CNS Cyberinfrastructure for Network Science Center

INDIANA UNIVERSITY
SCHOOL OF INFORMATICS, COMPUTING, AND ENGINEERING

Data Visualization Literacy

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Computer Aided Drug Design, Gordon Research Conference

Mount Snow, West Dover, VT | July 17, 2019

Overview

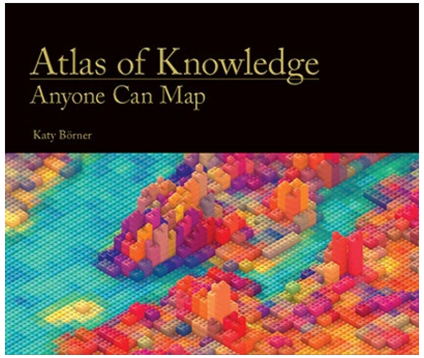
This talk will introduce a theoretical data visualization framework (DVL) meant to empower anyone to systematically render data into insights using temporal, geospatial, topical, and network analyses and visualizations.

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

The DVL was applied to map science and technology, see interactive data visualizations from the *Places & Spaces: Mapping Science* exhibit (http://scimaps.org) and recent *PNAS* special issue on *Modelling and Visualizing Science and Technology Developments* (https://www.pnas.org/modeling)

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

Börner, Katy. 2010. *Atlas of Science: Visualizing What We Know*. Cambridge, MA: The MIT Press.



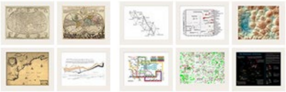
Atlas of Forecasts

Places & Spaces: Mapping Science Exhibit

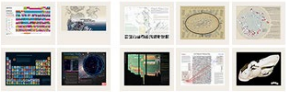
1st Decade (2005-2014)

Maps

Iteration I (2005)
The Power of Maps



Iteration II (2006)
The Power of Reference Systems



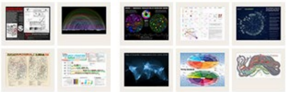
Iteration III (2007)
The Power of Forecasts

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

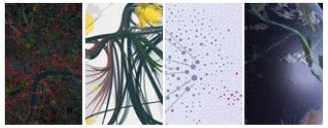
2nd Decade (2015-2024)

Macroscopes

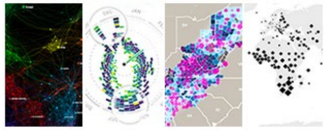
Iteration XI (2015)
Macroscopes for Interacting with Science

Iteration XIII (2017)
Macroscopes for Playing with Scale

Iteration XII (2016)
Macroscopes for Making Sense of Science

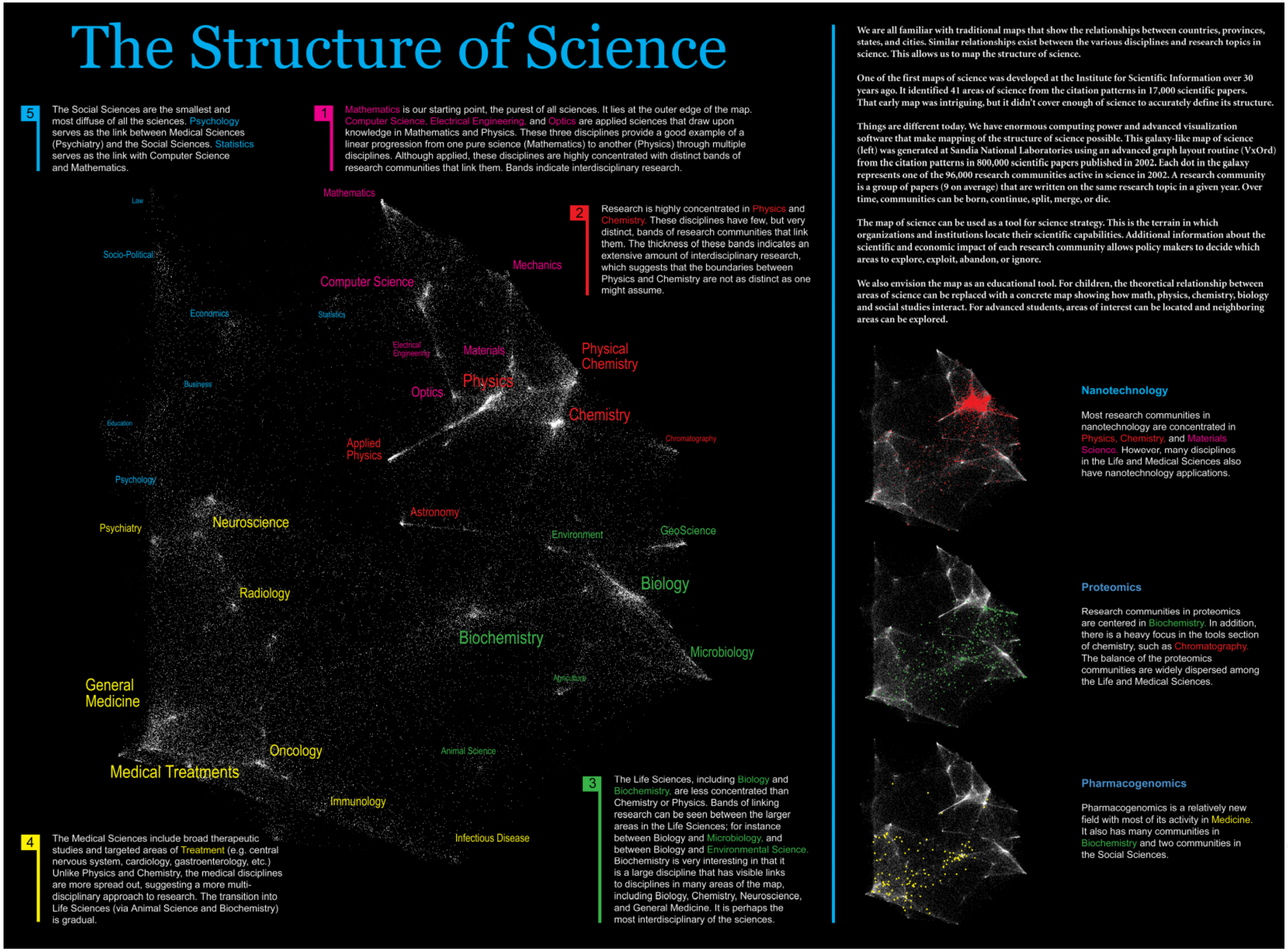


Iteration XIV (2018)
Macroscopes for Ensuring our Well-being

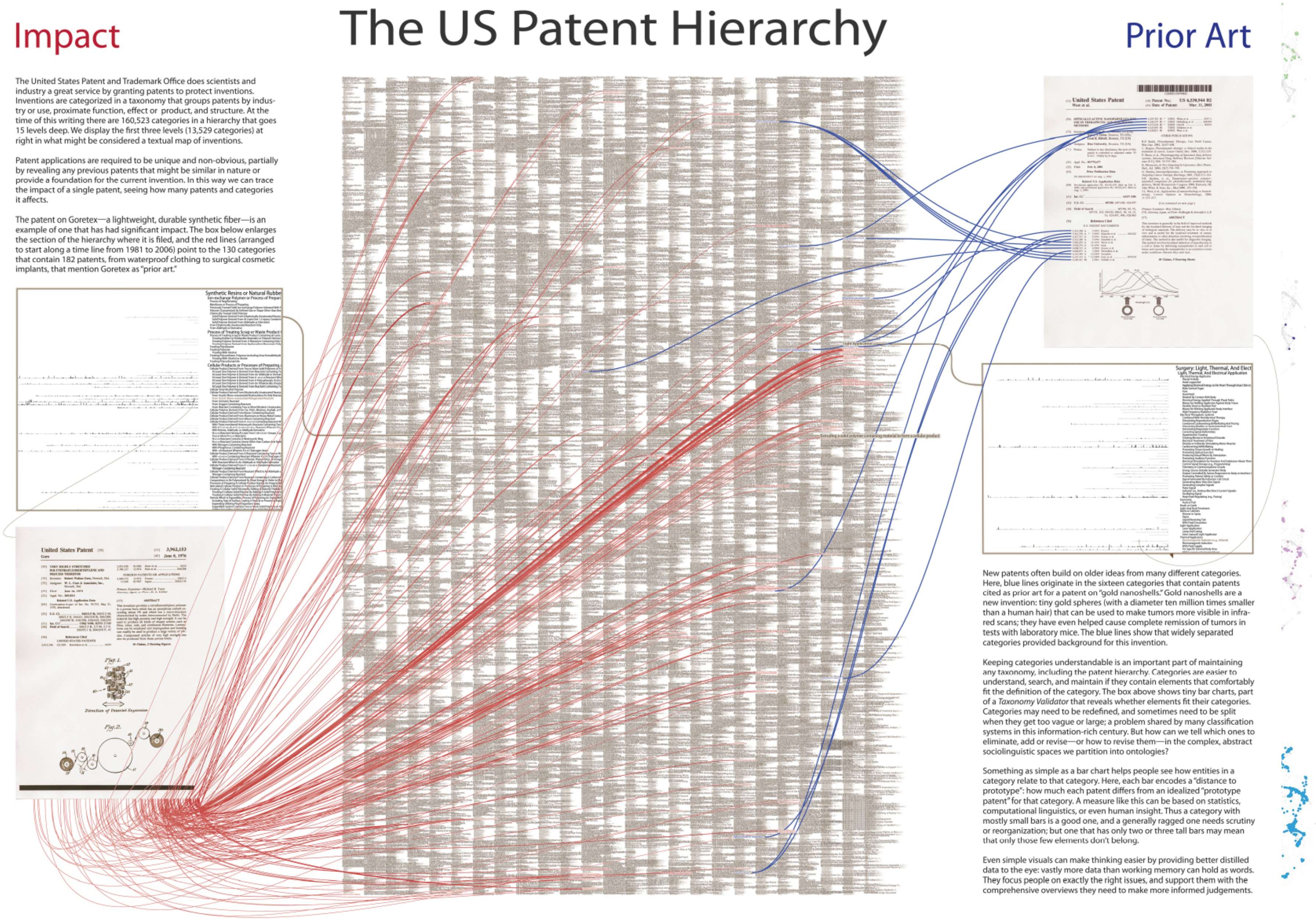


3rd Decade (2015-2034)

http://scimaps.org



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



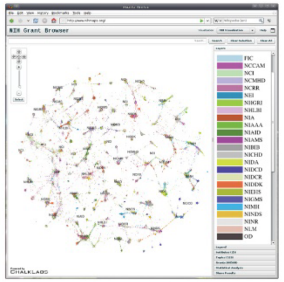
II.8 *Taxonomy Visualization of Patent Data* - Katy Börner, Elisha F. Hardy, Bruce W. Herr II, Todd Holloway, and W. Bradford Paley - 2006

A Topic Map of NIH Grants 2007

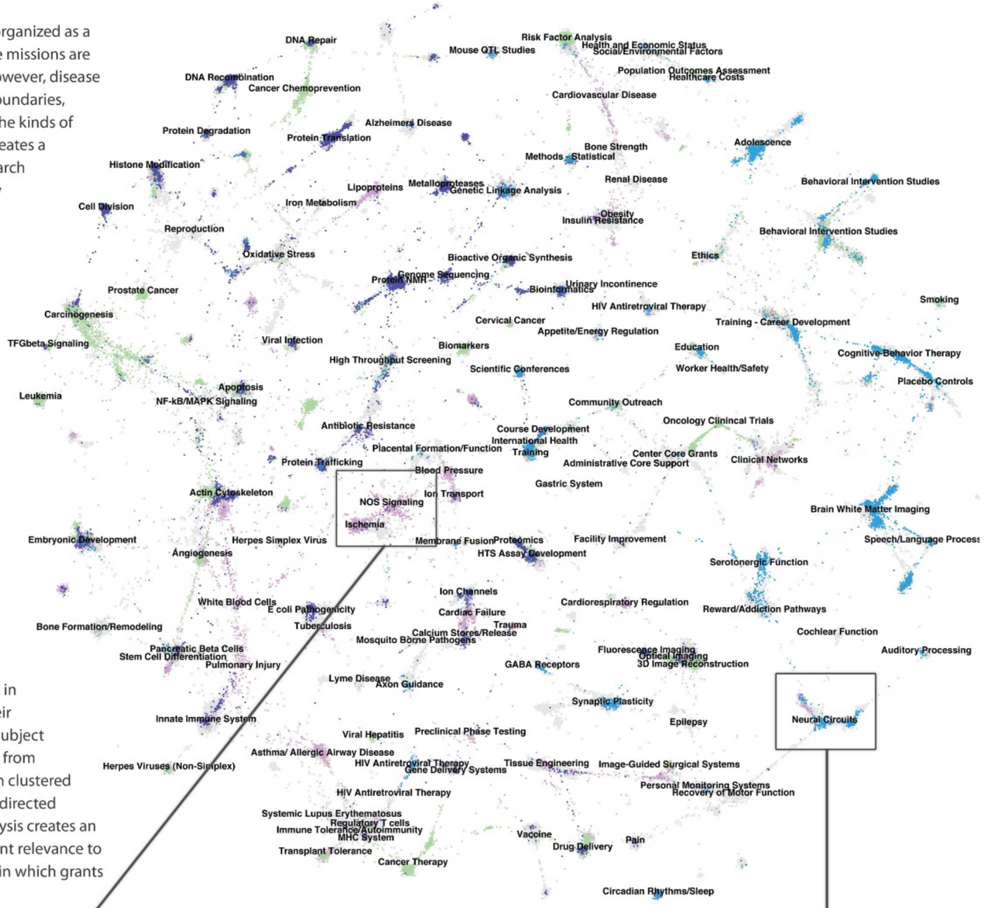
ChalkLabs ISI UCIrvine

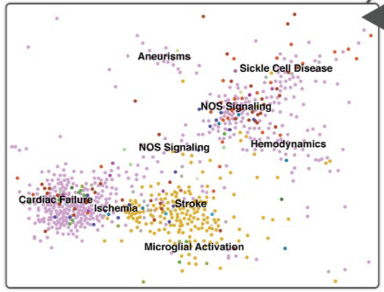
Bruce W. Herr II (Chalklabs & IU), Gully Burns (ISI), David Newman (UCI), Edmund Talley (NIH)

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.



