CNS Cyberinfrastructure for Network Science Center

INDIANA UNIVERSITY
SCHOOL OF INFORMATICS, COMPUTING, AND ENGINEERING

Data Visualization Best Practices

Katy Börner @katycns

Victor H. Yngve Distinguished Professor of
Intelligent Systems Engineering & Information Science
Director, Cyberinfrastructure for Network Science Center
Luddy School of Informatics, Computing, and Engineering
Indiana University, Bloomington, IN, USA

Seed Networks Computational Biology Meeting
Virtual Event

April 6, 2021

2020 Flashback

Human Reference Atlas: Anatomical Structures, Cell Types & Biomarkers

Katy Börner | @katycns
Victor H. Yngve Distinguished Professor of
Intelligent Systems Engineering & Information Science
Luddy School of Informatics, Computing, and Engineering
Indiana University, Bloomington, IN

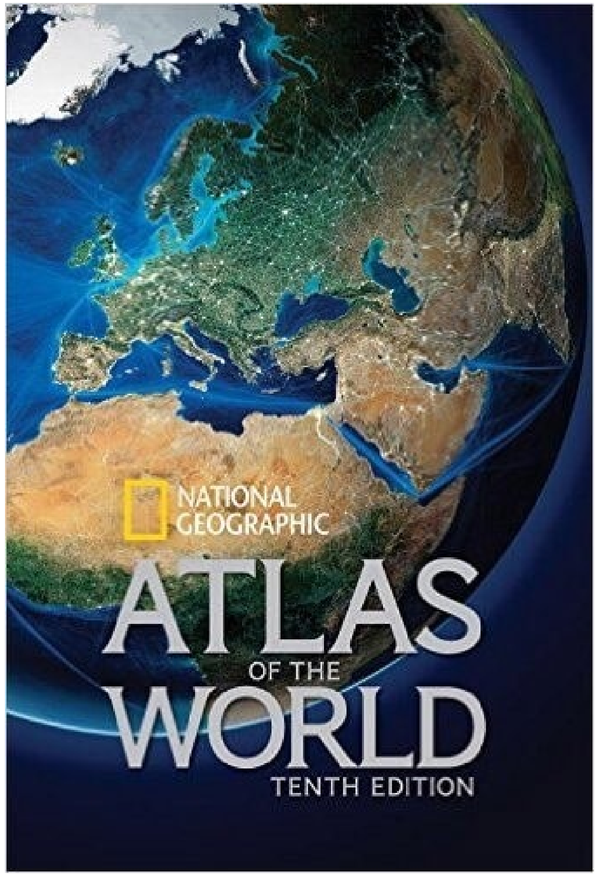
Seed Networks 2020 Annual Meeting
Virtual Event

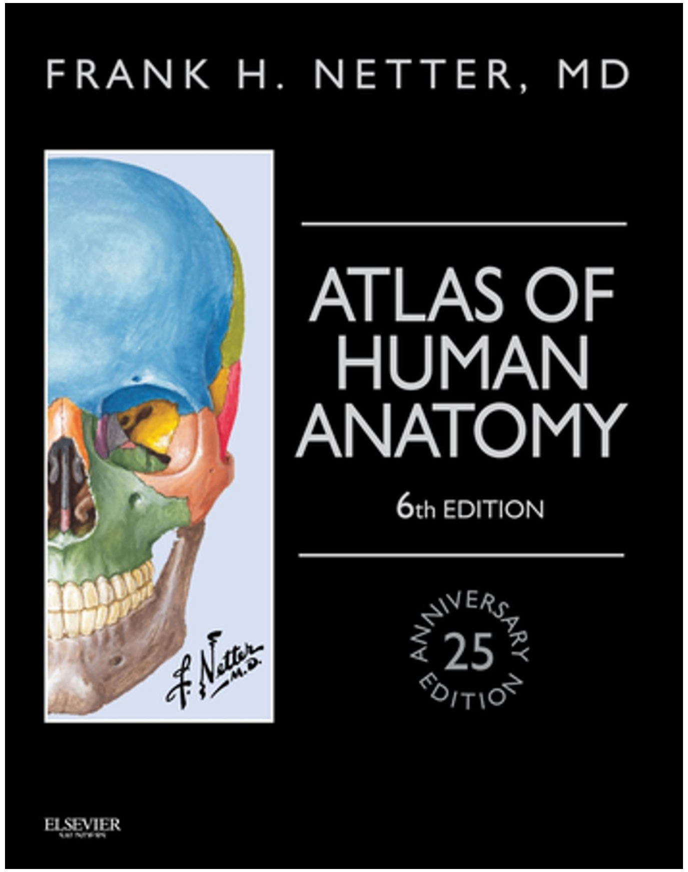
November 18, 2020

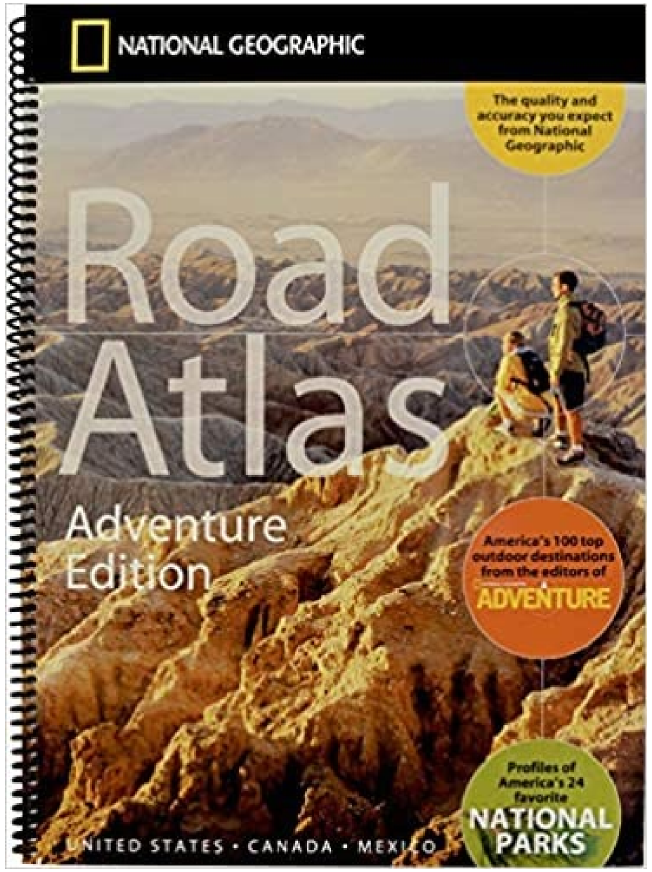
2020 Flashback

An **atlas** is an oversized, bound book of maps.

It has descriptive text, an index, possibly other data visualizations.







2020 Flashback

An **human cell atlas**

might show a landscape

of all cells, or

Maps of cells per tissue

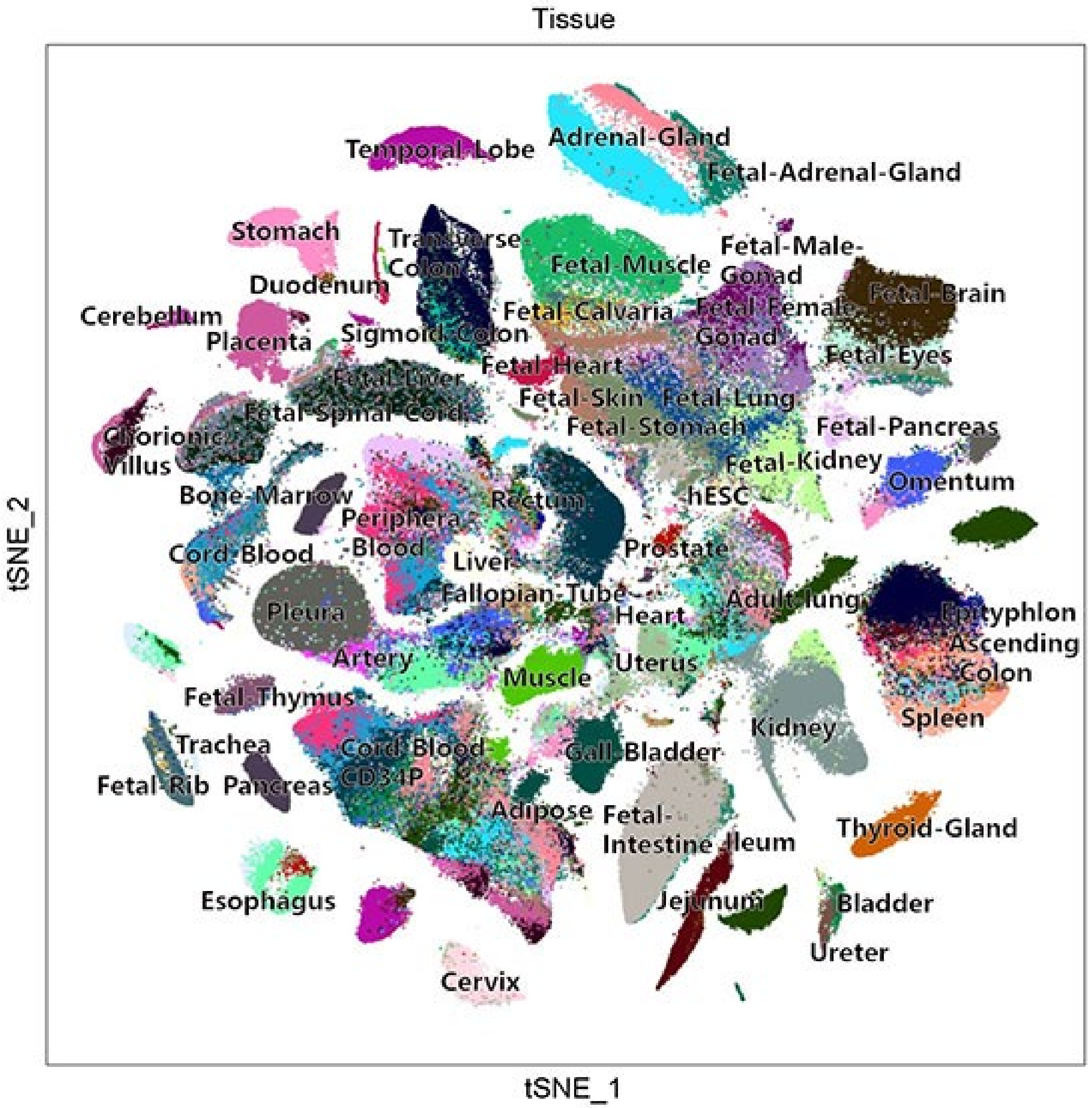
type/anatomical structure.

Article | Published: 25 March 2020

Construction of a human cell landscape at single-cell level

Xiaoping Han, Ziming Zhou, [...] Guoji Guo

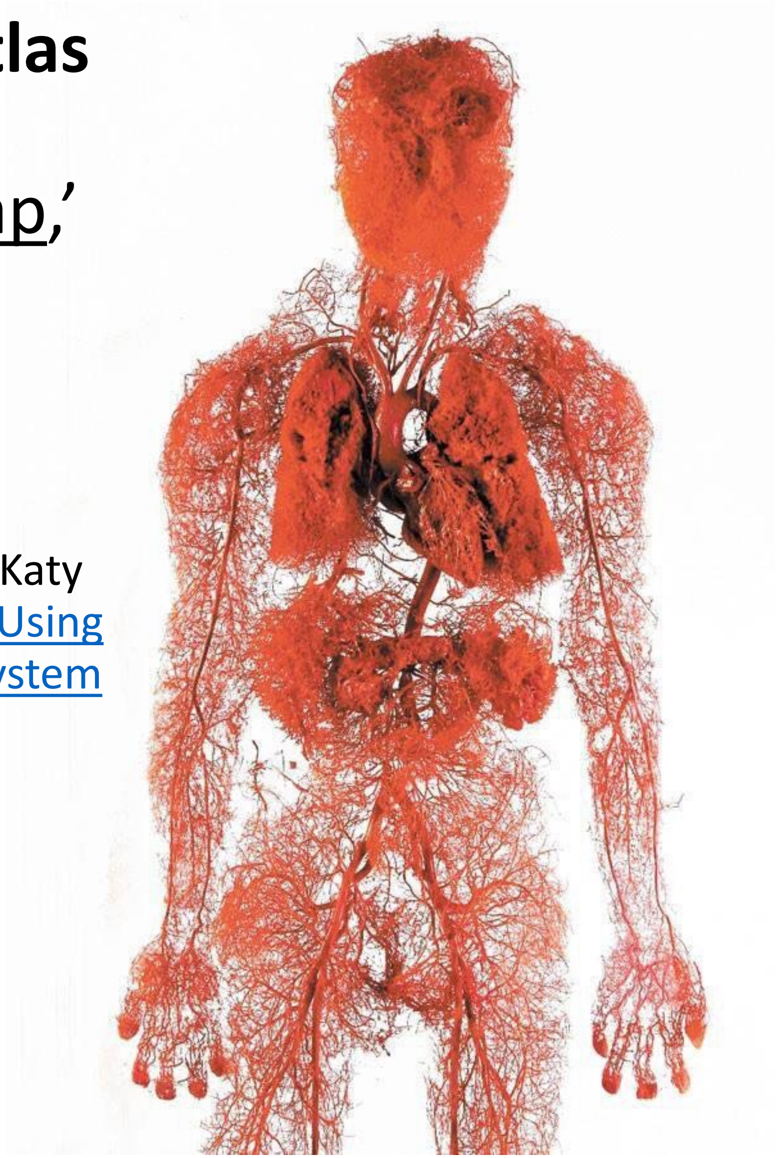
Nature **581**, 303–309(2020) | Cite this article



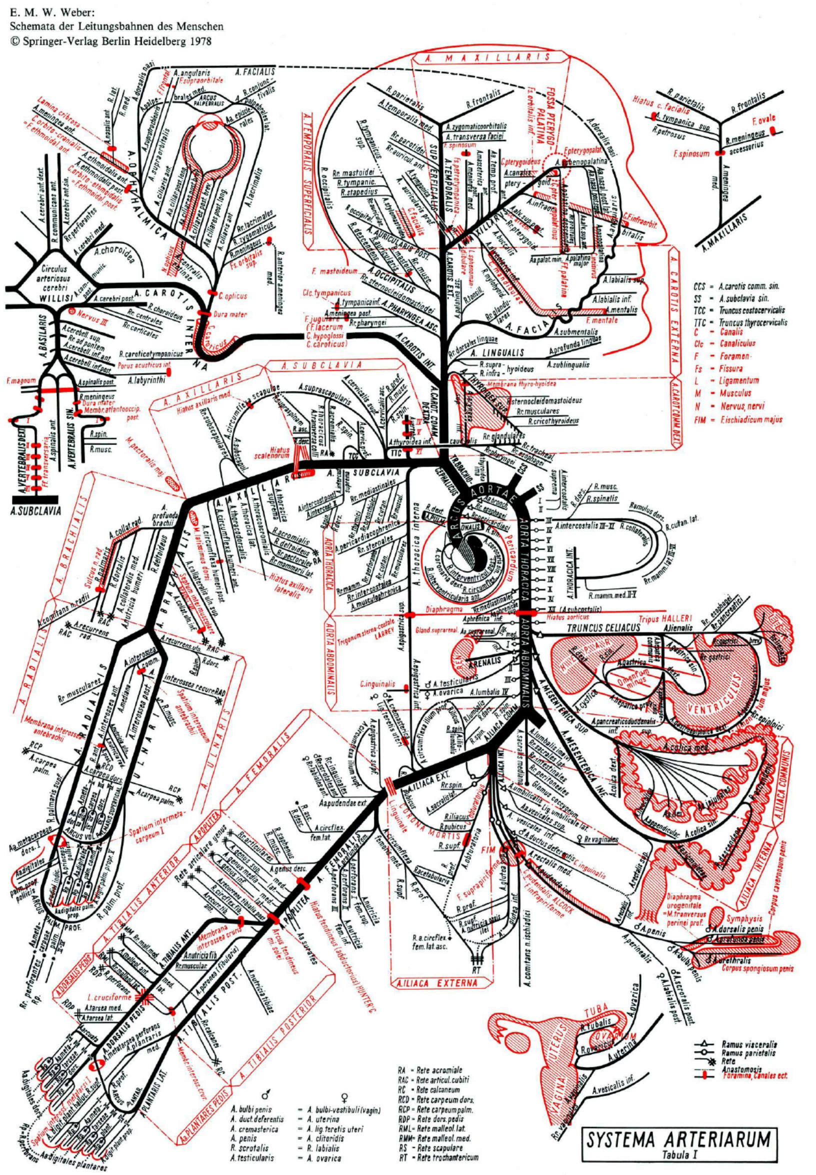
2020 Flashback

A **human reference atlas** might use human anatomy as a ‘basemap,’ or an abstract space.

