CNS Cyberinfrastructure for Network Science Center

INDIANA UNIVERSITY SCHOOL OF INFORMATICS, COMPUTING, AND ENGINEERING

(Data) Visualization Literacy

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Visualization Literacy for General Audiences - Can We Make A Difference? Panel at IEEE Vis2021 Conference
http://ieeevis.org/year/2021/info/panels

October 27, 2021

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Data Visualization Literacy

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

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

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.

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

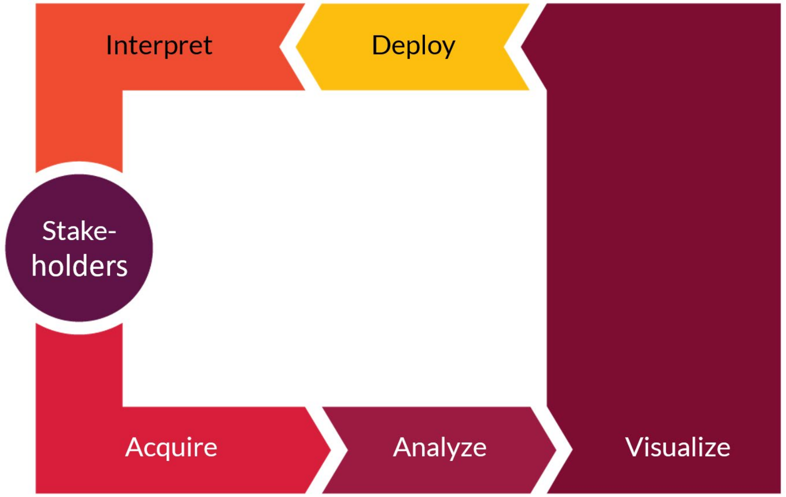
5 **Graphic Symbols**
- geometric symbols
  - point
  - line
  - area
  - surface
  - volume
- linguistic symbols
  - text
  - numerals
  - punctuation marks
- pictorial symbols
  - images
  - icons
  - statistical glyphs

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.



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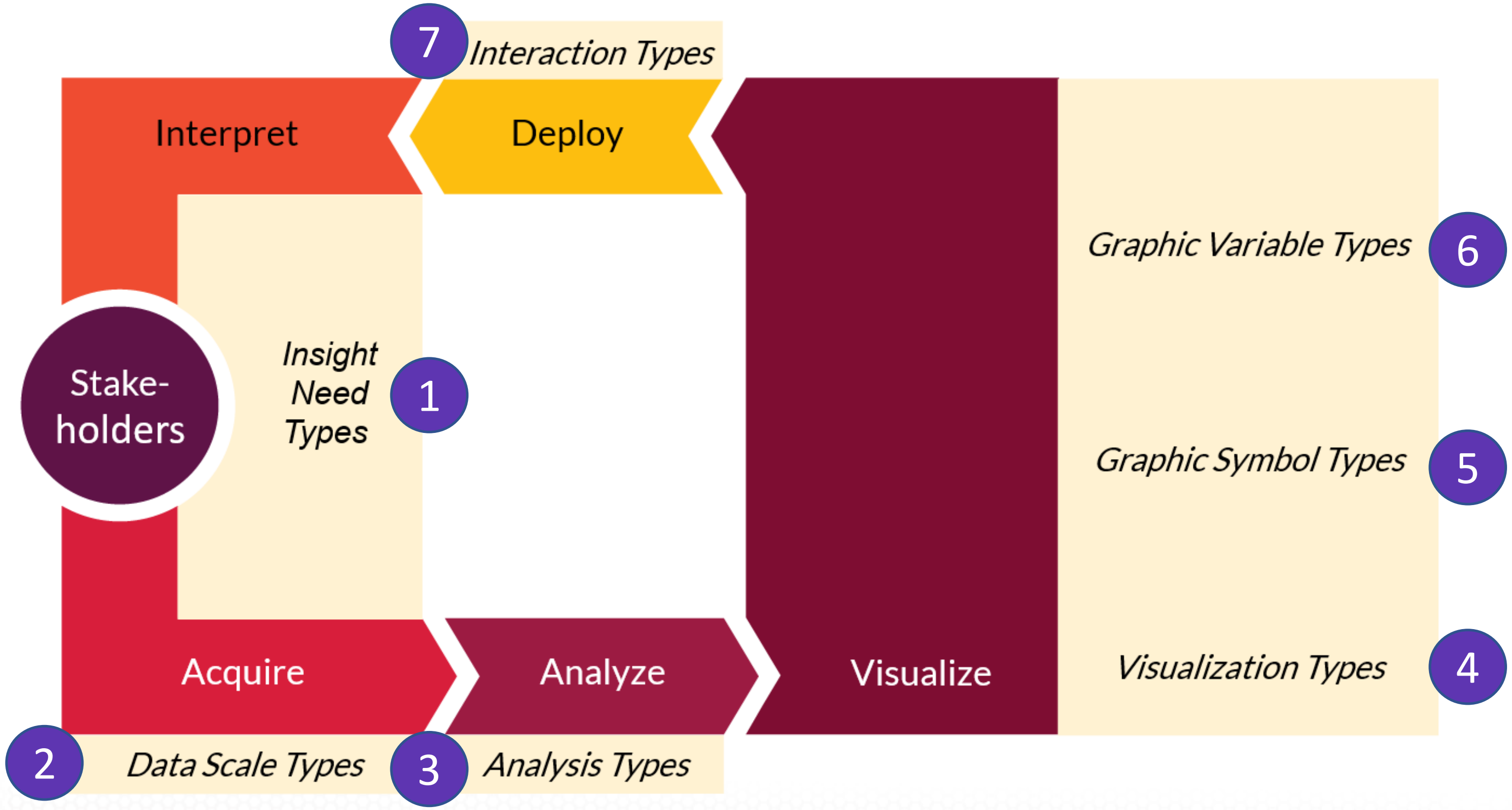
Data Visualization Literacy Framework (DVL-FW)

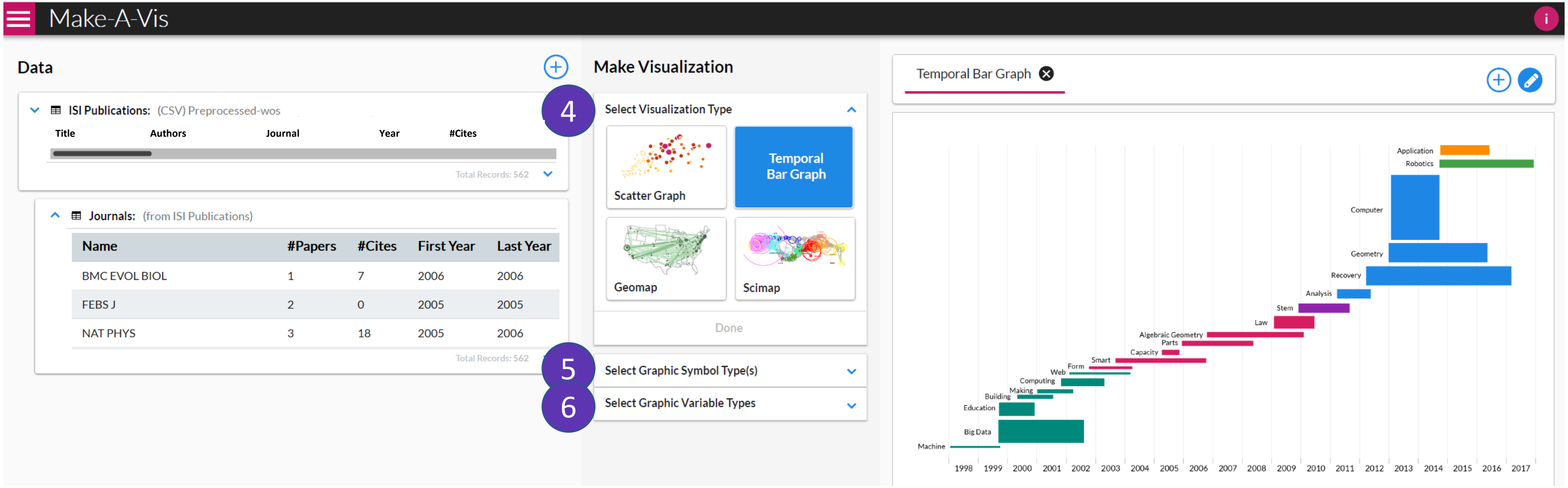
Consists of two parts that are interlinked:

DVL Typology +
DVL Workflow Process

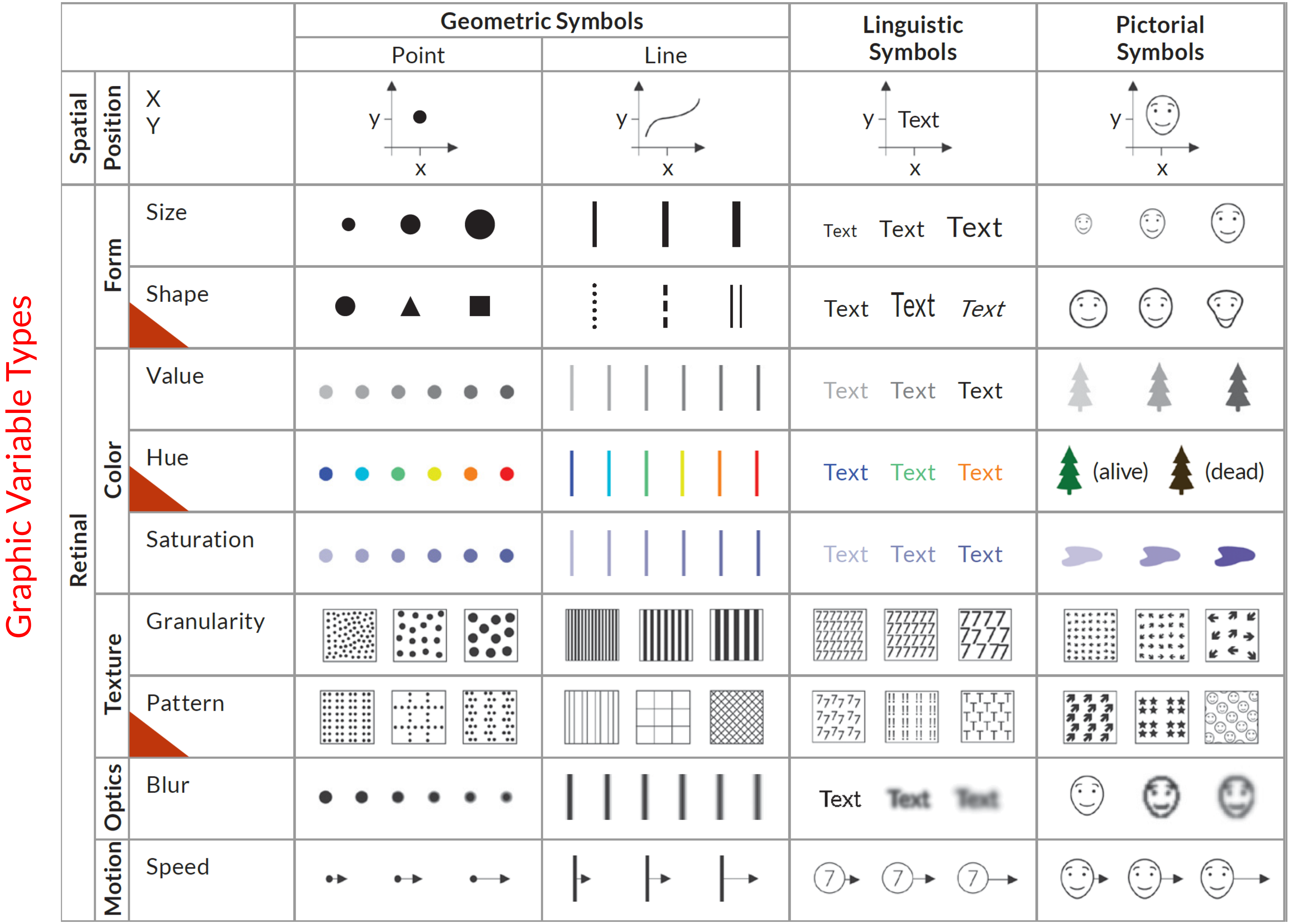


Data Visualization Literacy Framework (DVL-FW)

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



Graphic Symbol Types



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

Qualitative

Also called:

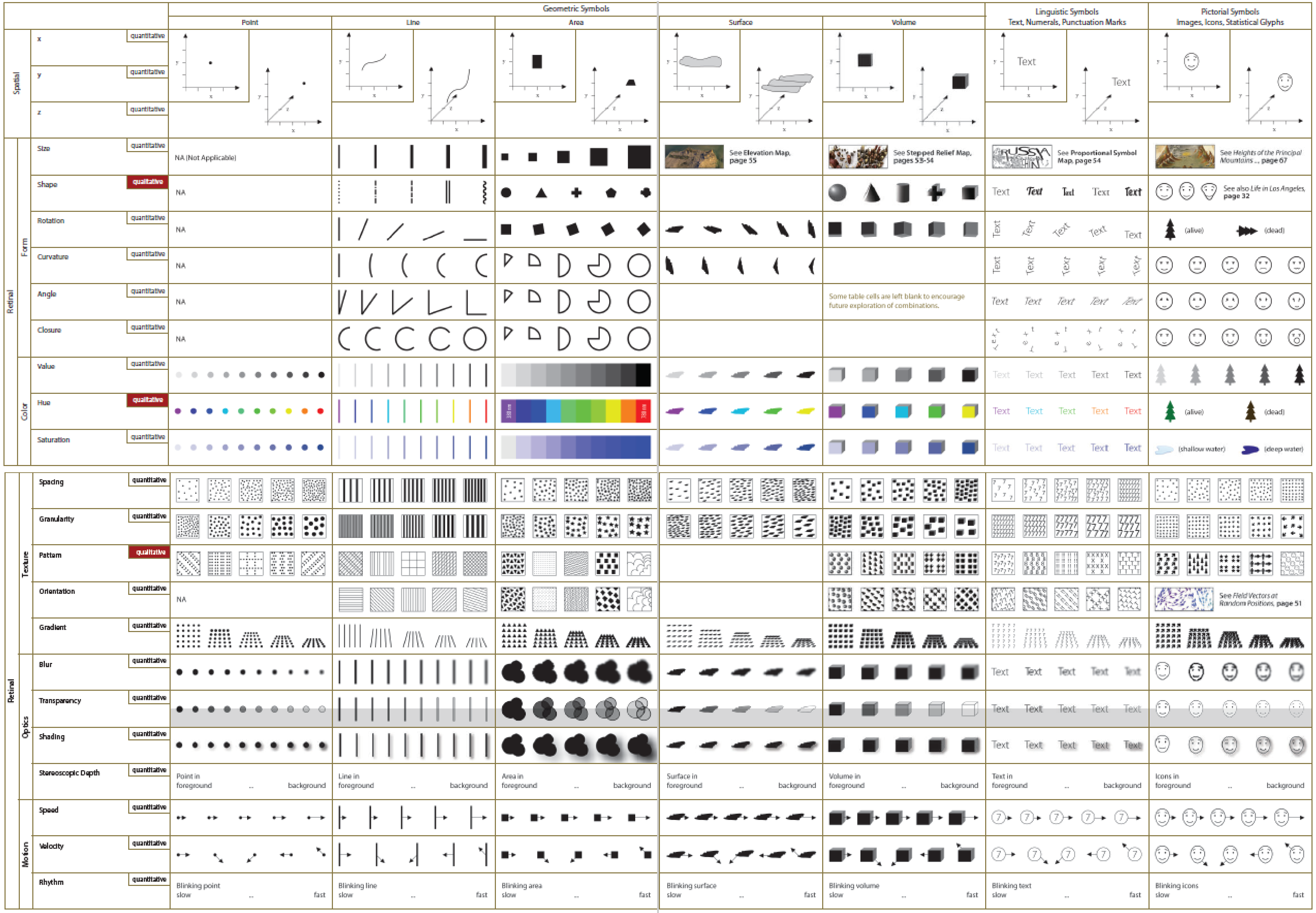
Categorical Attributes
Identity Channels