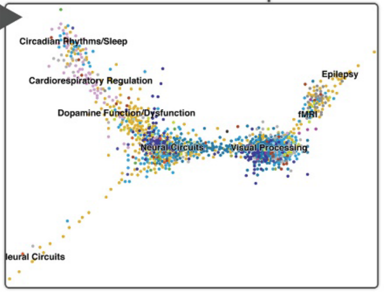


Cardiac Diseases Research

An area of the map focused on cardio-vascular 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 re-stricted blood supply. Also localized in this area are grants focused on Nitric Oxide (NOS) Signaling, a major biochem-ical 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)

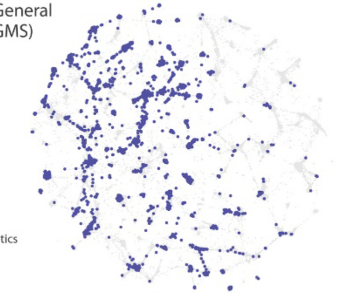
TOP 10 TOPICS

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

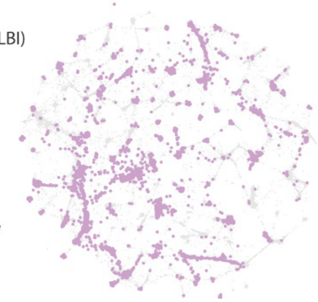
1. Bioactive Organic Synthesis
2. X-ray Crystallography
3. Protein NMR
4. Computational Models
5. Yeast Biology
6. Metalloproteases
7. Enzymatic Mechanisms
8. Protein Complexes
9. Invertebrate/Zebrafish Genetics
10. Cell Division



National Heart, Lung, and Blood Institute (NHLBI)

TOP 10 TOPICS

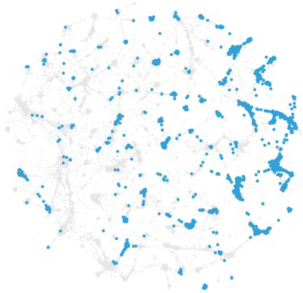
1. Cardiac Failure
2. Pulmonary Injury
3. Genetic Linkage Analysis
4. Cardiovascular Disease
5. Atherosclerosis
6. Hemostasis
7. Blood Pressure
8. Asthma/ Allergic Airway Disease
9. Gene Association
10. Lipoproteins



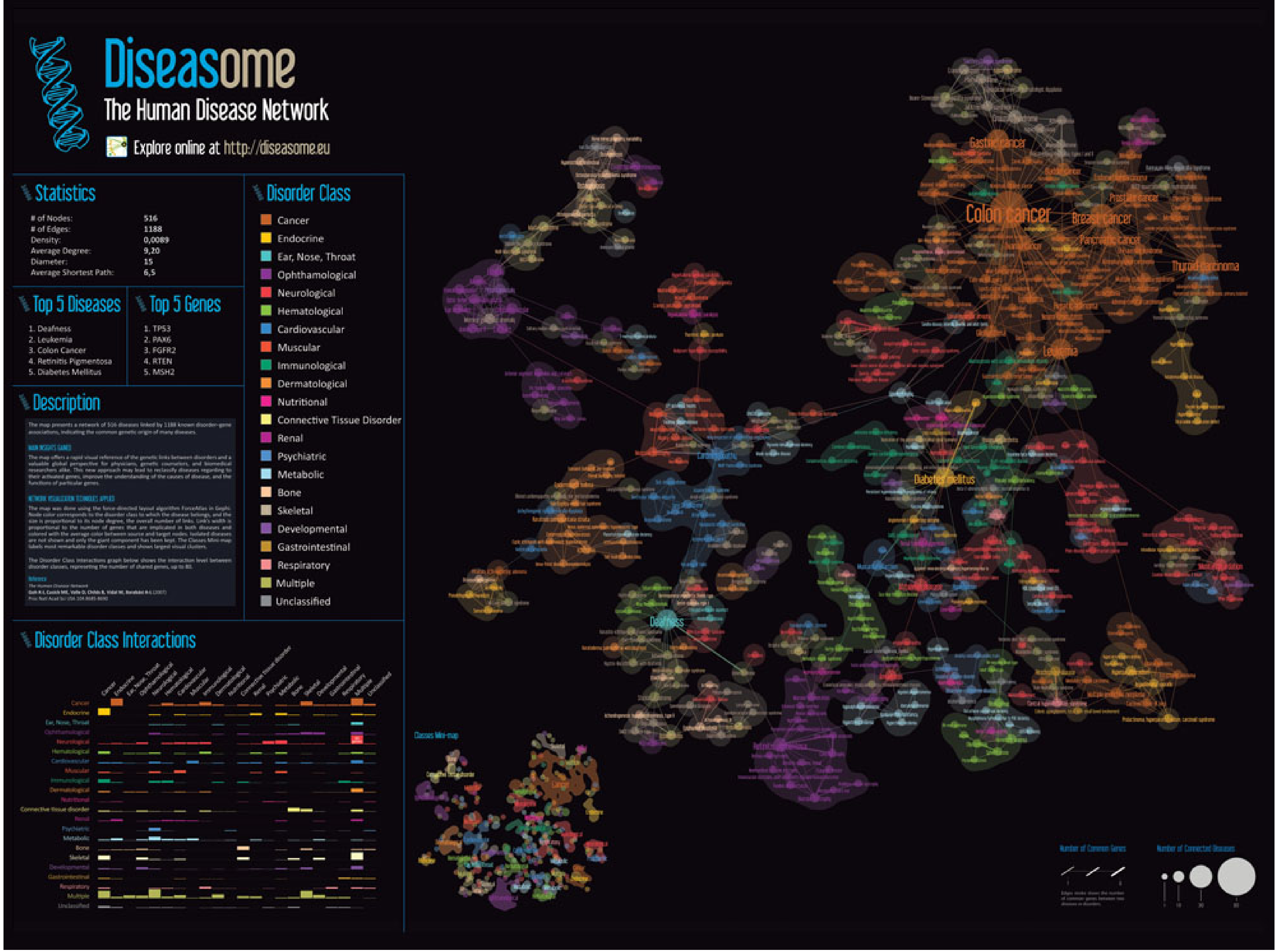
National Institute of Mental Health (NIMH)

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



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

Acknowledgements

Exhibit Curators

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

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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:

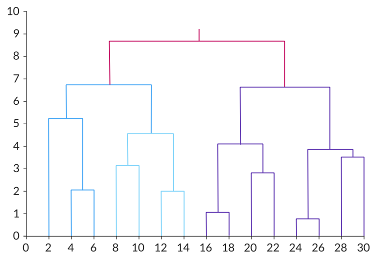
- literacy (ability to read and write text in titles, axis labels, legends, etc.),
- visual literacy (ability to find, interpret, evaluate, use, and create images and visual media), and
- mathematical literacy (ability to formulate, employ, and interpret math in a variety of contexts).

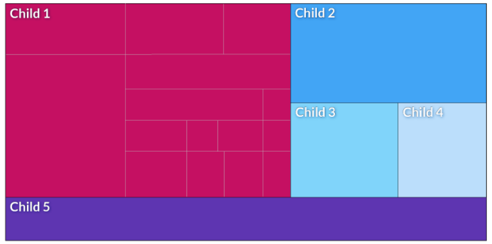
Being able to “read and write” data visualizations is becoming as important as being able to read and write text. Understanding, measuring, and improving data and visualization literacy is important to strategically approach local and global issues.

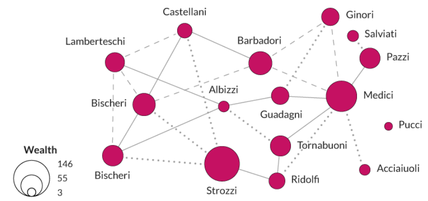
Visualization Frameworks

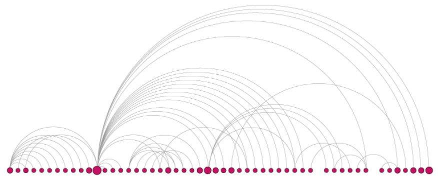
MANY frameworks and taxonomies have been proposed to

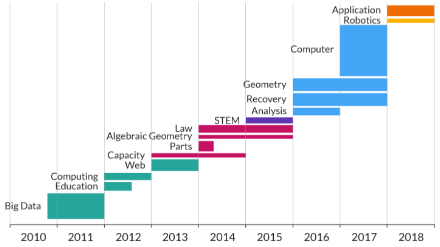
- help organize and manage the evolving zoo of 500+ different data visualization types,
- provide guidance when designing data visualizations, and
- facilitate teaching.

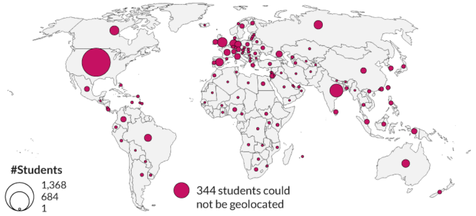


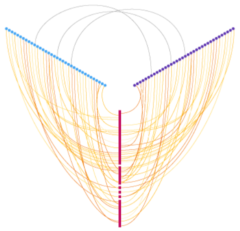


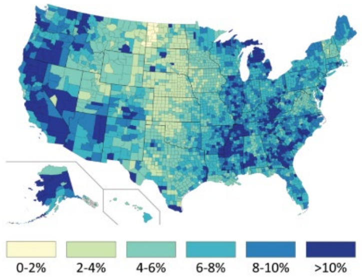


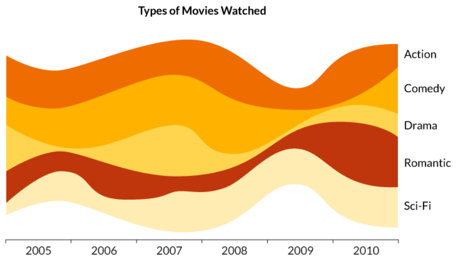








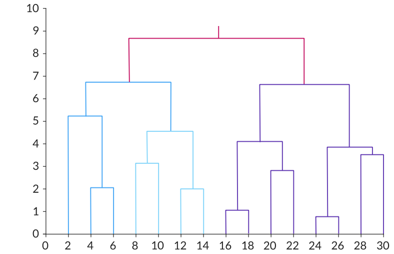


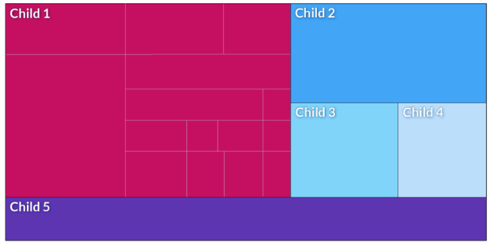


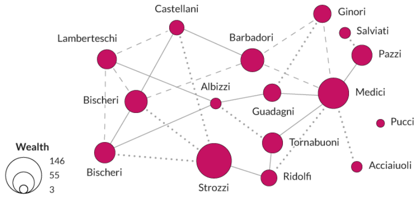
Existing Visualization Frameworks

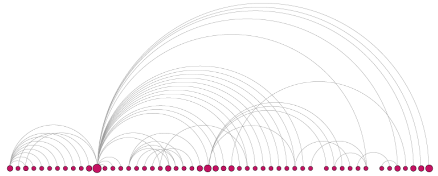
Organize data visualizations by

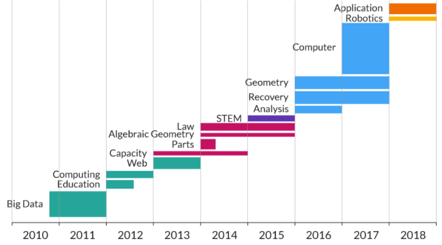
- User insight needs
- User task types
- Data to be visualized
- Data transformations
- Visualization technique
- Visual mapping transformations
- Interaction techniques
- Deployment options
- and other features ...

