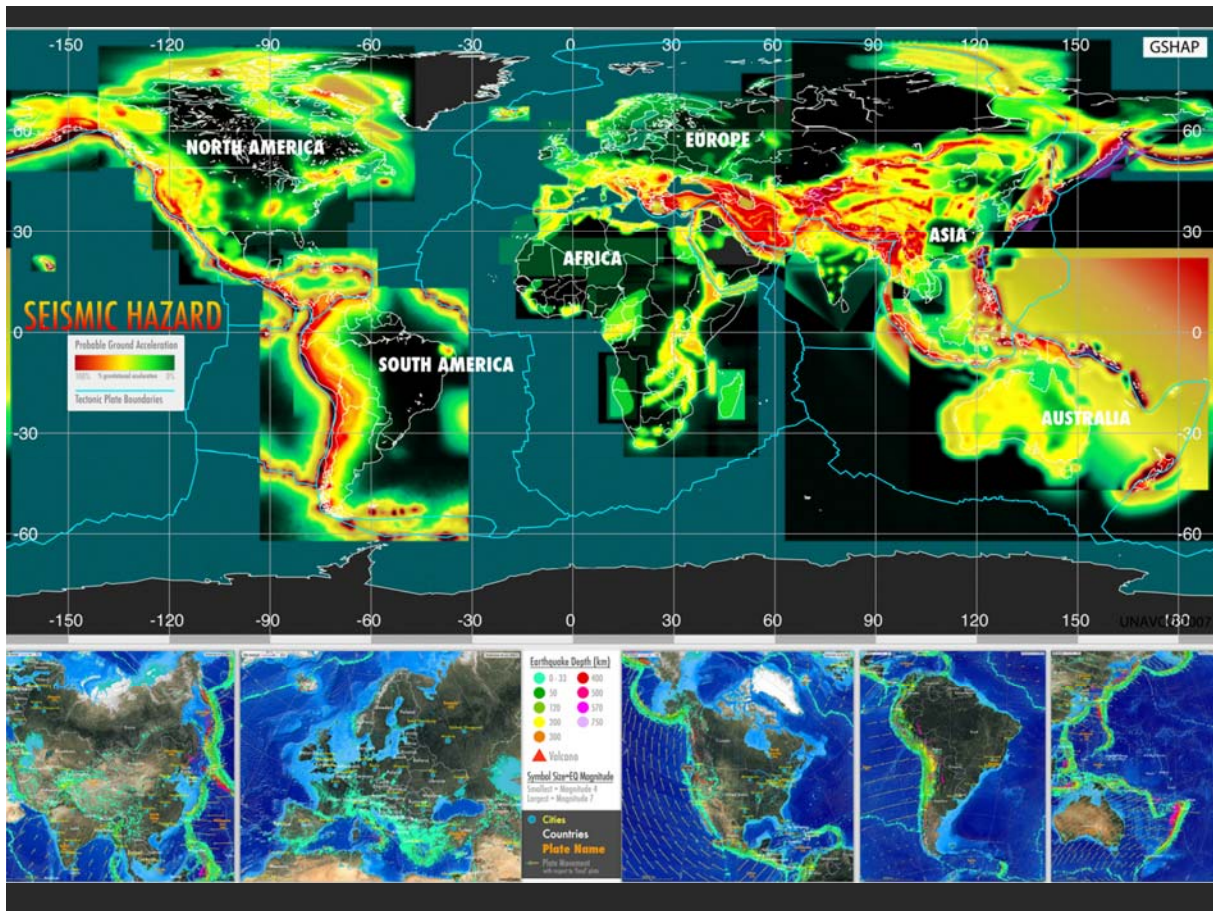
Science Forecasts (2013)

How to Lie with Science Maps (2014)

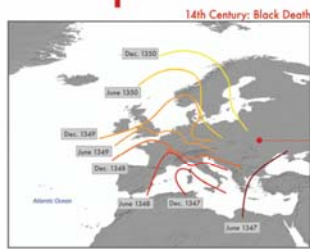
Exhibit has been shown in 72 venues on four continents. Currently at

