

Maps & Macroscopes: Drawing Actionable Insights From Data

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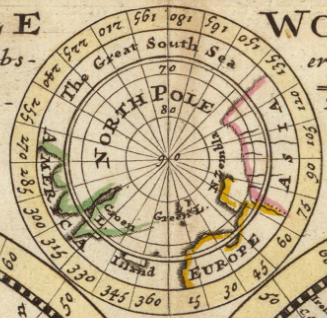
Venue: Bloomington Indiana

April 30, 2017

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

WORLD with the Trade winds
errations By H. Moll Geographer

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



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



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

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



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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 milieus 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 way of thinking about designing complex, robust technological systems. Finally, emergence is an accessible and vivid 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.

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 (ITFF)** 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 ITFF 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 ITFF'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 of Scientific Collaborations from 2005-2009



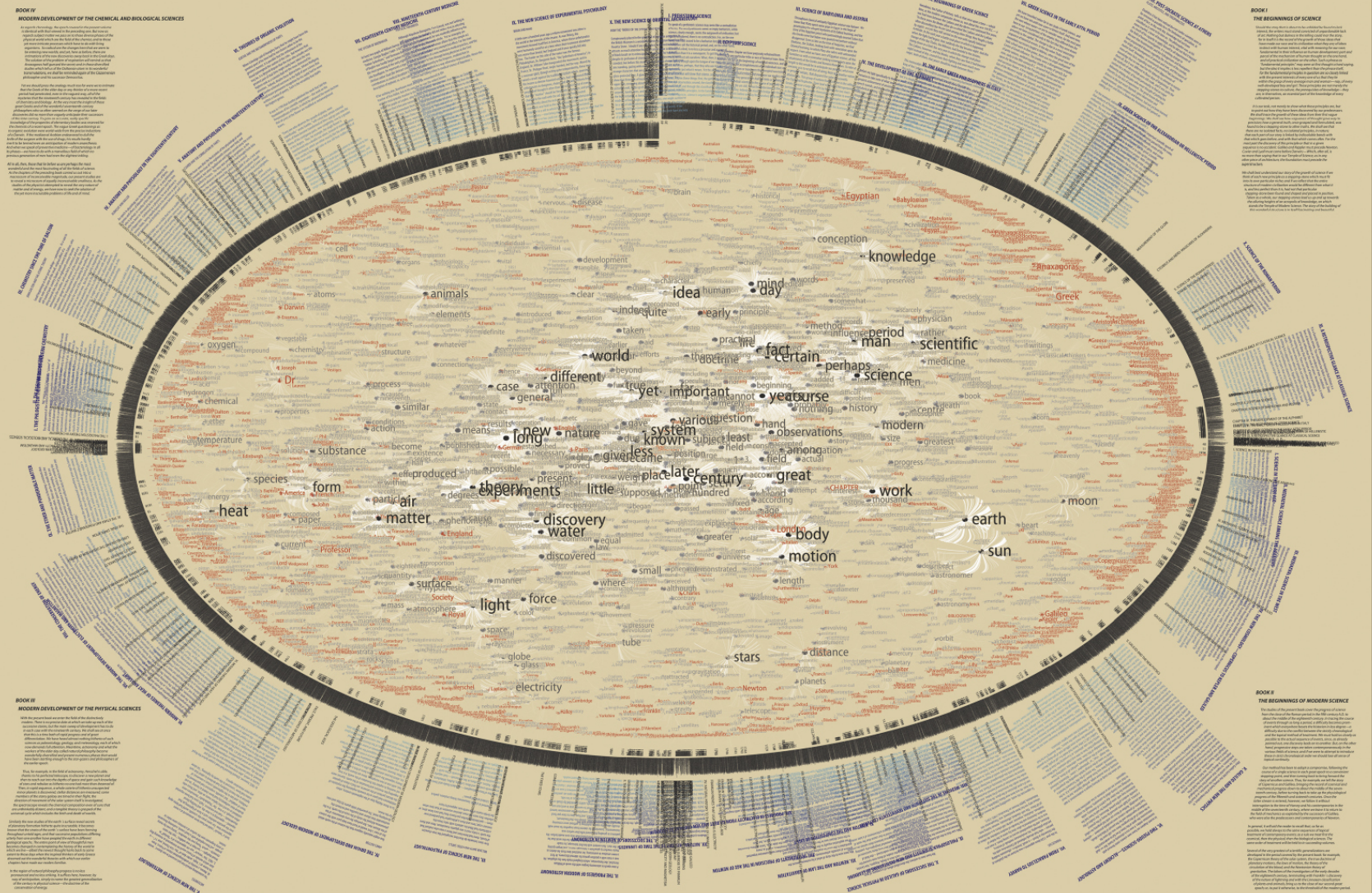
Computed Using Data from Elsevier's Scopus

Stream of Scientific Collaborations Between World Cities - Olivier H. Beauchesne - 2012

A NEW MAP OF THE HISTORY OF SCIENCE

Being a Treatise of sciences 1-10 of A History of Science by Henry Smith Williams, M.D., LL.D., edited by Edward K. Williams, M.D.
 Texts arranged in order first in the form of a clock showing how widely they place words and their more than 100,000
 in this average position - all 100,000 words published every year. A look for words in a circle in the words used.