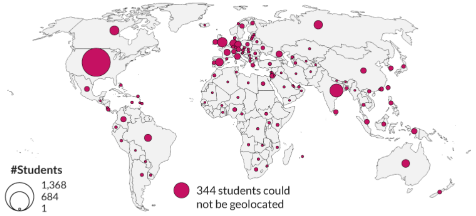


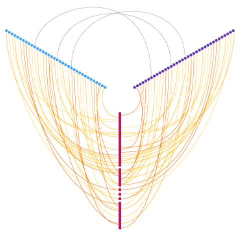


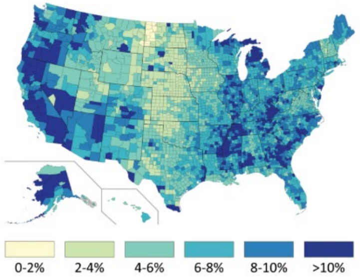


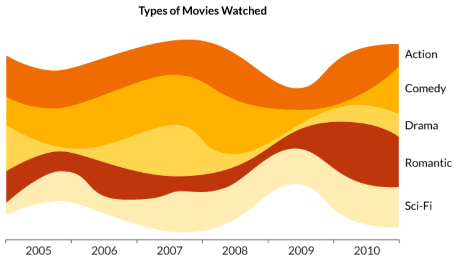












DVL Framework: Desirable Properties

- 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 15 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

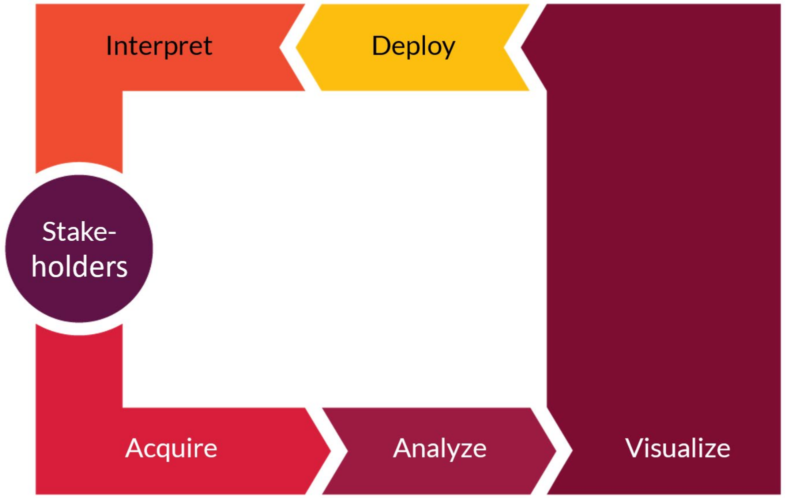
5. Graphic Symbols
- geometric symbols
  - point
  - line
  - area
  - surface
  - volume
- linguistic symbols
  - text
  - numerals
  - punctuation marks
- pictorial symbols
  - images
  - icons
  - statistical glyphs

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

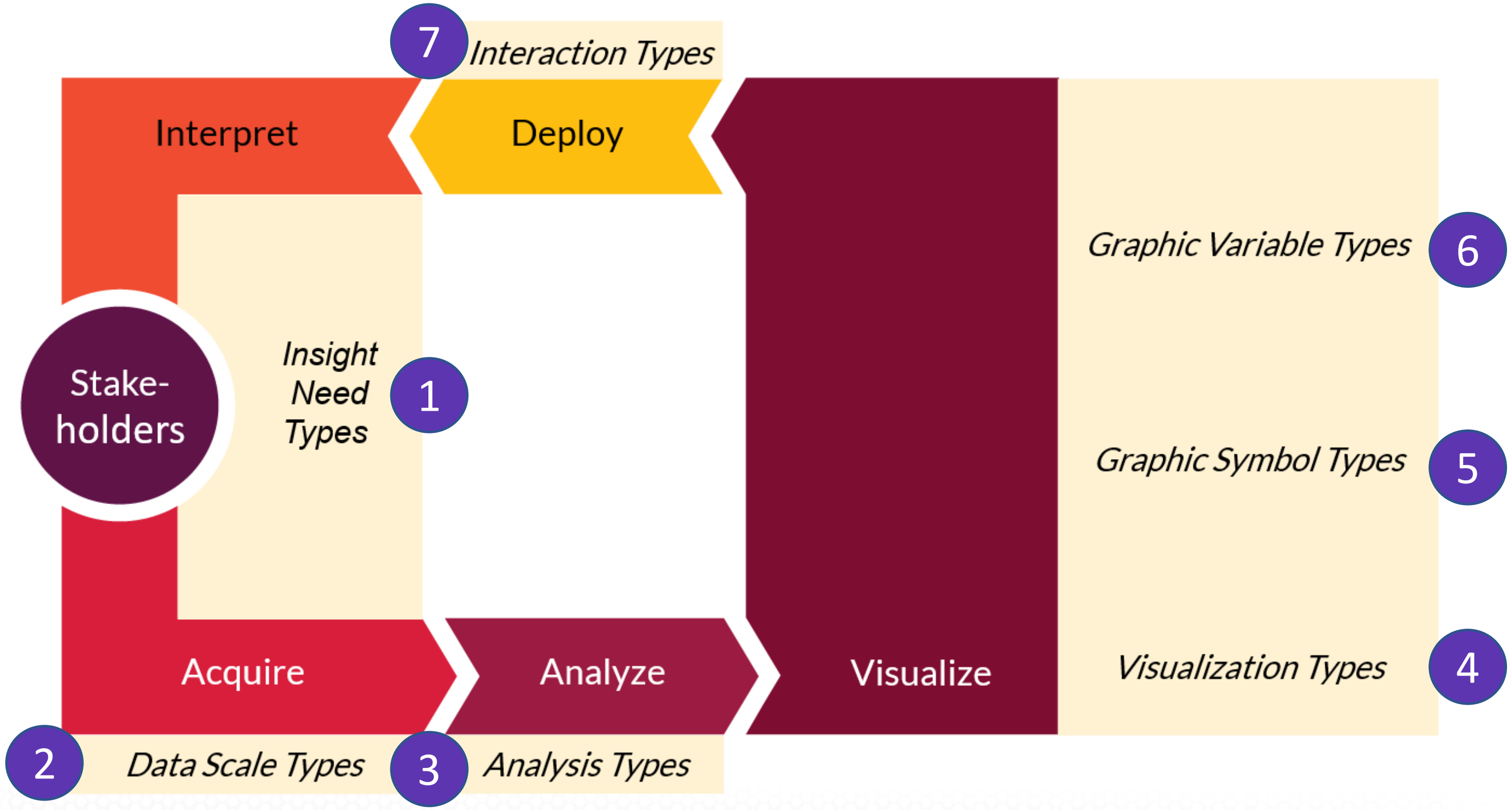
Defines 5 steps required to render data into insights.



Data Visualization Literacy Framework (DVL-FW)

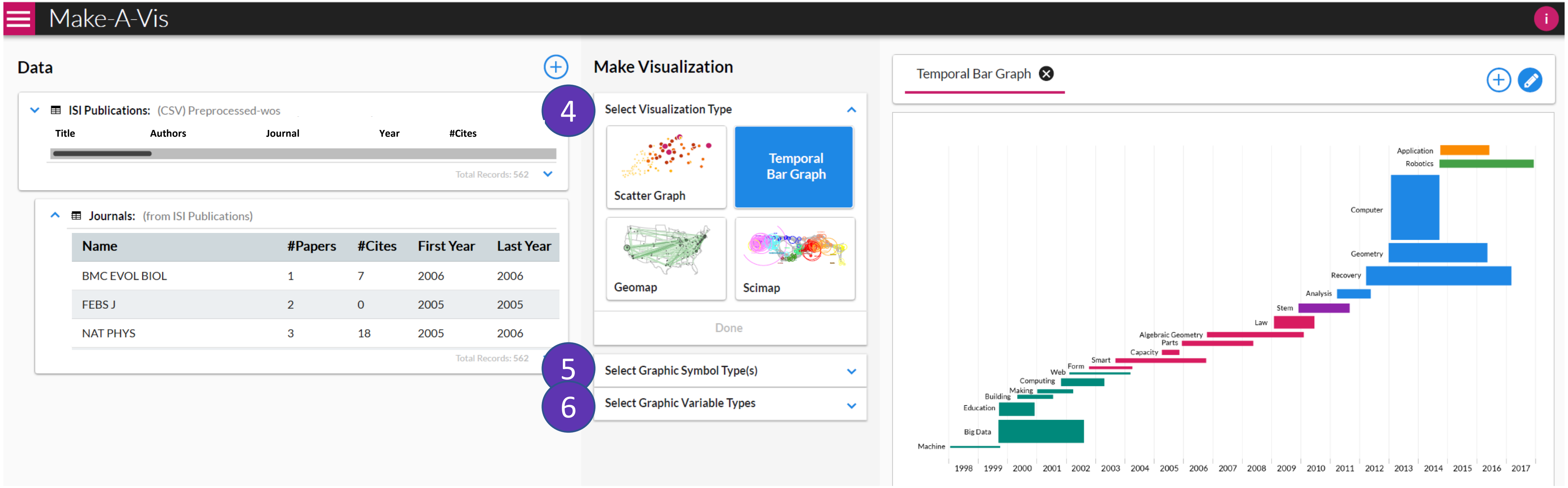
Consists of two parts that are interlinked:

DVL Typology +
DVL Workflow Process



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	2	3	4	5	6	7
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. 25.

Typology of the Data Visualization Literacy Framework

1

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. 26-27.

CNS Cyberinfrastructure for Network Science Center

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

2

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

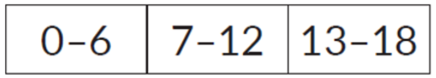
Börner, Katy. 2015. *Atlas of Knowledge: Anyone Can Map*. Cambridge, MA: The MIT Press. 28-29.

Data Scale Types

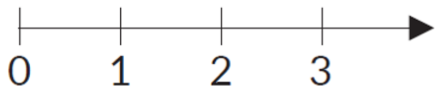
Nominal: A categorical scale, also called a nominal or category scale, is qualitative. Categories are assumed to be non-overlapping.

Ordinal: An ordinal scale, also called sequence or ordered, is quantitative. It rank-orders values representing categories based on some intrinsic ranking, but not at measurable intervals.

Interval: An interval scale, also called a value scale, is a quantitative numerical scale of measurement where the distance between any two adjacent values (or intervals) is equal, but the zero point is arbitrary.



Ratio: A ratio scale, also called a proportional scale, is a quantitative numerical scale. It represents values organized as an ordered sequence, with meaningful uniform spacing, and a true zero point.



Data Scale Types - Examples

Nominal: Words or numbers constituting the "categorical" names and descriptions of people, places, things, or events.

Ordinal: Days of the week, degree of satisfaction and preference rating scores (e.g., using a Likert scale), or rankings such as low, medium, high.

Interval: Temperature in degrees or time in hours. Spatial variables such as latitude and longitude are interval.

Ratio: Physical measures such as height, weight, (reaction) time, or intensity of light; number of published papers, co-authors, citations.

Data Scale Types - Examples

Nominal: Words or numbers constituting the "categorical" names and descriptions of people, places, things, or events.

Qualitative

Ordinal: Days of the week, degree of satisfaction and preference rating scores (e.g., using a Likert scale), or rankings such as low, medium, high.

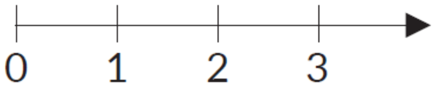
Quantitative

Interval: Temperature in degrees or time in hours. Spatial variables such as latitude and longitude are interval.