- NSF, 10th Floor, 4201 Wilson Boulevard, Arlington, VA
- Center of Advanced European Studies and Research, Bonn, Germany
- Science Train, Germany
- Cultural Dimensions of Innovation, UCD Conference, Dublin, Ireland





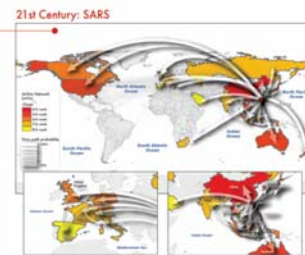
• Impact of Air Travel on Global Spread of Infectious Diseases •



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

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

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



• Forecasts of the Next Pandemic Influenza •

Seasonal



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

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

Geographical

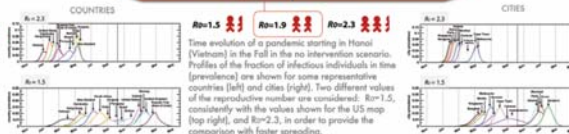
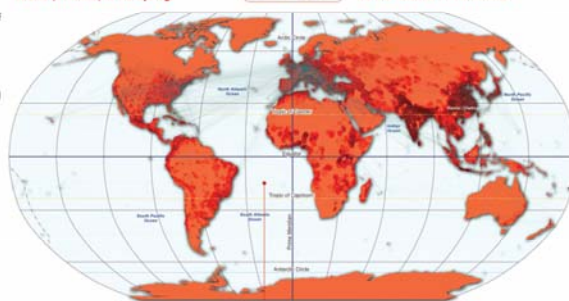


Numerical simulations provide results for the temporal and geographic evolution of the pandemic influenza in 3,100 urban areas located in 220 different countries. The model allows to study different spreading scenarios, characterized by different initial outbreak conditions, both geographical and seasonal.

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



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



Reproductive Number (R_0)



Intervention



The model includes the worldwide air transportation network (source: IATA) composed of 3,100 airports in 220 countries and 6-17,182 direct connections, each of them associated to the corresponding passenger flow. This dataset accounts for 99% of the worldwide traffic and is complemented by the census data of each large metropolitan area served by the corresponding airport.