While you come toward lines in which a word is mentioned. Words get larger and darker the more they are used. This particular TextArc
 has been enhanced to contrast and enlarge historical context: numbers (twenty years) appear inside the arc, chapter headings & introductory
 paragraphs words have introduction in the center. Typist and down in November, 2007 by W. Bradford Paley, all rights reserved



TexArc Visualization of "The History of Science" - W. Bradford Paley - 2006

The EMERGENCE of NANOTECHNOLOGY

MAPPING THE NANO REVOLUTION

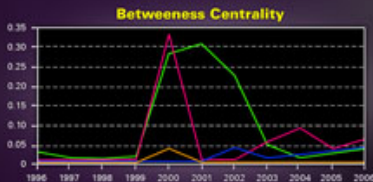
The emergence of nanotechnology has been one of the major scientific-technological revolutions in the last decade and it led to a structural reorganization of major fields of science. Price (1965) showed that fields of science and their development can be mapped using aggregated citations among the journals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

The frames to the right show the evolving journal citation network for the years 1998-2003. Distances are proportional to cosine values between the citation patterns of the respective journals. Textual descriptions of key events during the development of *Nanotechnology* are given below each frame. Most notably, leading papers in *Science* and *Nature* catalyzed the breakthrough around 2000.

CHANGING ROLES OF DIFFERENT JOURNALS

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

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



An animated sequence of this evolution is at: <http://www.leydesdorff.net/journals/nanotech>.

References

Leydesdorff, L. and T. Schank, 2008, Dynamic Animations of Journal Maps: Indicators of Structural Change and Interdisciplinary Developments. *Journal of the American Society for Information Science and Technology*, 59(11), 1810-1818.

Price, Derek J. de Solla (1965). Networks of scientific papers. *Science*, 149, no. 3683, 510- 515.

1998

During the period 1996-2000, the journal *Nanotechnology* is part of a group of journals in applied physics.

1999

Increasingly, chemistry journals play a role in the citation impact environment of the journal *Nanotechnology*.

LEGEND

- Science
- Nature
- Nanotechnology
- Nano Letters

Values



2003

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

2002

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

2000

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

2001

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

113 Years of Physical Review

This visualization aggregates 389,899 articles published in 720 volumes of 11 journals between 1893 and 2005. The 91,762 articles published from 1893 to 1976 take up the left third on the map. In 1977, the Physical Review introduced the Physics and Astronomy Classification Scheme (PACS) codes, and the visualization subdivides into the top-level PACS codes. The 217,503 articles from 1977 to 2000, for which good citation data is not available, occupy the middle third on the map. The 80,634 articles from 2001 to 2005, for which good citation data is available, fill the last third of the map.

Each vertical bar is subdivided vertically into the journals that appear in it with height proportional to the number of papers, and each journal is subdivided horizontally into the volumes of the journal appearing in the column.

On top of this base map, all citations from the papers in every top-level PACS code in 2005 are overlaid and then drawn from the source area to the individual volumes containing papers cited.

The small Nobel Prize medals indicate the 24 volumes containing the 26 papers appearing in Physical Review for 11 Nobel prizes between 1990 and 2005. Each year, Thomson ISI predicts three Nobel Prize awardees in physics based on citation counts, high impact papers, and discoverie or themes worthy of special recognition. Correct predictions by Thomson ISI are highlighted.

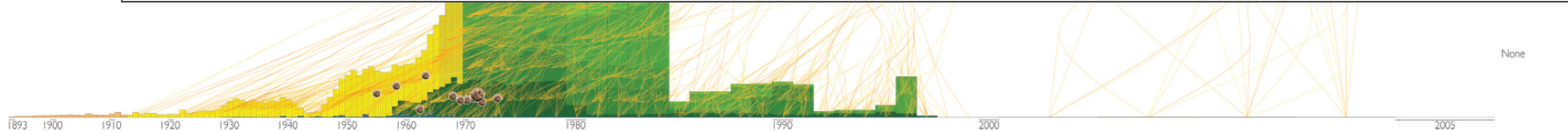
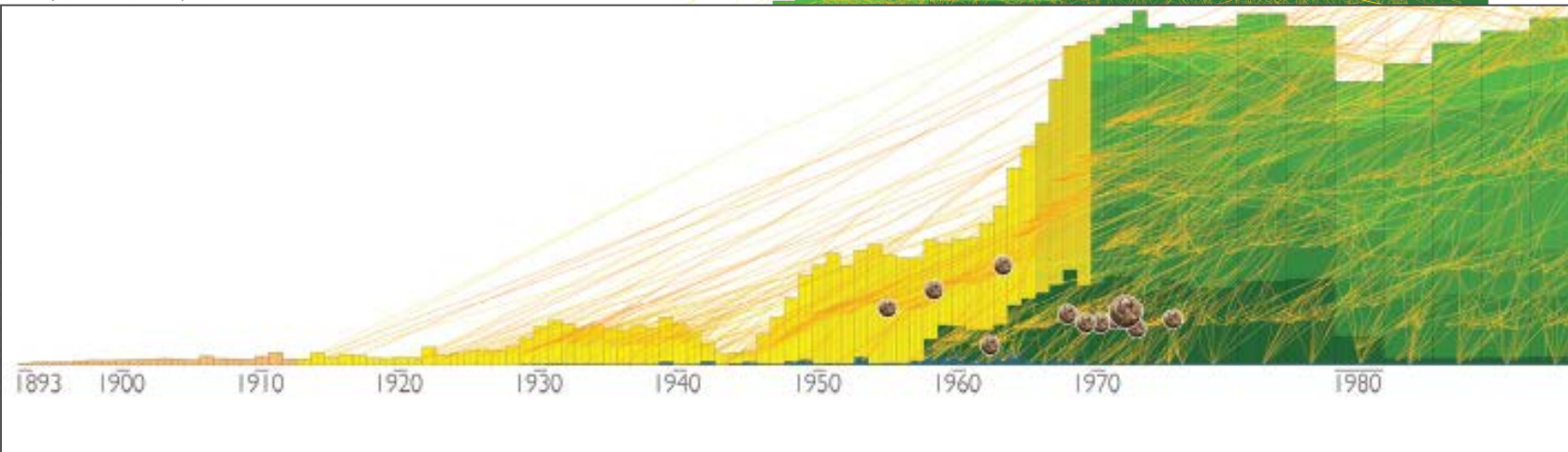
Nobel Prizes in Physical Review