Quantitative

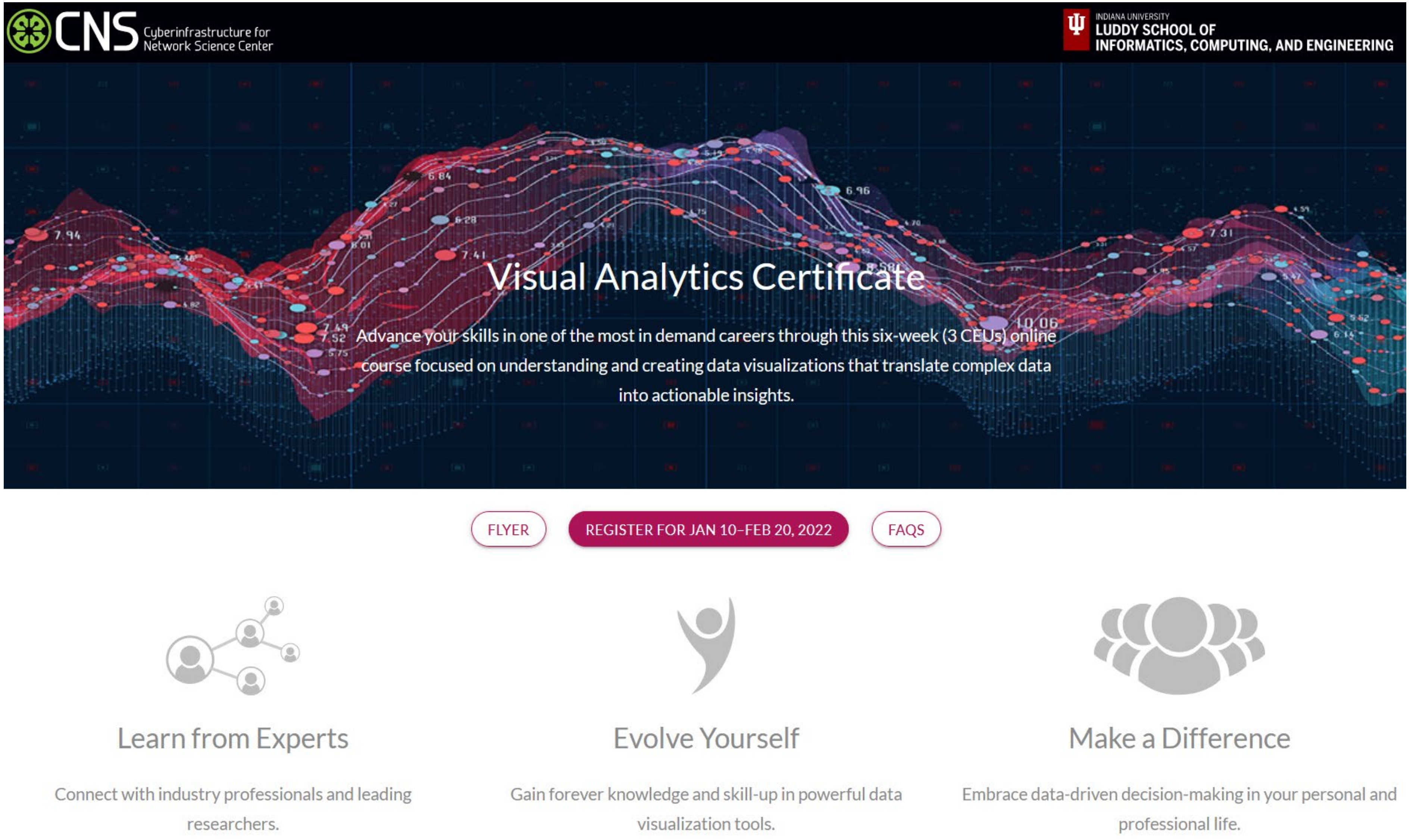
Also called:

Ordered Attributes
Magnitude Channels

Graphic Variable Types Versus Graphic Symbol Types



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



https://visanalytics.cns.iu.edu

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

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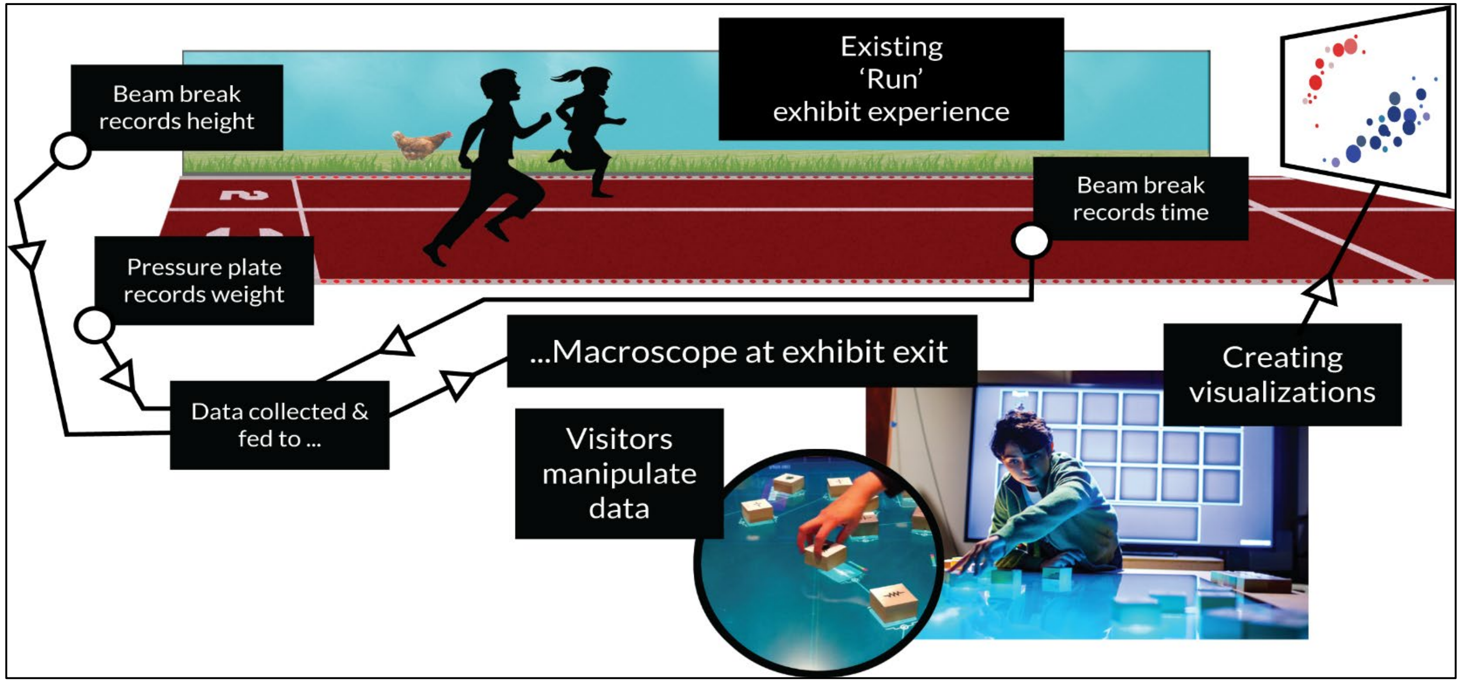
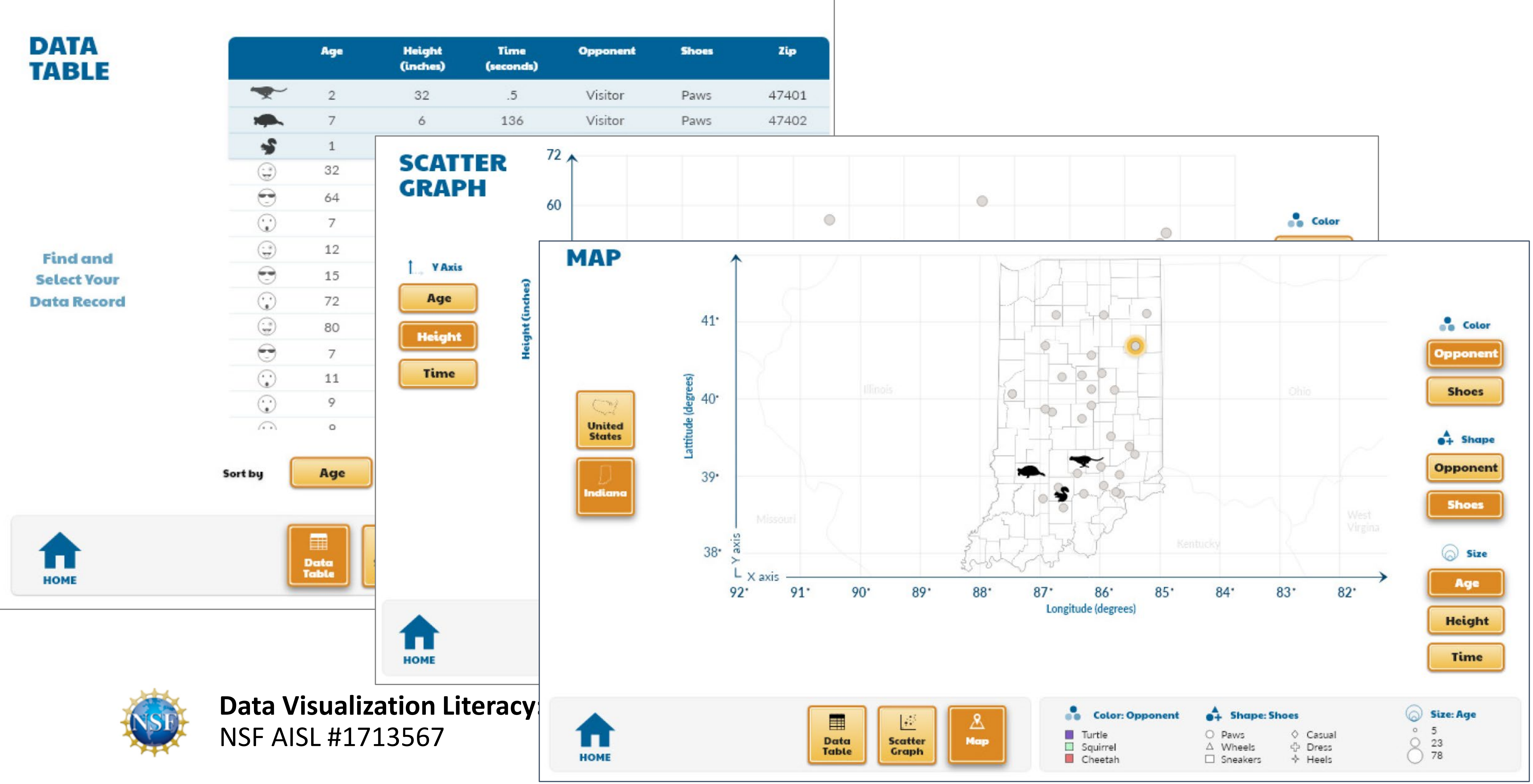
Teaching Data Visualization Literacy

in Science Museums

xMacroscopes in Science Museums



Data Visualization Literacy: Research and Tools that Advance Public Understanding of Scientific Data.
NSF AISL #1713567



Data Visualization Literacy:
NSF AISL #1713567

Investigating Aspects of Data Visualization Literacy Using 20 Information Visualizations and 273 Science Museum Visitors

https://cns.iu.edu/2015-VisLit.html

Börner, Katy, Joe E. Heimlich, Russell Balliet, and Adam V. Maltese. (Accepted). "Investigating Aspects of Data Visualization Literacy Using 20 Information Visualizations and 273 Science Museum Visitors". *Information Visualization*.

Abstract:

In the information age, a person's ability to read and make data visualizations is nearly as important as being able to read and write text. This paper reports the results of a multi-phase study conducted in informal learning environments in three U.S. science museums. The goal of the study was to determine the familiarity of youth and adult museum visitors with different visualization types. To address this, a total of 273 visitors were shown five out of 20 different visualizations that included two charts, five maps, eight graphs, and five network layouts. They were asked to judge the familiarity of the visualization, provide information on how to read it, and to provide a name, identify typical locations where they would encounter the data display and possible data sources that might be visualized in this way.

Results show that while most participants have a strong interest in science, math and art, many have a hard time naming and interpreting visualizations. Participants in this study commonly encounter visualizations in school, in books, at work, on the Internet, and in the news. Overall they were more familiar with basic charts, maps and graphs, but very few are familiar with network layouts and most have no ability in reading network visualizations. When asked how they would interpret the visualizations, most participants pointed to superficial features such as color, lines, or text as important to developing understanding. Overall, we found that participants were interested in the visualizations we presented to them, but had significant limitations in identifying and understanding them.

The results substantiate intuitions shared by many regarding the rather low level of data visualization literacy of general audiences. We hope they will help catalyze novel research on the development of easy-to-use yet effective visualizations with standardized names and guaranteed properties that can be readily used by those interested to understand and solve real world problems. Results also have implications for how information visualizations are taught and used in formal and informal education, the media, or in different professions.

Links:

- Data Collection Basics
- Instructions for Completing the Interview
- Data Collection Form
- 20 Visual Stimuli (see Figure 1)
- Refusal Log
- Blank Data Entry Spreadsheet

Data Visualization Literacy: Research and Tools that Advance Public Understanding of Scientific Data.
NSF AISL #1713567

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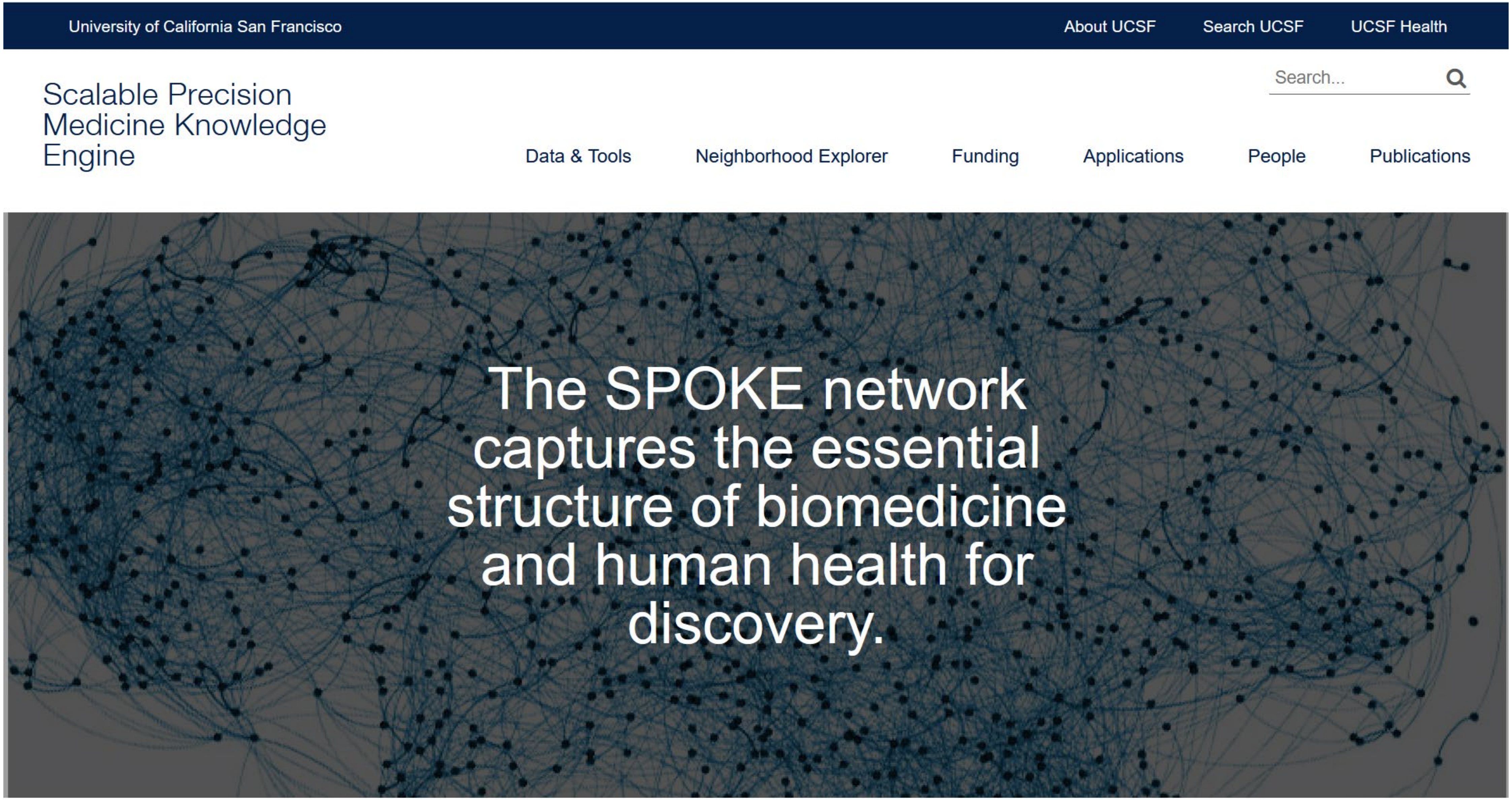
Visualizations of the Scalable Precision Medicine Knowledge Engine (SPOKE)

https://spoke.ucsf.edu



https://spoke.ucsf.edu

Lead Investigators

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Principal Investigator

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Sharat Israni, PhD

Mike Keiser, PhD

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Adil Harroud, MD

Elaine Meng, MD

Scooter Morris, PhD

Charlotte Nelson, PhD

Boris Oskotsky, PhD

Angela Rizk-Jackson, PhD

Peter Rose, PhD (UCSD)