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

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

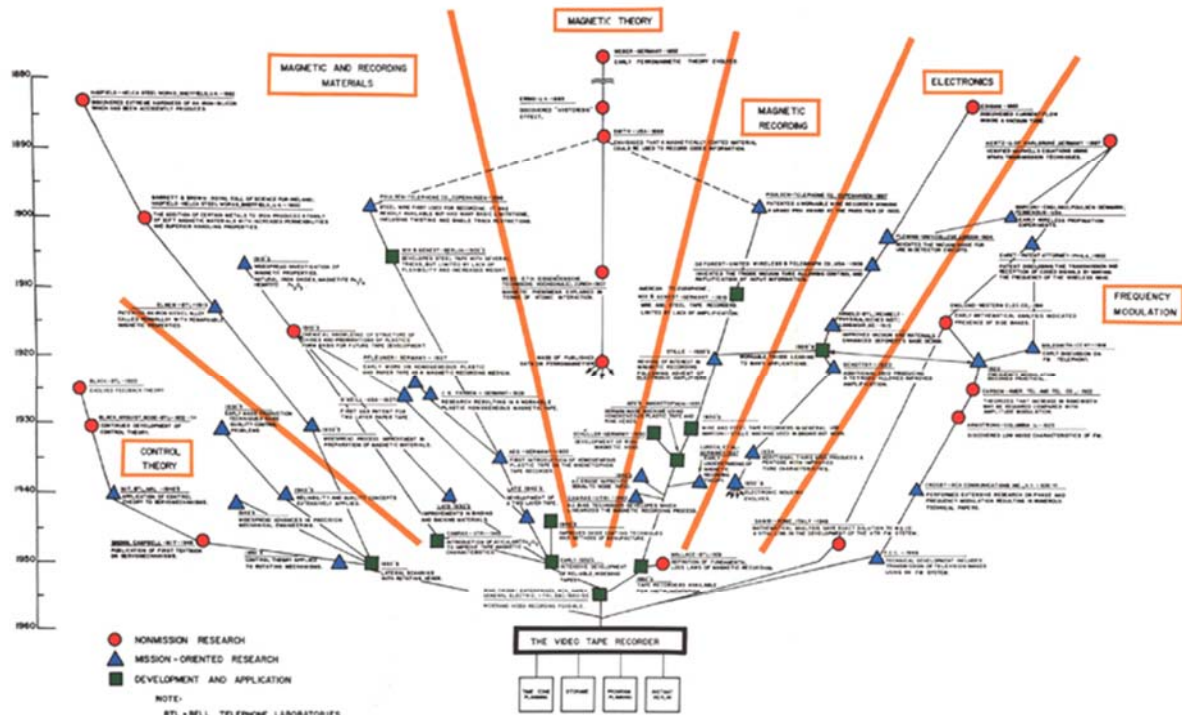
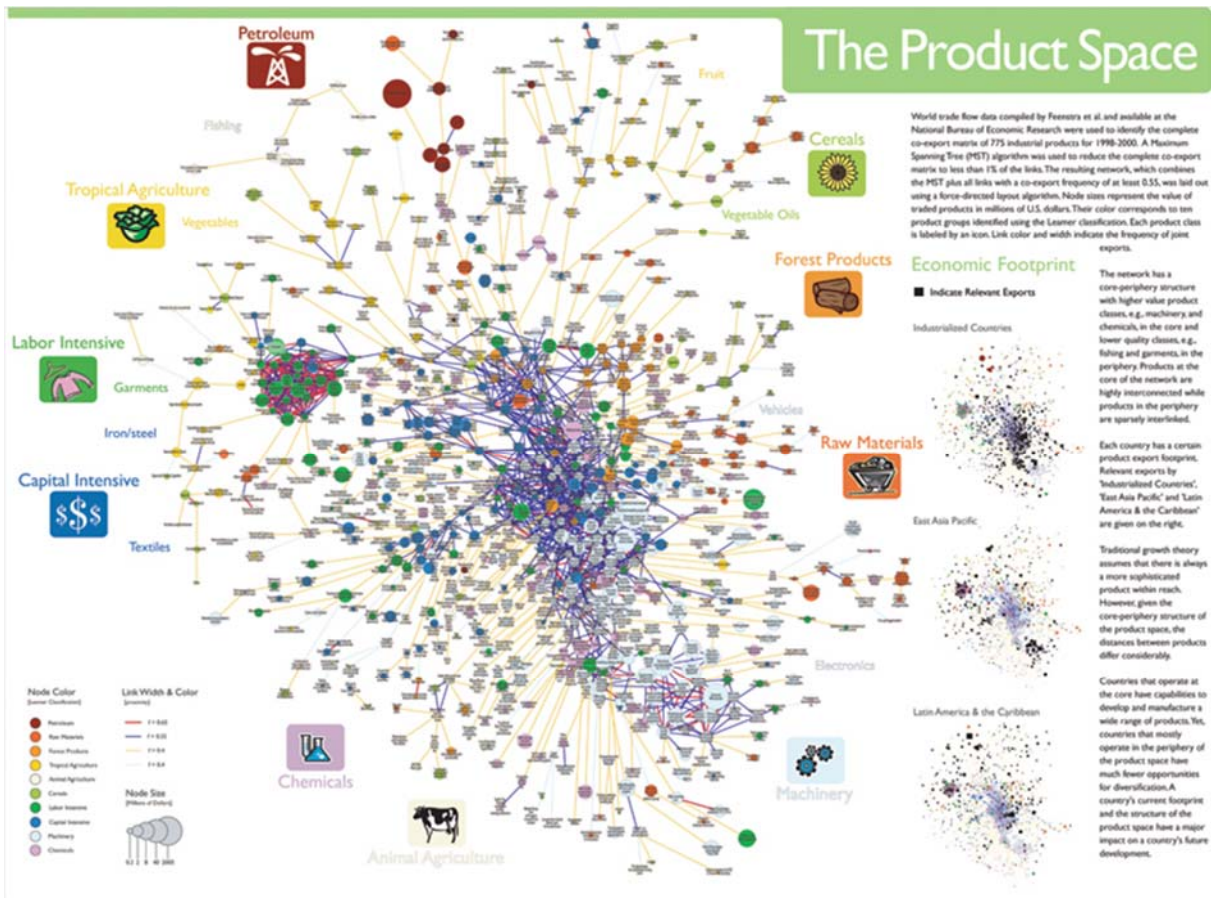