Weber, Griffin M, Yingnan Ju, and Katy Börner. 2020. "Considerations for Using the Vasculature as a Coordinate System to Map All the Cells in the Human Body". *Frontiers in Cardiovascular Medicine* 7 (29): doi: 10.3389/fcvm.2020.00029.



https://bodyworlds.com

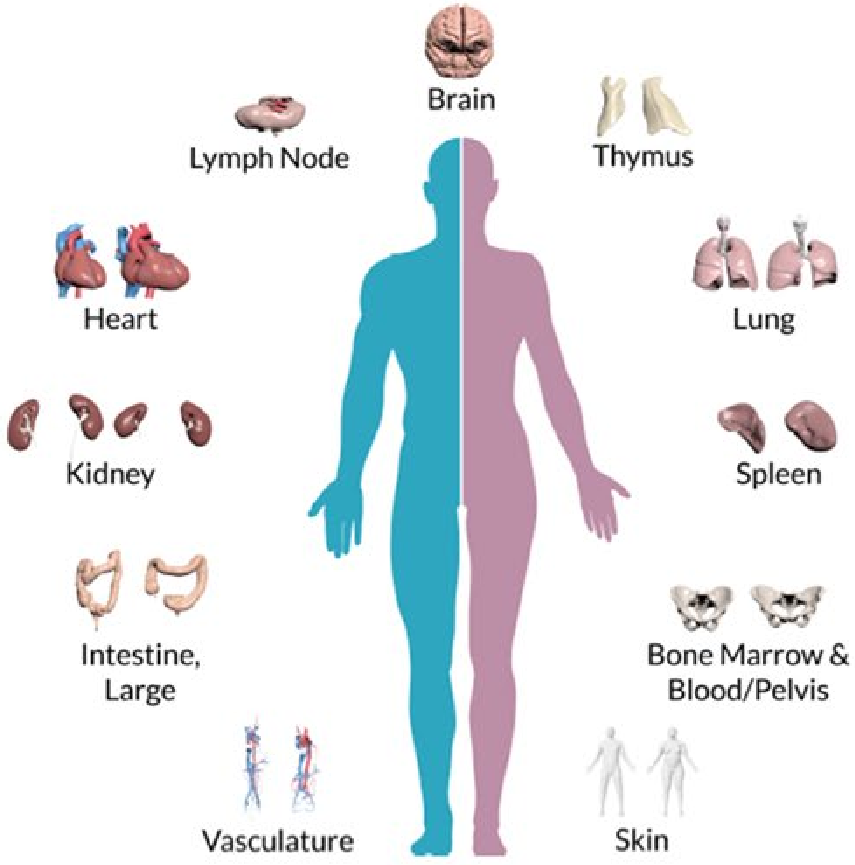


Weber, 1978

2020 Flashback

ASCT+B tables are used to construct a **human reference atlas** across 16 consortia. Register at WG Expert Registration to receive invites/info.

Organ	#AS	#CT	#B Total	#BG	#BP	#AS-AS	#AS-CT	#CT-B
Bone Marrow & Blood/Pelvis	3	46	327	201	126	2	70	710
Brain	187	127	254	254	0	187	127	330
Heart	52	25	48	48	0	61	164	78
Intestine, Large	65	69	94	88	6	389	1,361	197
Kidney	68	63	152	152	0	67	59	257
Lung	161	92	176	172	4	1,633	12,094	286
Lymph Node	41	49	266	108	158	62	135	544
Skin	16	42	70	0	70	17	19	105
Spleen	46	66	255	80	145	68	172	414
Thymus	25	41	511	388	123	38	180	657
Vasculature	870	2	1	1	0	869	606	2
Totals:	1,534	622	2,154	1,492	632	3,393	14,987	3,580

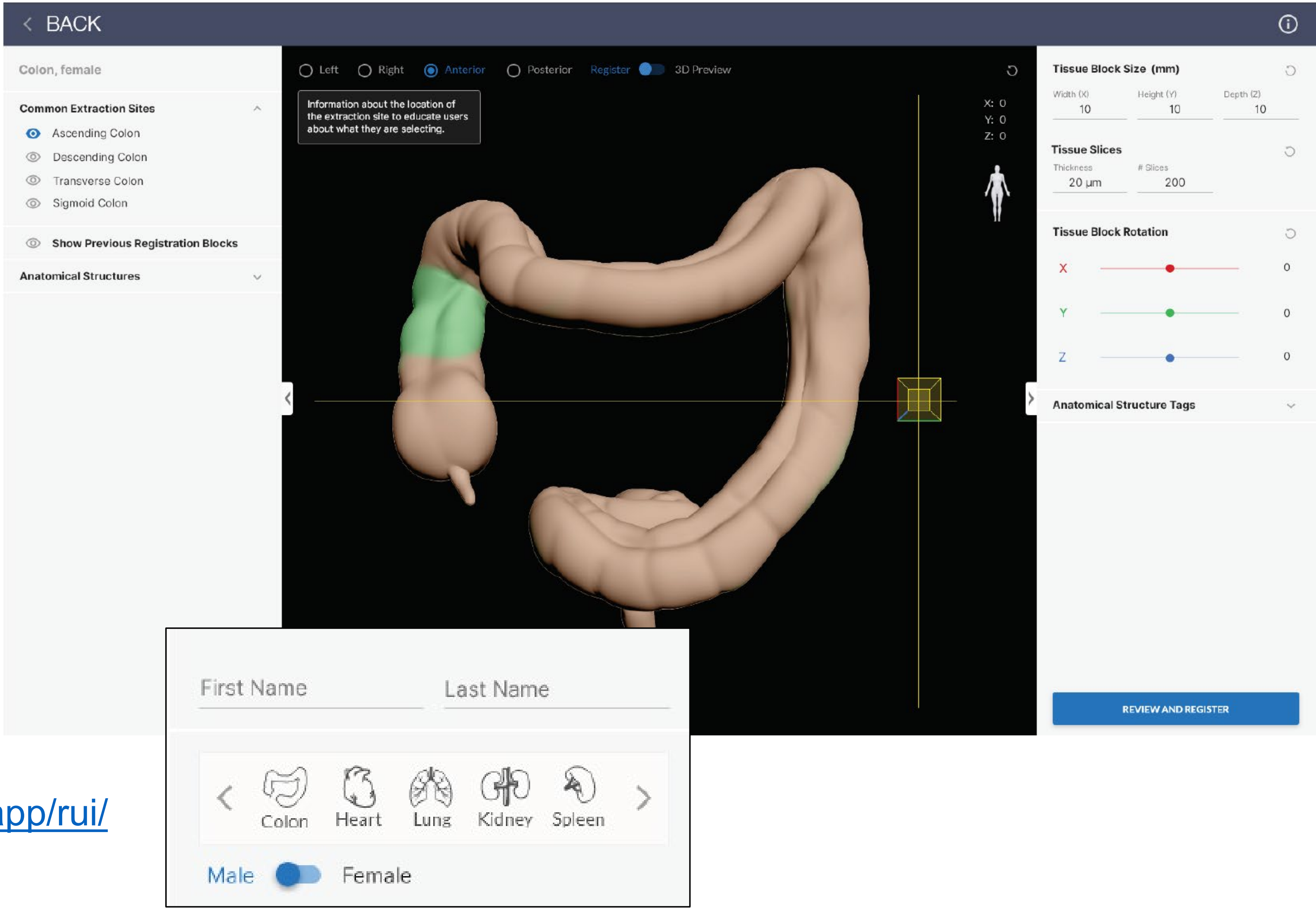


CCF Registration User Interface (RUI) v1.0.0

2020 Flashback

New Features:

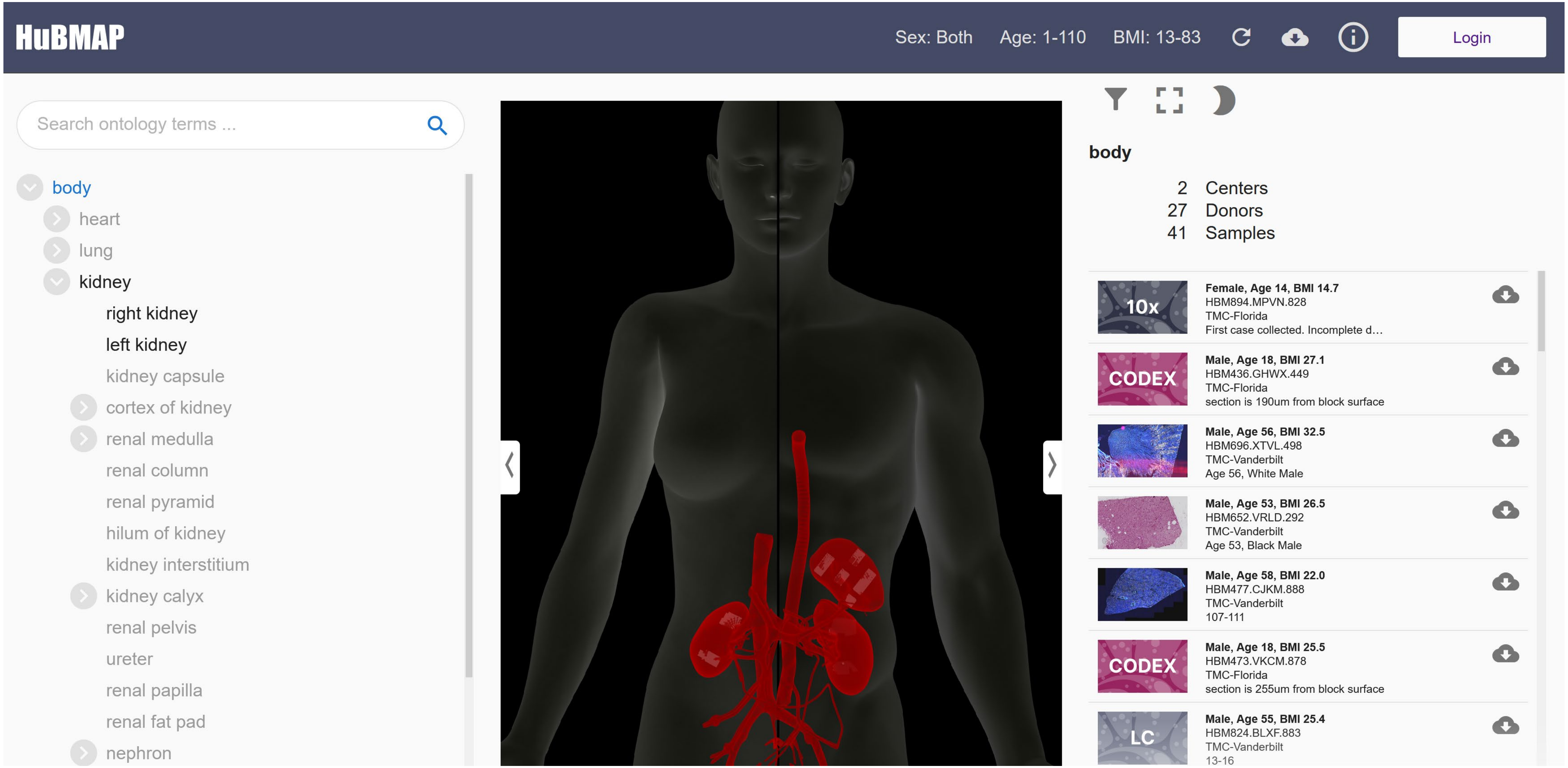
- Organ carousel with 4 reference organs
- Support for tissue extraction sites
- Expanded ontology
- Semantic annotation via collision detection & manual annotation
- Support for non-HuBMAP usage



https://hubmap-ccf-ui.netlify.app/rui/

CCF Exploration User Interface (EUI)

2020 Flashback



https://portal.hubmapconsortium.org/ccf-eui

2020 Flashback

	HuBMAP	RBK	KPMP	SPARC	LungMAP	HTAN	HCA	GUDMAP	Gut Cell Atlas	BICCN	Allen Brain	TCGA	Wellcome	MRC	H2020	GTEx	Total
Kidney	1	1	1	0	0	0	1	1	0	0	0	1	1	1	0	1	9
Liver	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	3
Spleen	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	1	4
Heart	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	1	4
Lung	1	0	0	1	1	1	1	0	0	0	0	1	1	1	1	1	10
L intestine/Colon	1	0	0	1	0	1	1	0	1	0	0	1	0	0	0	1	7
S intestine	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2
Bladder	1	0	0	1	0	0	0	1	0	0	0	1	0	0	0	1	5
Ureters	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	2
Thymus	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	2
Lymph nodes	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	2
mediastinal lymph node	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
Eye	1	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	3
Brain	0	0	0	0	0	0	1	0	0	1	1	1	0	0	1	1	6
Brain stem	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
Cerebellum	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	1	3
Spinal cord	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	2
Pancreas	0	0	0	0	0	1	1	0	0	0	0	1	0	0	1	1	5
Breast	0	0	0	0	0	1	1	0	0	0	0	1	1	0	0	1	5
Skin	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	1	3
Pediatric systems	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	2
Ovaries	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	2
Testes	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	2
Cervix	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
Uterus	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	5
Blood	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	2
Bone	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
Placenta	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
Decidua	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
Embryo	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
esophagus	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	3
hematopoietic system	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	2
immune system bulk	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
Stomach	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	3
Thyroid	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	2
Prostate	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	3
Adrenal gland	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	3
Totals	11	1	1	7	1	6	21	4	1	2	2	20	7	5	4	21	114

Table compiled for, during, and after the NIH-HCA Joint Meeting in March 2020, https://hubmapconsortium.org/nihhca2020

VH Massive Open Online Course (VHMOOC)

2020 Flashback

Goals

- Communicate tissue data acquisition and analysis,
- Demonstrate single-cell analysis and CCF mapping techniques, and
- Introduce major features of the HuBMAP portal.

Learning modules come with

- Videos (incl. interviews, tool demos)
- Hands-on exercises
- Self-quizzes

HuBMAP Visible Human MOOC (VHMOOC)

Started Aug 4, 2020

GO TO CANVAS COURSE

You are enrolled.

INDIANA UNIVERSITY

Course Introduction

This 10h course introduces the HuBMAP project which aims to create an open, global reference atlas of the human body at the cellular level. Among others, the course describes the compilation and coverage of HuBMAP data, demonstrates new single-cell analysis and mapping techniques, and introduces major features of the HuBMAP portal.

Delivered entirely online, all coursework can be completed asynchronously to fit busy schedules. If you have questions or experience issues during registration, please email cnscntr@indiana.edu.

Learning Outcomes

- Theoretical and practical understanding of different single-cell tissue analysis techniques.
- Expertise in single-cell data harmonization used to federate data from different individuals analyzed using different technologies in diverse labs.
- Hands-on skills in the design and usage of semantic ontologies that describe human anatomy, cell types, and biomarkers (e.g., marker genes or proteins).
- Knowledge on the design and usage of a semantically annotated three-dimensional reference system for the healthy human body.
- An understanding of how the HuBMAP reference atlas might be used to understand human health but also to diagnose and treat disease.

Module Topics Include

- HuBMAP Overview: Project Goals, Setup, and Ambitions
- Tissue Data Acquisition and Analysis
- Biomolecular Data Harmonization
- Ontology, 3D Reference Objects, and User Interfaces
- HuBMAP Portal Design and Usage

Meet the Instructors

Katy Börner, Victor H. Yngve Distinguished Professor of Engineering and Information Science. Founding Director of the Cyberinfrastructure for Network Science Center at Indiana University.

Ellen M. Quardokus, staff in the Chemistry Department and research scientist, Cyberinfrastructure for Network Science Center, SICE with expertise in molecular biology, microscopy, anatomy, and interdisciplinary communication.

Andreas Bueckle, PhD Candidate in Information Science, performing research on information visualization, specifically virtual and augmented reality.

Length: 10 hours

Department: Cyberinfrastructure Network Science

Credit: None

Audience: Biomedical students and professionals interested in single-cell tissue analysis and visualization

https://expand.iu.edu/browse/sice/cns/courses/hubmap-visible-human-mooc

CNS Cyberinfrastructure for Network Science Center

Indiana University School of Informatics, Computing, and Engineering

Data Visualization Best Practices

Overview

Mapping Science: An Exhibit

Data Visualization Literacy Framework

Empower Yourself!