Brett Smith (ISB)

Karthik Soman, PhD

Xiaoyuan Zhou, PhD

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Mark Musen, MD, PhD (Stanford)

Camille Nebeker, EdD, MS (UCSD)

Roger Pearce, PhD (LNL)

SPOKE investigative teams

The SPOKE team members are from the following organizations. *Team members listed below are from UCSF, except when indicated.*

- Google
- Indiana University (IU)
- Institute for Systems Biology (ISB)
- Lawrence Livermore National Lab (LLNL)
- Stanford University
- University of California, San Diego (UCSD)
- University of California, San Francisco (UCSF)

SPOKE Scalable Precision Medicine Knowledge Engine

Envisioning SPOKE: 3M Nodes and 30M Edges

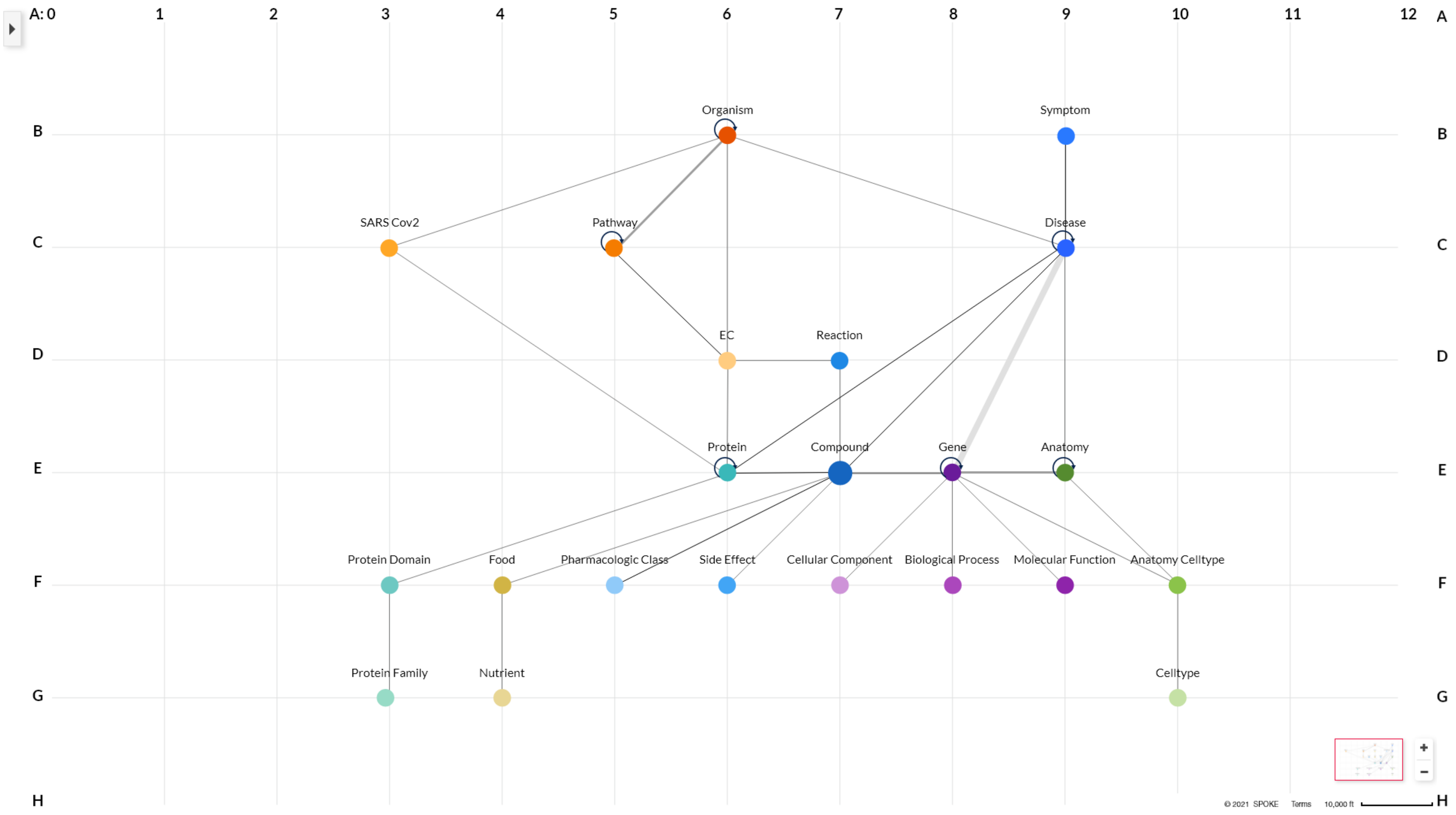
The Scalable Precision Medicine Oriented Knowledge Engine (SPOKE) graph federates about 19 open datasets into a public data commons of health relevant knowledge. This site lets users explore the massive SPOKE knowledge graph.

The site was designed for two user groups: (1) novice users interested to understand the coverage and quality of SPOKE data and (2) expert users interested to analyze and optimize the interlinked knowledge graphs in SPOKE.
The overview visualization shows the different entity type and their diverse interlinkages. Detail

SPOKE is a fully interactive tool for exploring the interconnections between data.

Explore SPOKE

NSF NIH National Center for Advancing Translational Sciences UCSF CNS Cyberinfrastructure for Network Science Center



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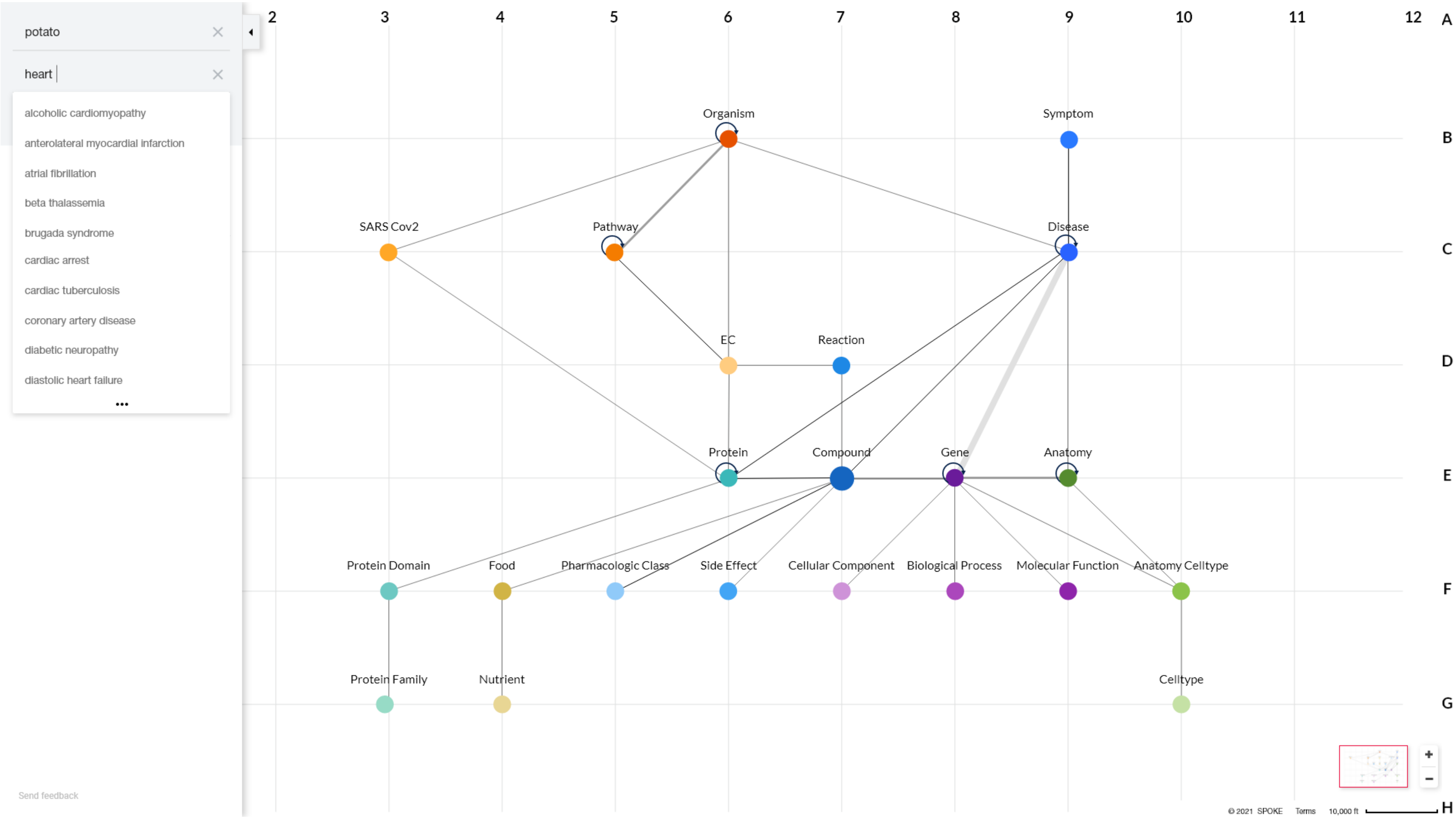
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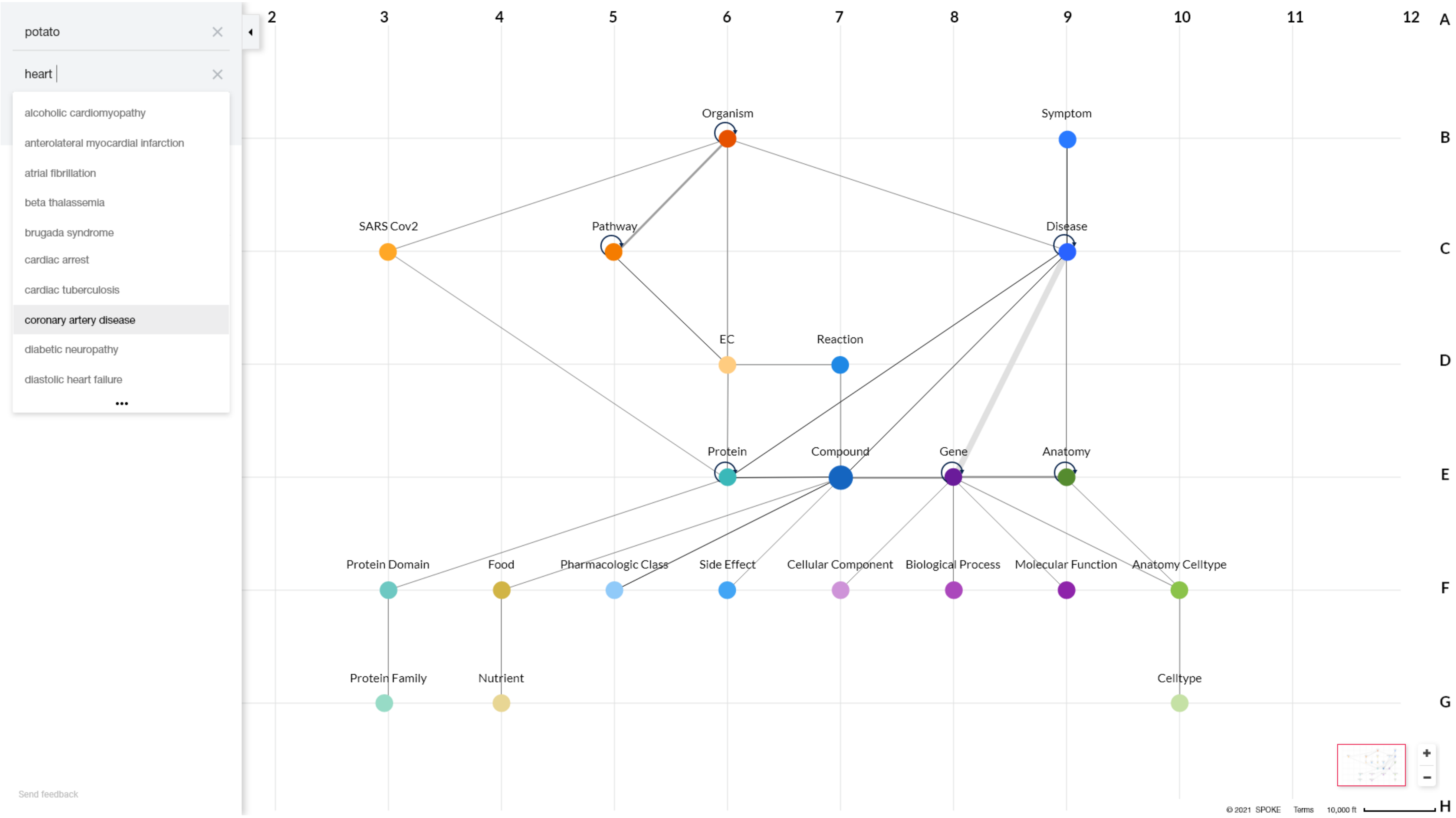
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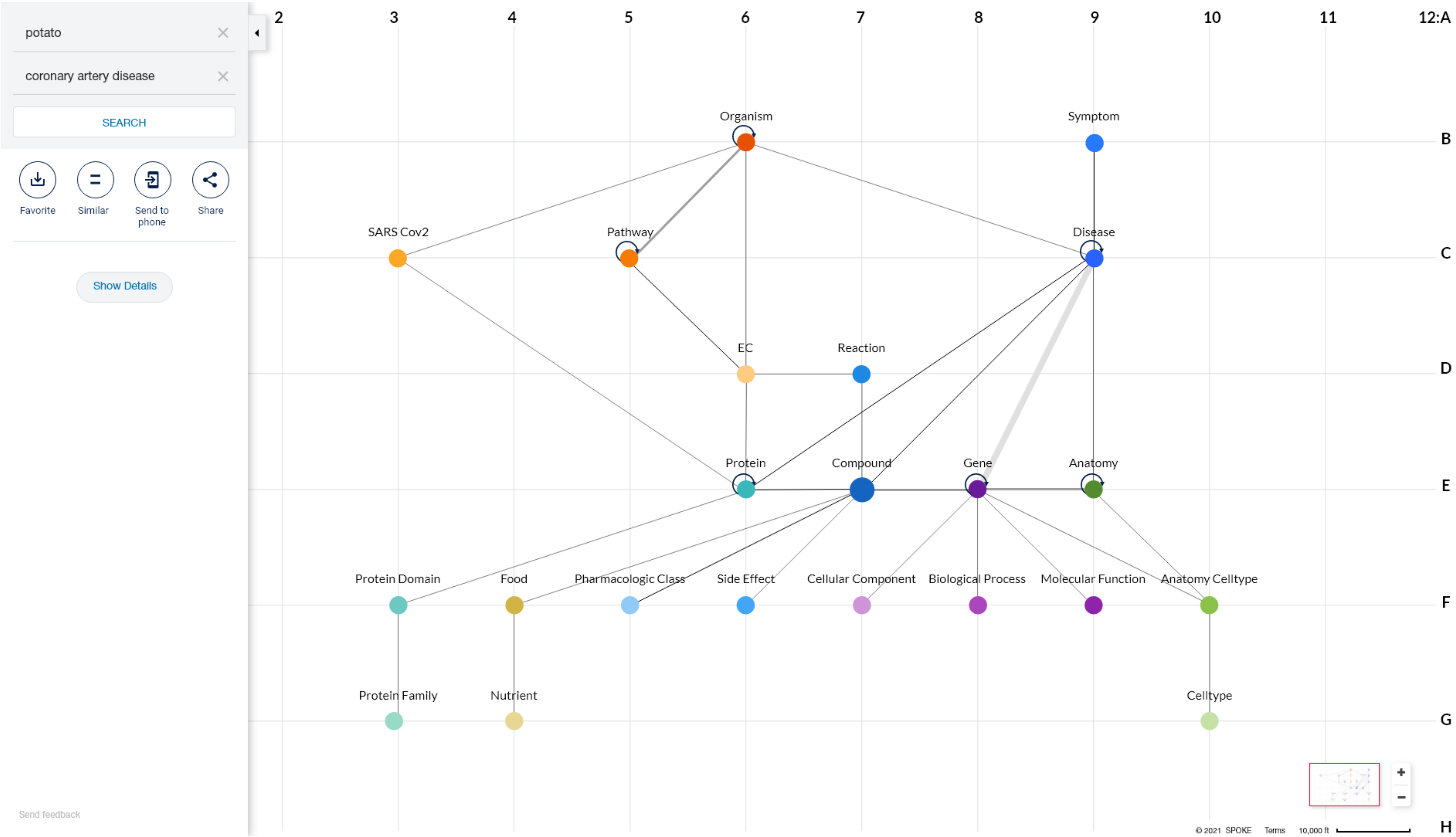
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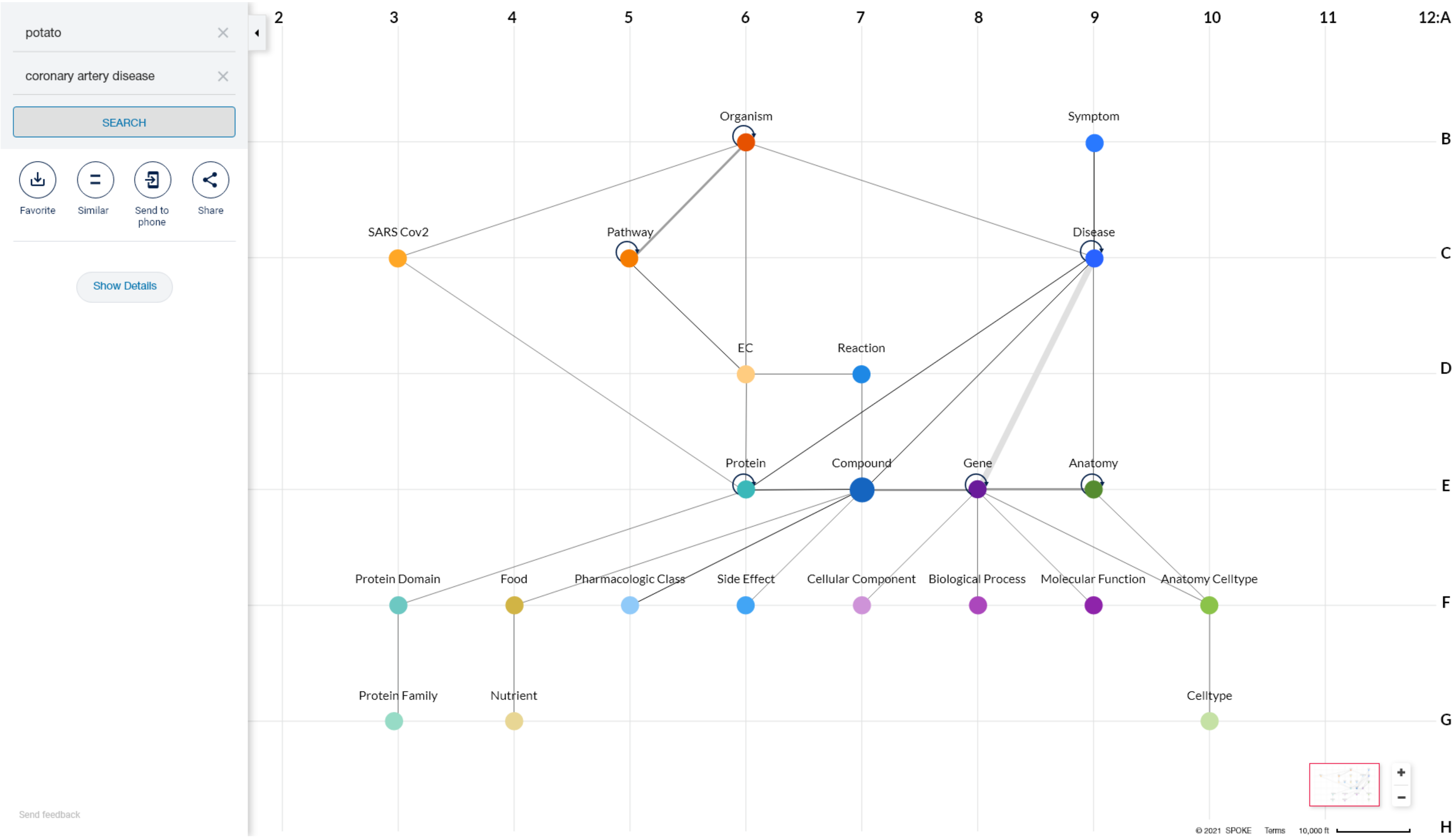