Ratio: Physical measures such as weight, height, (reaction) time, or intensity of light; number of published papers, co-authors, citations.

Data Scale Types - Mathematical Operations

This table shows the logical mathematical operations permissible, the measure of central tendency, and examples for the different data scale types.

Data Scale Types	Logical Mathematical Operations				Measure of Central Tendency	Examples
	= ≠	< >	+ -	x ÷		
Nominal	y				mode	
Ordinal	y	y			median	
Interval	y	y	y		arithmetic mean	0–6 | 7–12 | 13–18
Ratio	y	y	y	y	geometric mean	

Qualitative

Quantitative

Typology of the Data Visualization Literacy Framework

3

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. 25.

CNS Cyberinfrastructure for Network Science Center

Analysis Types

- When: Temporal Data Analysis + Statistical
- Where: Geospatial Data Analysis
- What: Topical Data Analysis
- With Whom: Network Analysis

Typology of the Data Visualization Literacy Framework

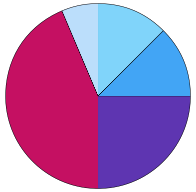
4

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

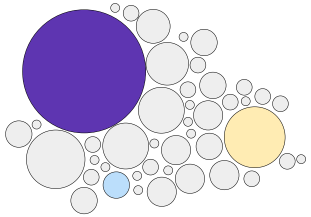
Börner, Katy. 2015. *Atlas of Knowledge: Anyone Can Map*. Cambridge, MA: The MIT Press. 30-31.

Visualization Types

Chart

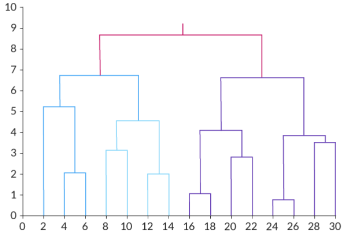


Pie Chart

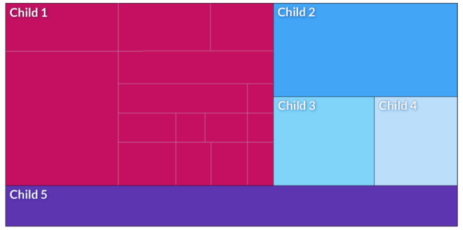


Bubble Chart

Tree

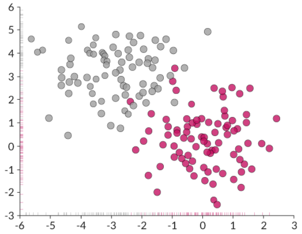


Dendrogram

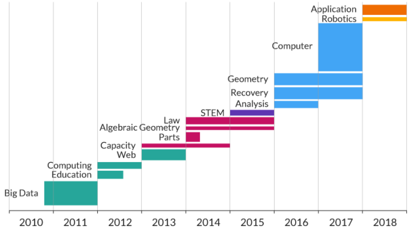


Tree Map

Graph

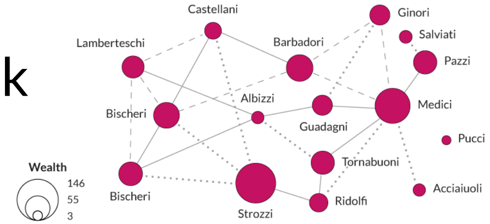


Scatter Graph

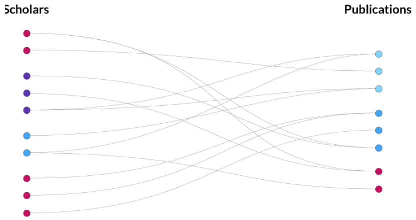


Temporal Bar Graph

Network

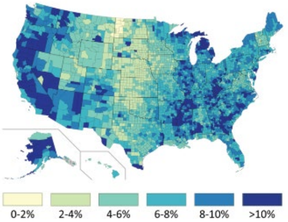


Dendrogram

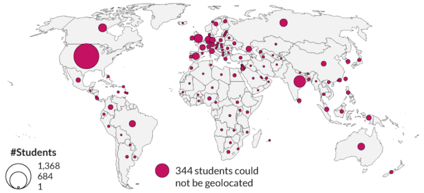


Tree Map

Map



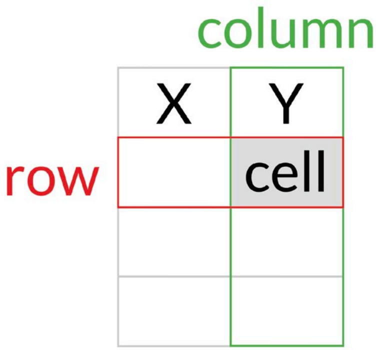
Choropleth Map



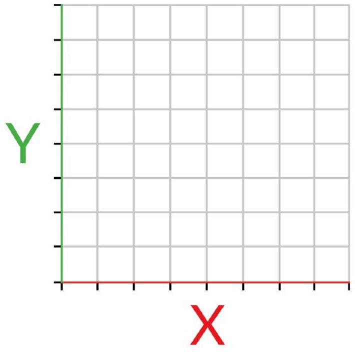
Proportional Symbol Map

Visualize: Reference Systems

Table
columns by rows

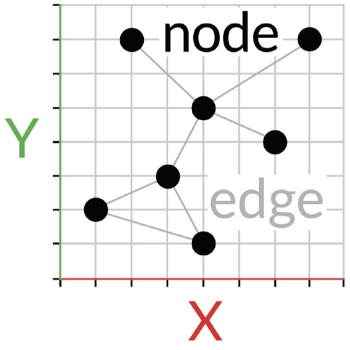


Graph
x-y coordinates



Map
latitude/
longitude

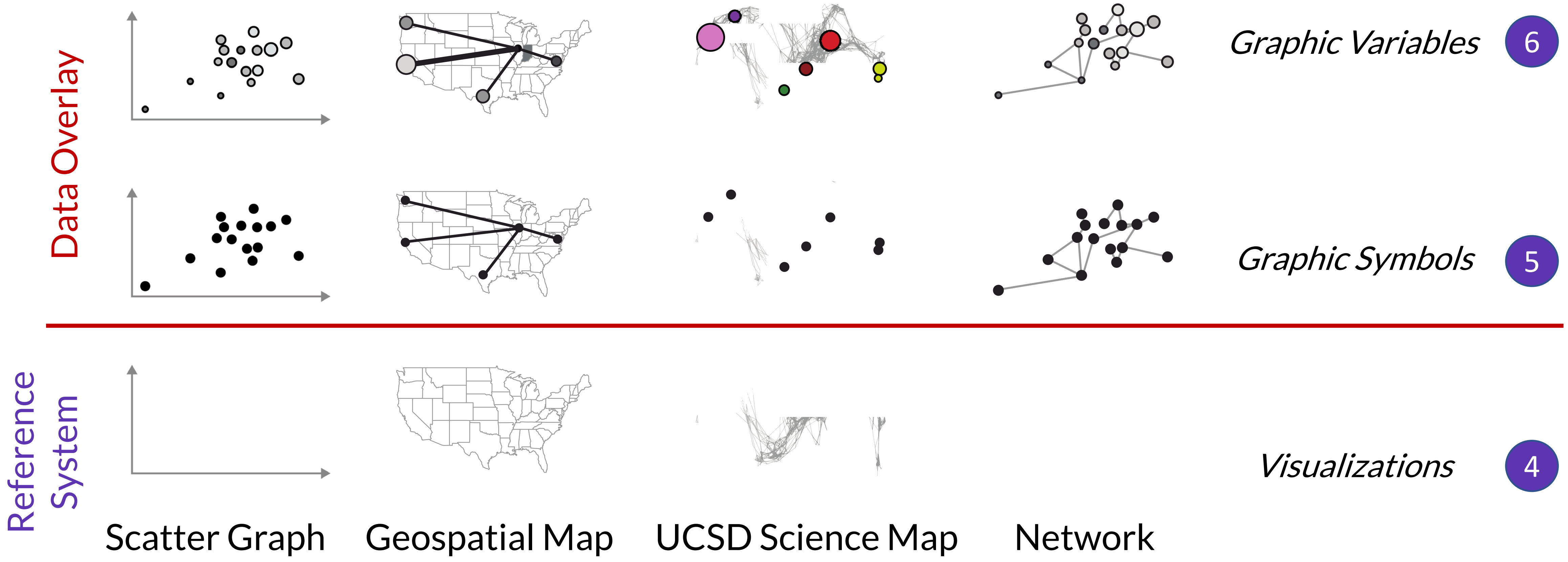
Network
local similarity



4

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

Visualize: Reference Systems, Graphic Symbols and Variables



Typology of the Data Visualization Literacy Framework

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

5

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
- 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. 34-35.

Graphic Variable Types

Position: x, y; possibly z	Quantitative
Form:	
• Size	Quantitative
• Shape	Qualitative
• Rotation (Orientation)	Quantitative
Color:	
• Value (Lightness)	Quantitative
• Hue (Tint)	Qualitative
• Saturation (Intensity)	Quantitative

Optics: Blur, Transparency, Shading, Stereoscopic Depth

Texture: Spacing, Granularity, Pattern, Orientation, Gradient

Motion: Speed, Velocity, Rhythm

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

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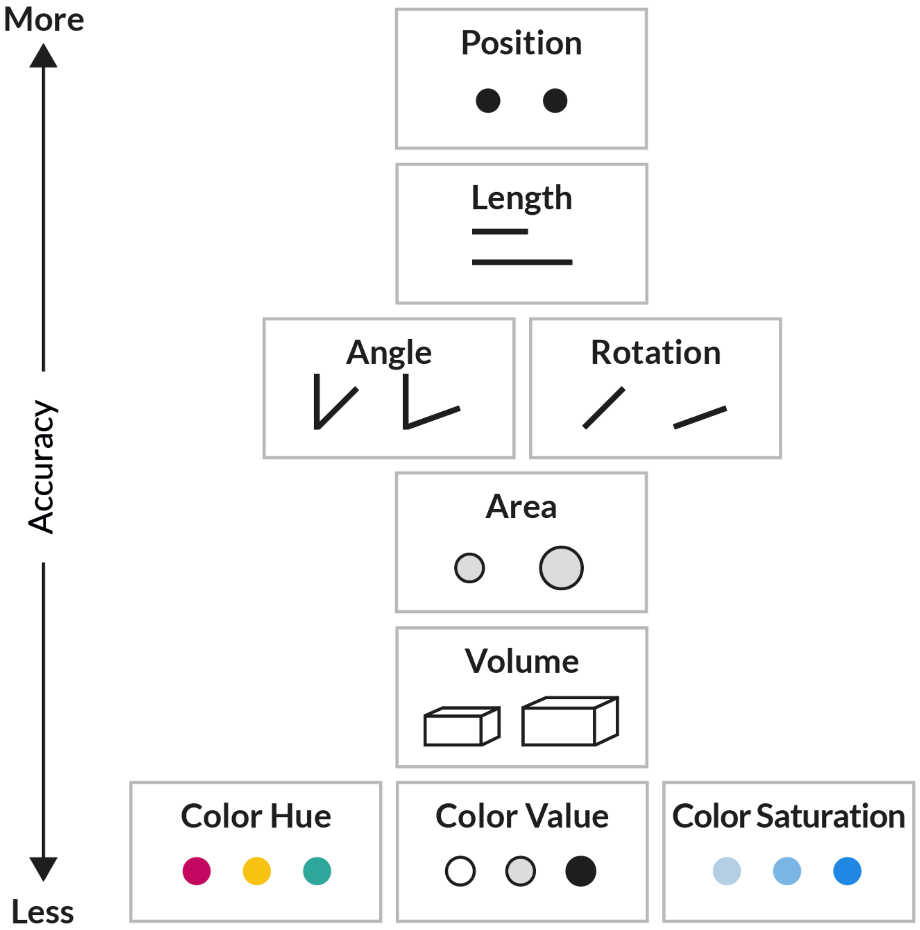
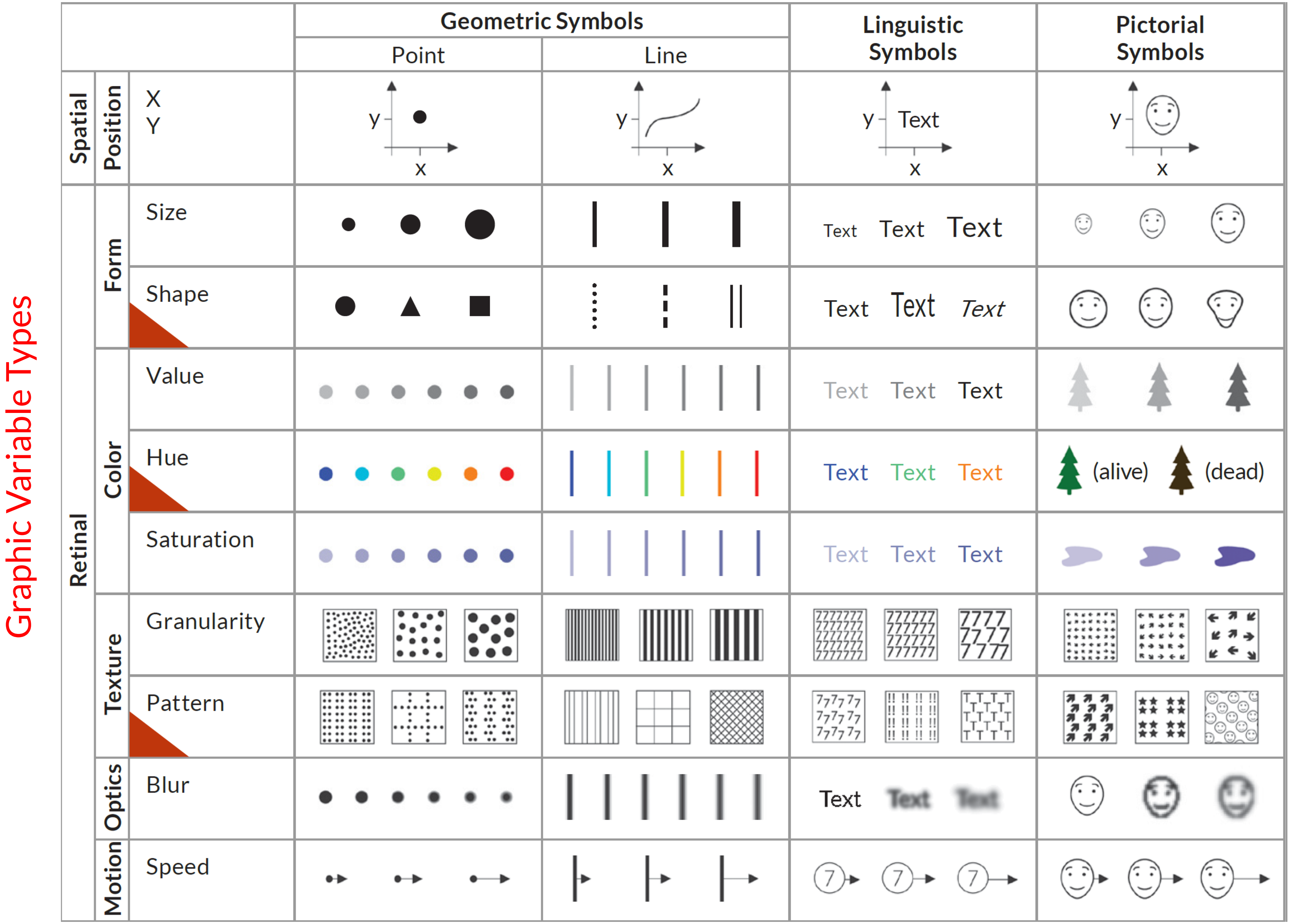
Motion: Speed, Velocity, Rhythm