CNS Cyberinfrastructure for Network Science Center

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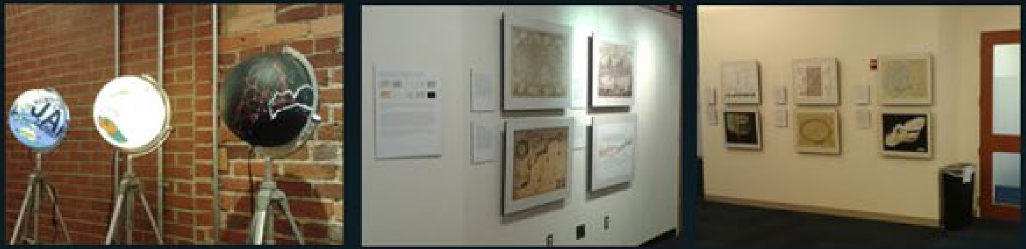
Mapping Science Exhibit

http://scimaps.org

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

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



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

http://scimaps.org

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

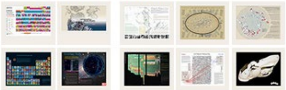
Places & Spaces: Mapping Science Exhibit

1st Decade (2005-2014)

Maps

Iteration I (2005)
The Power of Maps

Iteration II (2006)
The Power of Reference Systems



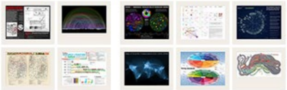
Iteration III (2007)
The Power of Forecasts

Iteration IV (2008)
Science Maps for Economic Decision Makers

Iteration V (2009)
Science Maps for Science Policy Makers

Iteration VI (2010)
Science Maps for Scholars

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



Iteration VIII (2012)
Science Maps for Kids

Iteration IX (2013)
Science Maps Showing Trends and Dynamics

Iteration X (2014)
The Future of Science Mapping

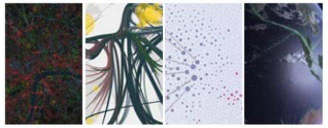
2nd Decade (2015-2024)

Macroscopes

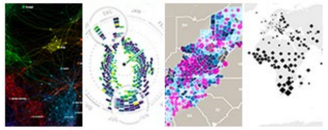
Iteration XI (2015)
Macroscopes for Interacting with Science

Iteration XIII (2017)
Macroscopes for Playing with Scale

Iteration XII (2016)
Macroscopes for Making Sense of Science



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



100
MAPS
in large format, full color, and high resolution.

248
MAPMAKERS
from fields as disparate as art, urban planning, engineering, and the history of science.

43
MACROSCOPE MAKERS
including one whose job title is "Truth and Beauty Operator."

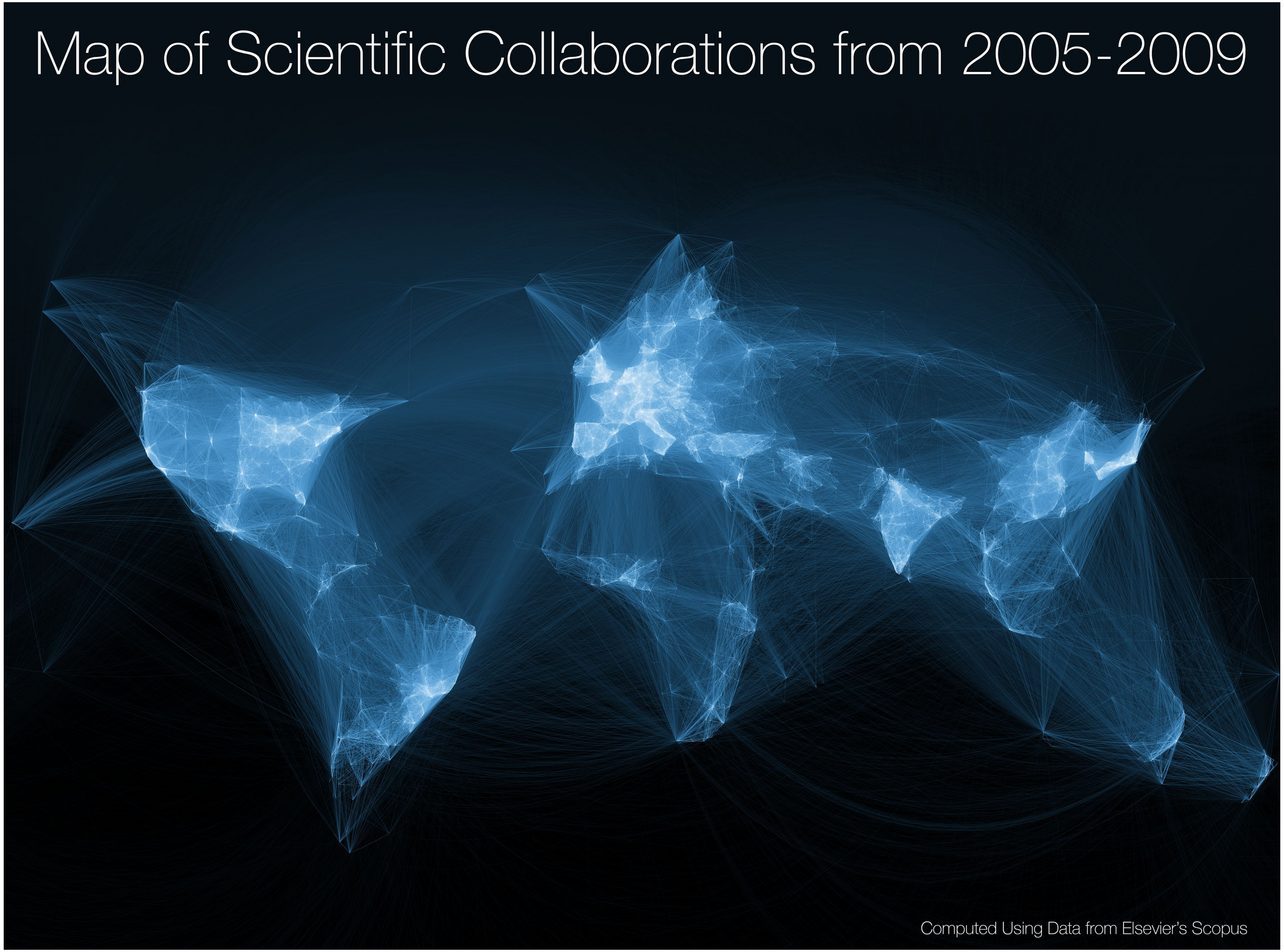
20
MACROSCOPES
for touching all kinds of data.

382
DISPLAY VENUES
from the Cannes Film Festival to the World Economic Forum.

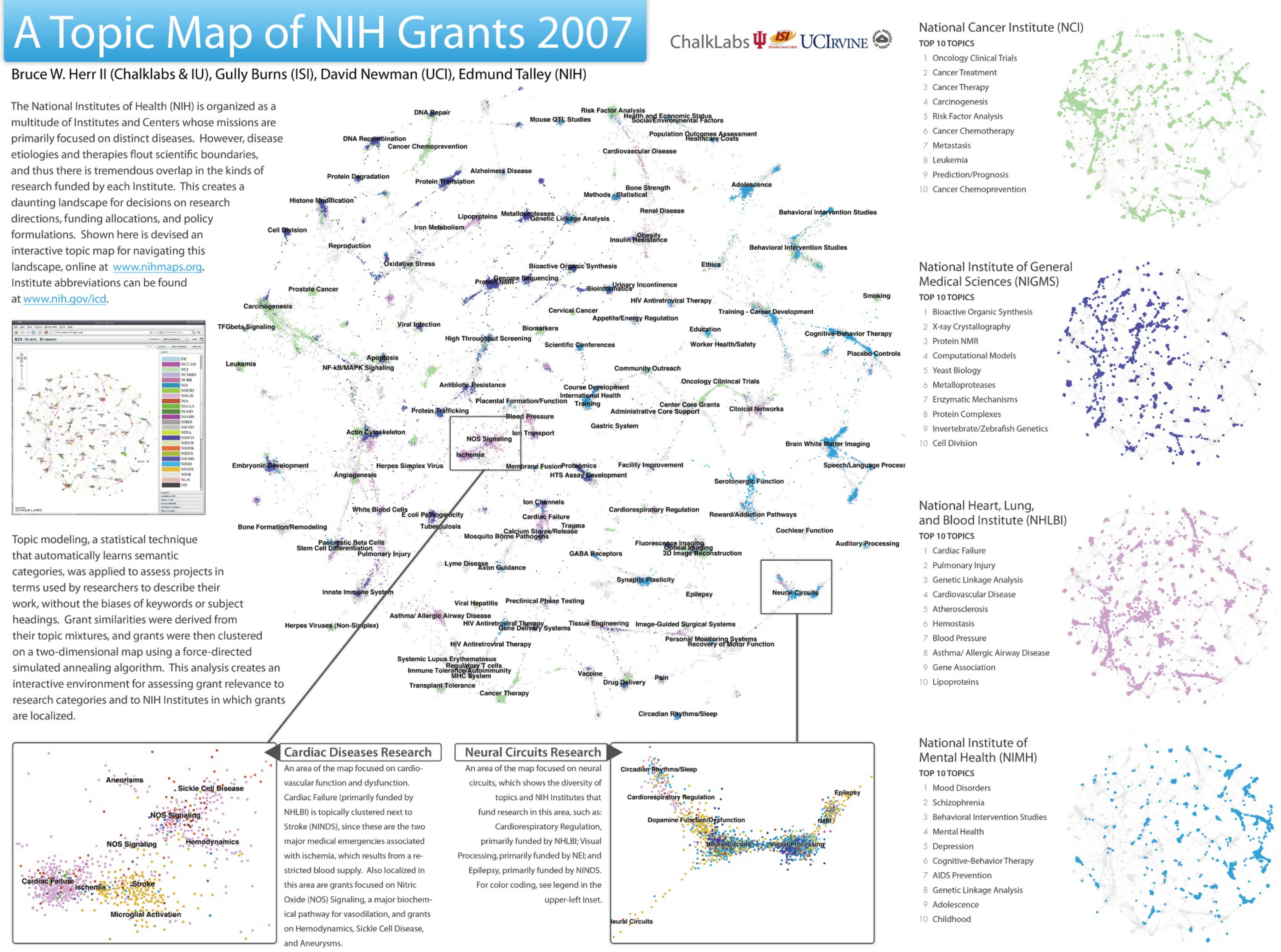
354
PRESS ITEMS
including articles in *Nature*, *Science*, *USA Today*, and *Wired*.

http://scimaps.org

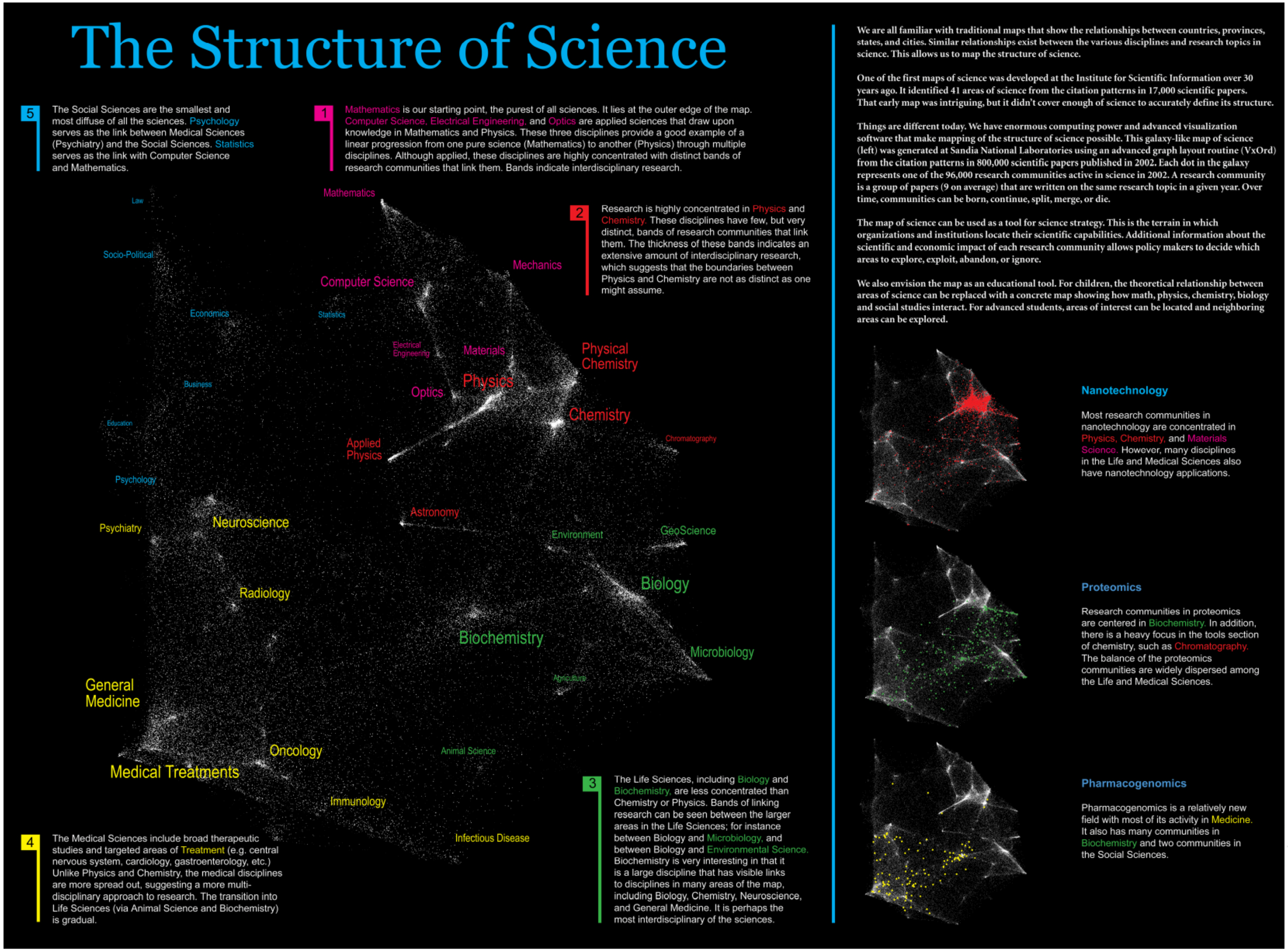
CNS Cyberinfrastructure for Network Science Center



VII.6 Stream of Scientific Collaborations Between World Cities - Olivier H. Beauchesne - 2012



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



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

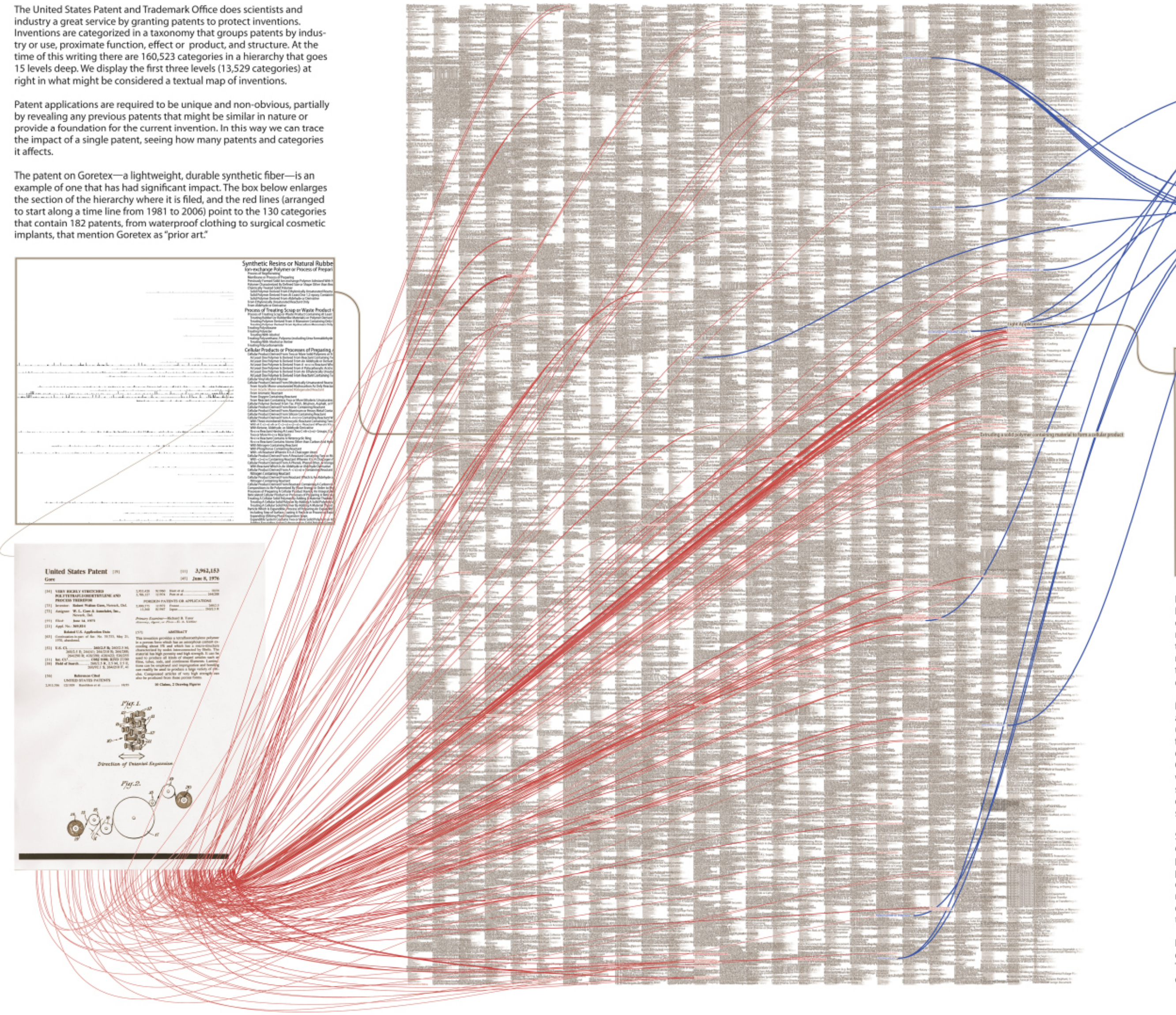
The US Patent Hierarchy

Impact

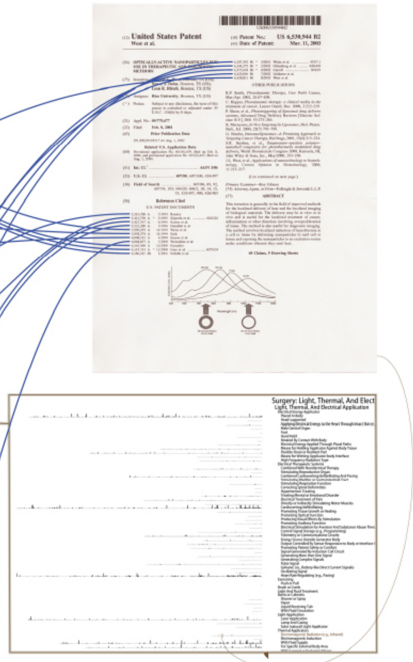
The United States Patent and Trademark Office does scientists and industry a great service by granting patents to protect inventions. Inventions are categorized in a taxonomy that groups patents by industry or use, proximate function, effect or product, and structure. At the time of this writing there are 160,523 categories in a hierarchy that goes 15 levels deep. We display the first three levels (13,529 categories) at right in what might be considered a textual map of inventions.