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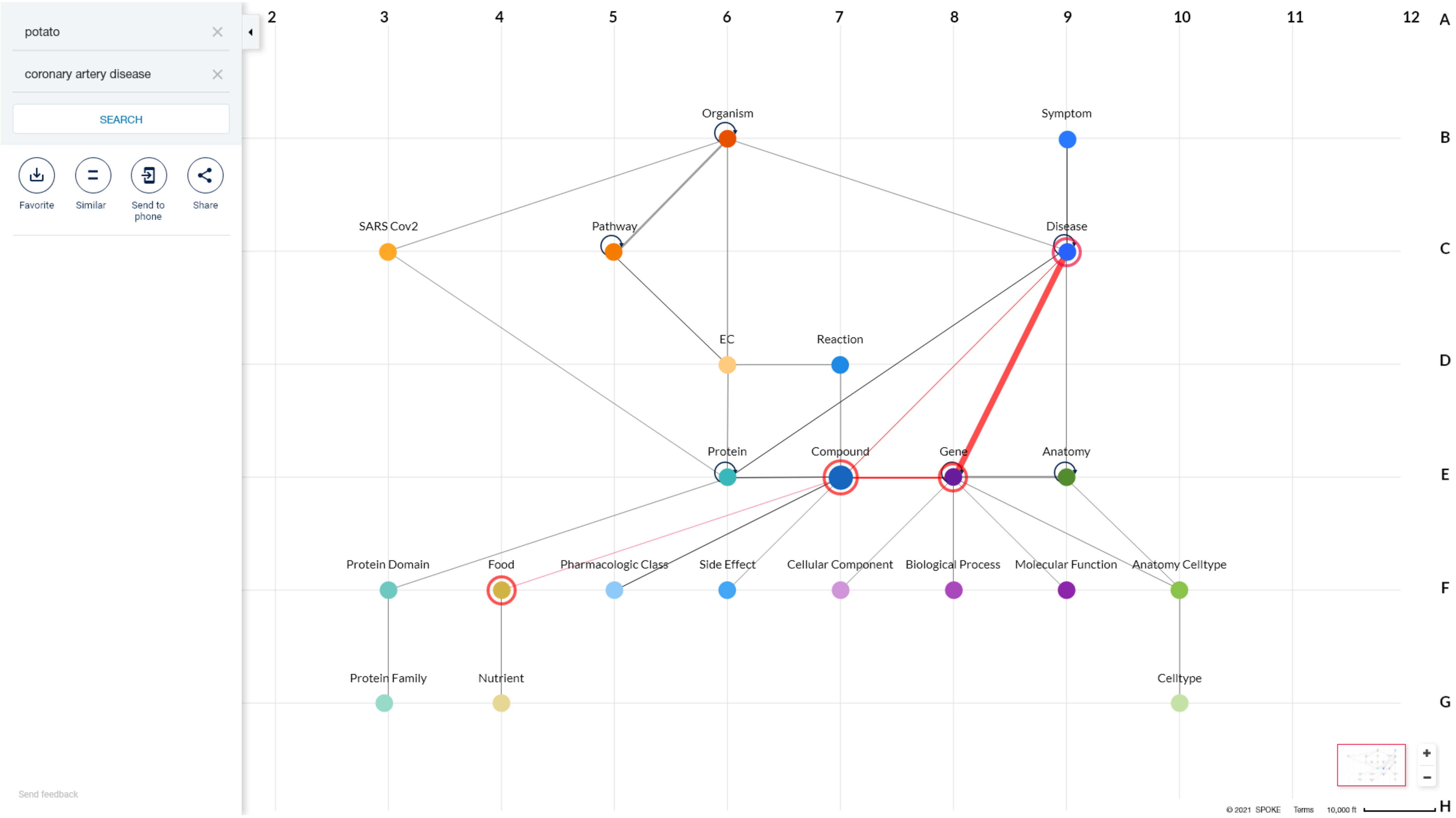
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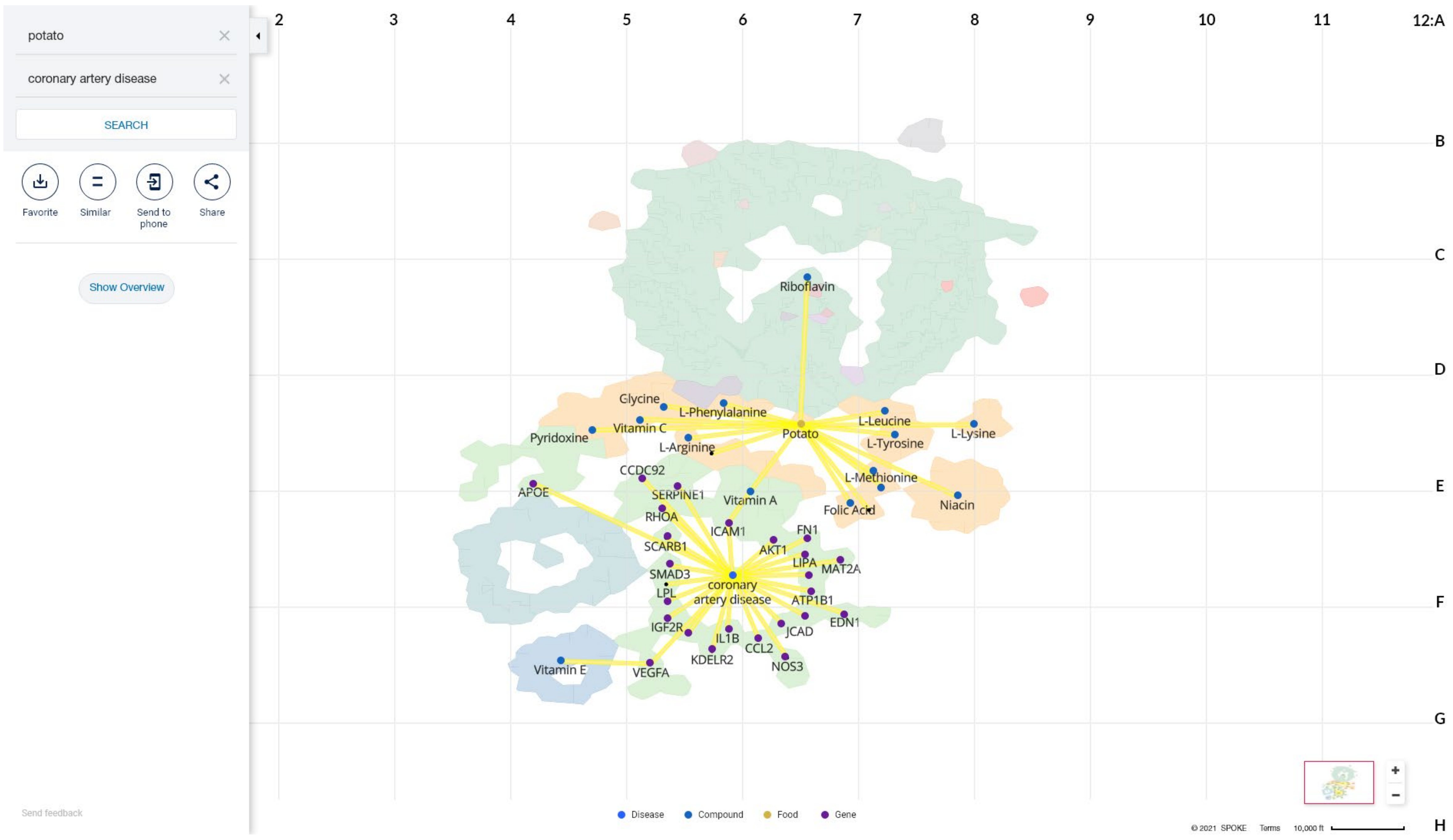
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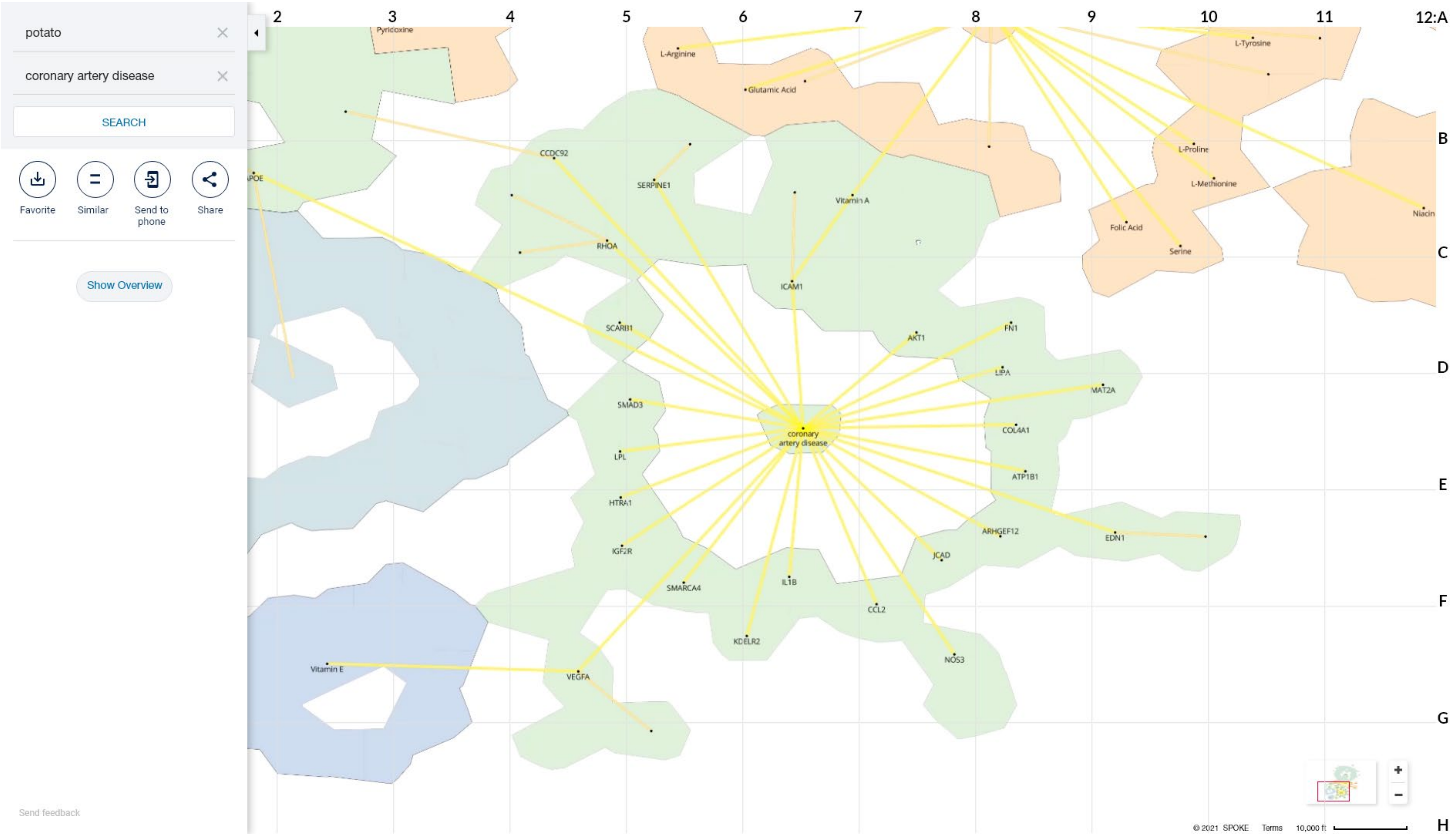
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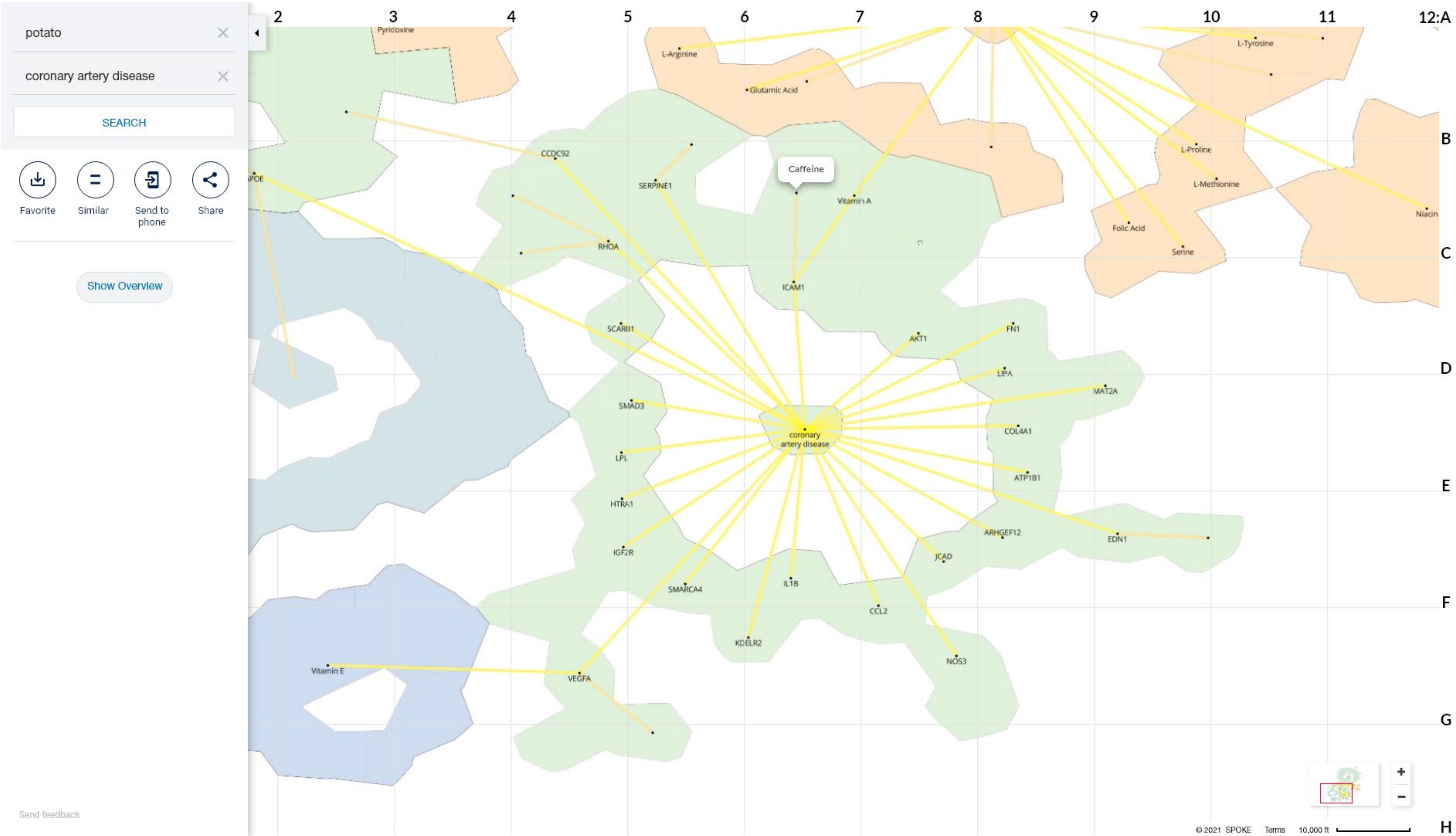
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HuBMAP: Mapping 30+ Trillion Cells

