Places & Spaces: Mapping Science
On Display at the Monroe County Public Library
May 1 – May 30, 2007

# Exhibit Explanation

## General Introduction

Cartographic maps of physical places have guided mankind's explorations for centuries. They have enabled the discovery of new worlds while also marking unknown territories. Without maps, we would literally be lost.

Maps of abstract spaces, like ideas, aim to serve today's explorers who are navigating the world of science. Today, scholarly knowledge is stored in a huge number of papers, books, emails, and other formats. To understand this information, maps are generated through scientific analysis of large-scale scholarly data in an effort to connect and make sense of the bits and pieces of knowledge they contain. They can be used to objectively identify major research areas, experts, and ideas in a domain of interest. Science maps can provide overviews of "all-of-science" or of a specific area. They allow us to track the emergence, evolution, and disappearance of topics and help to identify the most promising areas of future research.

The display at the New York Hall of Science features the first two out of 10 iterations of the Places & Spaces exhibition entitled *The Power of Maps* and *The Power of Reference Systems*. Each iteration contains ten large-format, high-resolution maps that compare and contrast four existing maps to six maps of sciences. Also on display are:

- *Illuminated Diagram display*. Here visitors can see where science gets done, how the different areas of science interrelate, and how knowledge diffuses in geospatial and topic space.
- *Worldprocessor globes*. Discover zones of inventions and patenting activity while spinning the beautiful and informative Worldprocessor globes.
- *Hands-on Science Maps for Kids.* Solve the hands-on science map puzzle by placing major scientists, inventors and inventions at their proper places on a world map and on a map of science. Look for the many hints hidden in the beautiful paintings to find the perfect place for each puzzle piece.

## Learning Objectives

- What major scientific disciplines exist and how are these disciplines interconnected? (Boyack et al map in 1st iteration)

- Where do major inventions and inventors go on a map of science and a map of the world? (Kids Puzzle)
- Where on a map of science and a map of the world is what kind of science done today? (Illuminated Diagram)
- What impact can one single scientists have on science and on the world? (Explore people buttons in Illuminated Diagram)
- Draw a map of your knowledge.
- Learn about the design and usage of maps of science. (All pieces of the exhibit)

**Exhibit Components**

- Maps
- Illuminated Diagrams
- Worldprocessor Globes
- Kids Puzzle Map

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**Introduction to the 1st Iteration**

We have all used maps to help us find our way to a certain location, perhaps a train station across town or a city far away. But did you know that maps can also be used to show the way to certain ideas or knowledge?

Early maps of the world weren't perfect. But travelers still relied on them for navigation, exploration, and communication. These maps helped explorers avoid monsters and find promising new lands. Early maps of science aren't perfect either. They are based on only a small portion of mankind's knowledge. More accurate maps of science will require a better understanding of mankind's knowledge.

Each of the six early maps of science uses a different metaphor. Discuss which metaphors are most effective in displaying images of scientific knowledge.

**Learning Objectives**

- Maps can show physical places and abstract concept 'spaces.'
- Making maps of places and making maps of ideas are both challenging because it is difficult to obtain accurate data.
- How were early maps flawed and what makes maps more accurate today?
- What challenges do you think scientists face when they map information?
- Which of the six early maps do you like best?
- Draw a map of your knowledge. Where would you place a monster that needs to be avoided? Where are the promising lands?

**Exhibit Components**

- *Cosmographia* World Map by Claudius Ptolemy
- *Nova Anglia, Nowm Belgivm et Virginia* by Jan Jansson

- *A New Map of the Whole World with the Trade Winds According to the Latest and Most Exact Observations* by Herman Moll
- *Napoleon's March to Moscow* by Charles Joseph Minard
- *1996 Map of Science: A Network Representation of the 43 Fourth Level Clusters Based on Data from the 1996 Science Citation Index* by Henry Small
- *Treemap View of 2004 Usenet Returnees* by Marc Smith, Danyel Fisher, and Tony Capone
- *In Terms of Geography* by André Skupin
- *Ph.D. Thesis Map* by Keith V. Nesbitt
- *Timeline of 60 years of Anthrax Research Literature* by Steven Morris
- *The Structure of Science* by Kevin Boyack and Richard Klavans

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**Introduction to the 2nd Iteration**

Can there be a common reference system for all of mankind's scholarly knowledge? If so, what images best represent this knowledge?

Throughout history, scientists have battled to agree on standardized reference systems for their respective fields of research. Some examples are the first four maps you see here: the electromagnetic spectrum, the periodic table of elements, geographic projections, and the celestial reference systems. These standards are invaluable for efficiently indexing, storing, accessing, and managing scientific data. The other six maps are *potential* reference systems, or unique displays for scientific knowledge.

Each map – from the *Taxonomy Visualization of Patent Data*, or the *Map of Scientific Paradigm*, to the *Zones of Invention- Patterns of Patents* – could be used to identify the "location" of an author, paper, patent, or grant, to show the impact of a particular work.