Patent applications are required to be unique and non-obvious, partially by revealing any previous patents that might be similar in nature or provide a foundation for the current invention. In this way we can trace the impact of a single patent, seeing how many patents and categories it affects.

The patent on Goretex—a lightweight, durable synthetic fiber—is an example of one that has had significant impact. The box below enlarges the section of the hierarchy where it is filed, and the red lines (arranged to start along a time line from 1981 to 2006) point to the 130 categories that contain 182 patents, from waterproof clothing to surgical cosmetic implants, that mention Goretex as "prior art."



Prior Art



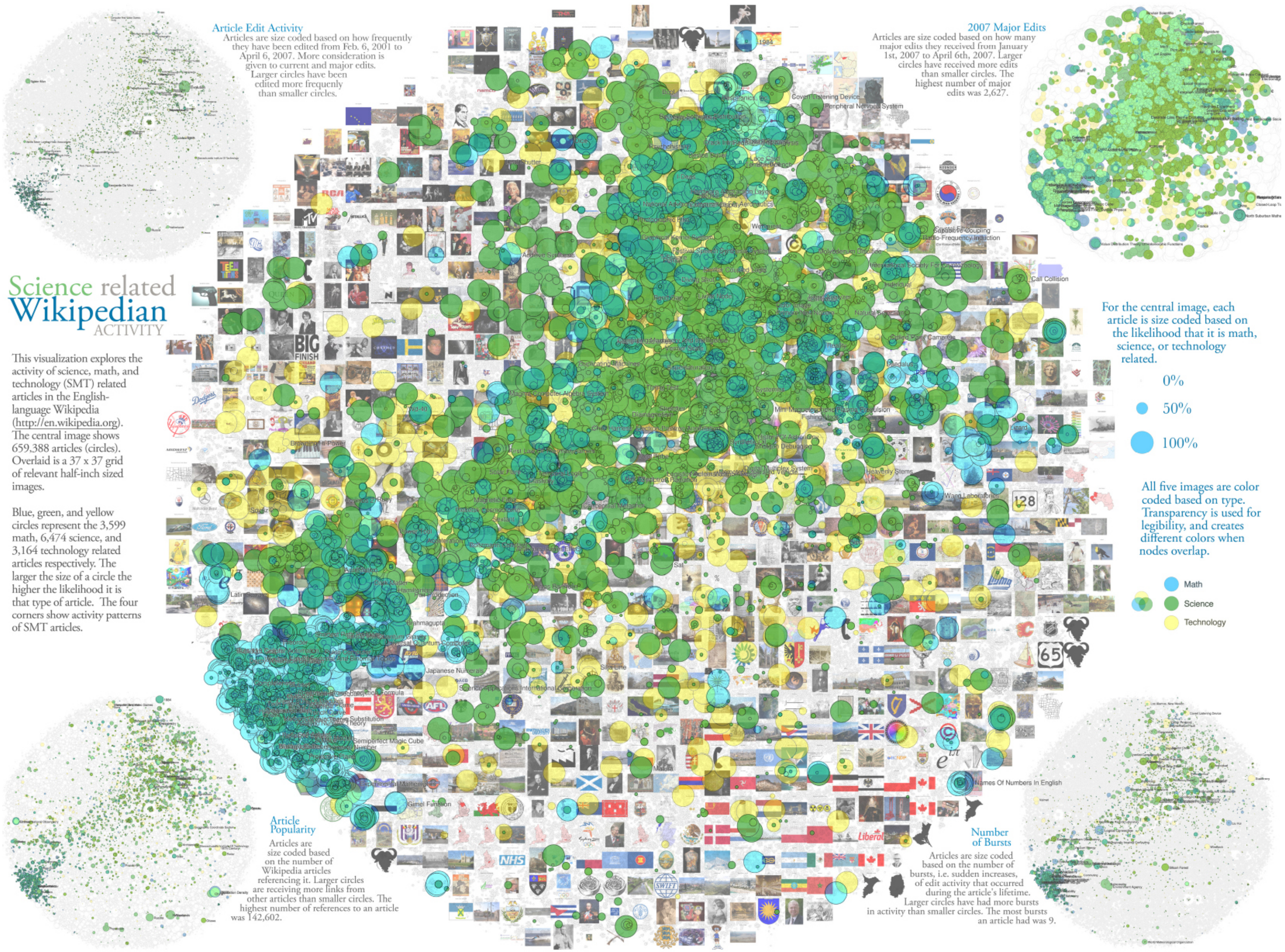
New patents often build on older ideas from many different categories. Here, blue lines originate in the sixteen categories that contain patents cited as prior art for a patent on "gold nanoshells." Gold nanoshells are a new invention: tiny gold spheres (with a diameter ten million times smaller than a human hair) that can be used to make tumors more visible in infrared scans; they have even helped cause complete remission of tumors in tests with laboratory mice. The blue lines show that widely separated categories provided background for this invention.

Keeping categories understandable is an important part of maintaining any taxonomy, including the patent hierarchy. Categories are easier to understand, search, and maintain if they contain elements that comfortably fit the definition of the category. The box above shows tiny bar charts, part of a *Taxonomy Validator* that reveals whether elements fit their categories. Categories may need to be redefined, and sometimes need to be split when they get too vague or large; a problem shared by many classification systems in this information-rich century. But how can we tell which ones to eliminate, add or revise—or how to revise them—in the complex, abstract sociolinguistic spaces we partition into ontologies?

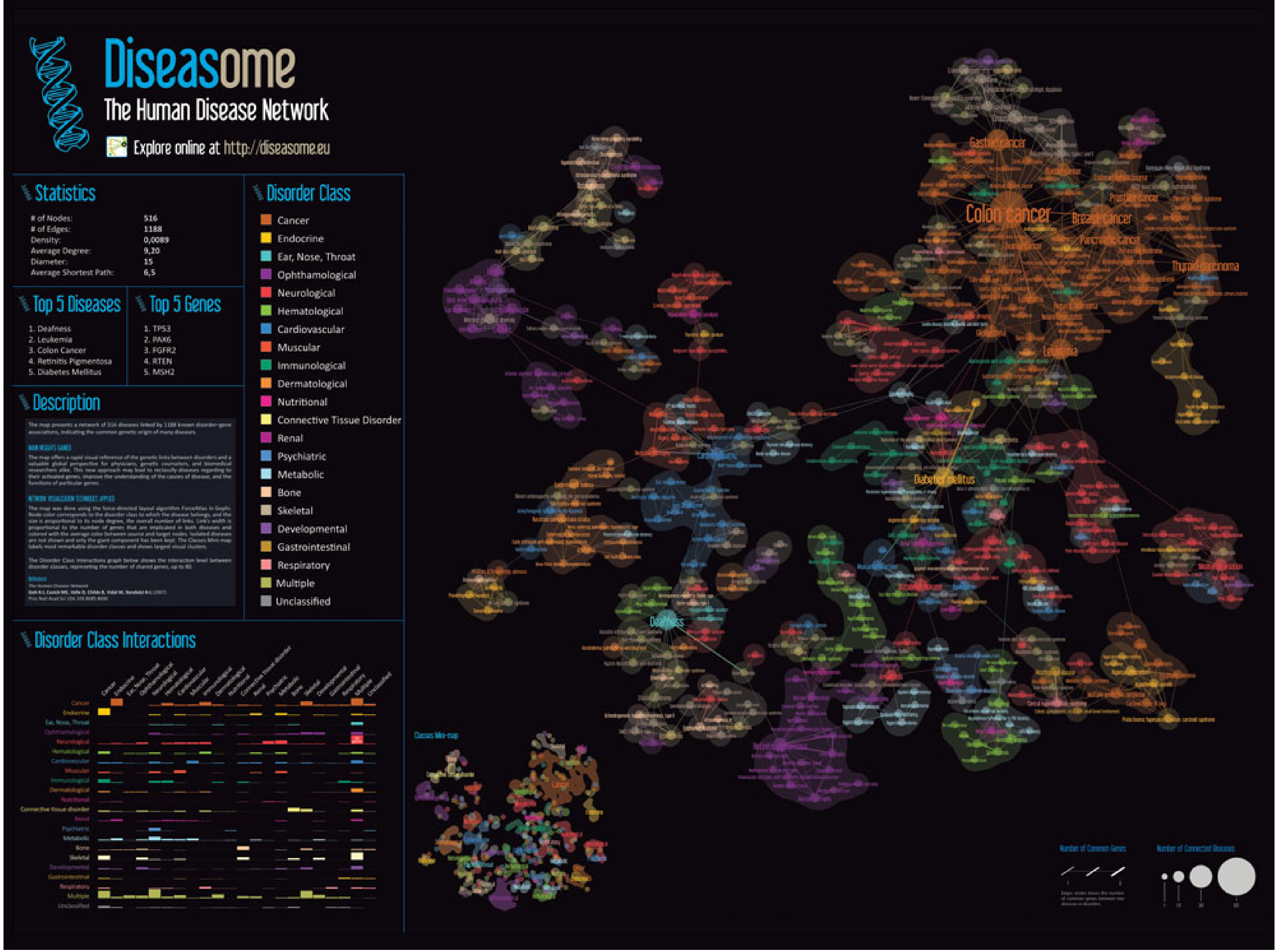
Something as simple as a bar chart helps people see how entities in a category relate to that category. Here, each bar encodes a "distance to prototype": how much each patent differs from an idealized "prototype patent" for that category. A measure like this can be based on statistics, computational linguistics, or even human insight. Thus a category with mostly small bars is a good one, and a generally ragged one needs scrutiny or reorganization; but one that has only two or three tall bars may mean that only those few elements don't belong.

Even simple visuals can make thinking easier by providing better distilled data to the eye: vastly more data than working memory can hold as words. They focus people on exactly the right issues, and support them with the comprehensive overviews they need to make more informed judgements.

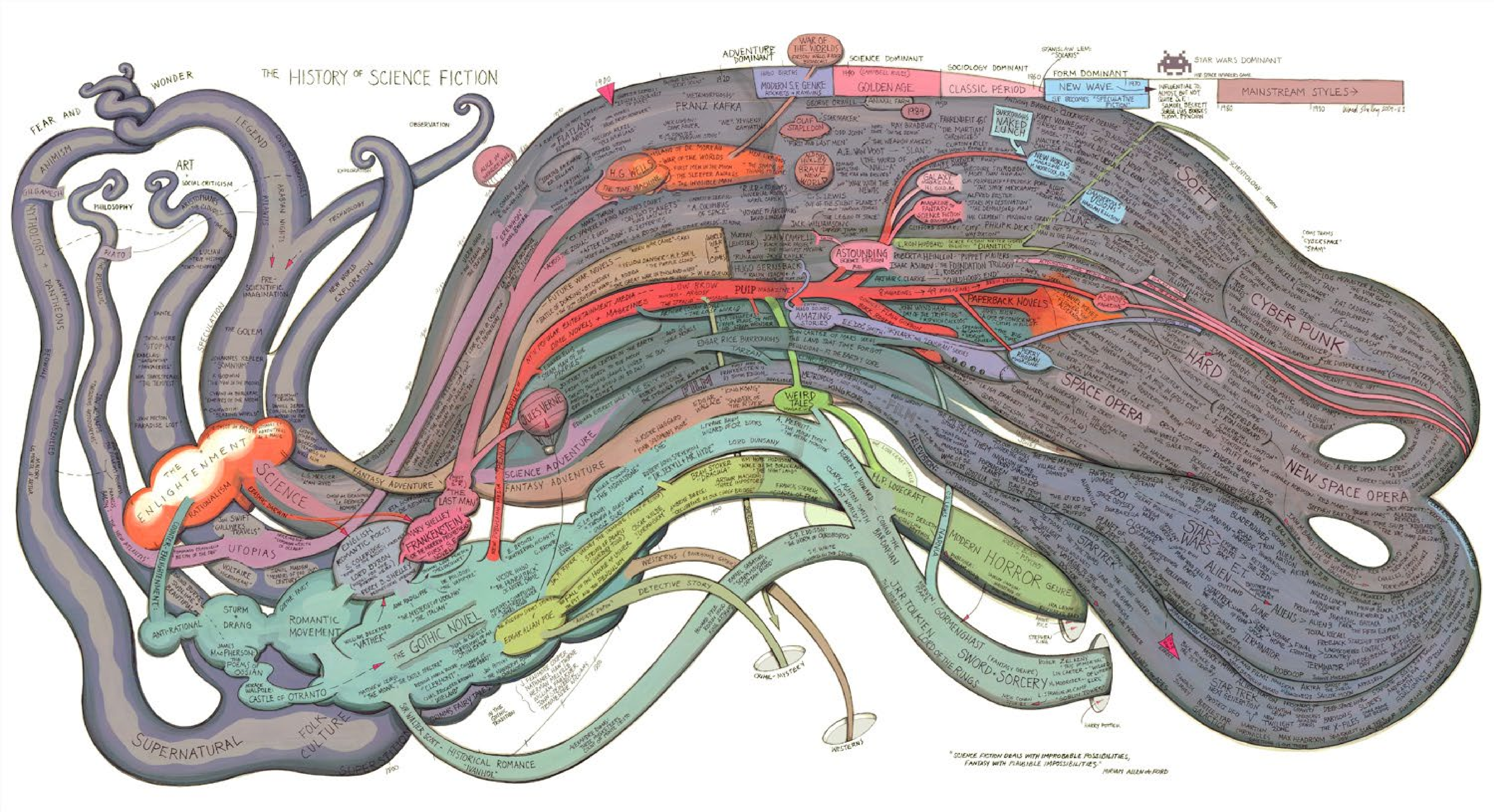
II.8 *Taxonomy Visualization of Patent Data* - Katy Börner, Elisha F. Hardy, Bruce W. Herr II, Todd Holloway, and W. Bradford Paley - 2006