Michael P. Snyder, et al. 2019. The human body at cellular resolution: The NIH Human Biomolecular Atlas Program. *Nature*. 574, p. 187-192.
https://www.nature.com/articles/s41586-019-1629-x.pdf

HuBMAP

Vision
Catalyze the development of an open, global framework for comprehensively mapping the human body at 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 theprogram

The Human Body at Cellular Resolution:
The NIH Human Biomolecular Atlas Program.
Snyder et al. *Nature*. 574, p. 187-192.

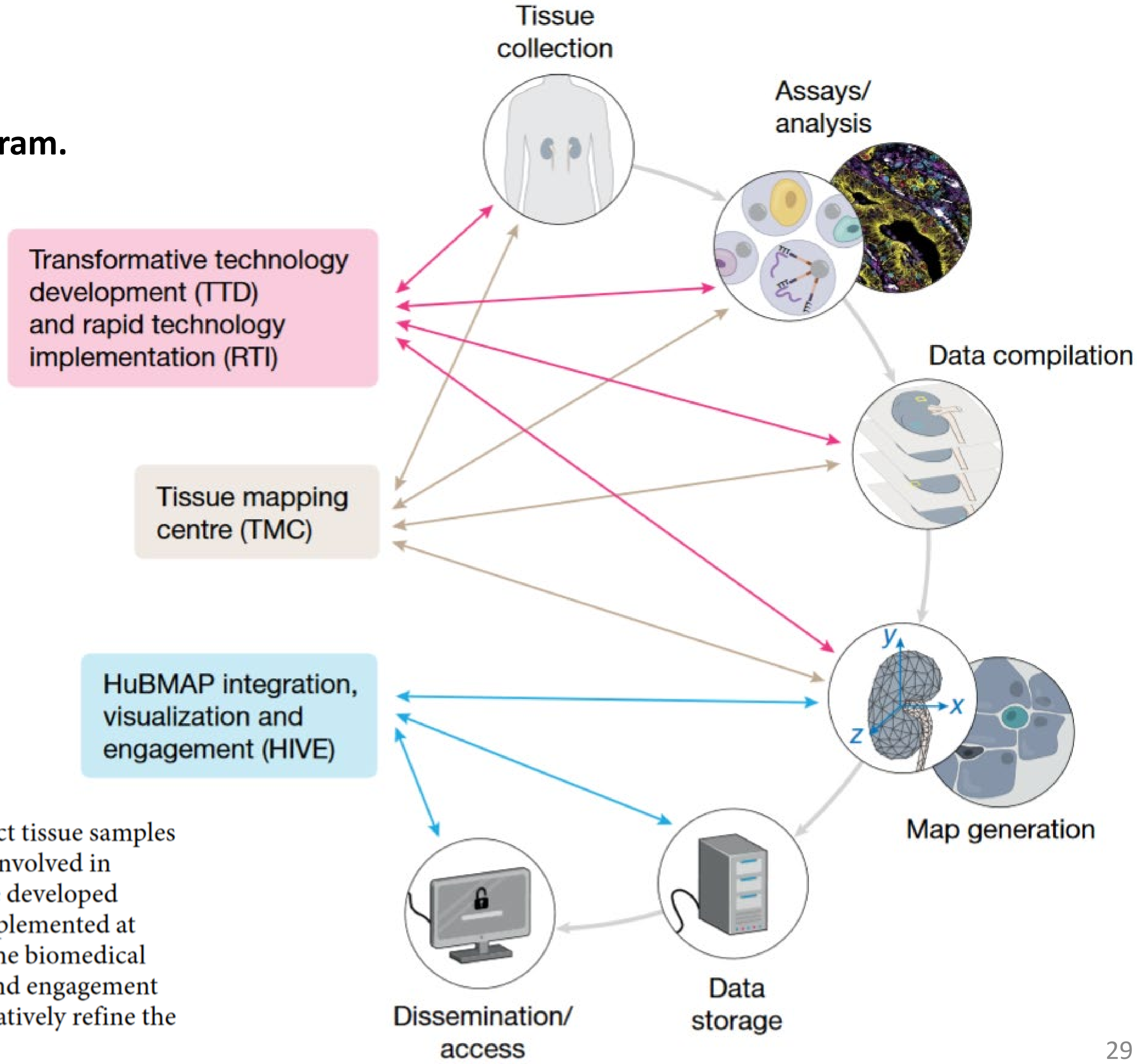


Fig. 1 | The HubMAP consortium. The TMCs will collect tissue samples and generate spatially resolved, single-cell data. Groups involved in TTD and RTI initiatives will develop emerging and more developed technologies, respectively; in later years, these will be implemented at scale. Data from all groups will be rendered useable for the biomedical community by the HuBMAP integration, visualization and engagement (HIVE) teams. The groups will collaborate closely to iteratively refine the atlas as it is gradually realized.

The Human Body at Cellular Resolution:
The NIH Human Biomolecular Atlas Program.
Snyder et al. *Nature*. 574, p. 187-192.

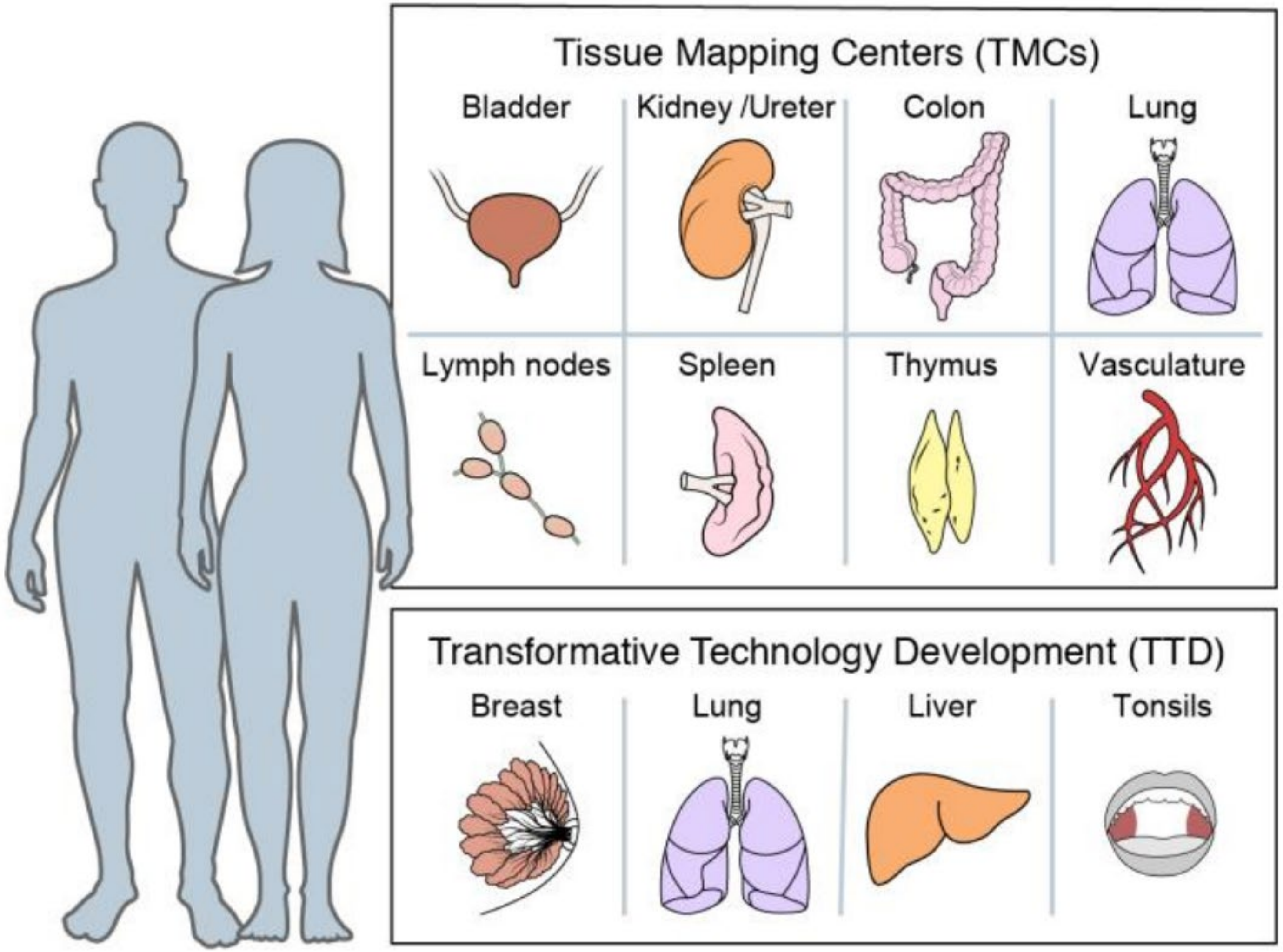


Fig. 2 | Key tissues and organs initially analysed by the consortium. Using innovative, production-grade ('shovel ready') technologies, HuBMAP TMCs will generate data for single-cell, three-dimensional maps of various human tissues. In parallel, TTD projects (and later RTI projects) will refine assays and analysis tools on a largely distinct set of human tissues. Samples from individuals of both sexes and different ages will be studied. The range of tissues will be expanded throughout the program.

The Human Body at Cellular Resolution: The NIH Human Biomolecular Atlas Program. Snyder et al. *Nature*. 574, p. 187-192.