Graphic Symbol Types



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

Qualitative

Also called:

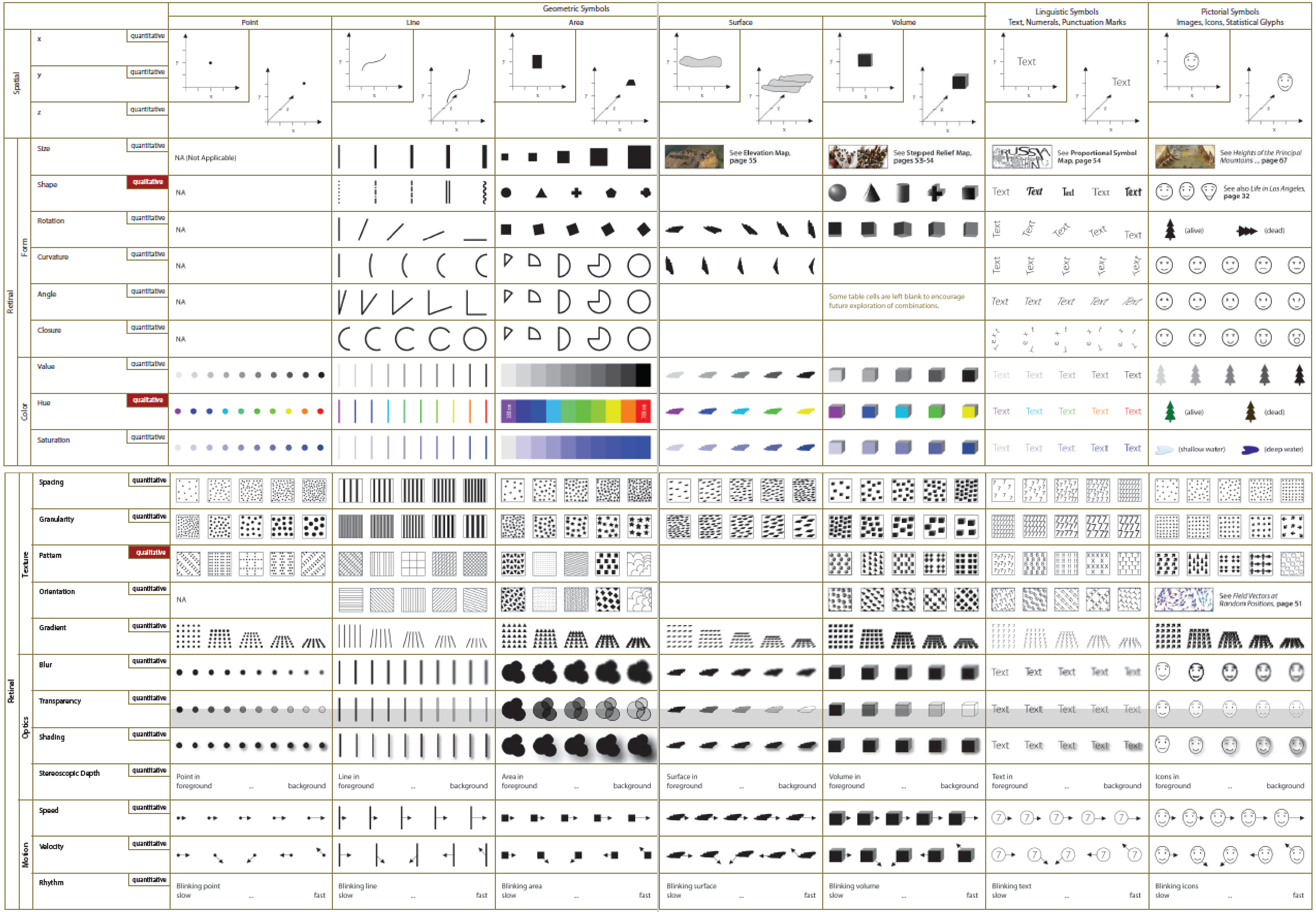
Categorical Attributes
Identity Channels

Quantitative

Also called:

Ordered Attributes
Magnitude Channels

Graphic Variable Types Versus Graphic Symbol Types

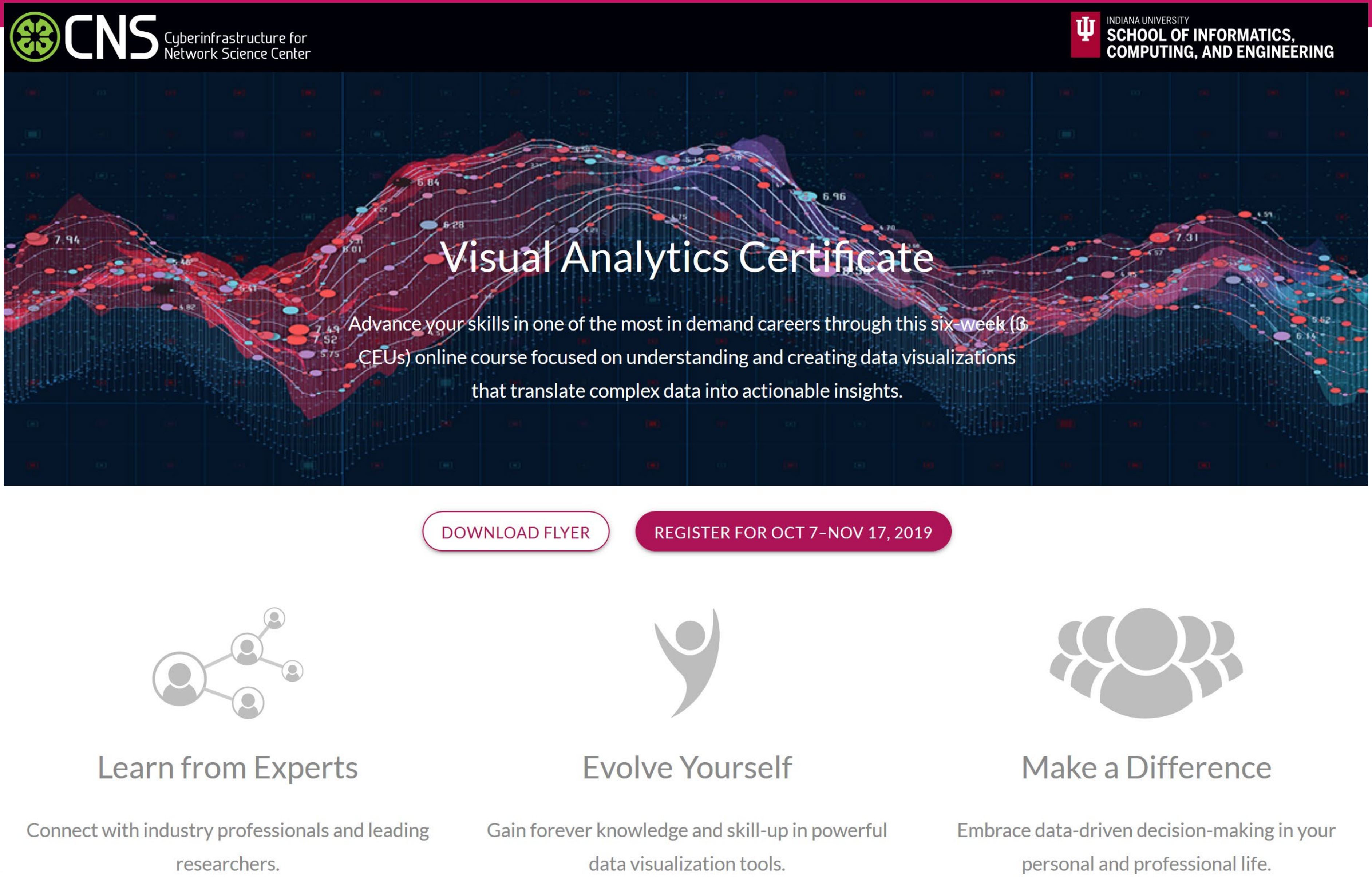


See *Atlas of Knowledge* pages 36-39 for complete table.

Typology of the Data Visualization Literacy Framework

Insight Needs	Data Scales	Analyses	Visualizations	Graphic Symbols	Graphic Variables	7 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, 68-69.



https://visanalytics.cns.iu.edu

CNS Cyberinfrastructure for Network Science Center

INDIANA UNIVERSITY
SCHOOL OF INFORMATICS, COMPUTING, AND ENGINEERING

Human BioMolecular Atlas Program (HuBMAP)

Mapping the Human Body at Cellular Resolution—
The NIH Common Fund Human BioMolecular Atlas Program
Snyder et al. https://arxiv.org/abs/1903.07231

HuBMAP Goals

Vision

Catalyze the development of an open, global framework for comprehensively mapping the human body at a cellular resolution.