FIG. 7. THE VIDEO TAPE RECORDER



The EMERGENCE of NANOTECHNOLOGY

MAPPING THE NANO REVOLUTION

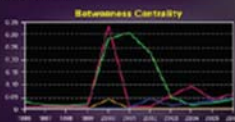
The emergence of nanotechnology has been one of the major scientific/technological revolutions in the last decade and it led to a structural reorganization of major fields of science. Price (1992) showed that fields of science and their development can be mapped using aggregated citations among the journals in the fields and their network organizations.

The frames to the right show the evolving journal citation networks for the years 1998-2003. Distances are proportional to cosine values between the citation patterns of the respective journals. The size of nodes and the thickness of lines are proportional to the cosine values. Most notably, leading papers in Science and Nature captured the breakthrough around 2000.

CHANGING ROLES OF DIFFERENT JOURNALS

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

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



An animated sequence of this evolution is at: <http://www.levinscience.com/animations/>

References

Leydesdorff, L. and T. Schank, 2006. Dynamic Animations of Journal Maps: Indicators of Structural Change and Interdisciplinary Development. *Journal of the American Society for Information Science and Technology*, 57(11), 1210-1218.

Price, Derek J. de Solla (1965). Networks of scientific papers. *Science*, 149, no. 3662, 510-515.

1998

During the period 1998-2000, the journal *Nanotechnology* is published as part of a journal in *Applied Physics*.

1999

Increasingly, chemistry journals play a role in the studies (report) management of the journal *Nanotechnology*.

LEGEND



Values
 0.0
 0.2
 0.33

2000

The journal *Science* interfaces with research journals in both pure chemistry and applied physics. *Nanotechnology* emerges as core journal.

2001

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

2003

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

2002

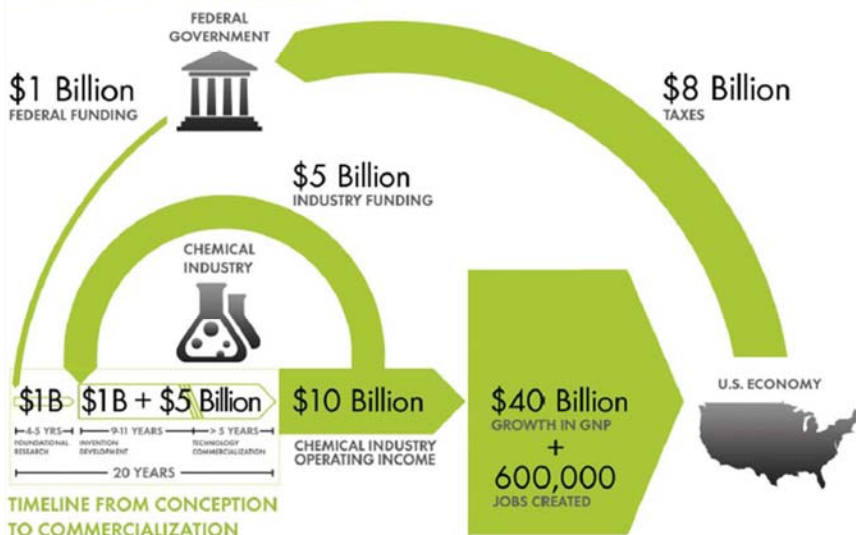
Other journals in nanotechnology and technology begin to emerge, and the leading journal *Nanotechnology* gradually shifts. *Nano Letters* and the *Journal of Nanoscience and Nanotechnology* join the new field of nanotechnology.