Year of Nobel Prize Winners Publication Year(s) (indicated by Nobel Prize medals on the right)

- 2005 Roy J. Glauber, John L. Hall, and Theodor W. Hänsch 1963, 1971
- 2004 David J. Gross, H. David Politzer, and Frank Wilczek 1973
Thomson ISI successfully predicted a winner in this year, with the following paper:
Gross D, Wilczek F. Ultraviolet Behavior of Non-Abelian Gauge Theories. *Physical Review Letters* 30: 1343 & 1973
- 2003 Anthony J. Leggett 1970
- 2002 Raymond Davis Jr., Masatoshi Koshiba, and Riccardo Giacconi 1962, 1968, 1987
- 2001 Eric A. Cornell, Wolfgang Ketterle, and Carl E. Wieman 1995, 1996
- 1998 Robert B. Laughlin 1982, 1983
- 1997 Steven Chu and William D. Phillips 1985, 1986, 1988
- 1996 David M. Lee, Douglas D. Osheroff, and Robert C. Richardson 1972
- 1995 Martin L. Perl 1959, 1975
- 1994 Bertram N. Brockhouse and Clifford G. Shull 1955, 1958
- 1990 Jerome I. Friedman, Henry W. Kendall, and Richard E. Taylor 1969

Bar Graph

- Physical Review
- Physical Review
- Physical Review
- Physical Review
- Physical Review
- Physical Review
- Physical Review
- Physical Review
- Physical Review
- Physical Review Topics Accoles
- Physical Review Physics Educa
- Physical Review Modern Phys



114 Years of Physical Review - Bruce W. Herr II, Russell Duhon, Katy Borner, Elisha Hardy, Shashikant Penumarthy - 2007

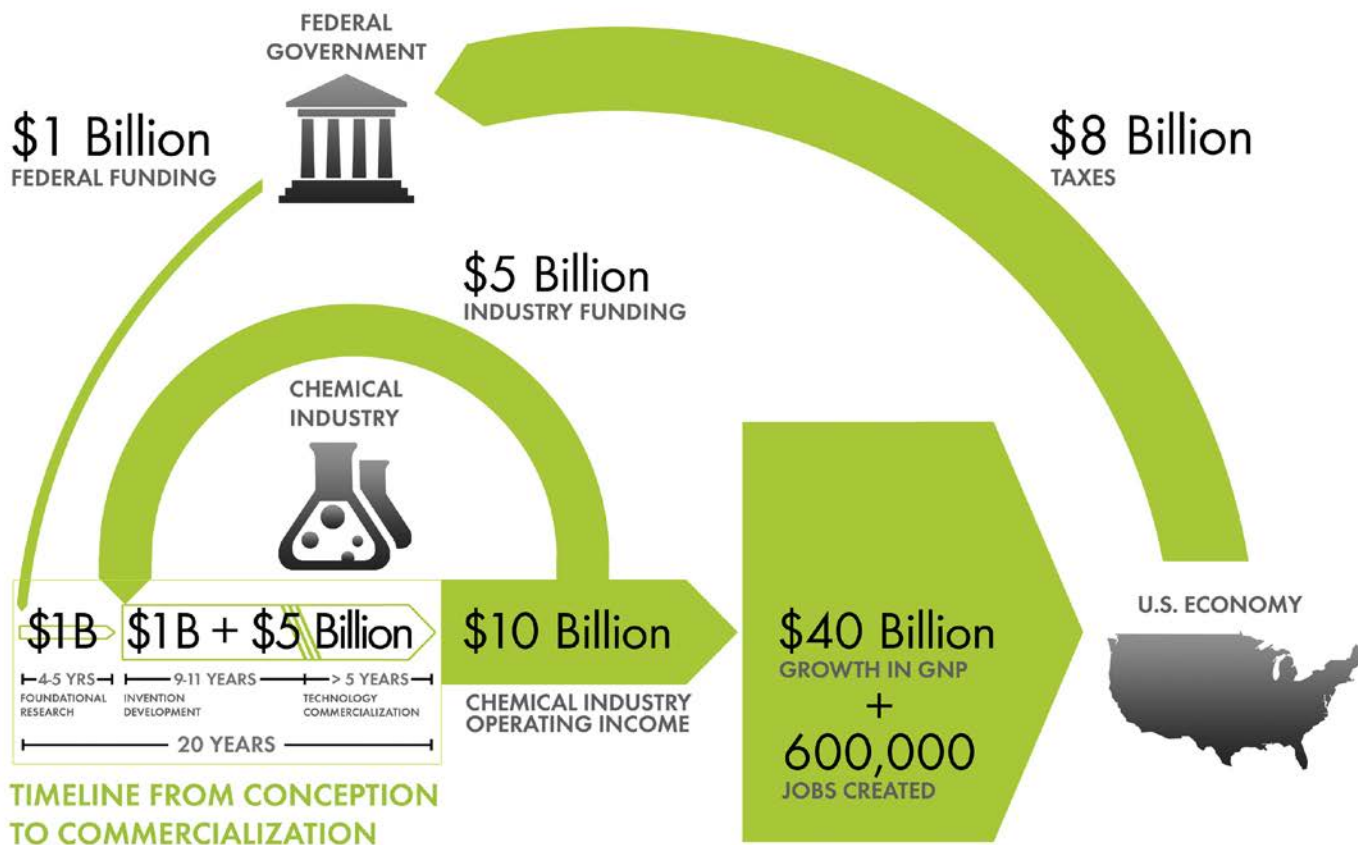
Chemical Research & Development Powers the U.S. Innovation Engine