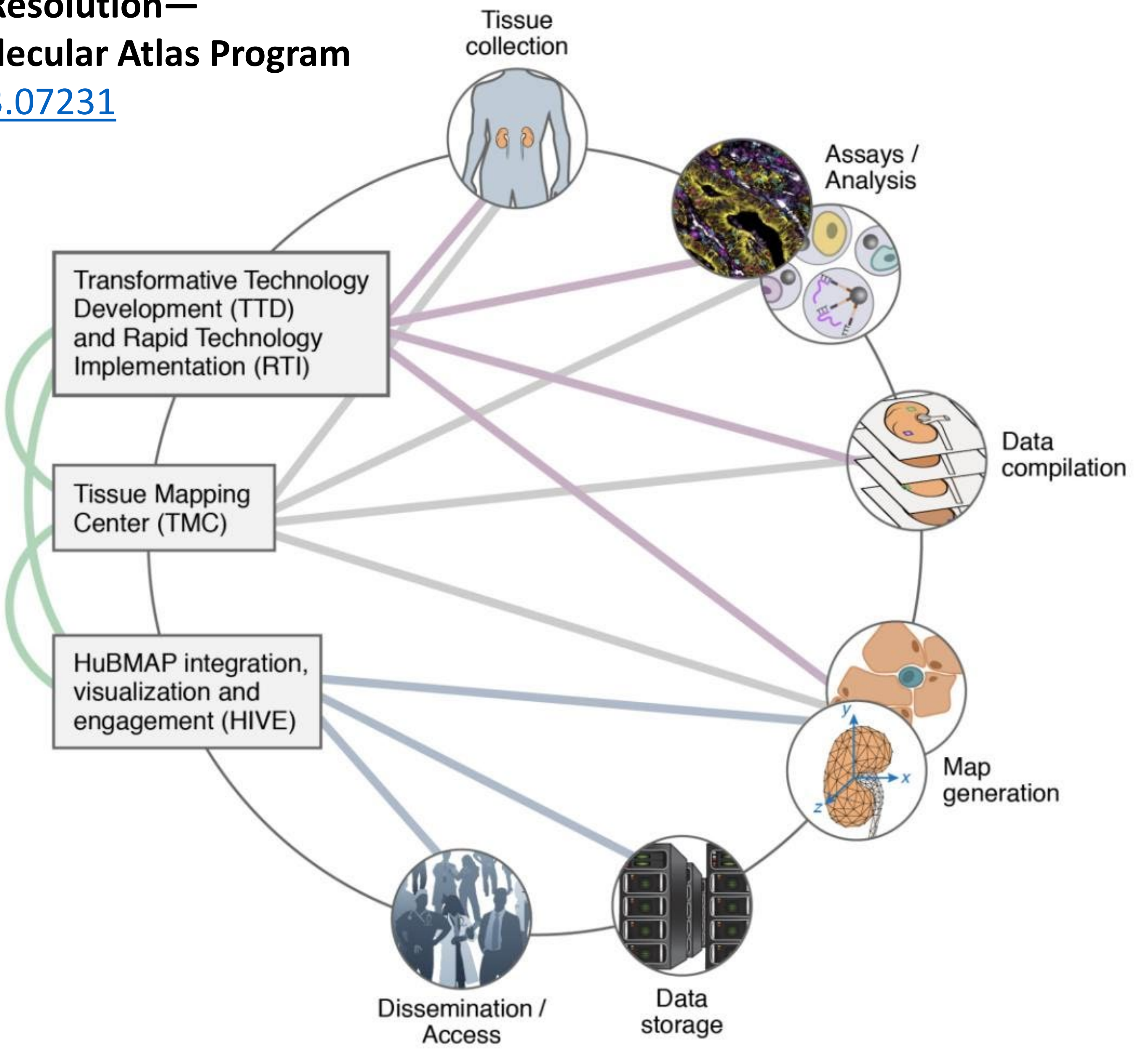
https://commonfund.nih.gov/HuBMAP

Goals

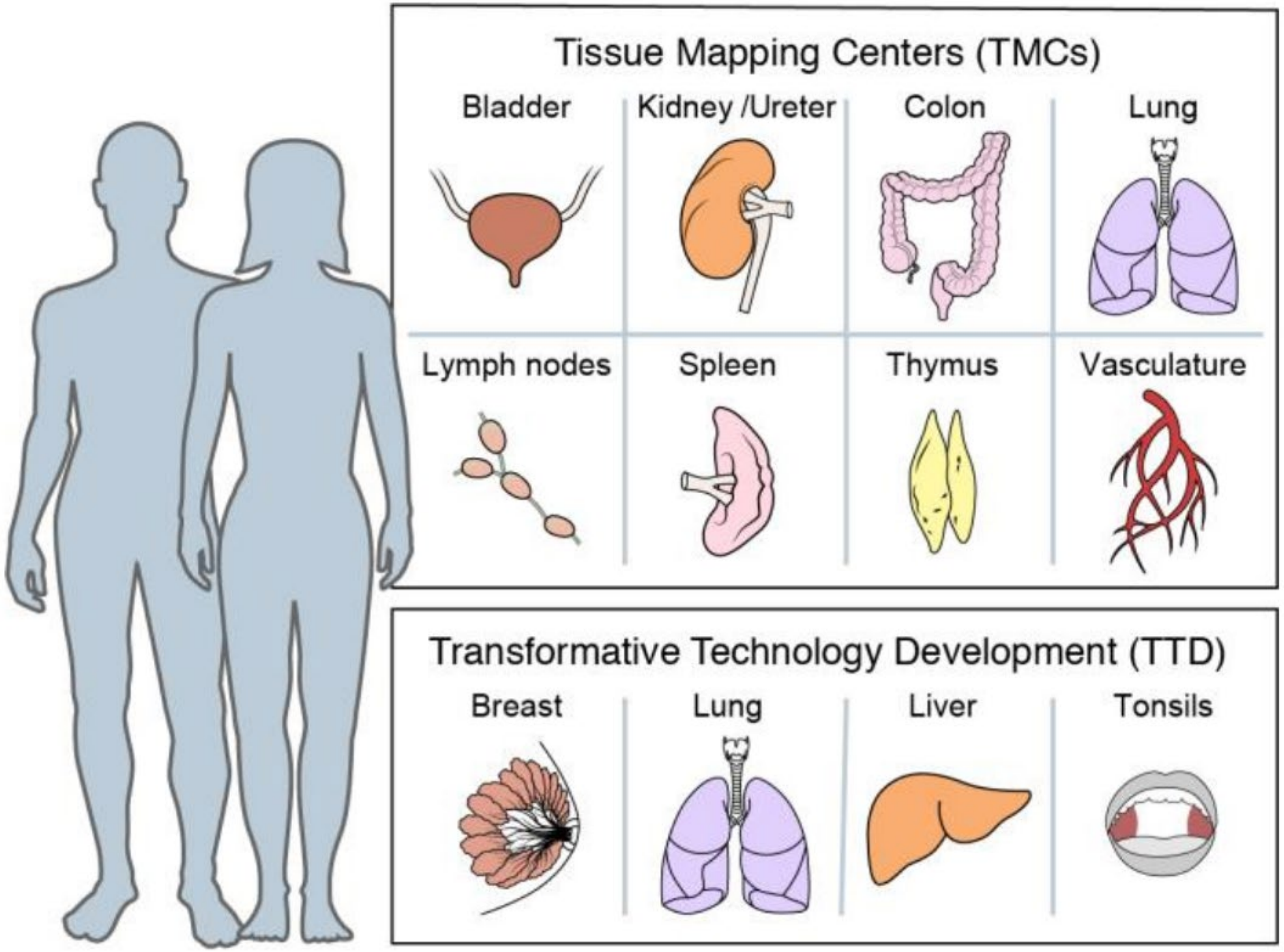
1. Accelerate the development of the next generationof tools and techniques for constructing high resolution spatial tissue maps
2. Generate foundational 3D tissue maps
3. Establish an open data platform
4. Coordinate and collaborate with other funding agencies, programs, and the biomedical research community
5. Support projects that demonstrate the value of the resources developed by the program

Mapping the Human Body at Cellular Resolution—
The NIH Common Fund Human BioMolecular Atlas Program

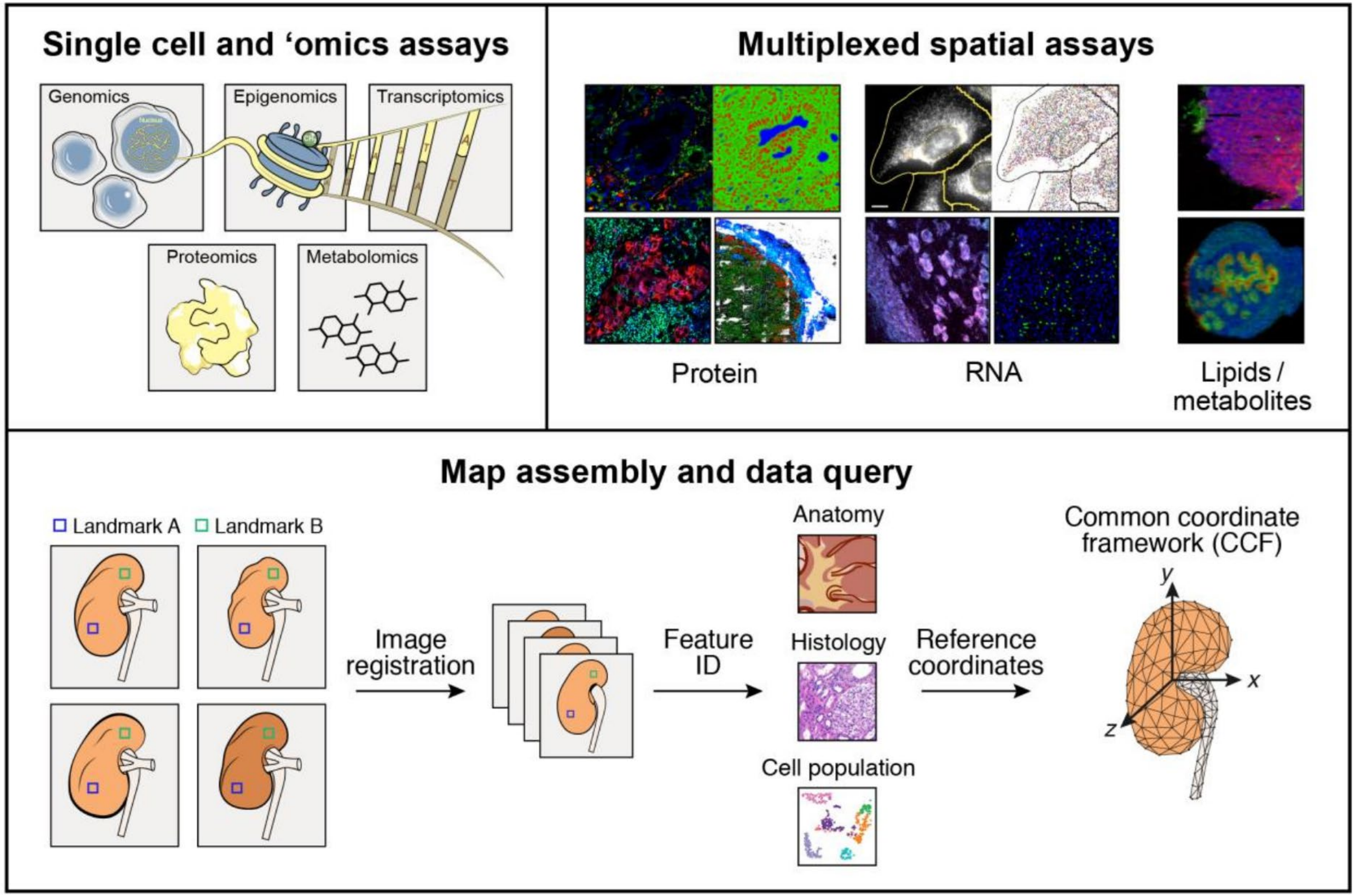
Snyder et al. https://arxiv.org/abs/1903.07231

