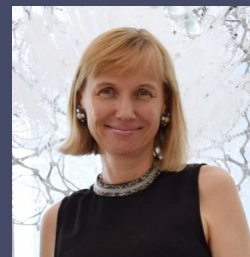# HuBMAP Reference Atlas:
Toward a human [reference] map

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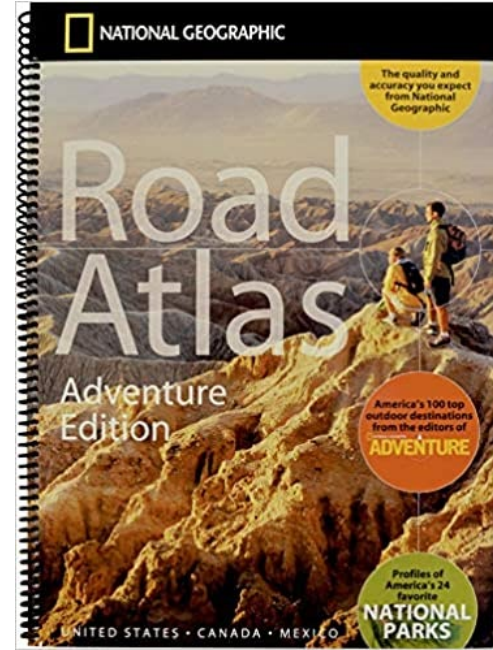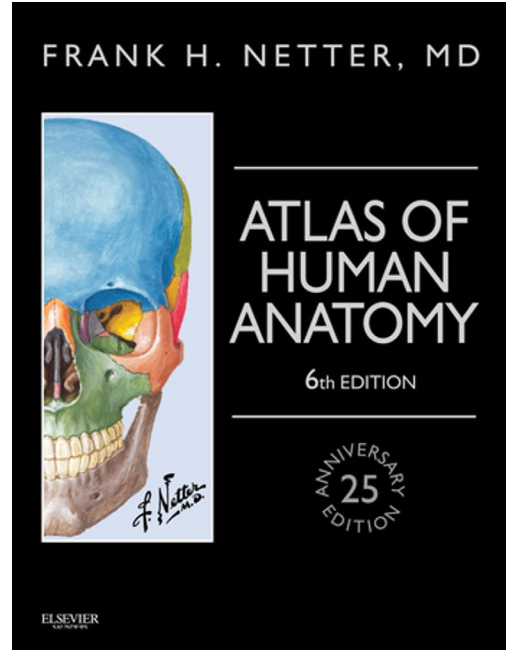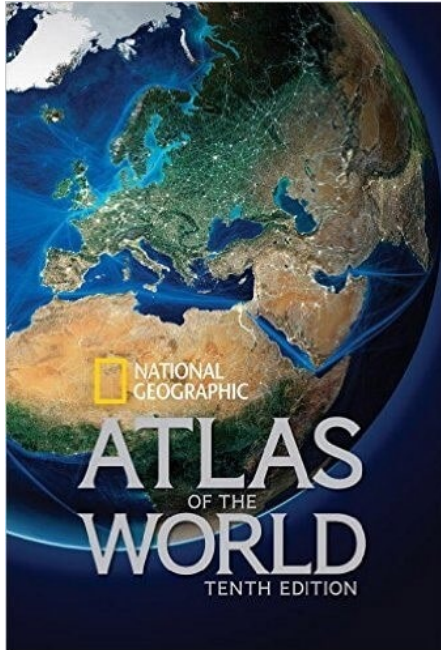Indiana University, Bloomington, IN