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



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

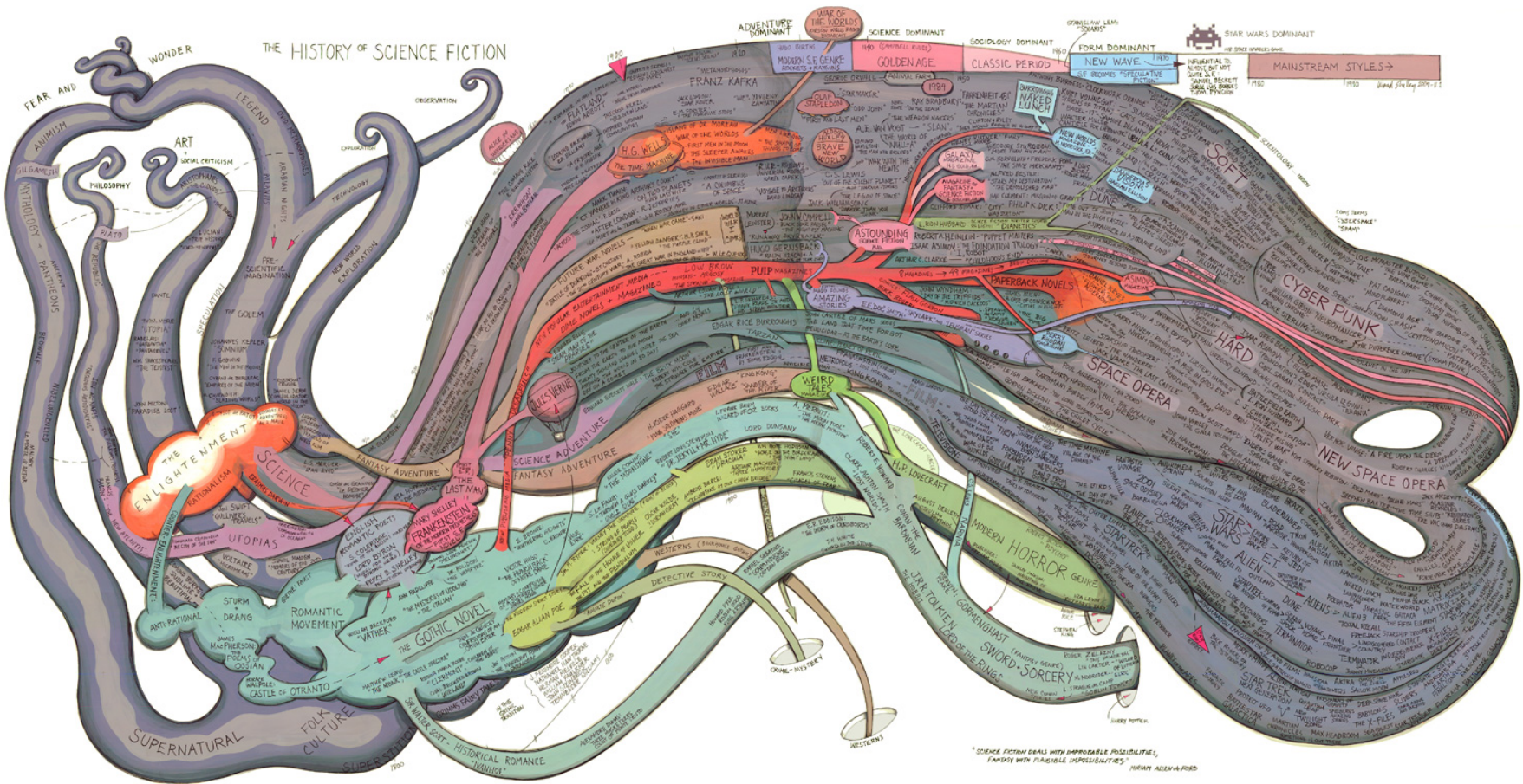
INVESTMENT IN CHEMICAL SCIENCE R&D



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



Map of the Internet - Martin Vargic - 2014



History of Science Fiction - Ward Shelley - 2011

Check out our **Zoom Maps** online!