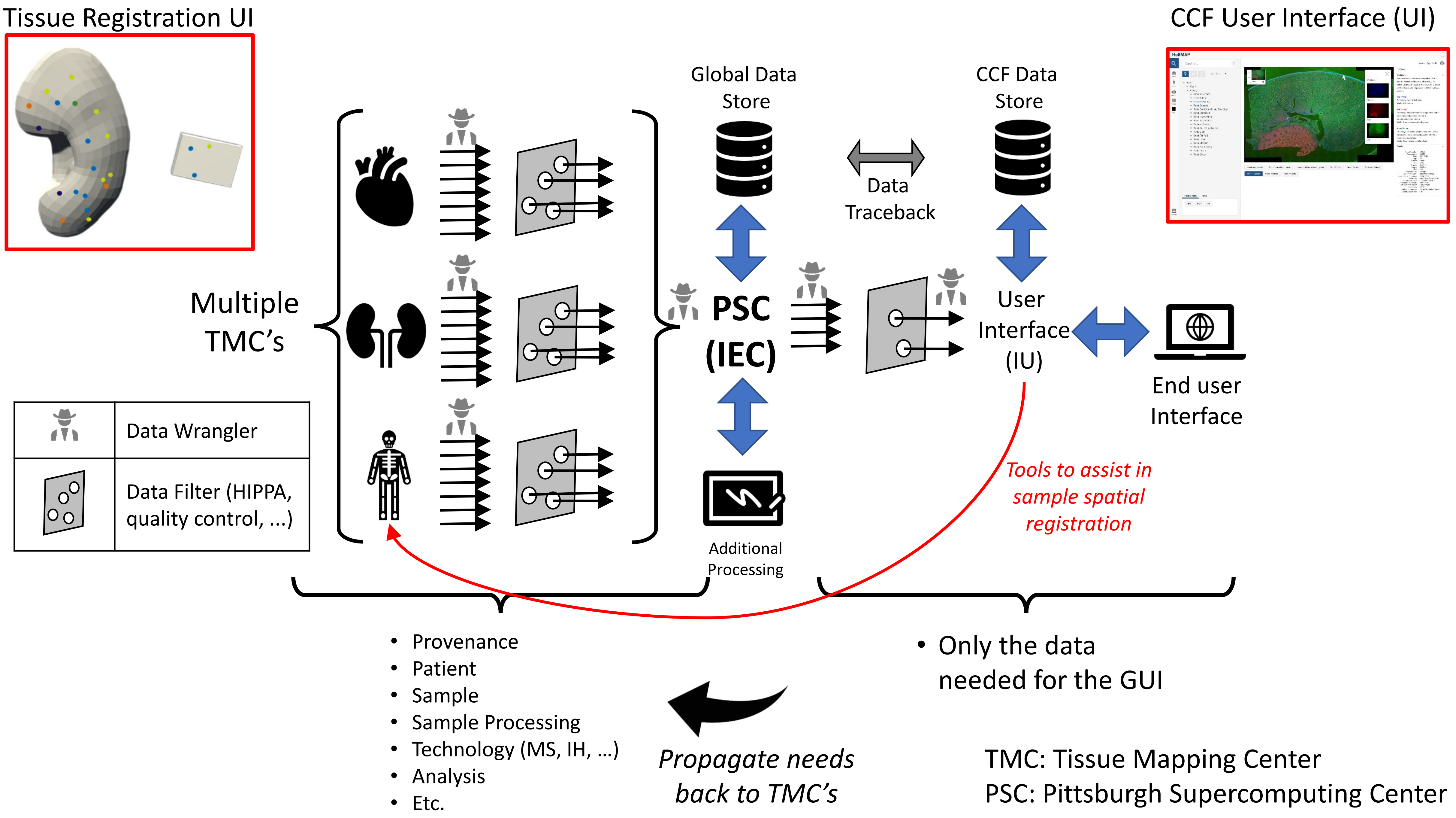


Mapping the Human Body at Cellular Resolution—
The NIH Common Fund Human BioMolecular Atlas Program
Snyder et al. https://arxiv.org/abs/1903.07231



Mapping the Human Body at Cellular Resolution—
The NIH Common Fund Human BioMolecular Atlas Program
Snyder et al. https://arxiv.org/abs/1903.07231





Tissue Registration UI
CCF User Interface (UI)
Global Data Store
CCF Data Store
Data Traceback
Multiple TMC's
PSC (IEC)
User Interface (IU)
End user Interface
Additional Processing
Data Wrangler
Data Filter (HIPPA, quality control, ...)
Tools to assist in sample spatial registration
Provenance
Patient
Sample
Sample Processing
Technology (MS, IH, ...)
Analysis
Etc.
Only the data needed for the GUI
Propagate needs back to TMC's
TMC: Tissue Mapping Center
PSC: Pittsburgh Supercomputing Center

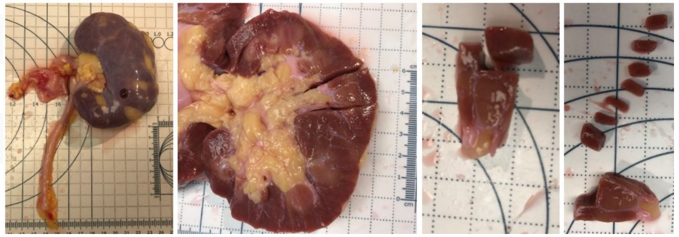
Tissue from 9 Organs | 25 Assays

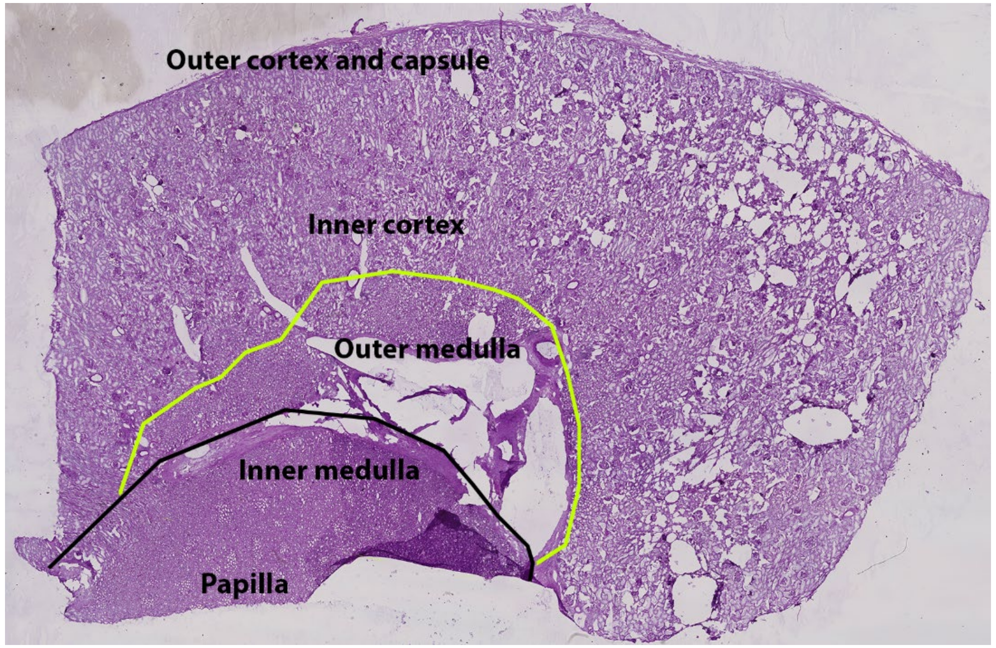
Kidney: Jeff Spraggins et al., VU

See data on Globus, BIOMIC_patient-64354

- BIOMIC_patient-64354_clinical_and_spatial_metadata.xlsx
- BIOMIC_patient-64354_data_guide.pptx
- BIOMIC_patient-64354_overview.png
- BIOMIC_patient-64354_Sample-20-Histology.tif
- neg_ion_mode_section
- pos_ion_mode_section

BUKMAP, Zhang Group

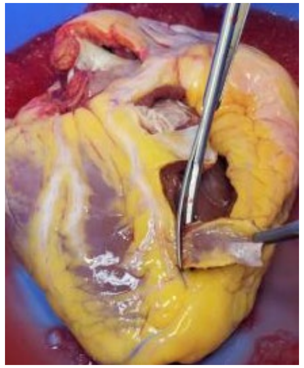




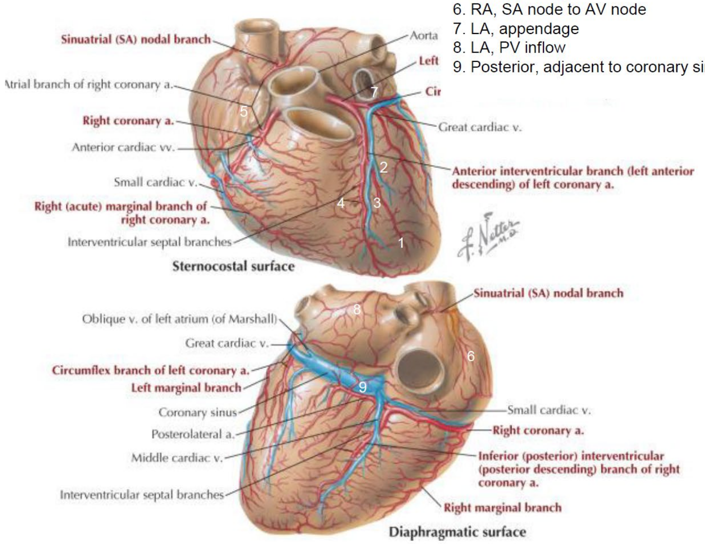
Heart: Shin Lin, UW

Year 1: Tissue data for 1-2cm cubed volumes from 9 sites for 1 heart from 1 individual.

Terminology; Coordinates and photos to spatialize



Sites	Distinctive features
1. LV, apex	
2. LV, free wall 3 cm from apex	
3. septum, 3cm from apex including LAD	major arterial vessel, Purkinje fiber CM
4. RV, free wall 3 cm from apex	
5. RA appendage	
6. RA, SA node to AV node	pacemaker CM
7. LA, appendage	
8. LA, PV inflow	
9. Posterior, adjacent to coronary sinus	major venous vessel



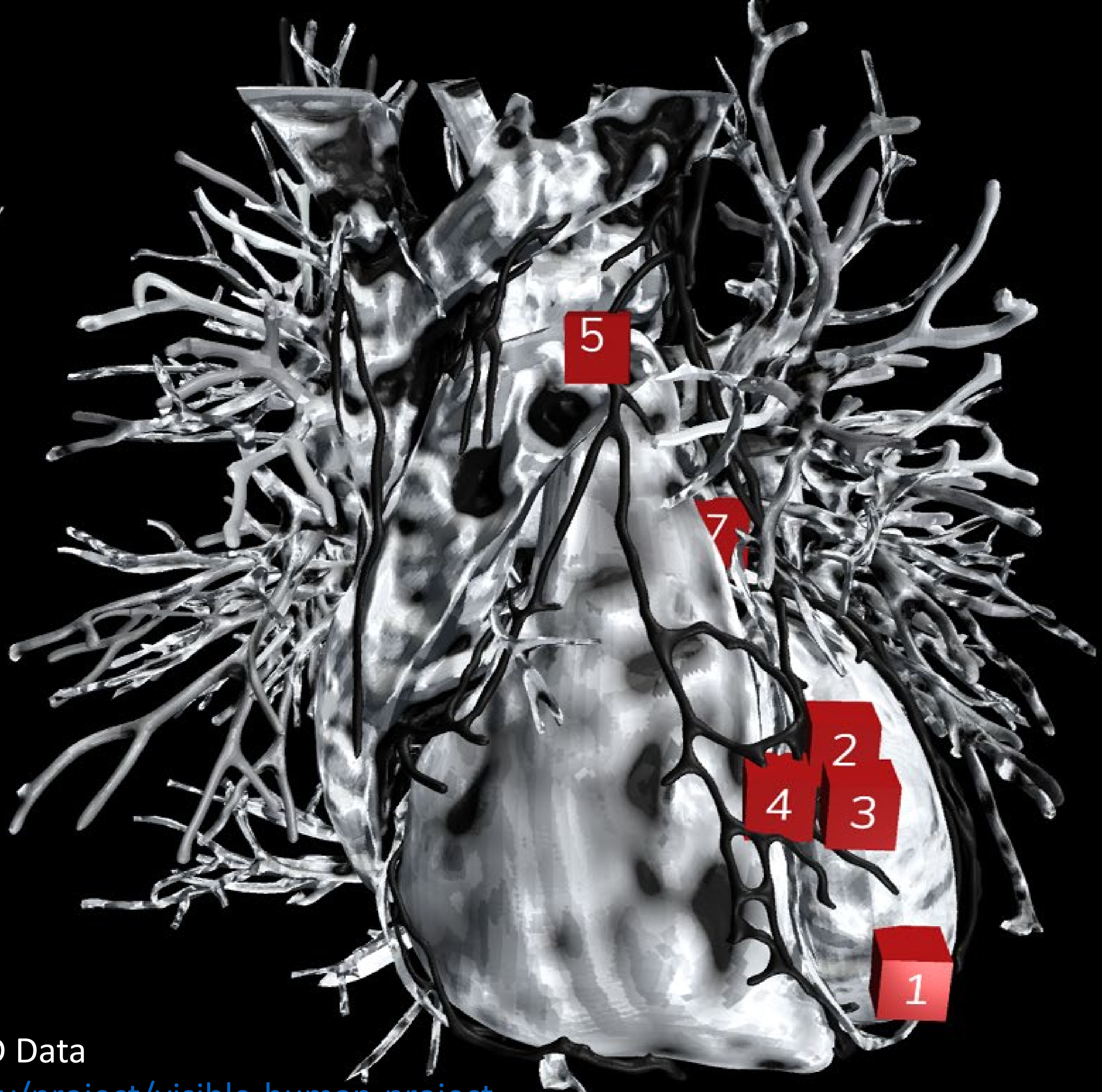
Heart

Human heart with data overlay
Developer: Andreas Bueckle

Show/hide

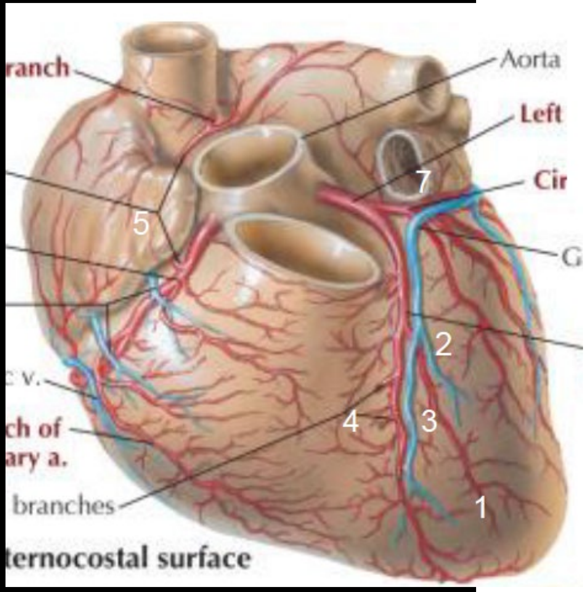
- ☑ Coronary arteries
- ☑ Coronary veins
- ☑ Left atrium
- ☑ Left ventricle
- ☑ Right atrium
- ☑ Right ventricle
- ☑ Markers

Adjust camera speed



Currently Selected

Please click any of the red markers!