**Learning Objectives**

- Reference systems can have different dimensionalities.
- Identify all one-dimensional reference systems. (Answer: *U.S. Frequency Allocations Chart* and *HistCite™ Visualization of DNA Development*)
- Identify all geospatial reference systems. (Answer: *Cartographica Extraordinaire* and *Zones of Invention. Etc.*
- Create a reference system to chart a normal day in your life. (Possible answer: 'time of day' vs. 'distance from home' two dimensional reference system in which major events can be plotted)

**Exhibit Components**

- *U.S. Frequency Allocations Chart* by the National Telecommunications and Information Administration
- *Visual Elements Periodic Table* by Murray Robertson and John Emsley
- *Cartographica Extraordinaire: The Historical Map Transformed* by David Rumsey and Edith M. Punt

- *Sky Chart for New York City in April 2006* by Roger W. Sinnot and Interactive Factory
- *HistCite™ Visualization of DNA Development* by Eugene Garfield, Elisha Hardy, Katy Börner, Ludmila Pollock, Jan Witkowski
- *History Flow Visualization of the Wikipedia Entry on 'Evolution'* by Martin Wattenberg, Fernanda Viégas
- *Taxonomy Visualization of Patent Data* by Katy Börner, Elisha Hardy, Bruce Herr, Todd Halloway, Bradford Paley
- *TextArc Visualization of "The History of Science"* by W. Bradford Paley
- *Map of Scientific Paradigms* by Kevin W. Boyack and Richard Klavans
- *Zones of Invention- Patterns of Patents* by Ingo Günther

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**Introduction to Illuminated Diagrams**

The word science covers a huge diversity of topics: from mathematics and astronomy to medicine and even certain approaches to the humanities. This map shows how distinct areas of study are defined and how they are related. The nodes, 776 of them, are distributed around a generally ring-like structure. They represent scientific topics, more properly called paradigms, and are essentially groups of recently published papers. Each node represents tens or thousands of papers; this map was created by scrutinizing more than 1.3 million papers.

This second map plots the locations of where scientific papers were published: each white dot represents 10 or fewer papers; they are scattered around the exact location for visibility, within a labeled brown circle whose size is proportional to the number of papers published in that place.

The Illuminated Diagram display uses a computer and two projectors, projecting spots of light on the prints, to highlight different kinds of scientific research on the map of scientific paradigms and the areas in the world where such science was performed on the world map. Use the touch panel display to select areas of science and areas of the world that interest you.

**Learning Objectives**

- Find your country of birth on the map of the world. How does the number of scientific papers produced there compare with the productivity of other countries?
- Select the nanoscience button and see if your country of birth conducts nanoscience research.
- Touch your country of birth and see what areas of research highlight in the map of science.

**Exhibit Components**

- *Illuminated Diagram of Topic Map: How Scientific Paradigms Relate*, by Kevin Boyack and Dick Klavans, W. Bradford Paley and Peter Kennard

- *Illuminated Diagram of Geographic Map: Where Science Gets Done,* by Kevin Boyack and Dick Klavans, John Burgoon, Peter Kennard and W. Bradford Paley

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**Introduction to Worldprocessor Globes**

The first globe in our series of three, represents U.S. patents registered to foreign holders – or about half of all patents in the U.S. Countries with more than 1000 patents registered in the U.S. are indicated by name, with text scaled to size (the point size of the representative text scaled according to the square root of the total number of U.S. patents held). The number of American patent holders is left out because, according to this logic, the entire surface of the globe would be covered.

The second globe plots the total amount of patents granted worldwide, beginning in 1883. Additionally, nations where residents are granted an average of 500 or more U.S. patents per year are called out in red by their respective averages in the years after 2000.

The third globe, the "Shape of Science" is a prospective tangible sculpture based on the research of Richard Klavans and Kevin Boyack, spatializing the quantified connectivities and relative flows of inquiry within the world of science.

**Learning Objectives**

- Discover who has the most patents.
- See how the number of patents increases over time.
- Explore how the world is interconnected through science.

**Exhibit Components**

- *Foreign U.S. Patent Holders [Worldprocessor #294]* by Ingo Günther Globes
- *Patterns of Patents & Zones of Invention [Worldprocessor #286]* by Ingo Günther
- *Shape of Science,* by Ingo Günther

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**Introduction to Hands on Science Maps for Kids**

The hands-on science maps for kids invite children to see, explore, and understand science from above. The world map shows the places where science is practiced and researched. The map of science shows major areas of science and their complex interrelationships. Both maps also appear in the *Illuminated Diagram* display. The watercolor paintings, by Fileve Palmer, were digitally added by Elisha Hardy to make different continents and different areas of science more tangible.

Children and adults alike are invited to help solve the puzzle by placing major scientists, inventors, and inventions at their proper places. Start by selecting one of the two maps, and either famous people or major inventions. Place the people or inventions in their proper place in science or the world. Then when you are done, turn the map over and start again. Look for the many hints hidden in the drawings to find the perfect place for each puzzle piece.

Next, go online at www.scimaps.org/exhibit/kids and learn about scientists, inventors, and the history of their inventions. Pick up a handout and start making your own map of science. What other inventors and inventions do you know? Where would your favorite science teachers and science experiments go on the map? What area of science do you want to explore next?

**Learning Objectives**

- Inventors and inventions exist all over the world.
- All areas of science contribute major inventors and inventions.
- Learn where major inventors and inventions go on a map of the world.
- Learn where the very same set of major inventors and inventions goes on a map of science.

**Exhibit Components**

- *Hands-on World Map* by Fileve Palmer, Elisha Hardy, Katy Börner and Julie Smith
- *Hands-on Map of Science* by Fileve Palmer, Elisha Hardy, Katy Börner and Julie Smith