VII.10
History of Science Fiction, by Ward Shelley

BROOKLYN, NY, 2011
Courtesy of Ward Shelley Studio

Ward Shelley is an artist identified with the Williamsburg scene in Brooklyn, New York, who has been writing and illustrating about art and culture. This map plots the science fiction literary genre from its nascent beginnings in the 18th century, emerging out of the data, here the narrative structure precedes and organizes the data. Shelley's map is a complex web of interconnected nodes and lines, color-coded in various shades of purple, blue, green, and orange. It branches out into numerous sub-topics, including 'TEAR AND WONDER', 'ART', 'SCIENCE', 'ADVENTURE', 'SPACE OPERA', 'CYBER PUNK', and 'NEW SPACE OPERA'. A prominent section in the center is titled 'FANTASY ADVENTURE' and 'SCIENCE ADVENTURE', with a detailed inset showing 'MARY SHELLEY OR THE MODERN PROMETHEUS' and 'FRANKENSTEIN'. Other authors and works mentioned include Jules Verne, Victor Hugo, and Mary Shelley. The map is presented on a dark background with a navigation interface on the left side, including a compass and zoom controls.

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

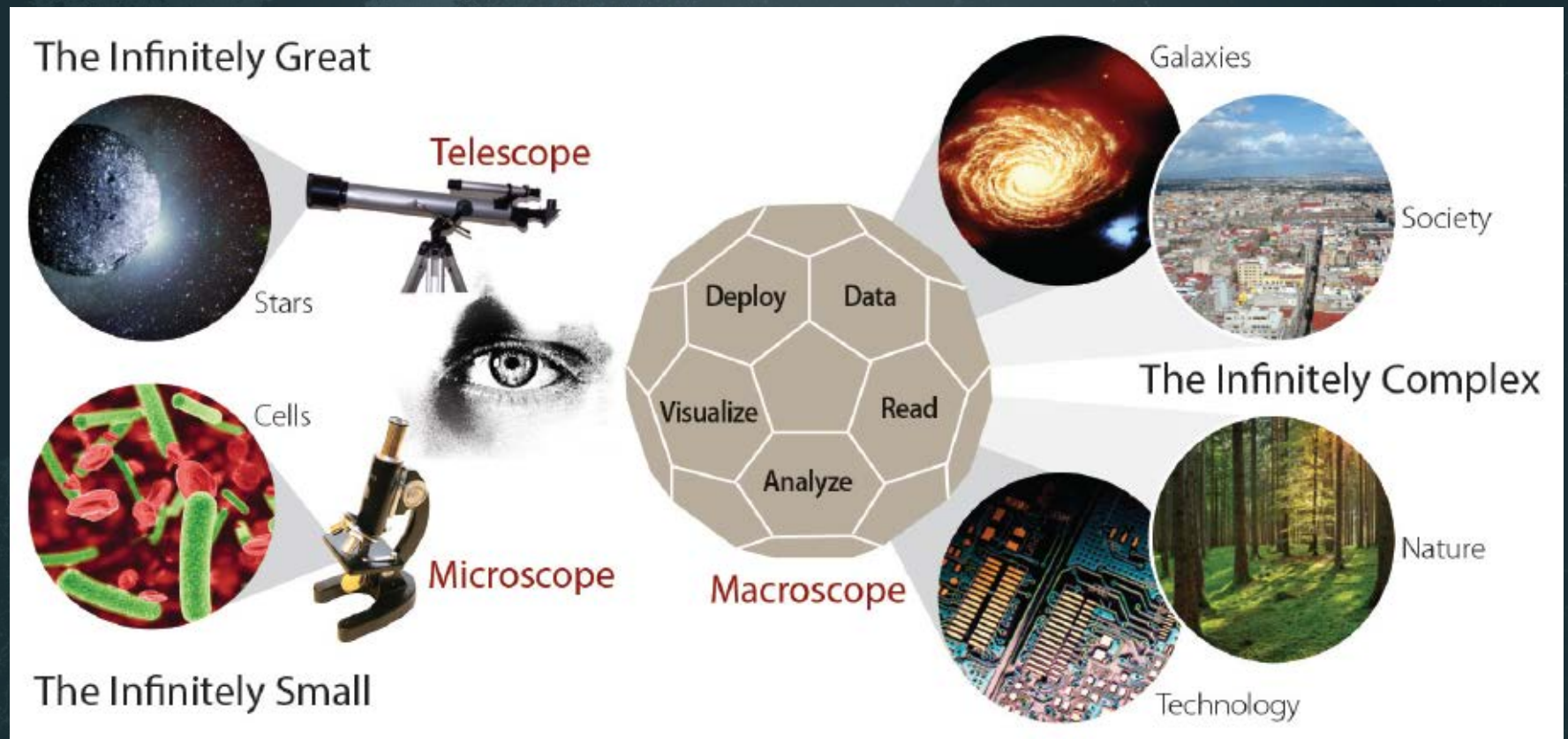
Macrosopes



PLACES
SPACES &
MAPPING SCIENCE

scimaps.org

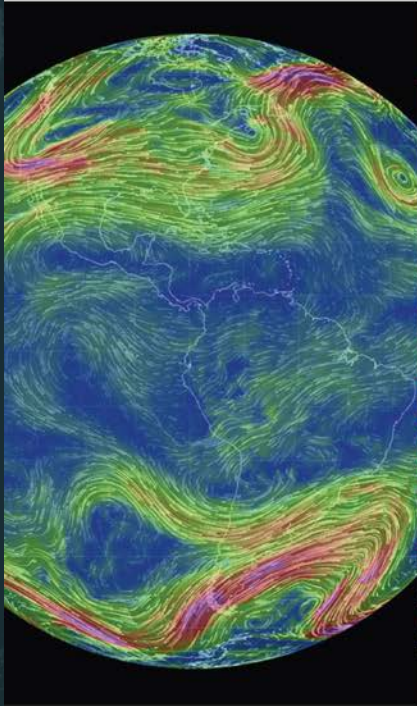
Microscopes & Telescopes vs. MACROSCOPES





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

i **MACROSCOPES FOR INTERACTING WITH SCIENCE**



Earth

Weather on a worldwide scale



AcademyScope

Exploring the scientific landscape



Mapping Global Society

Local news from a global perspective