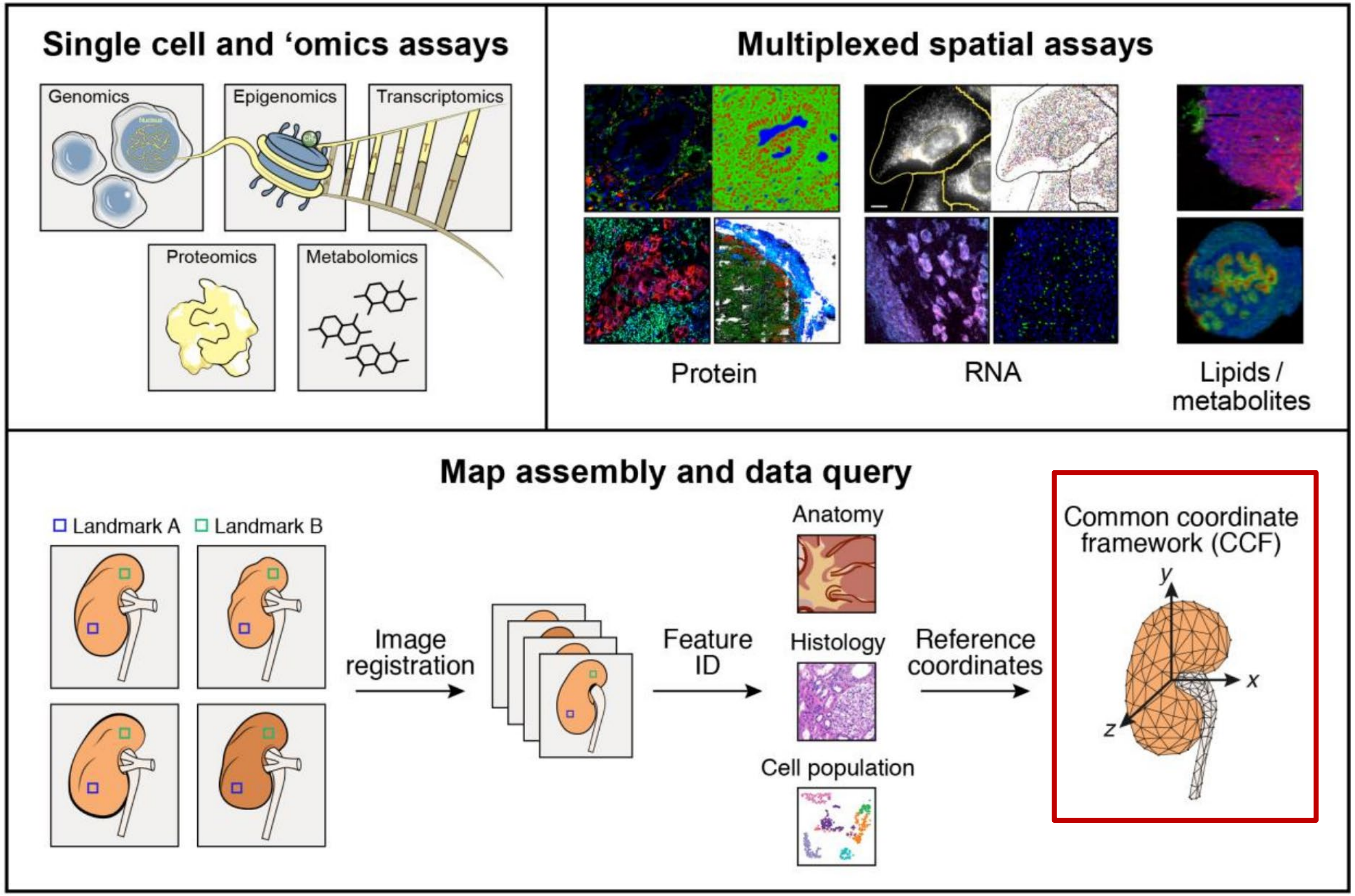


Fig. 3 | Map generation and assembly across cellular and spatial scales. HuBMAP aims to produce an atlas in which users can refer to a histological slide from a specific part of an organ and, in any given cell, understand its contents on multiple 'omic levels—genomic, epigenomic, transcriptomic, proteomic, and/or metabolomic. To achieve these ends, centres will apply a combination of imaging, 'omics and mass spectrometry techniques to specimens collected in a reproducible manner from specific sites in the body. These data will be then be integrated to arrive at a high-resolution, high-content three-dimensional map for any given tissue. To ensure inter-individual differences will not be confounded with collection heterogeneity, a robust CCF will be developed.

What is a Human Reference Atlas?

The Human Reference Atlas (HRA)

1. defines the 3D space and shape of anatomical structures and cell types that are of biomedical relevance plus the biomarkers used to characterize them. Anatomical structures, cell types and biomarkers are validated and represented in/added to ontologies (Uberon/FMA, CL, HGNC).
2. defines how new datasets can be mapped to the HRA, e.g., spatially using the Visible Human CCF and/or Vasculature CCF, via ASCT+B ontology terms/IDs such as gene or protein biomarkers, or via gene expression data as in Azimuth.
3. it is
    - authoritative (there exists expert agreement and it was validated by data),
    - computable (supports API queries, UIs, linkages; see slides #8 and #9),
    - published as LOD (connecting to disease and other ontologies and data),
    - open (anyone can use the HRA data and code), and
    - continuously evolving (e.g., as new technologies become available).

Börner, Katy, Sarah Teichmann, Ellen M. Quardokus, …, Sanjay Jain, Griffin M. Weber. 2021. “Human Anatomical Structures, Cell Types, and Biomarkers of the Human Reference Atlas”. ***Nature Cell Biology - Accepted***

ASCT+B Tables

Anatomical Structures (AS), Cell Types (CT), and Biomarkers (B) or ASCT+B tables aim to capture the partonomy of anatomical structures, cell types, and major biomarkers (e.g., gene, protein, lipid or metabolic markers).

ASCT Table

Structure/Region	Sub structure/Sub region	Cell Type
Renal Corpuscle	Bowman's (glomular) Capsule/parietal layer	Parietal epithelial Cell
	Bowman's (glomular) Capsule/visceral layer	Podocyte
	Glomerular Tuft	Capillary Endothelial Cell
		Mesangial Cell
Tubules	Proximal Tubule	Proximal Tubule Epithelial Cell (general)
		Proximal Convoluted Tubule Epithelial Cell Segment 1
		Proximal Tubule Epithelial Cell Segment 2
		Proximal Tubule Epithelial Cell Segment 2
	Loop of Henle, Thin Limb	Descending Thin Limb Cell (general)
		Ascending Thin Limb Cell (general)
	Loop of Henle, Thick Limb	Thick Ascending Limb Cell (general)
		Cortex-TAL Cell
		Medulla-TAL Cell
		TAL-Macula Densa Cell
	Distal Convolution	Distal Convoluted Tubule Cell (general)
		DCT Type 1 Cell
		DCT Type 2 Cell
	Connecting Tubule	Connecting Tubule Cell (general)
		CNT-Principal Cell

Ontology

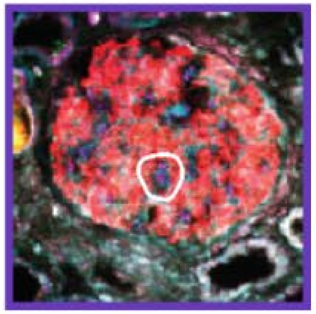
Anatomical Structures Partonomy

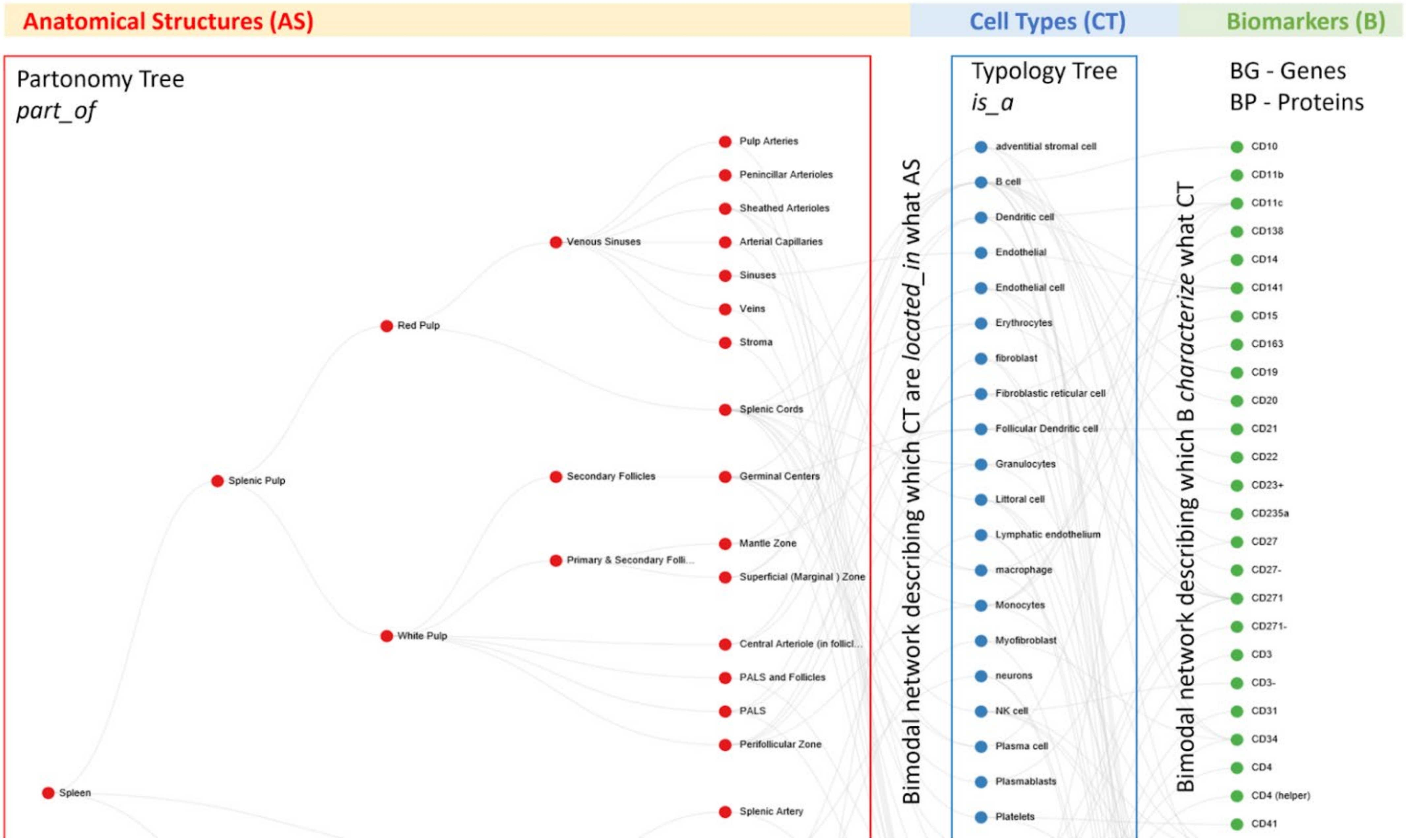
kidney
- kidney capsule
- cortex of kidney
  - outer cortex of kidney
- renal medulla

Cell Types Ontology

connective tissue cell
- pericyte cell
  - mesangial cell
    - extraglomerular mesangial cell
    - glomerular mesangial cell

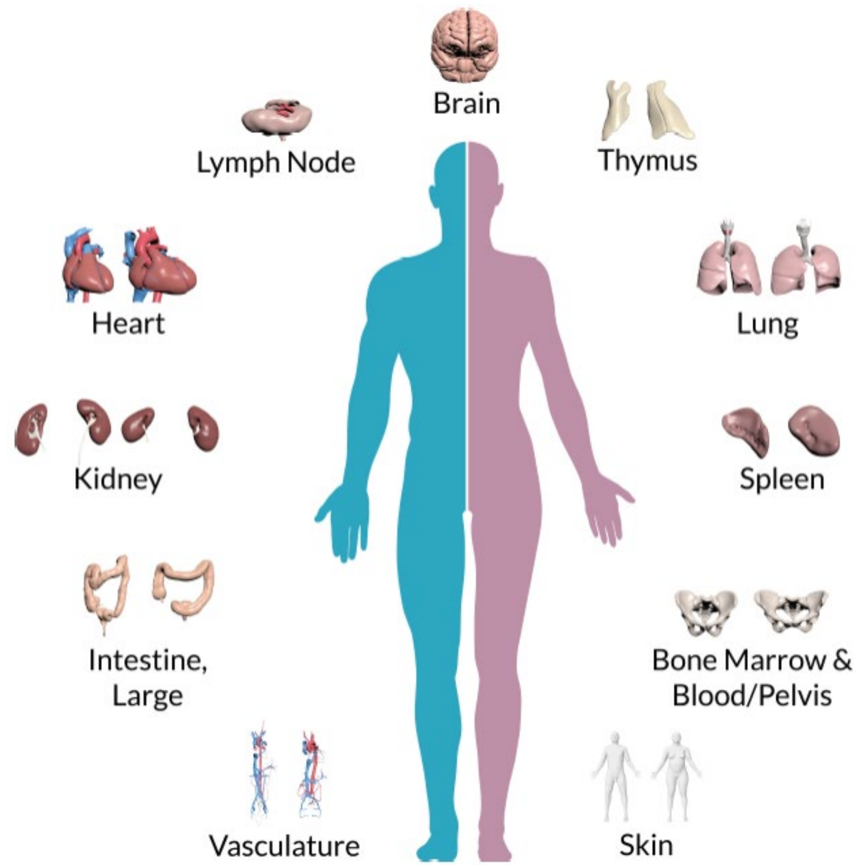
3D Reference Object Library




Anatomical Structures (AS)
Cell Types (CT)
Biomarkers (B)
Partonomy Tree
part_of
Pulp Arteries
Penincillar Arterioles
Sheathed Arterioles
Venous Sinuses
Arterial Capillaries
Sinuses
Veins
Red Pulp
Stroma
Splenic Cords
Splenic Pulp
Secondary Follicles
Germinal Centers
Mantle Zone
Primary & Secondary Folli...
Superficial (Marginal) Zone
White Pulp
Central Arteriole (in follicl...
PALS and Follicles
PALS
Perifollicular Zone
Spleen
Splenic Artery
Bimodal network describing which CT are located_in what AS
Typology Tree
is_a
adventitial stromal cell
B cell
Dendritic cell
Endothelial
Endothelial cell
Erythrocytes
fibroblast
Fibroblastic reticular cell
Follicular Dendritic cell
Granulocytes
Littoral cell
Lymphatic endothelium
macrophage
Monocytes
Myofibroblast
neurons
NK cell
Plasma cell
Plasmablasts
Platelets
Bimodal network describing which B characterize what CT
BG - Genes
BP - Proteins
CD10
CD11b
CD11c
CD138
CD14
CD141
CD15
CD163
CD19
CD20
CD21
CD22
CD23+
CD235a
CD27
CD27-
CD271
CD271-
CD3
CD3-
CD31
CD34
CD4
CD4 (helper)
CD41

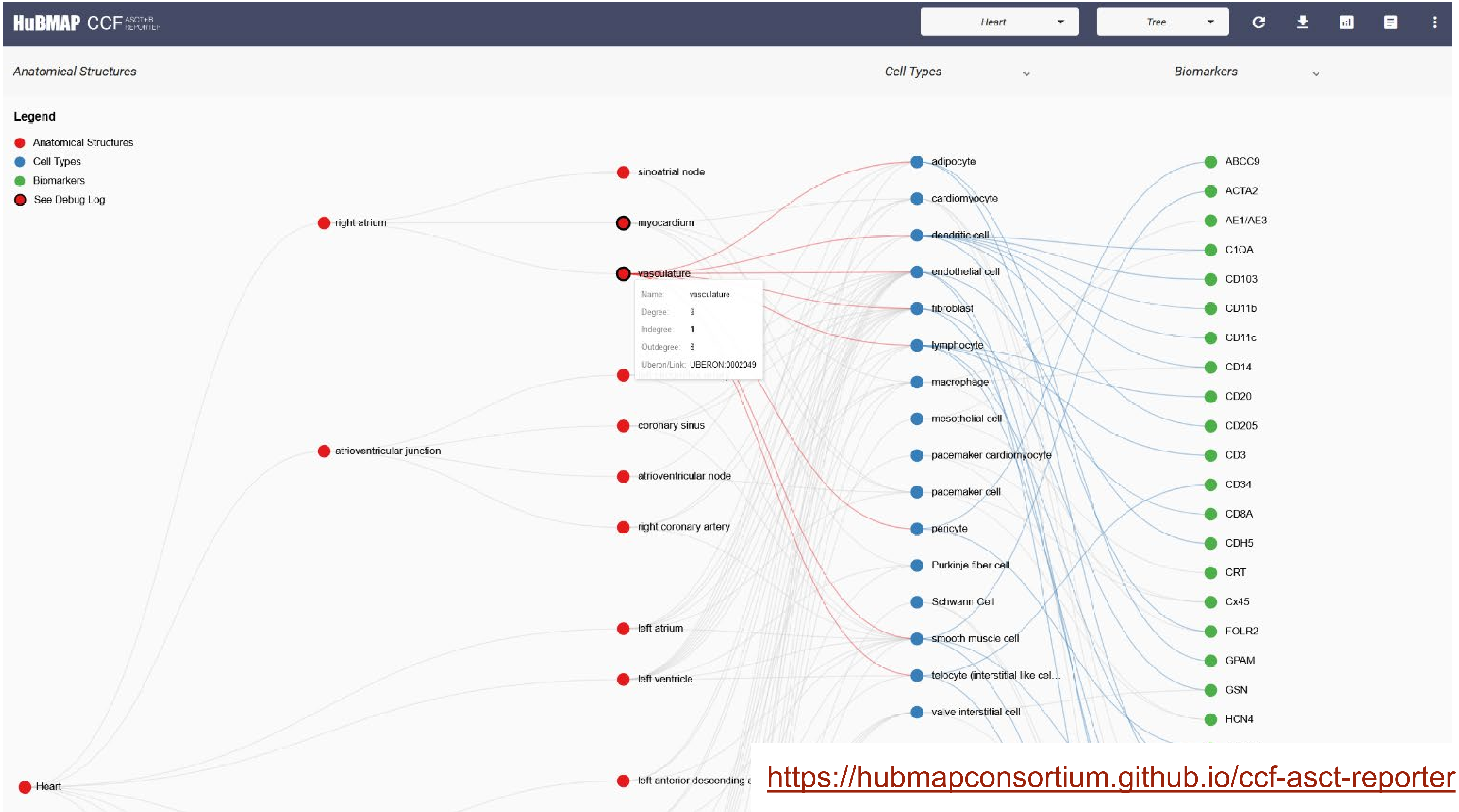
An Atlas describes & names 2/3D entities