Heart model from NLM3D Data
https://lhncbc.nlm.nih.gov/project/visible-human-project

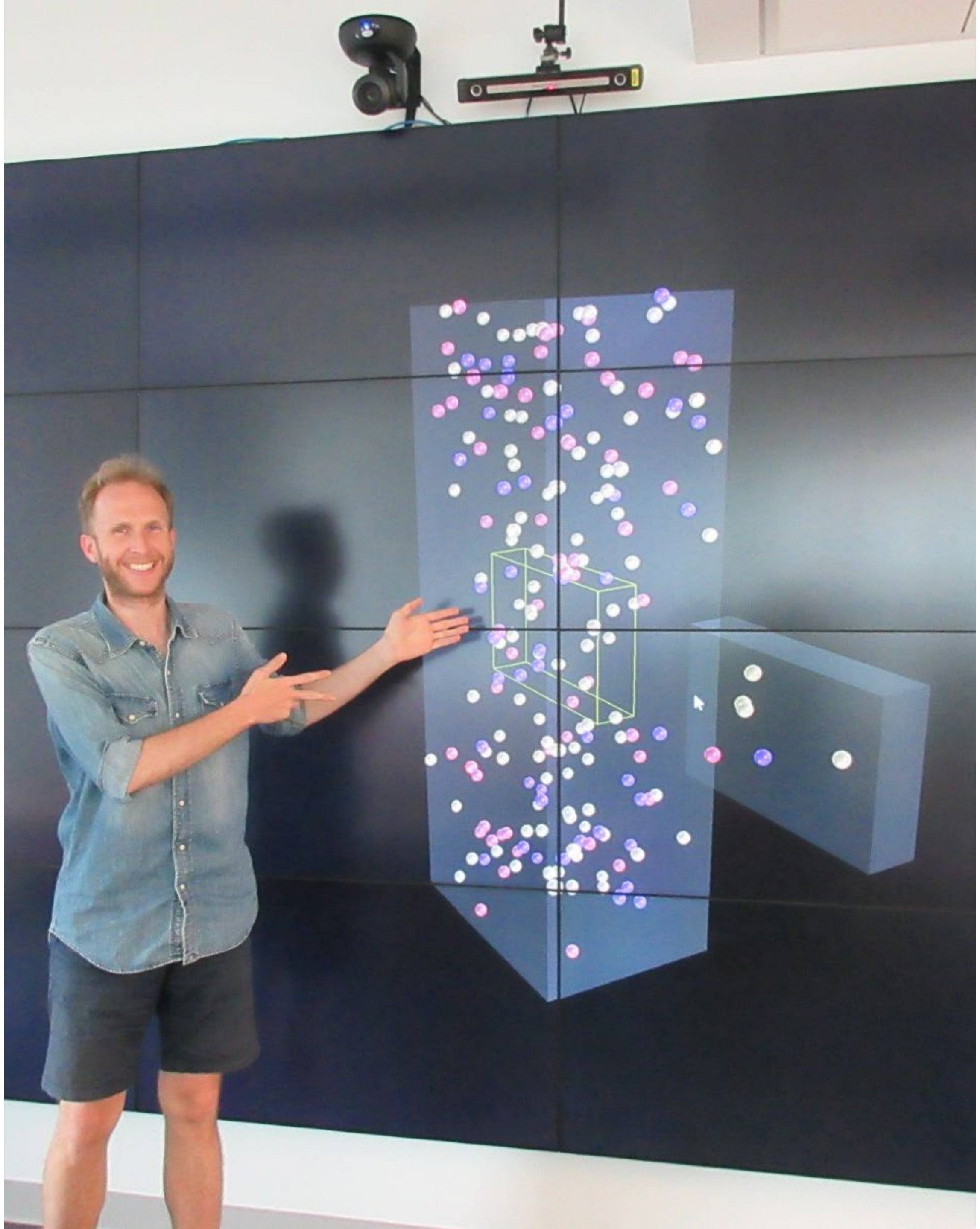
CCF Tissue Registration UI: Kidney

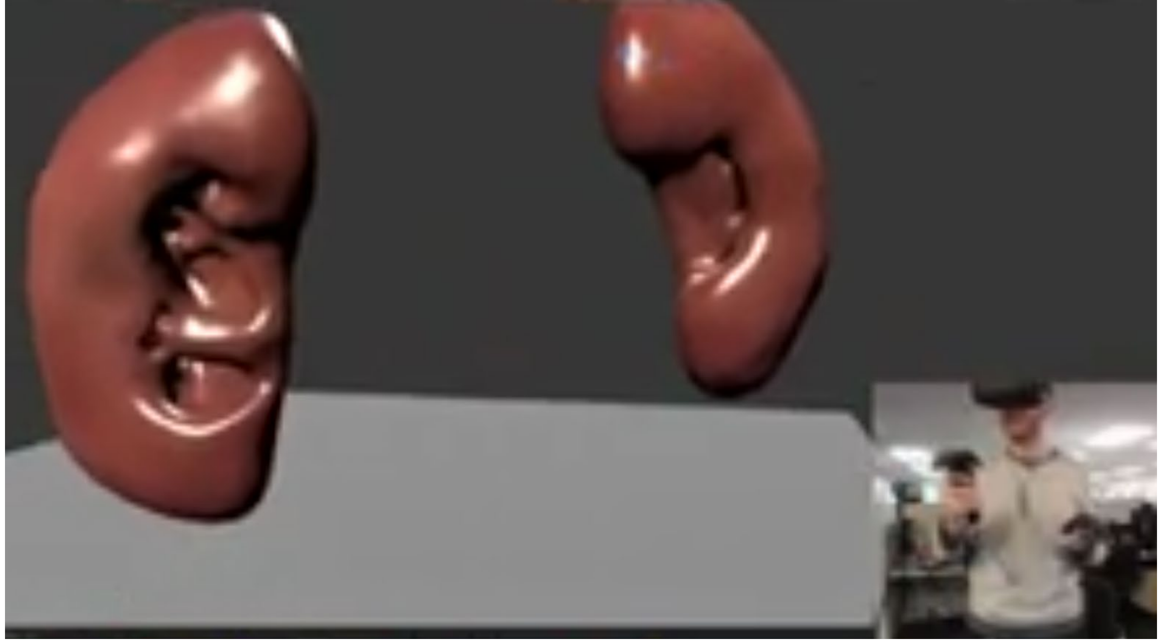
- Exploit human pattern recognition and fine motor skills (by surgeons) to register tissue in organs.
- Add info on anatomical landmarks, cell types, molecular data to support alignment.
- LATER: Use human alignment data as training data for machine learning algorithms, to better support manual alignment OR to possibly fully automatize alignment.

VIVE™ | VIVE Virtual Reality System
vive.com

How many of you have used a VIVE or space mouse?

Kidney model from NLM3D Data
https://lhncbc.nlm.nih.gov/project/visible-human-project



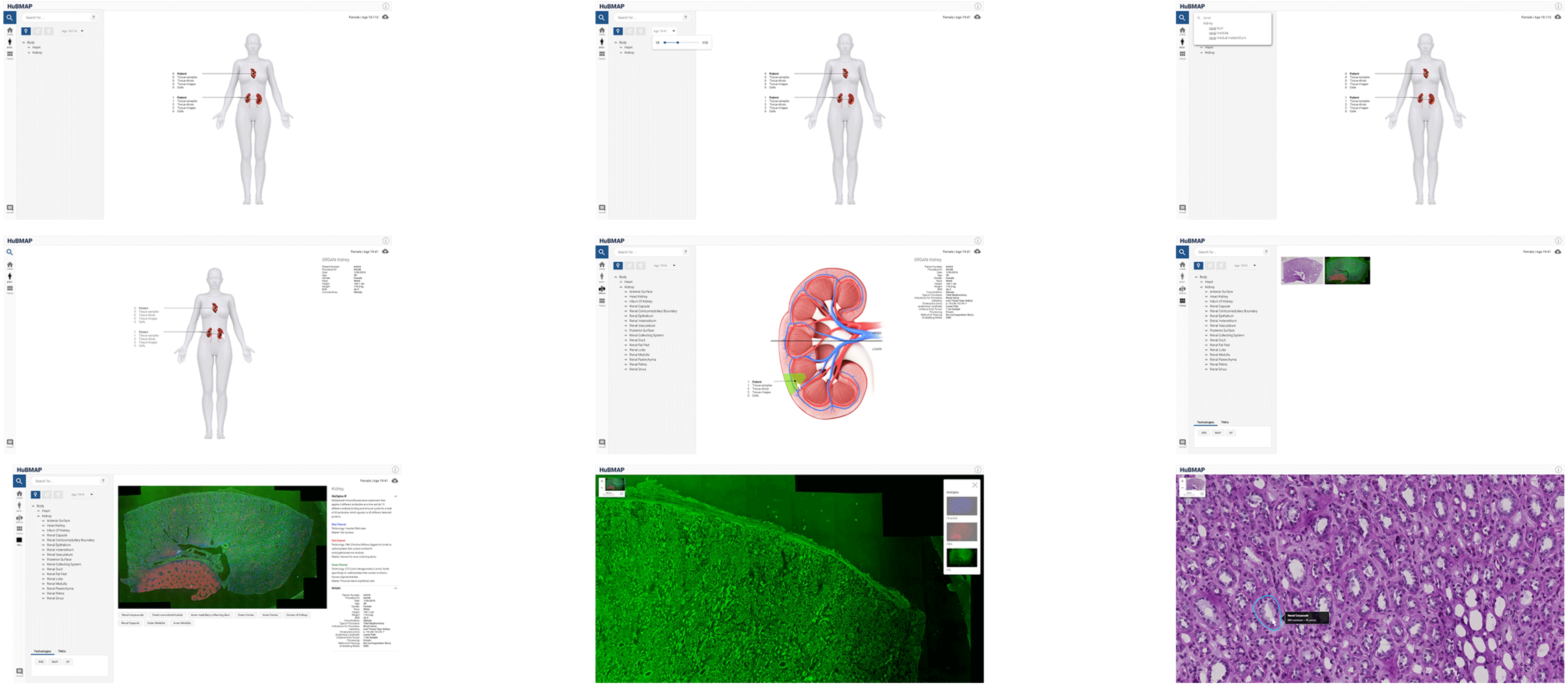


Kidney model from NLM3D Data
https://lhncbc.nlm.nih.gov/project/visible-human-project

CCF User Interface (UI)

GitHub demo site: https://hubmapconsortium.github.io/ccf-ui/

CCF User Interface (UI)



Acknowledgements

Jeffrey Spraggins
TMC-Vanderbilt
Vanderbilt University

Sanjay Jain
TMC-UCSD
Washington University, St. Louis

https://hubmapconsortium.org

MC-IU HIVE Team at IU

Plus, **patients** that agreed to volunteer healthy tissue and to use their data openly.

References

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