Charting Culture

2,600 years of human history in 5 minutes

Iteration XI (2015): Macroscopes for Interacting with Science

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



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

Call for Macroscope Tools for the *Places & Spaces: Mapping Science* Exhibit (2017) <http://scimaps.org/call>

Background and Goals

The *Places & Spaces: Mapping Science* exhibit is designed to open people's hearts and minds to the value, complexity, and beauty of maps of science and technology.

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



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



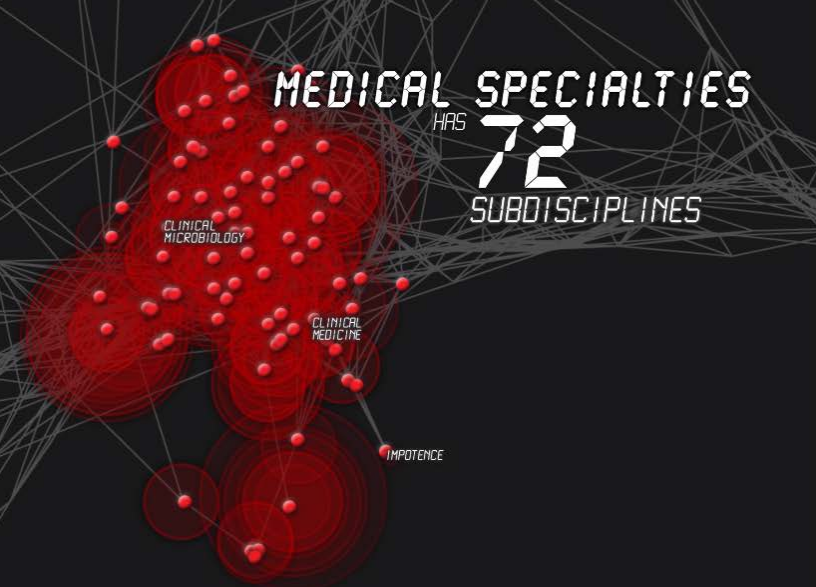
Places & Spaces Digital Display in North Carolina State's Immersion Theater

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

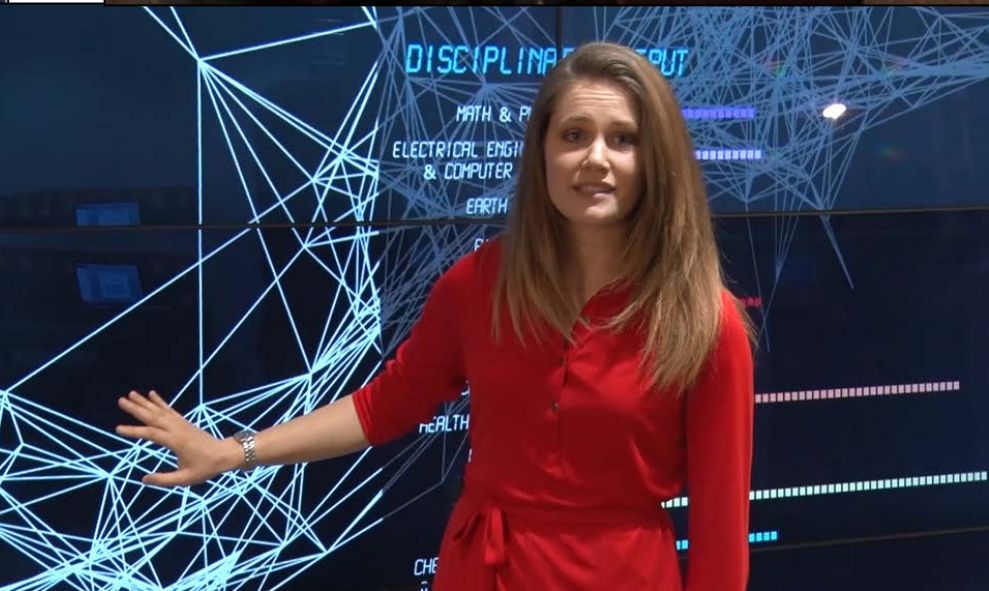


CDC Opening Event: Maps of Health

Tutorial and Symposium
February 4-5, 2016



Science Forecast S1:E1, 2015





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



Upcoming Colloquia

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

Reproducibility of Research: Issues and Proposed Remedies

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

Science of Science Communication III

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

Modelling and Visualizing Science and Technology Developments

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



NAKFI Conference on Art and Science, Engineering, and Medicine Frontier
Collaborations: Ideation, Translation & Realization, Arnold and Mabel
Beckman Center in Irvine, CA on November 12-14, 2015