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

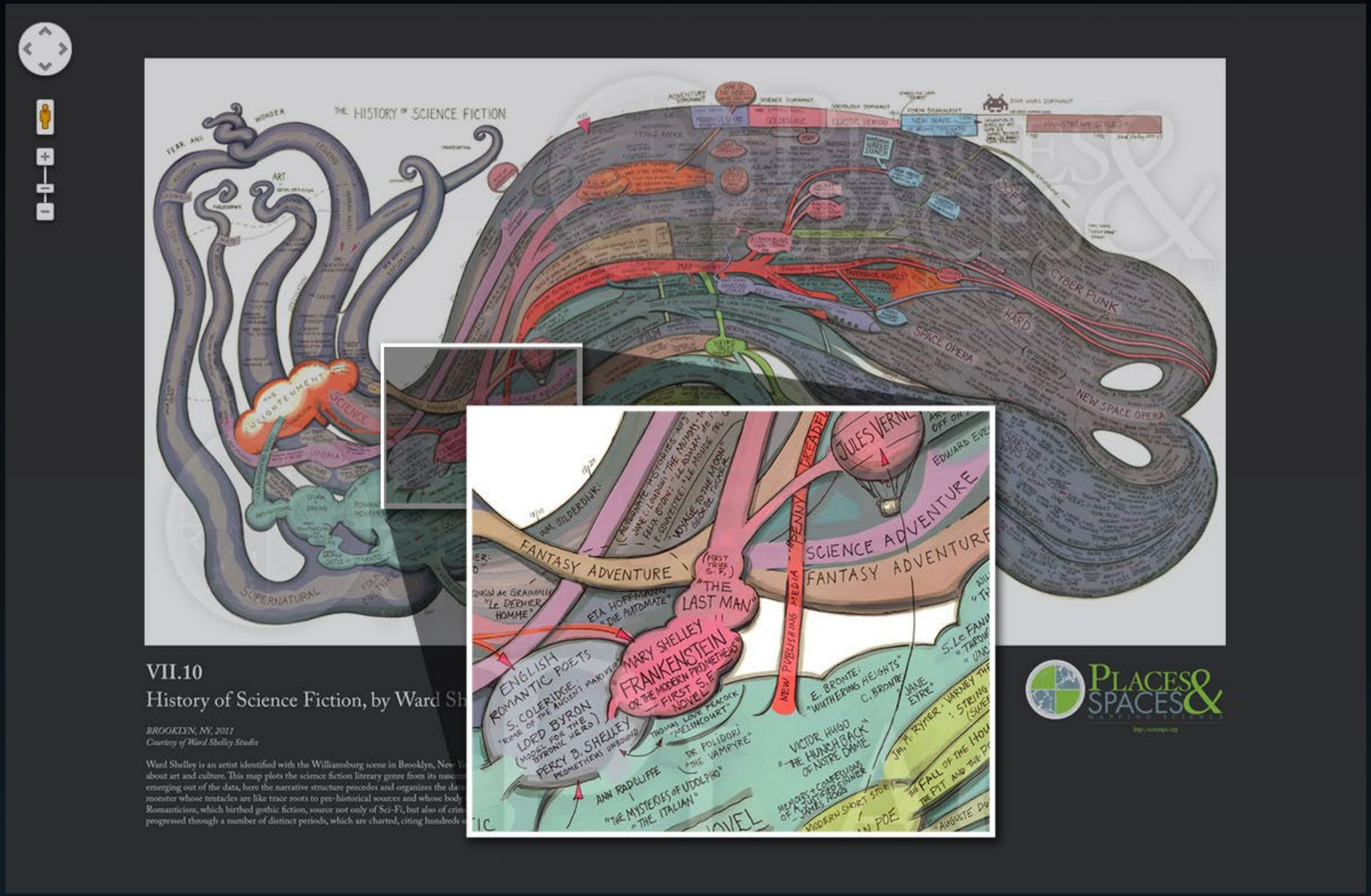


VI.3 *Diseasome: The Human Disease Network* - Mathieu Bastian and Sébastien Heymann - 2009



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

Check out our Zoom Maps online!



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MACROSCOPES FOR INTERACTING WITH SCIENCE
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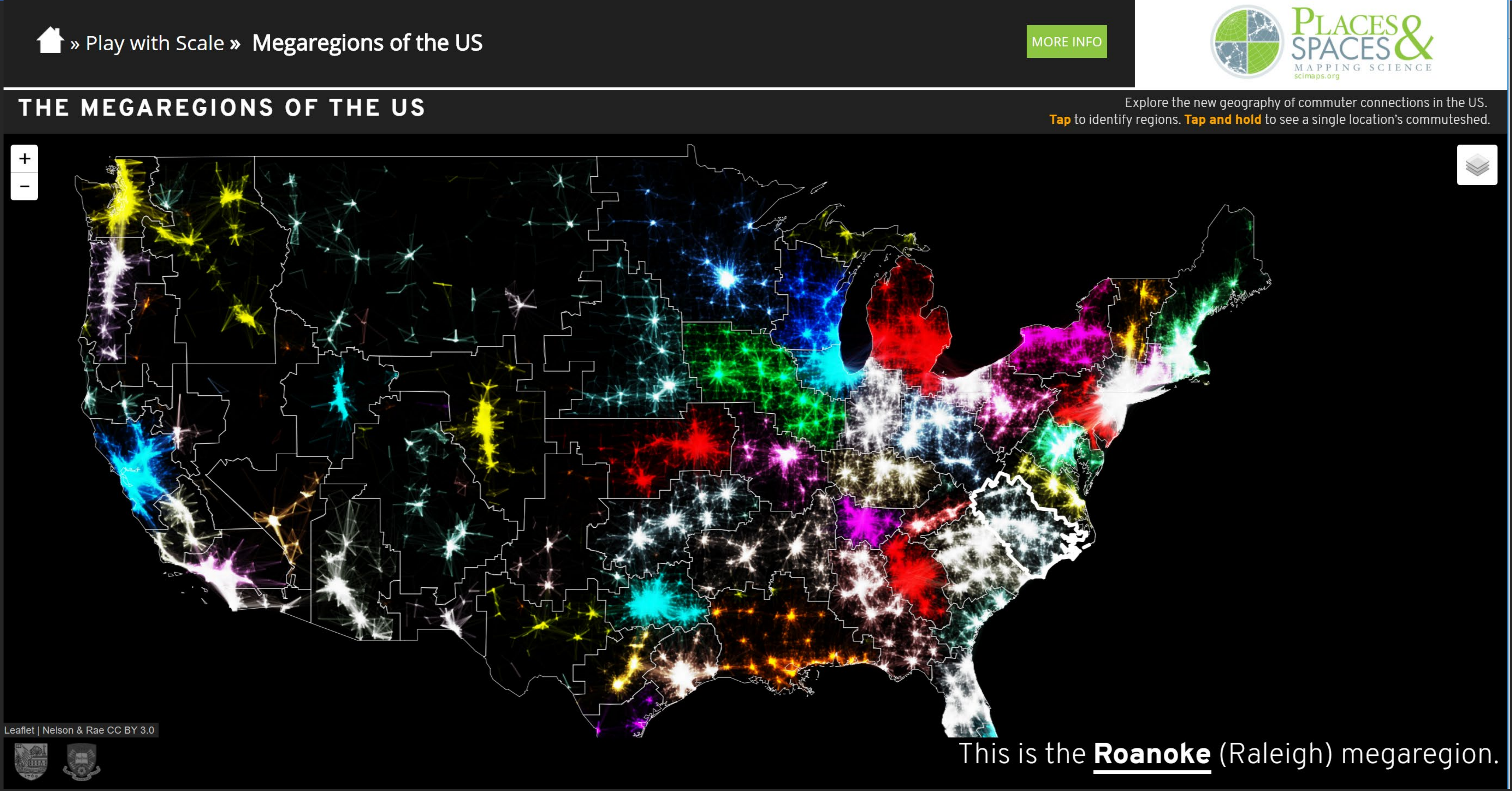
Earth
Weather on a worldwide scale
AcademyScope
Exploring the scientific landscape
Mapping Global Society
Local news from a global perspective
Charting Culture
2,600 years of human history in 5 minutes

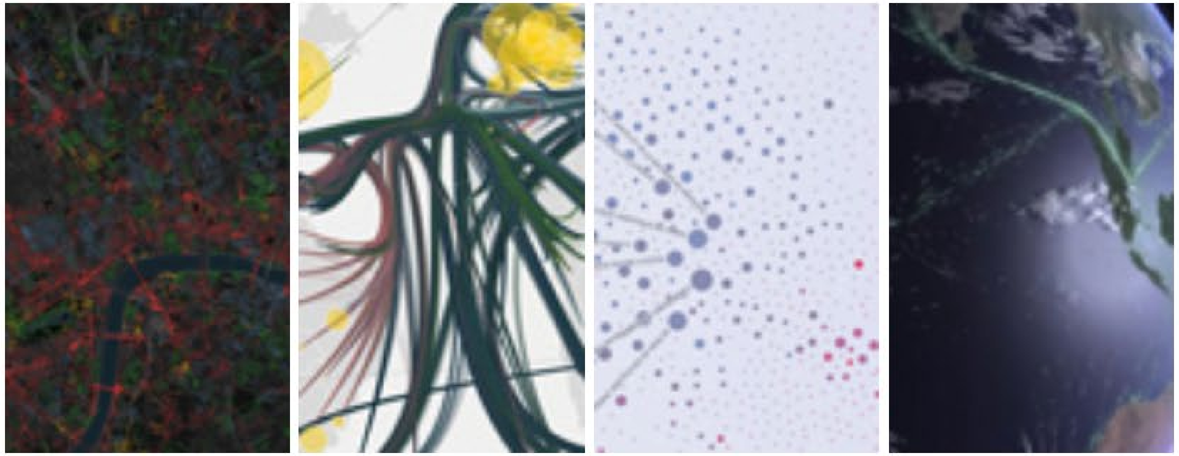


Megaregions of the US –Garrett Dash Nelson and Alasdair Rae – 2016

Smelly Maps – Daniele Quercia, Rossano Schifanella, and Luca Maria Aiello – 2015

Iteration XII (2016)

Macroscopes for Making Sense of Science

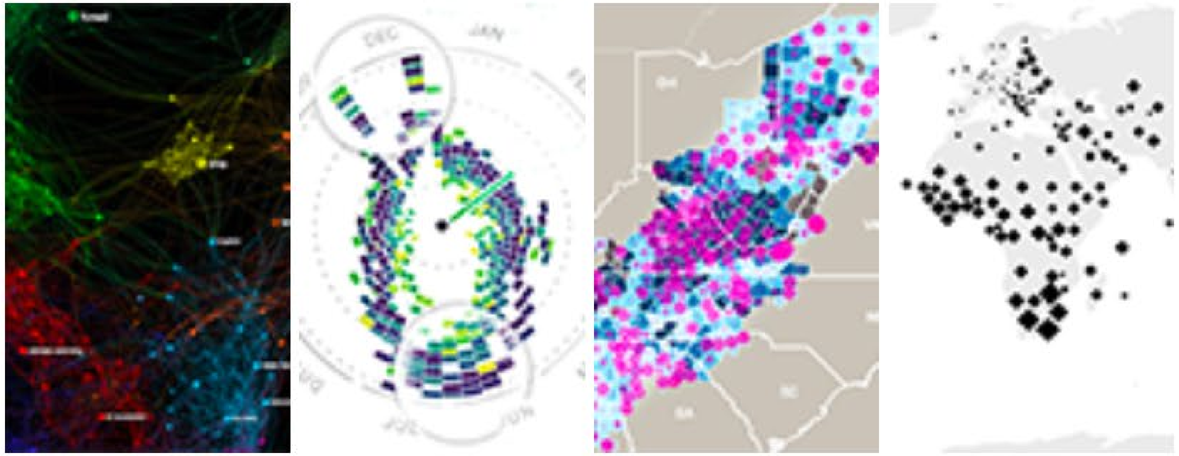


Iteration XIII (2017)

Macroscopes for Playing with Scale

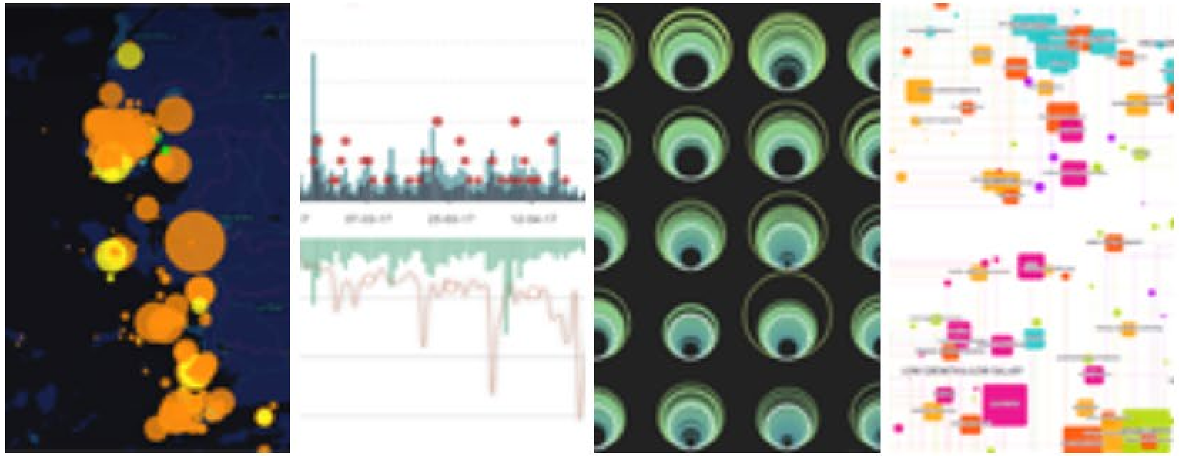
Iteration XIV (2018)

Macroscopes for Ensuring our Well-being

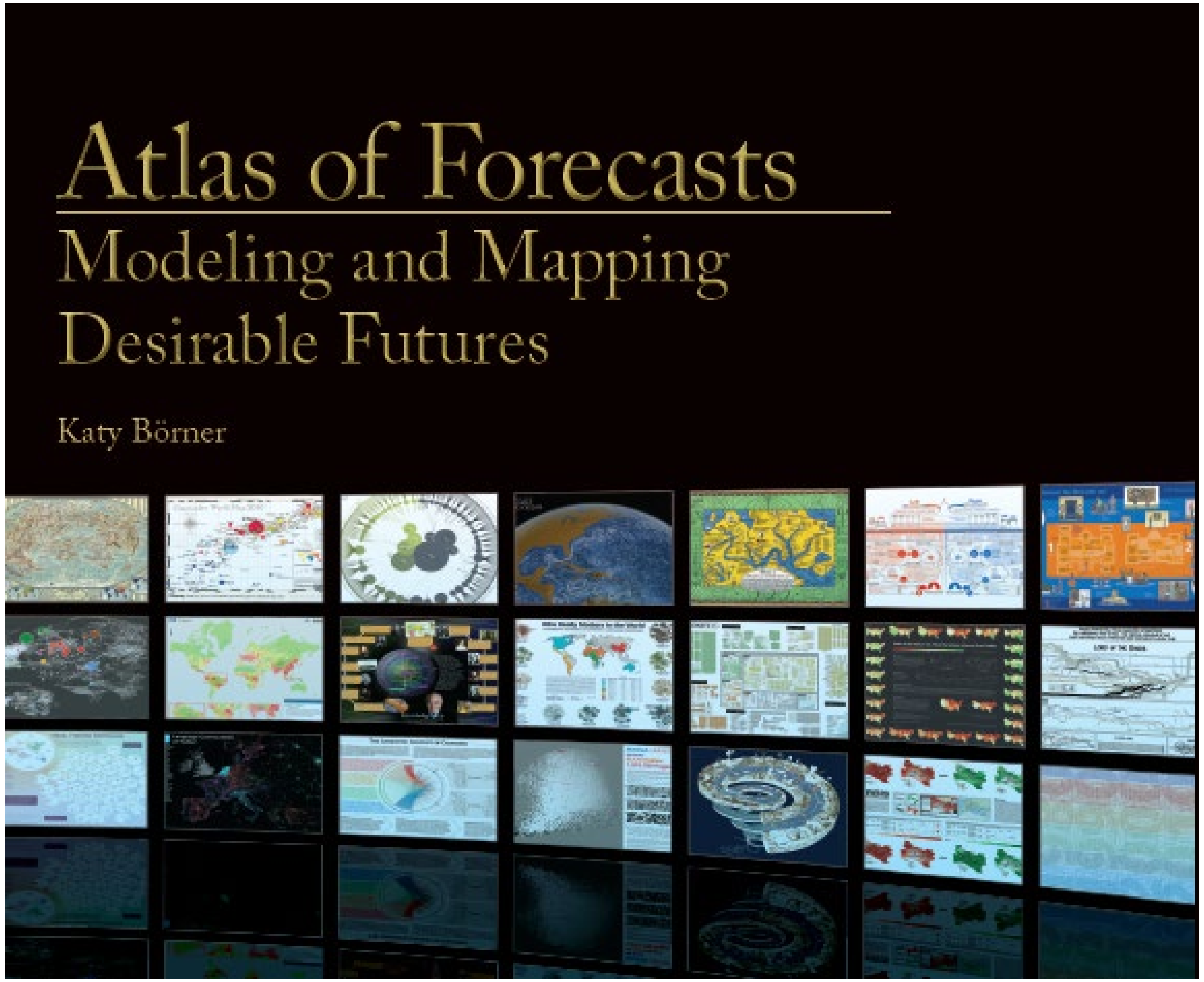


Iteration XV (2019)

Macroscopes for Tracking the Flow of Resources



https://www.pnas.org/modeling



https://mitpress.mit.edu/books/atlas-forecasts

Acknowledgments

Exhibit Curators

The exhibit team: Lisel Record, Katy Börner, and Todd Theriault.

http://scimaps.org

Plus, we thank the more than 250 authors of the 100 maps and 16 interactive macroscopes.