Loet Leydesdorff, Thomas Schank and the Journal of the American Society for Information Science and Technology, 2010. The Emergence of Nanoscience & Technology.

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

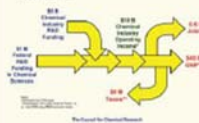
Macroeconomic Implications of Public and Private R&D Investments in Chemical Sciences

INVESTMENT IN CHEMICAL SCIENCE R&D



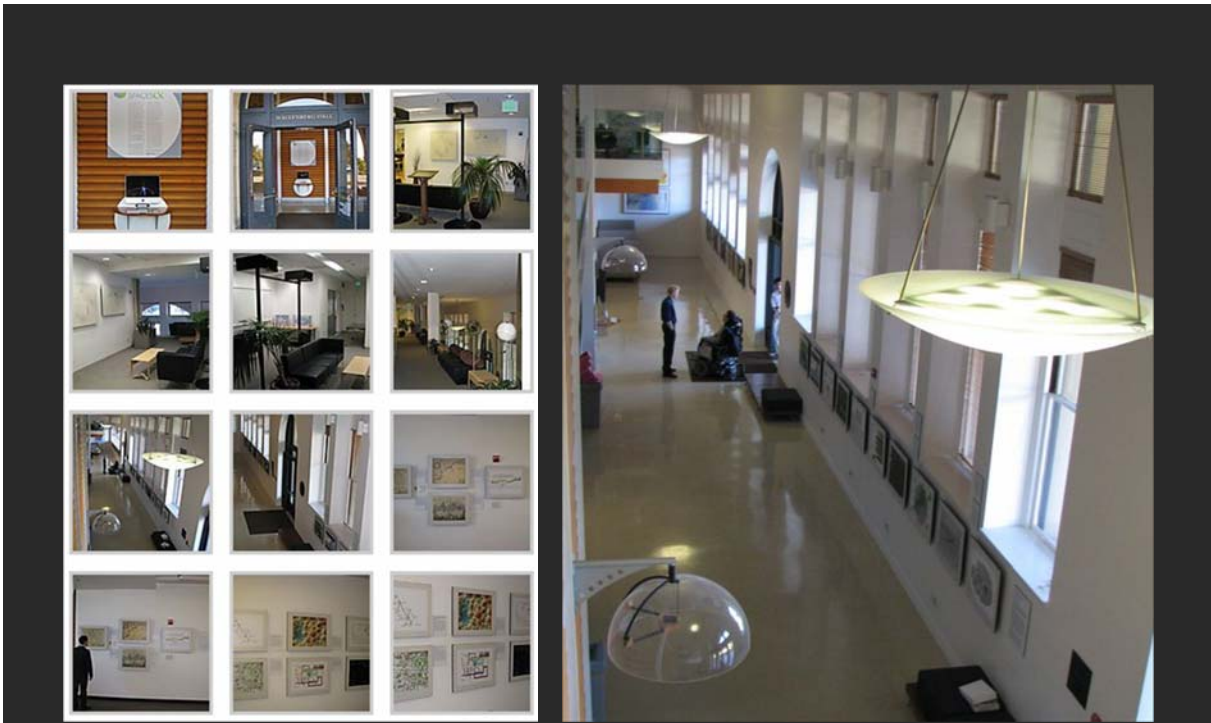
The Council for Chemical Research (CCR)

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

Council for Chemical Research, 2009. Chemical R&D Powers the U.S. Innovation Engine. Washington, DC. Courtesy of the Council for Chemical Research.



Debut of 5th Iteration of the Mapping Science Exhibit at MEDIA X was in 2009 at Wallenberg Hall, Stanford University, <http://mediax.stanford.edu>, <http://scaleindependentthought.typepad.com/photos/scimaps>



Science Maps in “Expedition Zukunft” science train visiting 62 cities in 7 months, 12 coaches, 300 m long. Opening was on April 23rd, 2009 by German Chancellor Merkel, <http://www.expedition-zukunft.de>