Modeling Science, Technology & Innovation Conference

WASHINGTON D.C. | MAY 17-18, 2016

[View Agenda](#)

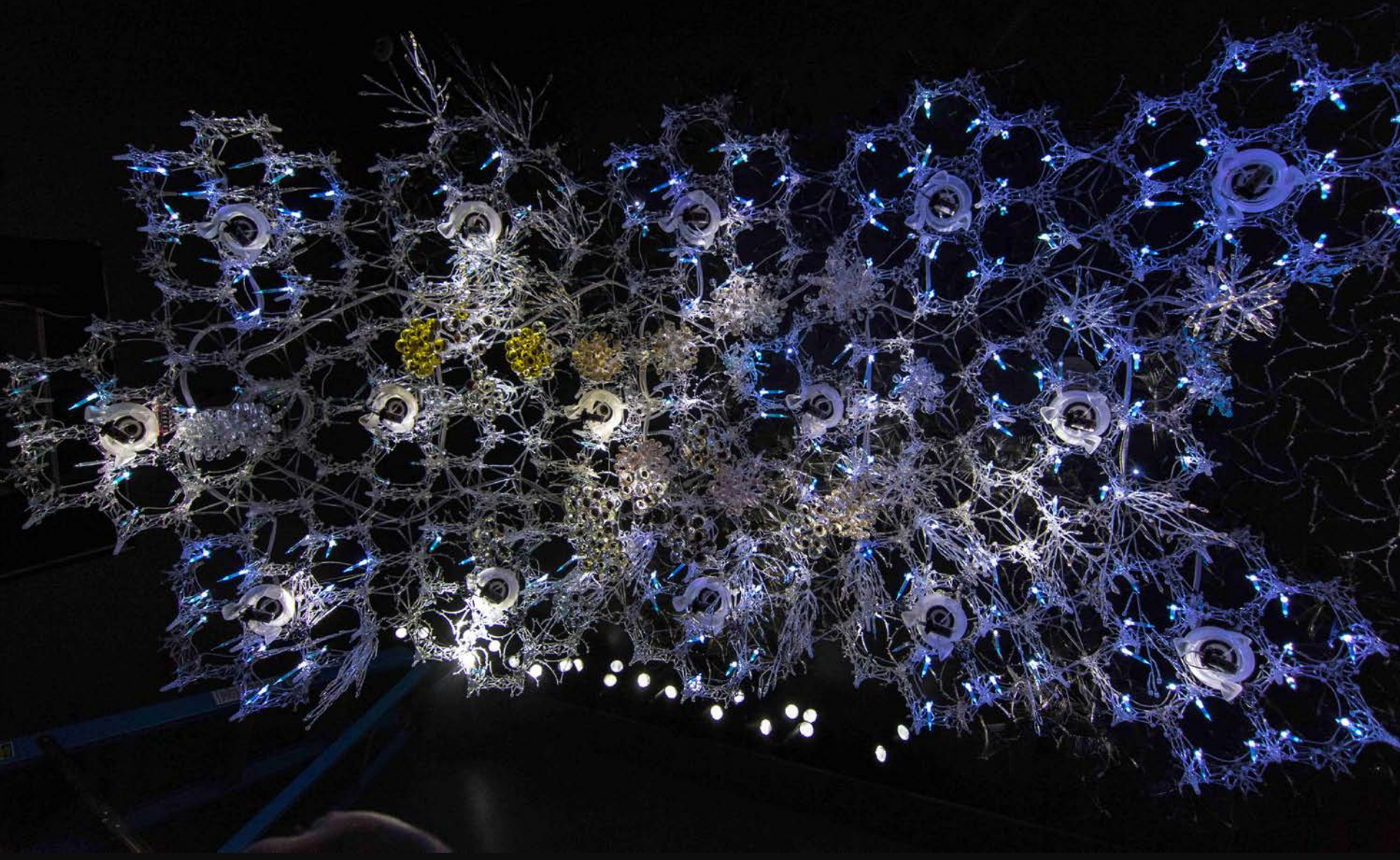


Slides, recordings, and report are available via <http://modsti.cns.iu.edu/report>