Exhibit Advisory Board

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Data Visualization Literacy Framework

Börner, Katy, Andreas Bueckle, and Michael Ginda. 2019. Data visualization literacy: Definitions, conceptual frameworks, exercises, and assessments. *PNAS*, 116 (6) 1857-1864.

Data Visualization Literacy (DVL)

Data visualization literacy (ability to read, make, and explain data visualizations) requires:

- literacy (ability to read and write text in titles, axis labels, legends, etc.),
- visual literacy (ability to find, interpret, evaluate, use, and create images and visual media), and
- mathematical literacy (ability to formulate, employ, and interpret math in a variety of contexts).

Being able to “read and write” data visualizations is becoming as important as being able to read and write text. Understanding, measuring, and improving data and visualization literacy is important to strategically approach local and global issues.

DVL Framework: Desirable Properties

- Most existing frameworks focus on **READING**. We believe that much expertise is gained from also **CONSTRUCTING** data visualizations.
- Reading and constructing data visualizations needs to take human perception and cognition into account.
- Frameworks should build on and consolidate prior work in cartography, psychology, cognitive science, statistics, scientific visualization, data visualization, learning sciences, etc. in support of a de facto standard.
- Theoretically grounded + practically useful + easy to learn/use.
- Highly modular and extendable.

DVL Framework: Development Process

- The initial DVL-FW was developed via an extensive literature review.
- The resulting DVL-FW typology, process model, exercises, and assessments were then tested in the *Information Visualization* course taught for more than 17 years at Indiana University. More than 8,500 students enrolled in the IVMOOC version (http://ivmooc.cns.iu.edu) over the last six years.
- The FW was further refined using feedback gained from constructing and interpreting data visualizations for 100+ real-world client projects.
- Data on student engagement, performance, and feedback guided the continuous improvement of the DVL-FW typology, process model, and exercises for defining, teaching, and assessing DVL.
- The DVL-FW used in this course supports the systematic construction and interpretation of data visualizations.

Data Visualization Literacy Framework (DVL-FW)

Consists of two parts:

DVL Typology

Defines 7 types with 4-17 members each.

1 **Insight Needs**
- categorize/cluster
- order/rank/sort
- distributions (also outliers, gaps)
- comparisons
- trends (process and time)
- geospatial
- compositions (also of text)
- correlations/ relationships

2 **Data Scales**
- nominal
- ordinal
- interval
- ratio

3 **Analyses**
- statistical
- temporal
- geospatial
- topical
- relational

4 **Visualizations**
- table
- chart
- graph
- map
- tree
- network

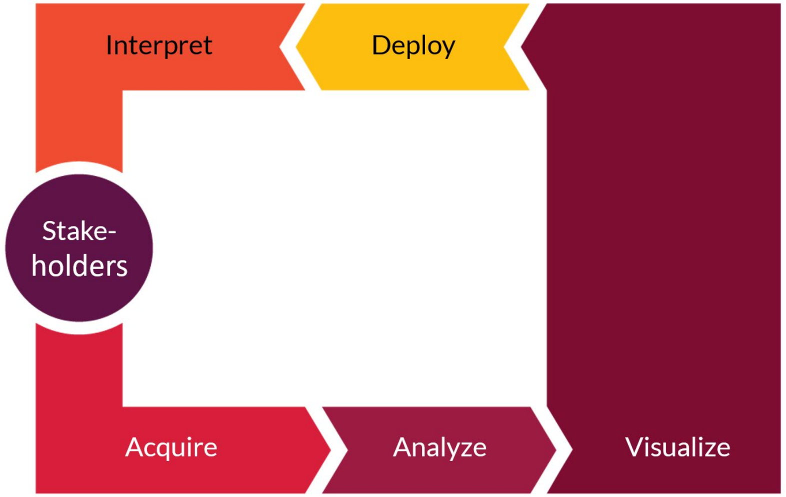
5 **Graphic Symbols**
- geometric symbols
  - point
  - line
  - area
  - surface
  - volume
- linguistic symbols
  - text
  - numerals
  - punctuation marks
- pictorial symbols
  - images
  - icons
  - statistical glyphs

6 **Graphic Variables**
- spatial
  - position
- retinal
  - form
  - color
  - optics
  - motion

7 **Interactions**
- zoom
- search and locate
- filter
- details-on-demand
- history
- extract
- link and brush
- projection
- distortion

DVL Workflow Process

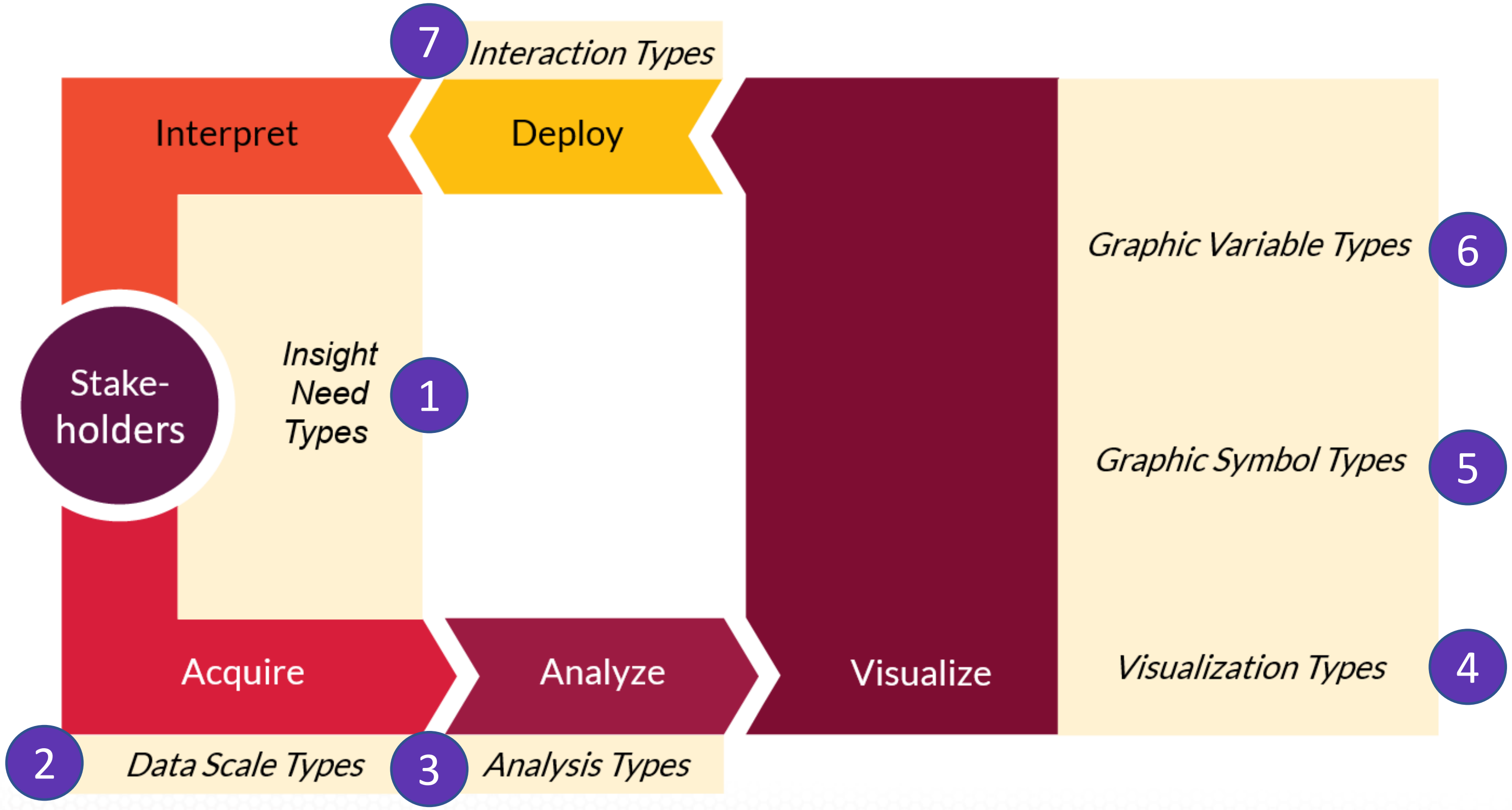
Defines 5 steps required to render data into insights.

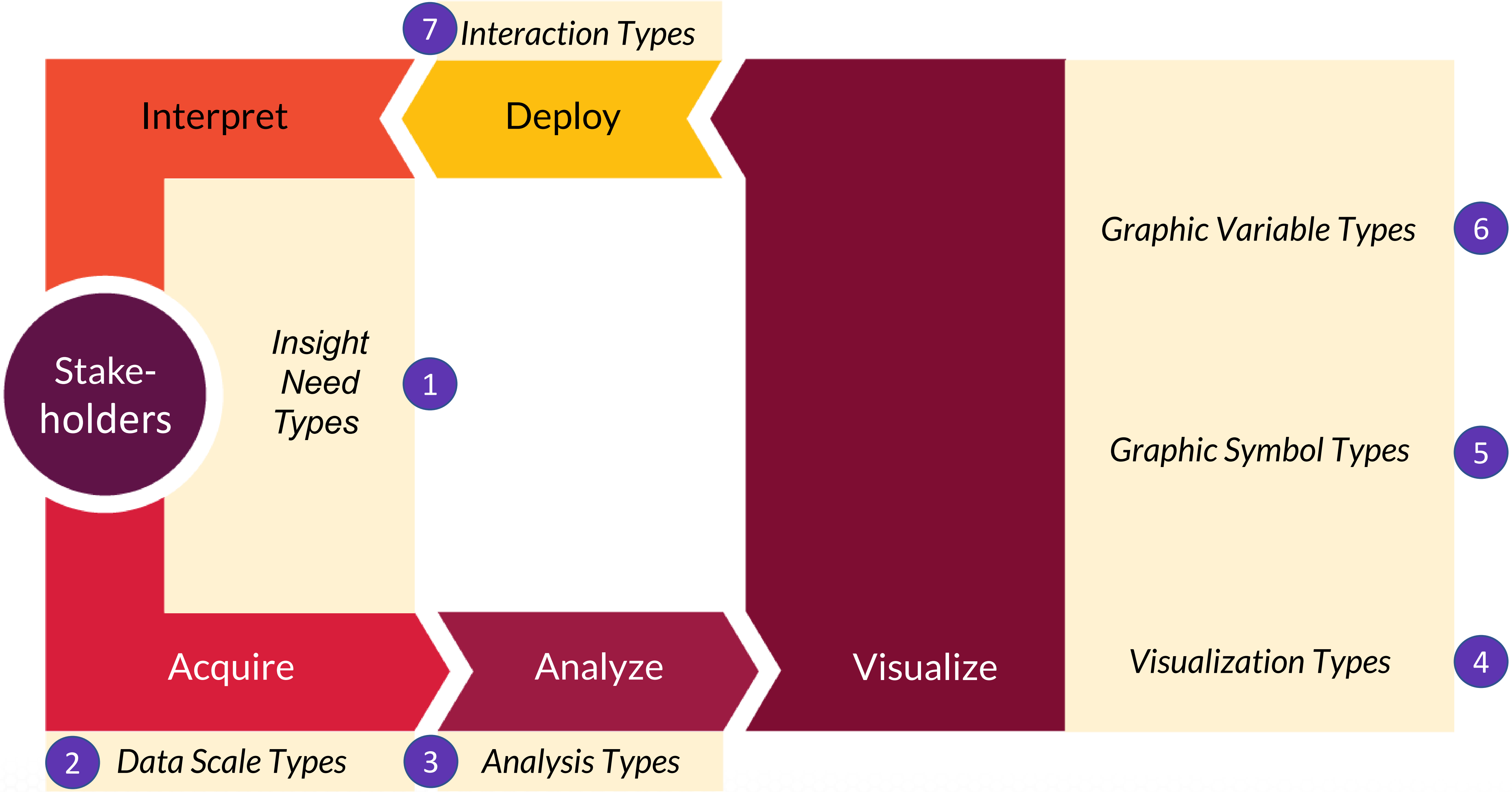


Data Visualization Literacy Framework (DVL-FW)

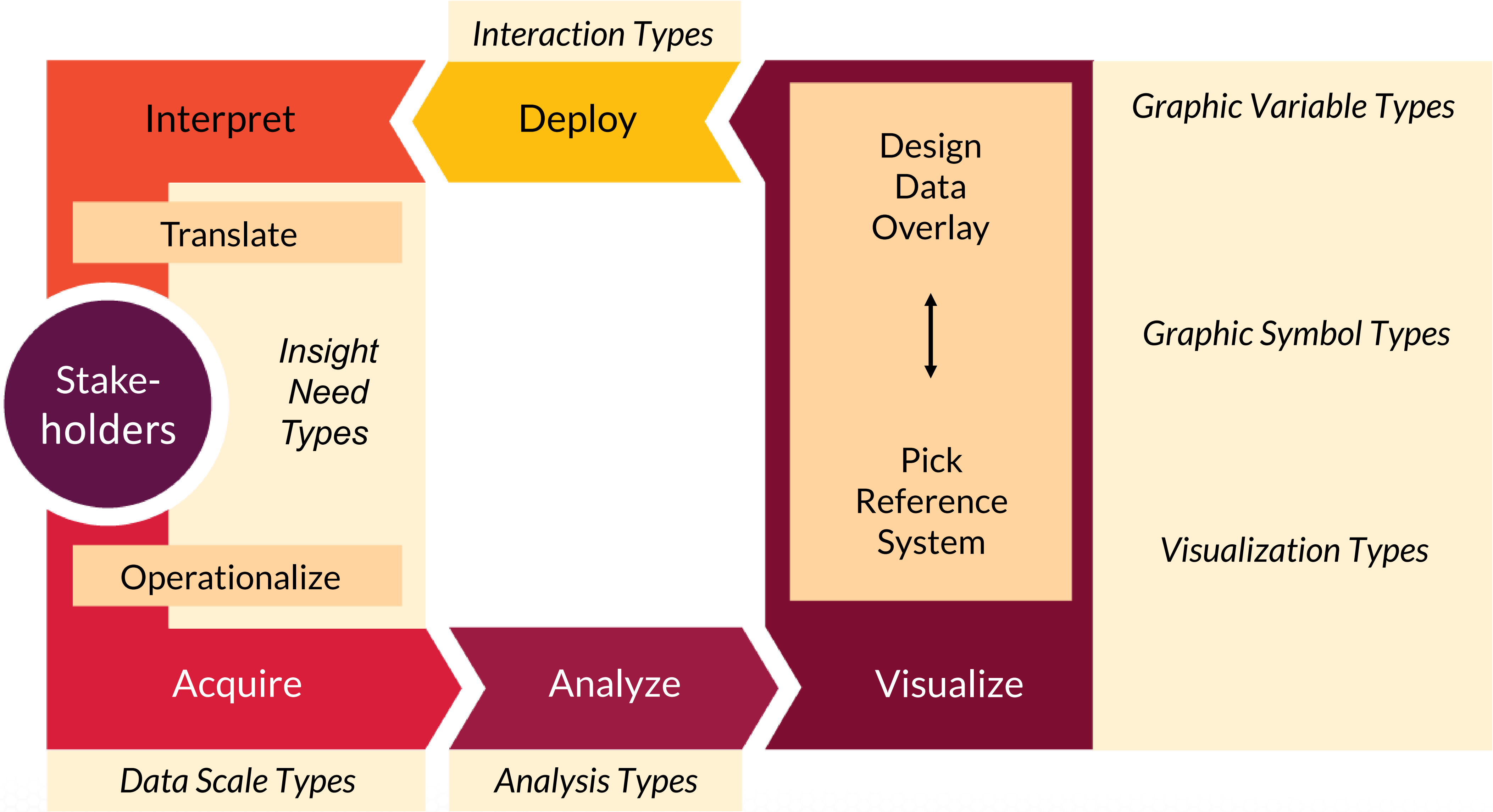
Consists of two parts that are interlinked:

DVL Typology +
DVL Workflow Process

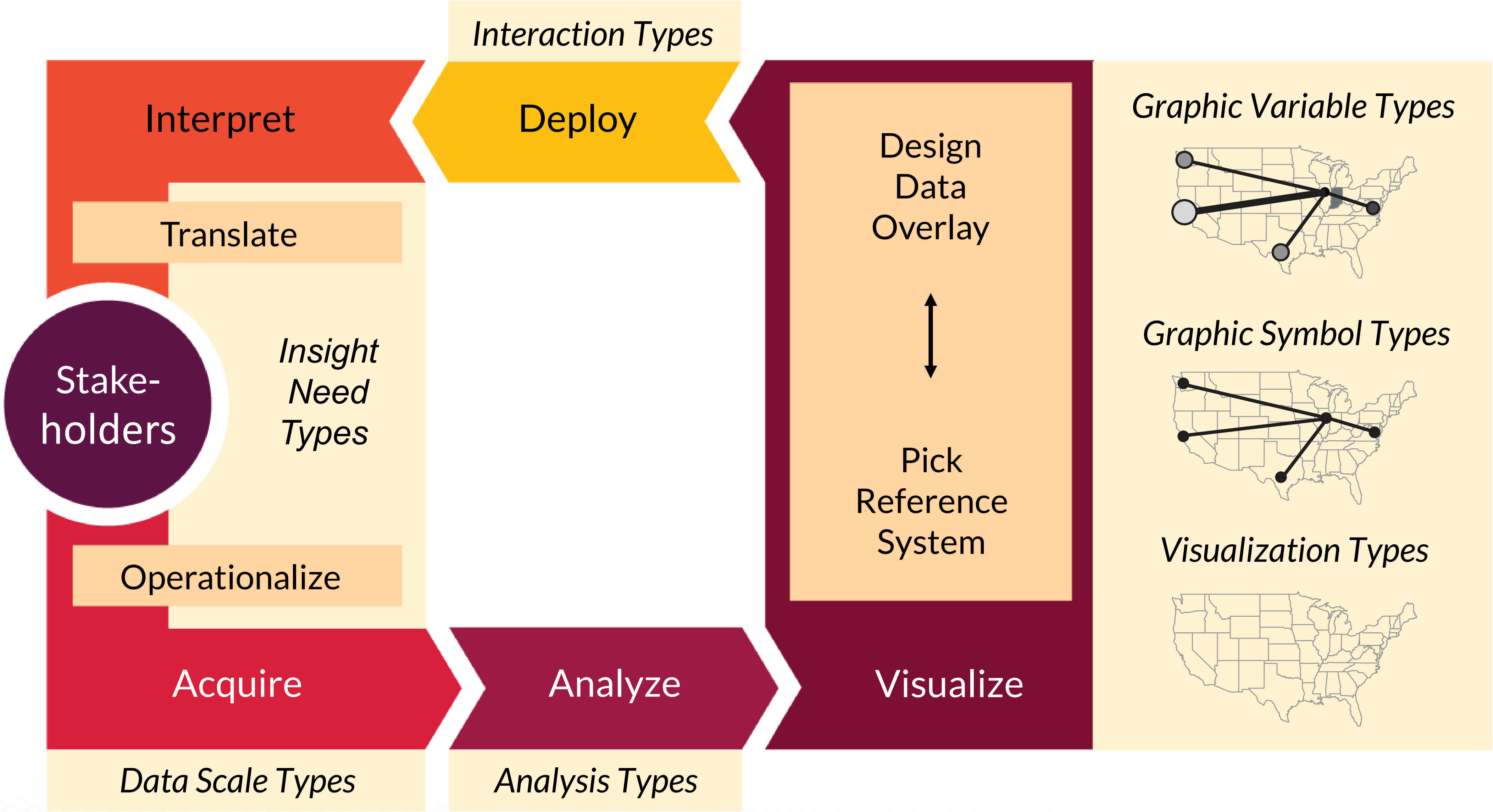




CNS Cyberinfrastructure for Network Science Center



CNS Cyberinfrastructure for Network Science Center



CNS Cyberinfrastructure for Network Science Center

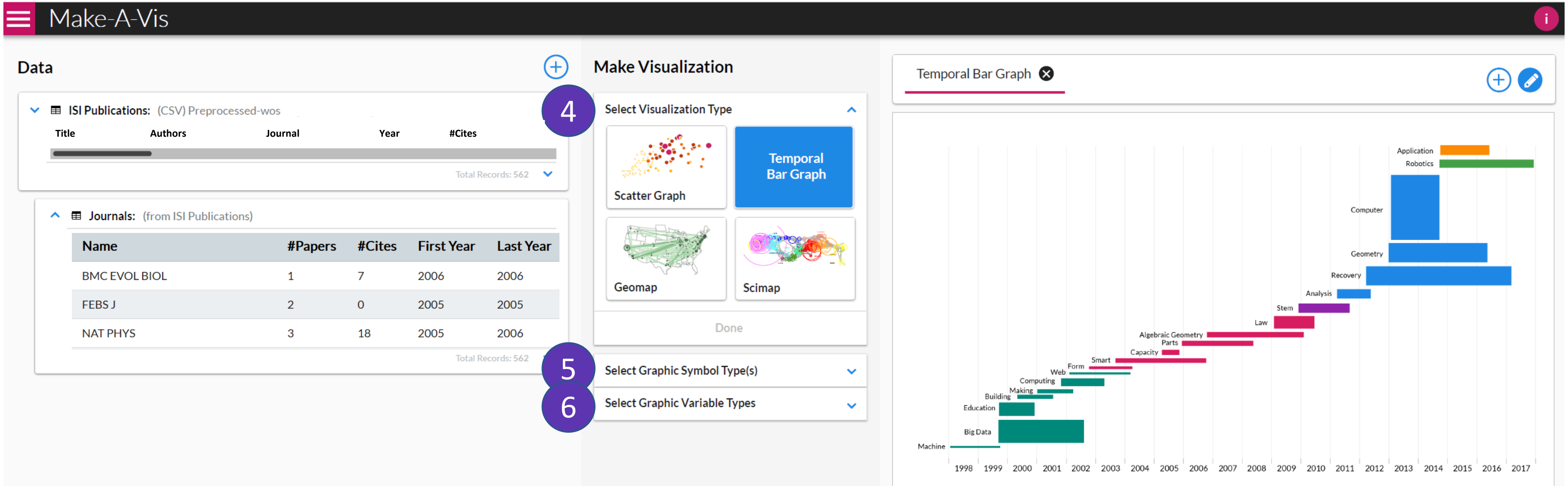
Audience Poll

How much time (out of project total) do you spent on

- Data acquisition?
- Data cleaning?
- Data analysis?
- Data visualization?
- Data interpretation?

Data Visualization Literacy Framework (DVL-FW)

Implemented in Make-A-Vis (MAV) to support learning via horizontal transfer, scaffolding, hands-on learning, etc.



Typology of the Data Visualization Literacy Framework

1. **Insight Needs**
   - categorize/cluster
   - order/rank/sort
   - distributions (also outliers, gaps)
   - comparisons
   - trends (process and time)
   - geospatial
   - compositions (also of text)
   - correlations/ relationships

2. **Data Scales**
   - nominal
   - ordinal
   - interval
   - ratio

3. **Analyses**
   - statistical
   - temporal
   - geospatial
   - topical
   - relational

4. **Visualizations**
   - table
   - chart
   - graph
   - map
   - tree
   - network

5. **Graphic Symbols**
   - geometric symbols
     point
     line
     area
     surface
     volume
   - linguistic symbols
     text
     numerals
     punctuation marks
   - pictorial symbols
     images
     icons
     statistical glyphs

6. **Graphic Variables**
   - spatial
     position
   - retinal
     form
     color
     optics
     motion

7. **Interactions**
   - zoom
   - search and locate
   - filter
   - details-on-demand
   - history
   - extract
   - link and brush
   - projection
   - distortion

Börner, Katy. 2015. *Atlas of Knowledge: Anyone Can Map*. Cambridge, MA: The MIT Press. 25.

Typology of the Data Visualization Literacy Framework

1

Insight Needs	Data Scales	Analyses	Visualizations	Graphic Symbols	Graphic Variables	Interactions
• categorize/cluster • order/rank/sort • distributions (also outliers, gaps) • comparisons • trends (process and time) • geospatial • compositions (also of text) • correlations/ relationships	• nominal • ordinal • interval • ratio	• statistical • temporal • geospatial • topical • relational	• table • chart • graph • map • tree • network	• geometric symbols point line area surface volume • linguistic symbols text numerals punctuation marks • pictorial symbols images icons statistical glyphs	• spatial position • retinal form color optics motion	• zoom • search and locate • filter • details-on-demand • history • extract • link and brush • projection • distortion

Börner, Katy. 2015. *Atlas of Knowledge: Anyone Can Map*. Cambridge, MA: The MIT Press. 26-27.

Bertin, 1967	Wehrend & Lewis, 1996	Few, 2004	Yau, 2011	Rendgen & Wiedemann, 2012	Frankel, 2012	Tool: Many Eyes	Tool: Chart Chooser	Börner, 2014
selection	categorize			category				categorize/ cluster
order	rank	ranking					table	order/rank/ sort
	distribution	distribution					distribution	distributions (also outliers, gaps)
	compare	nominal comparison & deviation	differences		compare and contrast	compare data values	comparison	comparisons
		time series	patterns over time	time	process and time	track rises and falls over time	trend	trends (process and time)
		geospatial	spatial relations	location		generate maps		geospatial
quantity		part-to-whole	proportions		form and structure	see parts of whole, analyze text	composition	compositions (also of text)
association	correlate	correlation	relationships	hierarchy		relations between data points	relationship	correlations/ relationships

Typology of the Data Visualization Literacy Framework

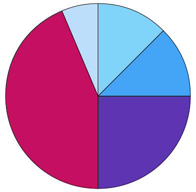
4

Insight Needs	Data Scales	Analyses	Visualizations	Graphic Symbols	Graphic Variables	Interactions
• categorize/cluster	• nominal	• statistical	• table	• geometric symbols	• spatial	• zoom
• order/rank/sort	• ordinal	• temporal	• chart	point	position	• search and locate
• distributions (also outliers, gaps)	• interval	• geospatial	• graph	line	• retinal	• filter
• comparisons	• ratio	• topical	• map	area	form	• details-on-demand
• trends (process and time)		• relational	• tree	surface	color	• history
• geospatial			• network	volume	optics	• extract
• compositions (also of text)				• linguistic symbols	motion	• link and brush
• correlations/ relationships				text		• projection
				numerals		• distortion
				punctuation marks		
				• pictorial symbols		
				images		
				icons		
				statistical glyphs		

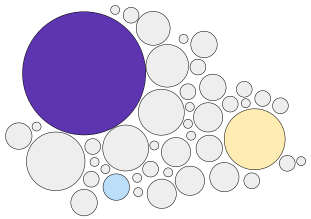
Börner, Katy. 2015. *Atlas of Knowledge: Anyone Can Map*. Cambridge, MA: The MIT Press. 30-31.

Visualization Types

Chart

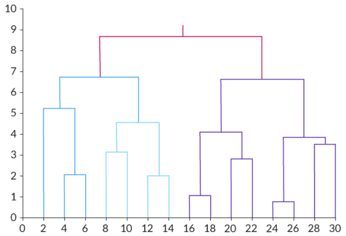


Pie Chart

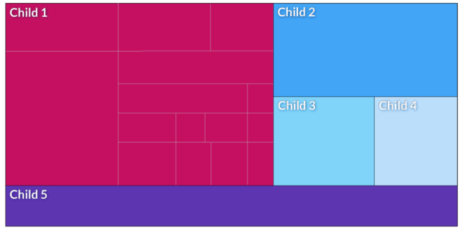


Bubble Chart

Tree

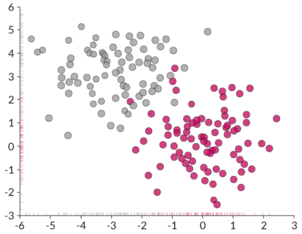


Dendrogram

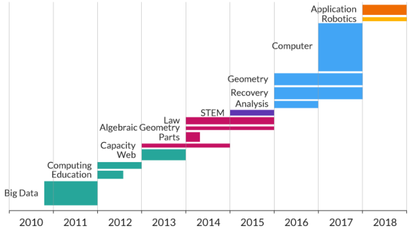


Tree Map

Graph

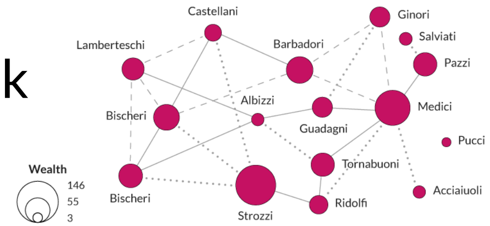


Scatter Graph

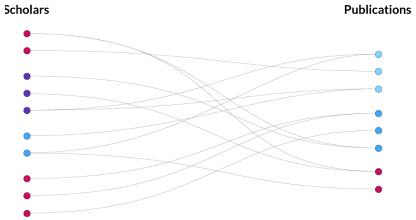


Temporal Bar Graph

Network

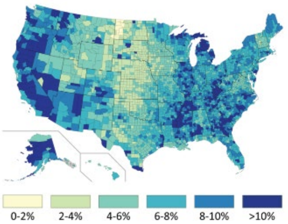


Force-Directed Network Layout

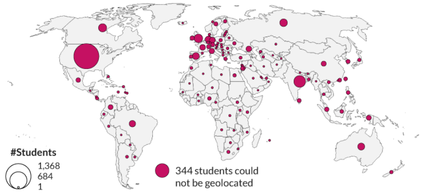


Bimodal Network Layout

Map



Choropleth Map



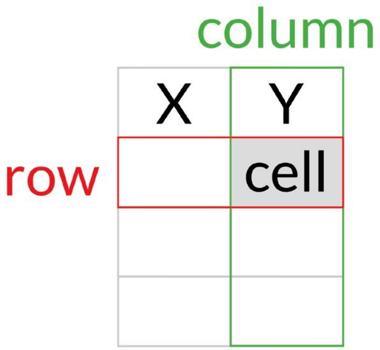
Proportional Symbol Map

Visualize: Reference Systems

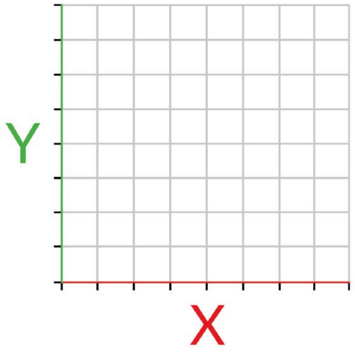
4

Visualization Types
- table
- chart
- graph
- map
- network layout

Table
columns by rows

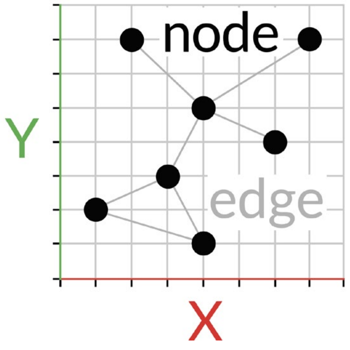


Graph
x-y coordinates

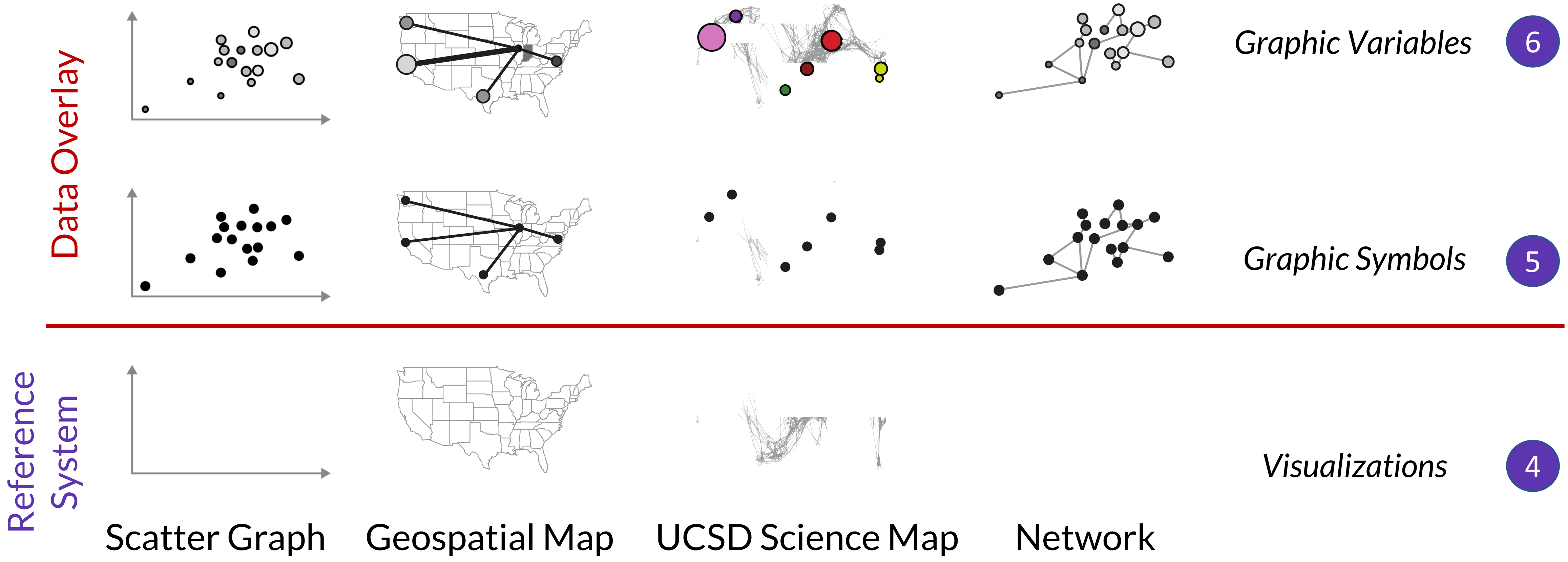


Map
latitude/
longitude

Network
local similarity



Visualize: Reference Systems, Graphic Symbols and Variables



Typology of the Data Visualization Literacy Framework

5

Insight Needs
- categorize/cluster
- order/rank/sort
- distributions (also outliers, gaps)
- comparisons
- trends (process and time)
- geospatial
- compositions (also of text)
- correlations/ relationships

Data Scales
- nominal
- ordinal
- interval
- ratio

Analyses
- statistical
- temporal
- geospatial
- topical
- relational

Visualizations
- table
- chart
- graph
- map
- tree
- network

Graphic Symbols
- geometric symbols
  point
  line
  area
  surface
  volume
- linguistic symbols
  text
  numerals
  punctuation marks
- pictorial symbols
  images
  icons
  statistical glyphs

Graphic Variables
- spatial
  position
- retinal
  form
  color
  optics
  motion

Interactions
- zoom
- search and locate
- filter
- details-on-demand
- history
- extract
- link and brush
- projection
- distortion

Börner, Katy. 2015. *Atlas of Knowledge: Anyone Can Map*. Cambridge, MA: The MIT Press. 32-33.