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**



https://hubmapconsortium.github.io/ccf/pages/ccf-anatomical-structures.html

https://hubmapconsortium.github.io/ccf/pages/ccf-3d-reference-library.html

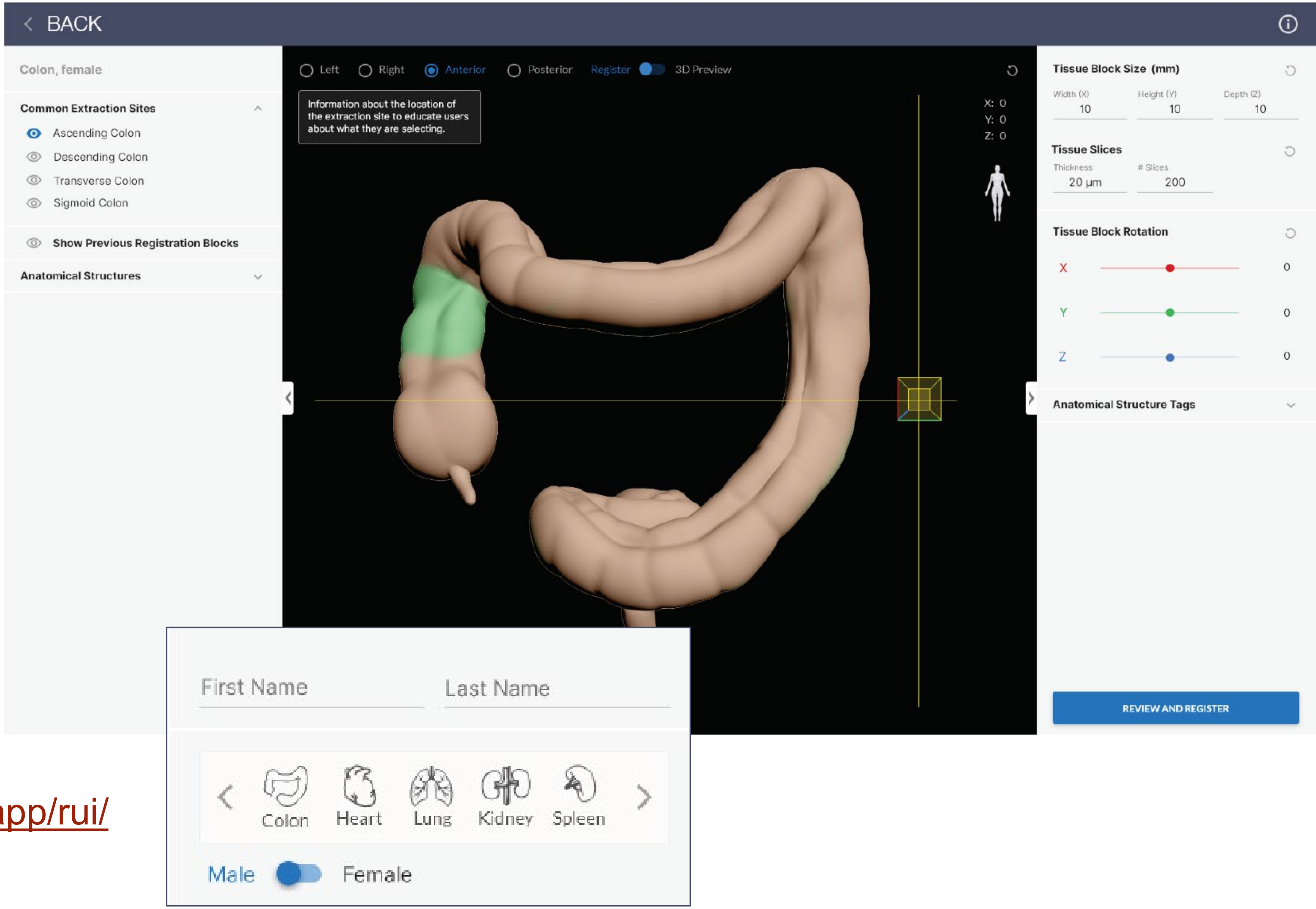


https://hubmapconsortium.github.io/ccf-asct-reporter

CCF Registration User Interface (RUI)

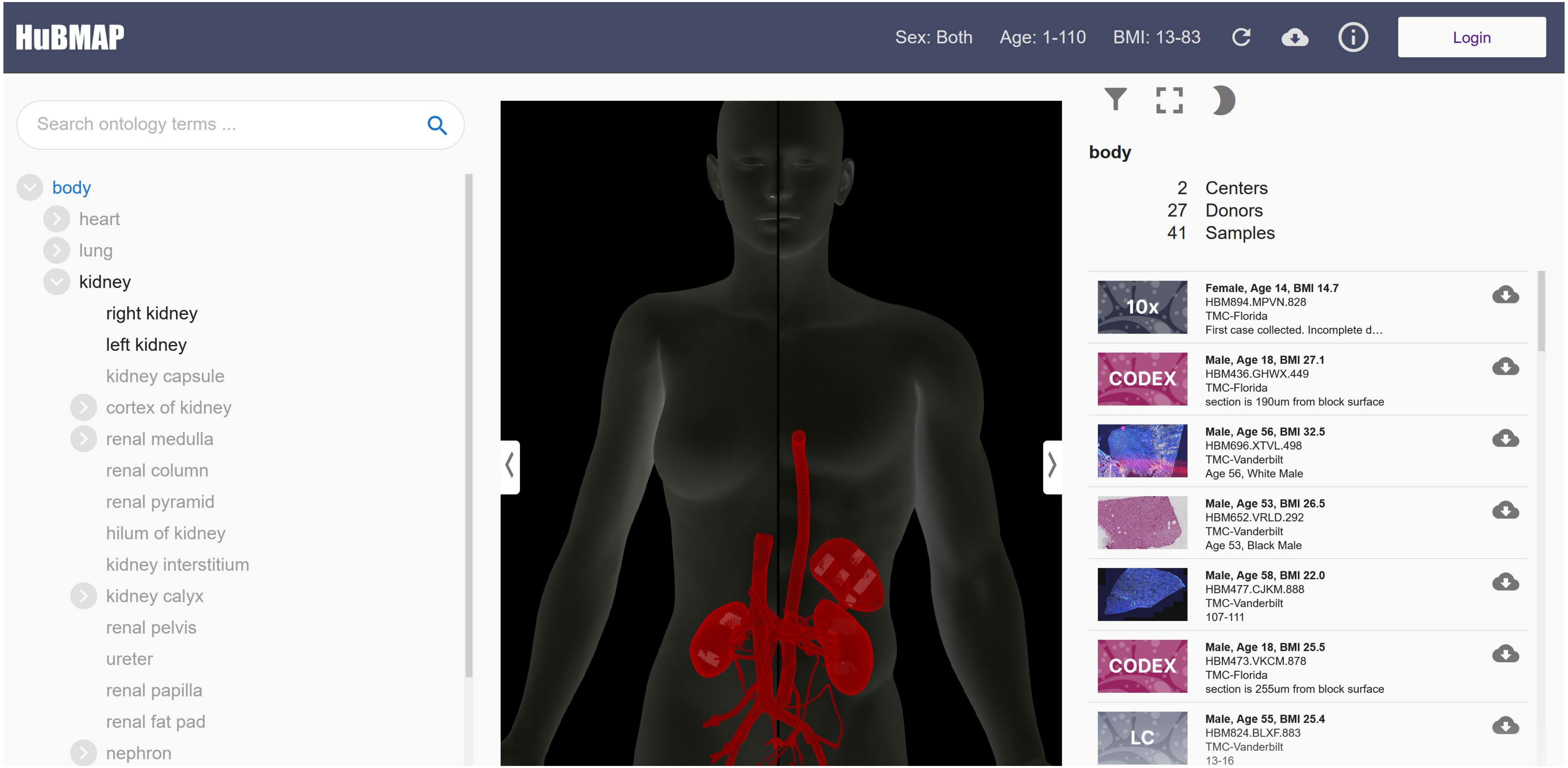
New Features:

- 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

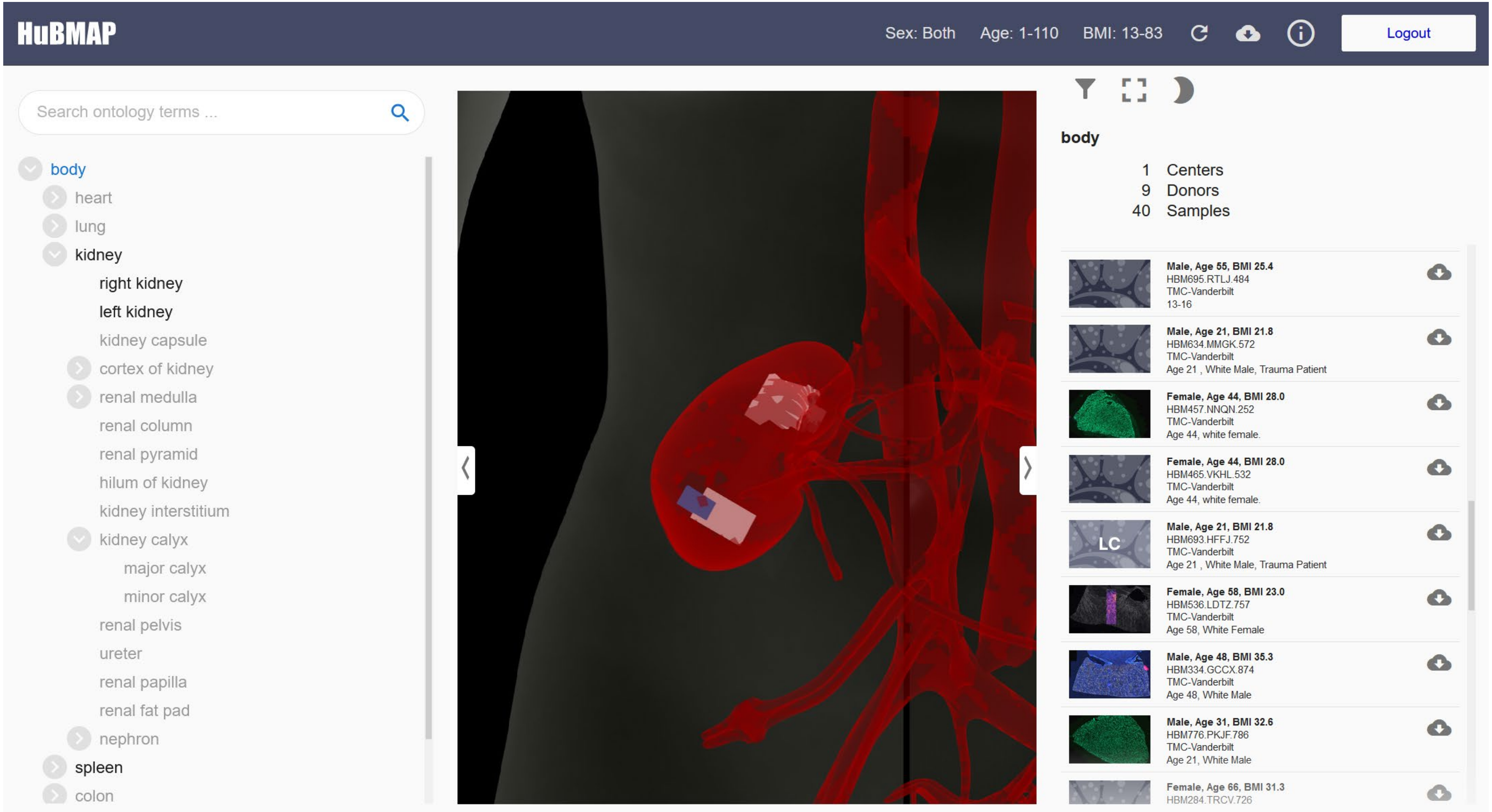


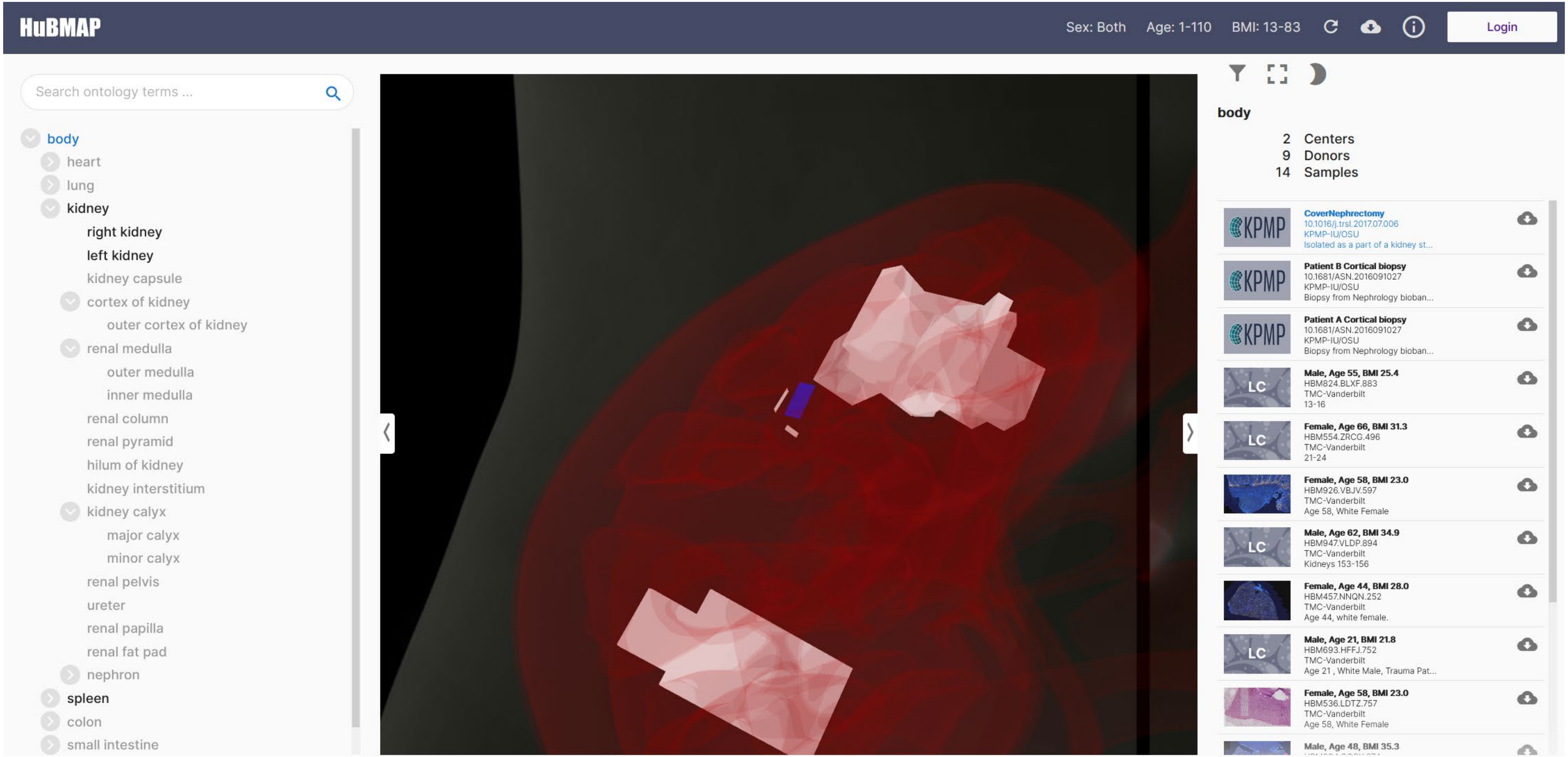
https://hubmap-ccf-ui.netlify.app/rui/

CCF Exploration User Interface (EUI)