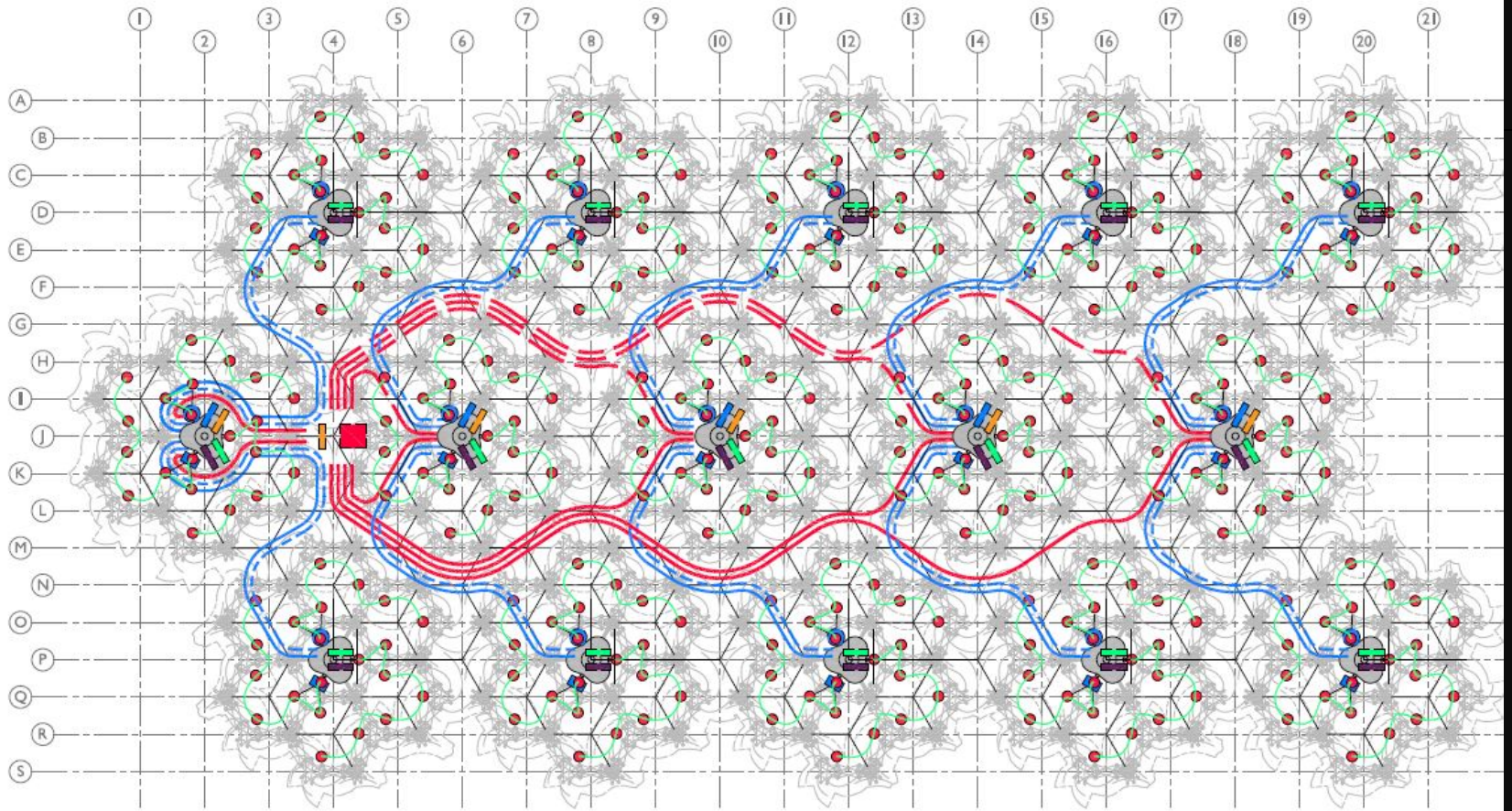


- Define Data Visualization Literacy (DVL)
- Develop metrics to measure DVL
- Compare approaches to increase DVL
- Use data visualization and AR/VR setups to communicate the inner workings of IoT

Sentient Veil, Isabella Stewart Gardner Museum, Boston, MA (2017)







Sentient Veil, Isabella Stewart Gardner Museum, Boston, MA (2017)



PCBs

-  Raspberry Pi 3.0 B
-  3.1 Control Node
-  3.1 Device Module
-  Power Distribution board
-  Mp3 Trigger board

Interactive Devices

-  Light Module Cluster
-  Sound Unit
-  Short Range IR Proximity Sensor
-  Microphone Sensor

Mechanisms

-  Main Power Trunk
-  Main Communications Trunk
-  Node to Device Module Power
-  Node to Device Module Communications
-  Neo Pixel Chain

Sentient Veil, Isabella Stewart Gardner Museum, Boston, MA (2017)



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Epiphyte Grove, Trondheim, Norway, 2012. ©PBAI

Sentient Architecture — Sculptures that Listen and Talk

June 12 - 16, 2017

As the built environment becomes increasingly more complex and integrated with new technologies—including the emerging Internet of Things (IoT)—there is an urgent need to understand how embedded technologies affect the experience of individuals that inhabit these spaces.

[View Sentient Architecture Camp](#)

ISE is proud to offer 9 weeks of 6 different camps during summer 2017. Students aged 13+ are welcome to register: <http://camps.engineering.indiana.edu>

Sentient Architectures:

Adding Empathic Intelligence to Luddy Hall

Creating a Model Organism for AI+Vis Research

Engaging Imagineers Around the Globe

Renaissance Engineering in Action

Philip Beesley

Practicing Visual Artist, Architect

Professor in Architecture at the University of Waterloo

Professor of Digital Design and Architecture & Urbanism at the European
Graduate School

April 30, 2017