Typology of the Data Visualization Literacy Framework

6

Insight Needs
- categorize/cluster
- order/rank/sort
- distributions (also outliers, gaps)
- comparisons
- trends (process and time)
- geospatial
- compositions (also of text)
- correlations/ relationships

Data Scales
- nominal
- ordinal
- interval
- ratio

Analyses
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- temporal
- geospatial
- topical
- relational

Visualizations
- table
- chart
- graph
- map
- tree
- network

Graphic Symbols
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  - point
  - line
  - area
  - surface
  - volume
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  - numerals
  - punctuation marks
- pictorial symbols
  - images
  - icons
  - statistical glyphs

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- retinal
  - form
  - color
  - optics
  - motion

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- details-on-demand
- history
- extract
- link and brush
- projection
- distortion

Börner, Katy. 2015. *Atlas of Knowledge: Anyone Can Map*. Cambridge, MA: The MIT Press. 34-35.

Graphic Variable Types

Position: x, y; possibly z

Form:

- Size
- Shape
- Rotation (Orientation)

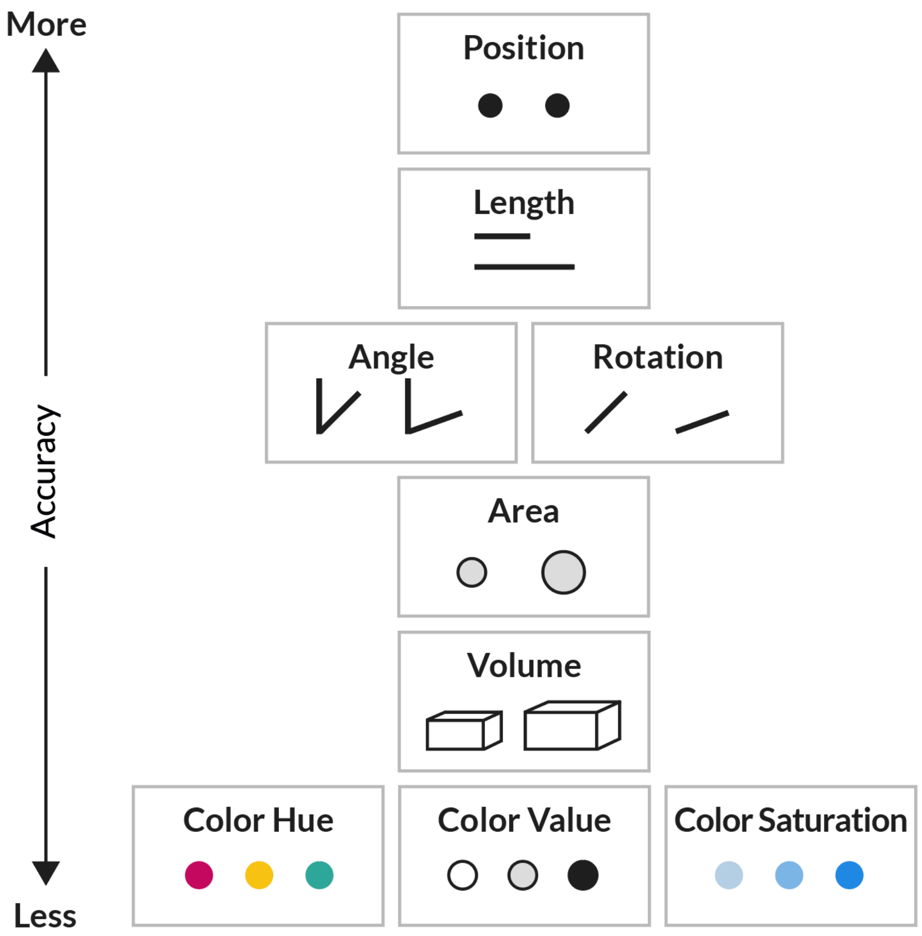
Color:

- Value (Lightness)
- Hue (Tint)
- Saturation (Intensity)

Optics: Blur, Transparency, Shading, Stereoscopic Depth

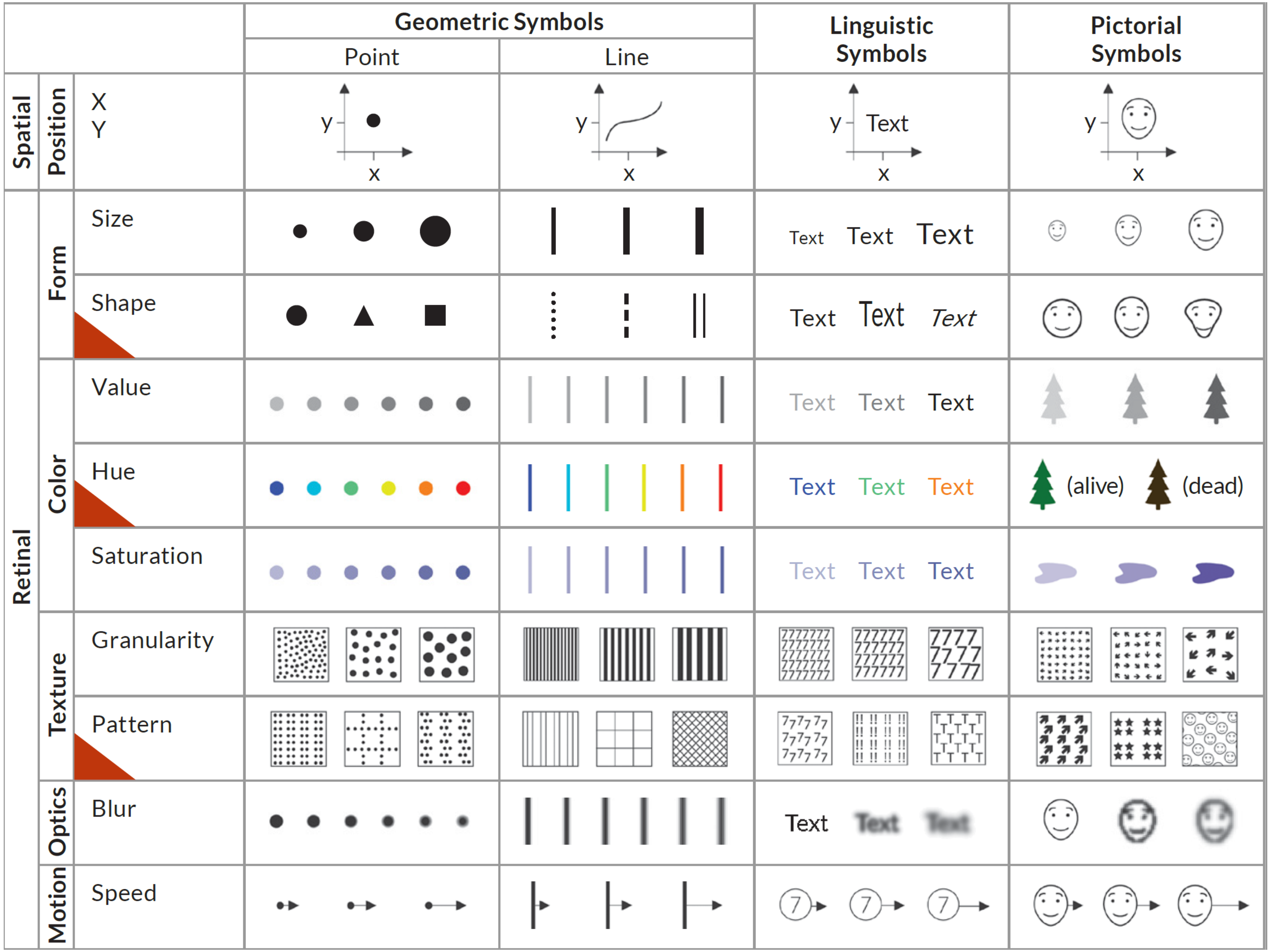
Texture: Spacing, Granularity, Pattern, Orientation, Gradient

Motion: Speed, Velocity, Rhythm



Graphic Symbol Types

Graphic Variable Types



See *Atlas of Knowledge* pages 36-39 for complete table.

Qualitative

Also called:

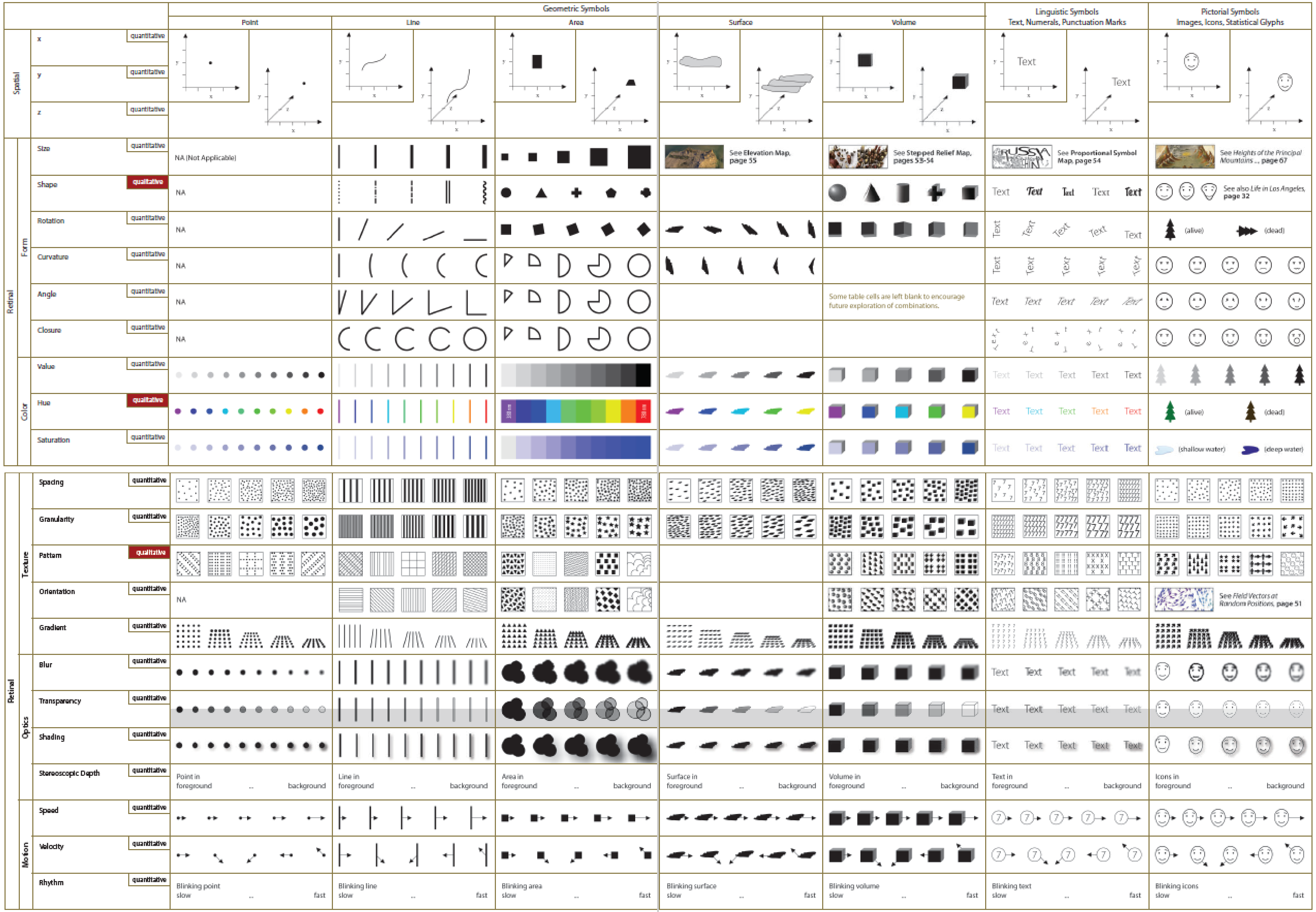
Categorical Attributes
Identity Channels

Quantitative

Also called:

Ordered Attributes
Magnitude Channels

Graphic Variable Types Versus Graphic Symbol Types



See *Atlas of Knowledge* pages 36-39 for complete table.

Empower Yourself and Others! Data Visualization Literacy

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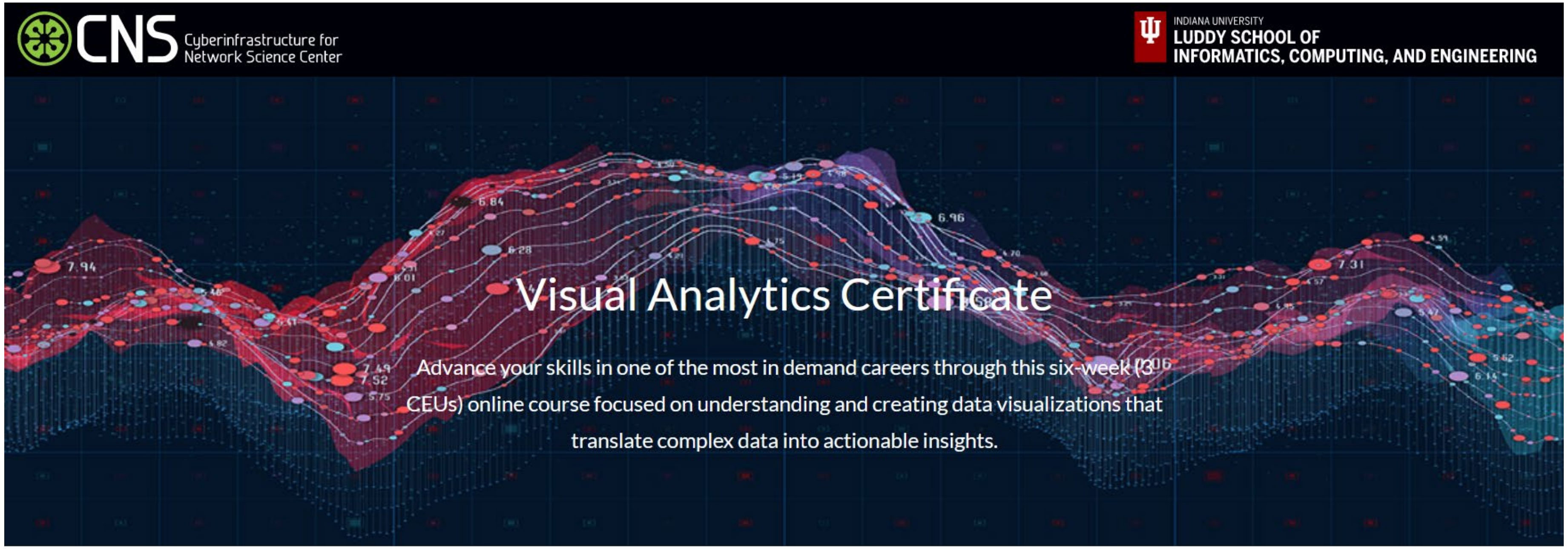

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https://visanalytics.cns.iu.edu

US Employers which have sent students include
The Boeing Company, Eli Lilly, DOE, CDC, NSWC Crane.

References

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