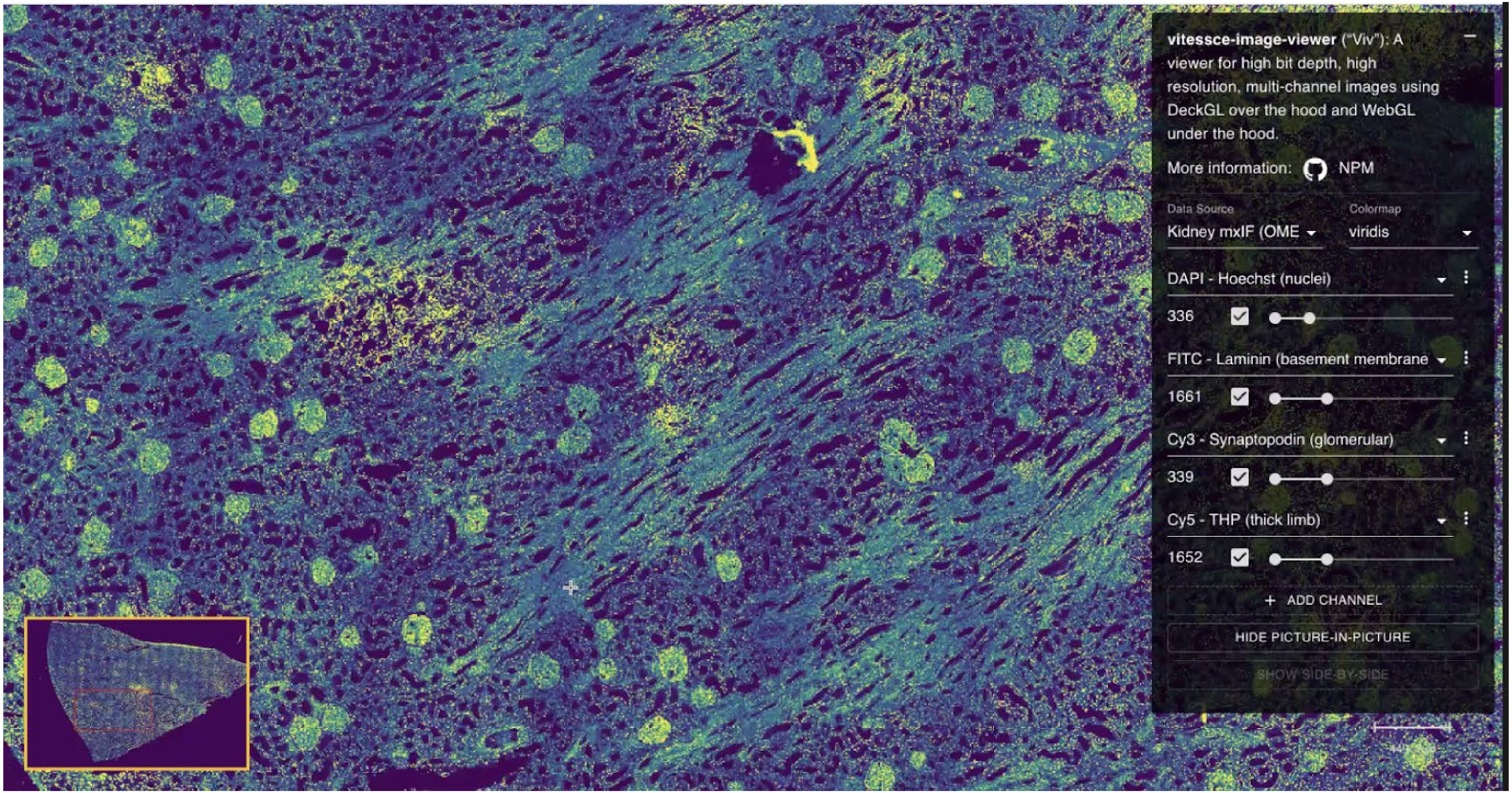


https://portal.hubmapconsortium.org/ccf-eui


HuBMAP
Sex: Both
Age: 1-110
BMI: 13-83
Logout
Search ontology terms ...
body
heart
lung
kidney
right kidney
left kidney
kidney capsule
cortex of kidney
renal medulla
renal column
renal pyramid
hilum of kidney
kidney interstitium
kidney calyx
major calyx
minor calyx
renal pelvis
ureter
renal papilla
renal fat pad
nephron
spleen
colon
body
1 Centers
9 Donors
40 Samples
Male, Age 55, BMI 25.4
HBM695.RTLJ.484
TMC-Vanderbilt
13-16
Male, Age 21, BMI 21.8
HBM634.MMGK.572
TMC-Vanderbilt
Age 21 , White Male, Trauma Patient
Female, Age 44, BMI 28.0
HBM457.NNQN.252
TMC-Vanderbilt
Age 44, white female.
Female, Age 44, BMI 28.0
HBM465.VKHL.532
TMC-Vanderbilt
Age 44, white female.
LC
Male, Age 21, BMI 21.8
HBM693.HFFJ.752
TMC-Vanderbilt
Age 21 , White Male, Trauma Patient
Female, Age 58, BMI 23.0
HBM536.LDTZ.757
TMC-Vanderbilt
Age 58, White Female
Male, Age 48, BMI 35.3
HBM334.GCCX.874
TMC-Vanderbilt
Age 48, White Male
Male, Age 31, BMI 32.6
HBM776.PKJF.786
TMC-Vanderbilt
Age 21, White Male
Female, Age 66, BMI 31.3
HBM284.TRCV.726



Register your data via https://hubmap-ccf-ui.netlify.app/rui/ so it can be spatially/semantically explored in EUI.



http://gehlenborglab.org/research/projects/vitessce/

VH Massive Open Online Course (VHMOOC)

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

Acknowledgements

HuBMAP Consortium (https://hubmapconsortium.org)

Thanks go to all the **patients** that agreed to volunteer healthy tissue and open use of their data.

NIH National Institutes of Health

Opportunity Pool Awardee
KIDNEY PRECISION MEDICINE PROJECT
kpmp.org

NSF

TMCs

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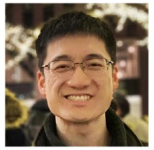

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CNS Cyberinfrastructure for Network Science Center

INDIANA UNIVERSITY
SCHOOL OF INFORMATICS, COMPUTING, AND ENGINEERING

Upcoming Events & Books

The July/Aug 2022 special issue in *IEEE Computer Graphics and Applications* on "Multi-Level Graph Representations for Big Data in Science"

Articles due for review:
December 29, 2021

Guest editors:

- Katy Börner, Indiana University, Bloomington, US
- Stephen G. Kobourov, University of Arizona, Tucson, US

https://www.computer.org/digital-library/magazines/cg/call-for-papers-special-issue-on-multi-level-graph-representations-for-big-data-in-science

Call for Papers: Special Issue on Multi-level Graph Representations for Big Data in Science

CG&A seeks submissions for this upcoming special issue.

For centuries, cartographic maps have guided human exploration. While being rather imperfect initially, they helped explorers find promised lands and return home safely. Recent advances in data, algorithms, and computing infrastructures make it possible to map humankind's collective scholarly knowledge and technology expertise by using topic maps on which "continents" represent major areas of science (e.g., mathematics, physics, or medicine) and zooming reveals successively more detailed subareas. Basemaps of science and technology are generated by analyzing citations links between millions of publications and/or patents. "Data overlays" (e.g., showing all publications by one scholar, institution, or country or the career trajectory of a scholar as a pathway) are generated by science-locating relevant publication records based on topical similarity. Despite the demonstrated utility of such maps, current approaches do not scale to the hundreds of millions of data records now available. The main challenge is designing efficient and effective methods to visualize and interact with more than 100 million scholarly publications at multiple levels of resolution.

This special issue invites researchers in cartography, data visualization, science of science, graph drawing, and other domains to submit novel and promising new research on graph mining and layout algorithms and their application to the development of science mapping standards and services. Topics of interest include:

- Science of science user needs and applications
- Efficient multi-level graph algorithms
- Network visualizations
- Effective user interfaces to large-scale data visualizations

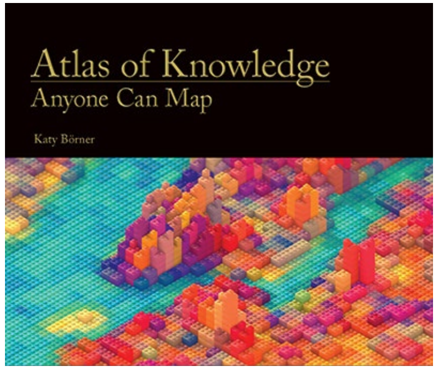
Deadlines

Submissions due: 29 December 2021
Preliminary notification: 2 March 2022
Revisions due: 6 April 2022
Final notification: 11 May 2022
Final version due: 25 May 2022
Publication: July/August 2022

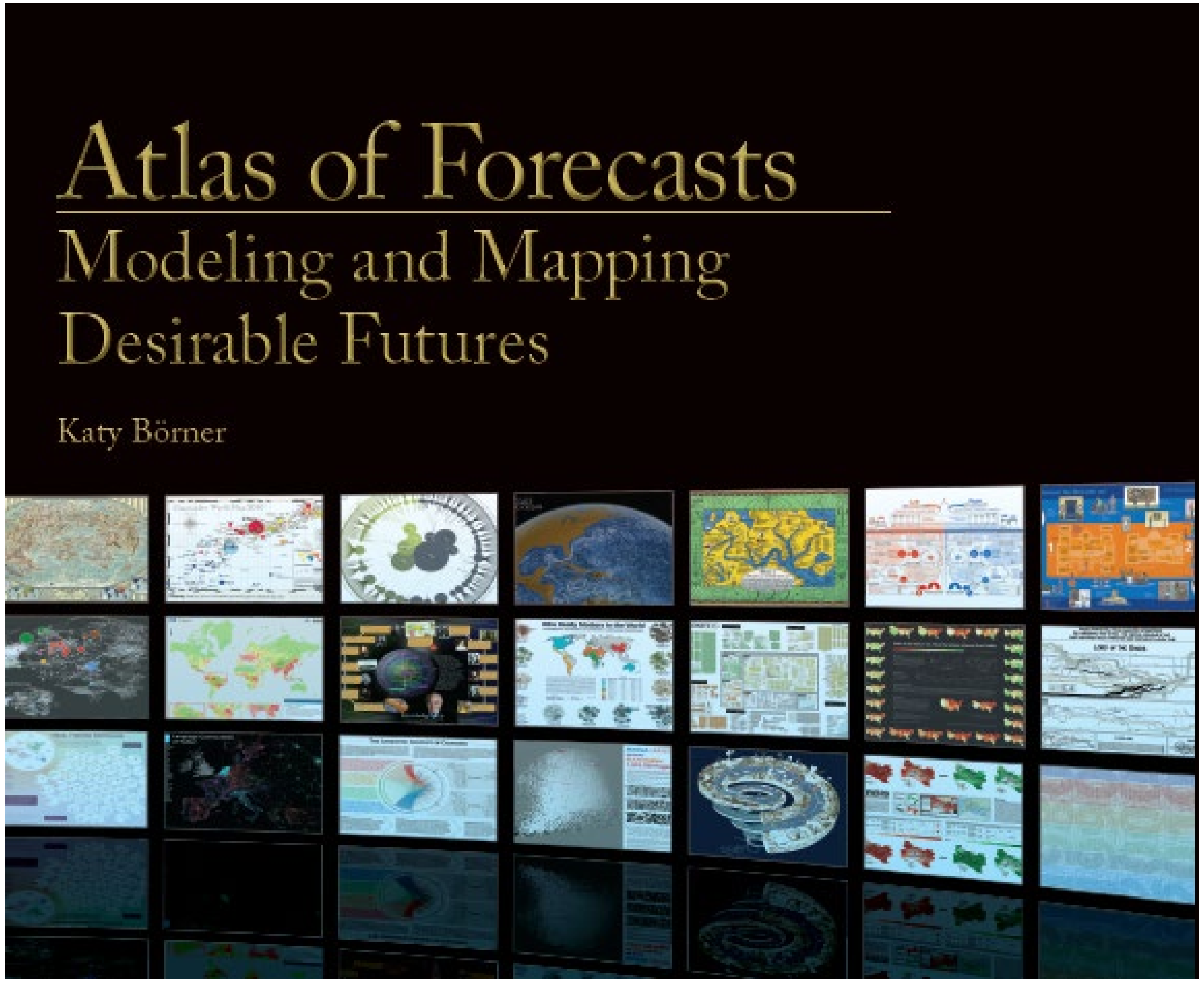

Indiana University Bloomington will host the
International Society of Scientometrics & Informetrics
Conference (ISSI)
in Summer 2023

Atlas Trilogy

2010

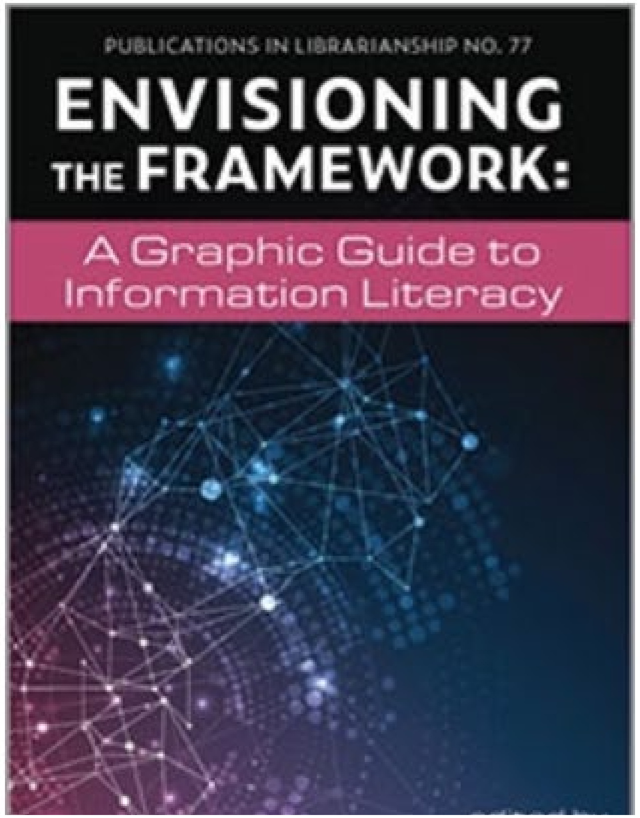


2015



2021

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



Envisioning the Framework: A Graphic Guide to Information Literacy

Jannette L. Finch

LibraryThing
Find it in WorldCat

Jannette L. Finch

Jannette L. Finch, MLIS, is a librarian in the College of Charleston Libraries system. Her research interests include information design and the effect of technology on student learning, online learning and teaching, effective teaching through experiential learning activities, constructivist techniques in the teaching and learning environment, visualizing data, library service models, the library role in the scholarly community, assessment, and planning. Contact her at finchj@cofc.edu.

Q&A