Center for Spatial Studies Lightning Talks
Virtual Event

March 16, 2021

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

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

An human cell **atlas**
might show a landscape
of all cells, or

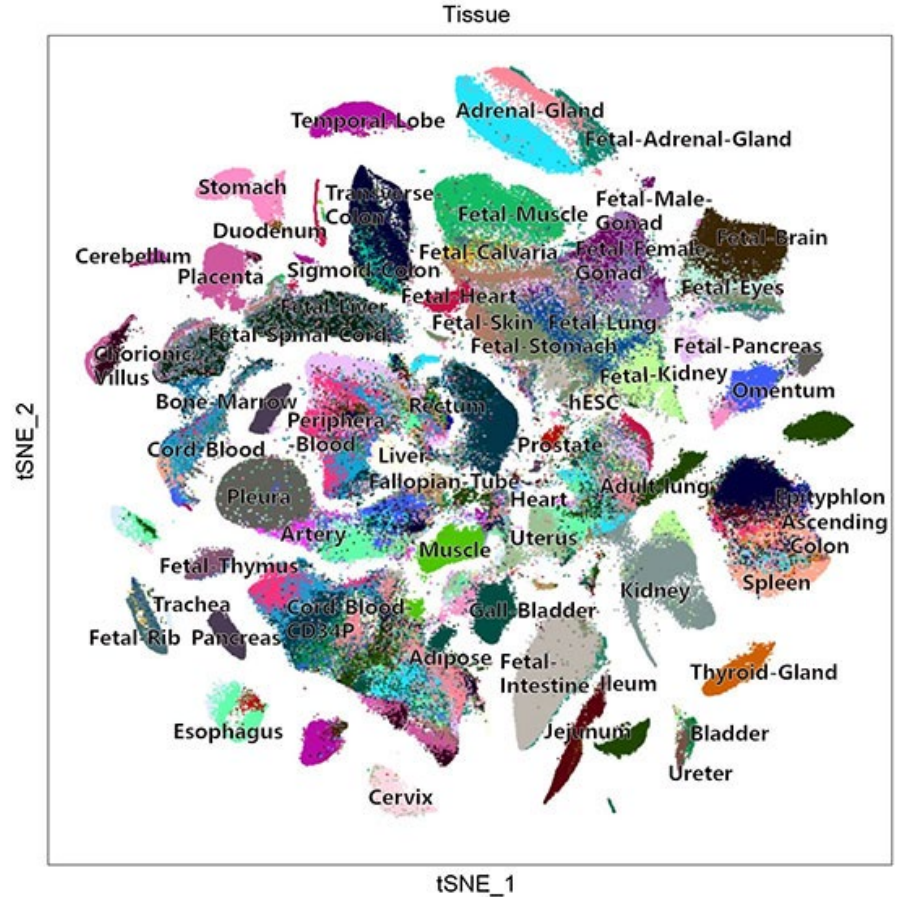Maps of cells per tissue
type/anatomical structure.

Tissue

A human reference **atlas** might use human anatomy as a 'basemap,' or

an abstract space.
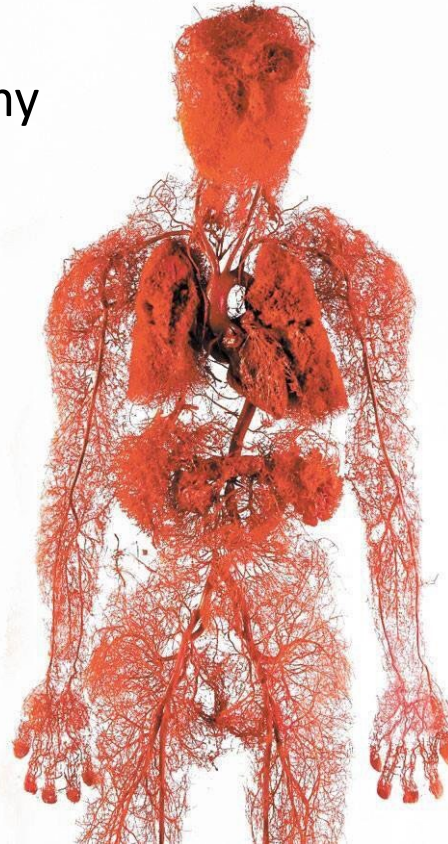
SYSTEMA ARTERIARUM
Tabula I

https://bodyworlds.com
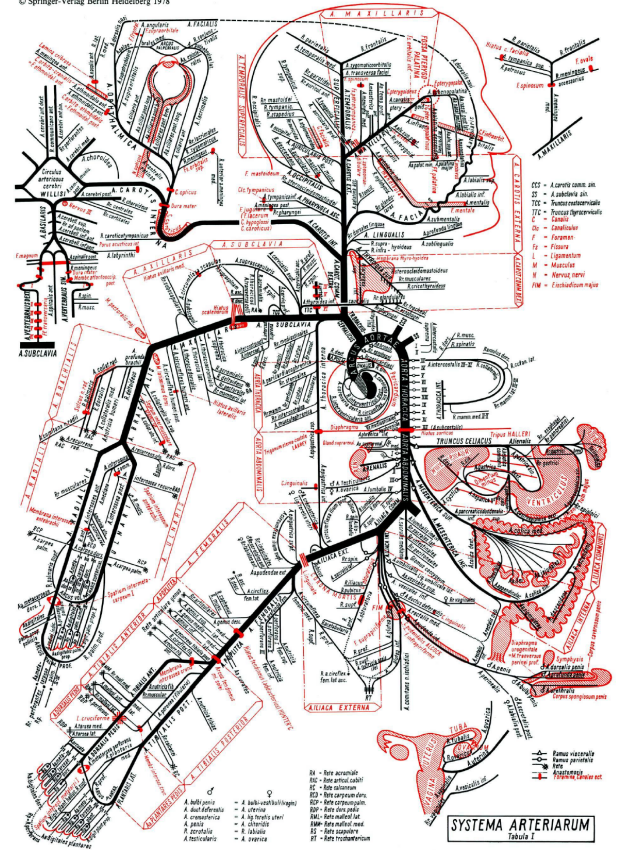
Weber, 1978

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

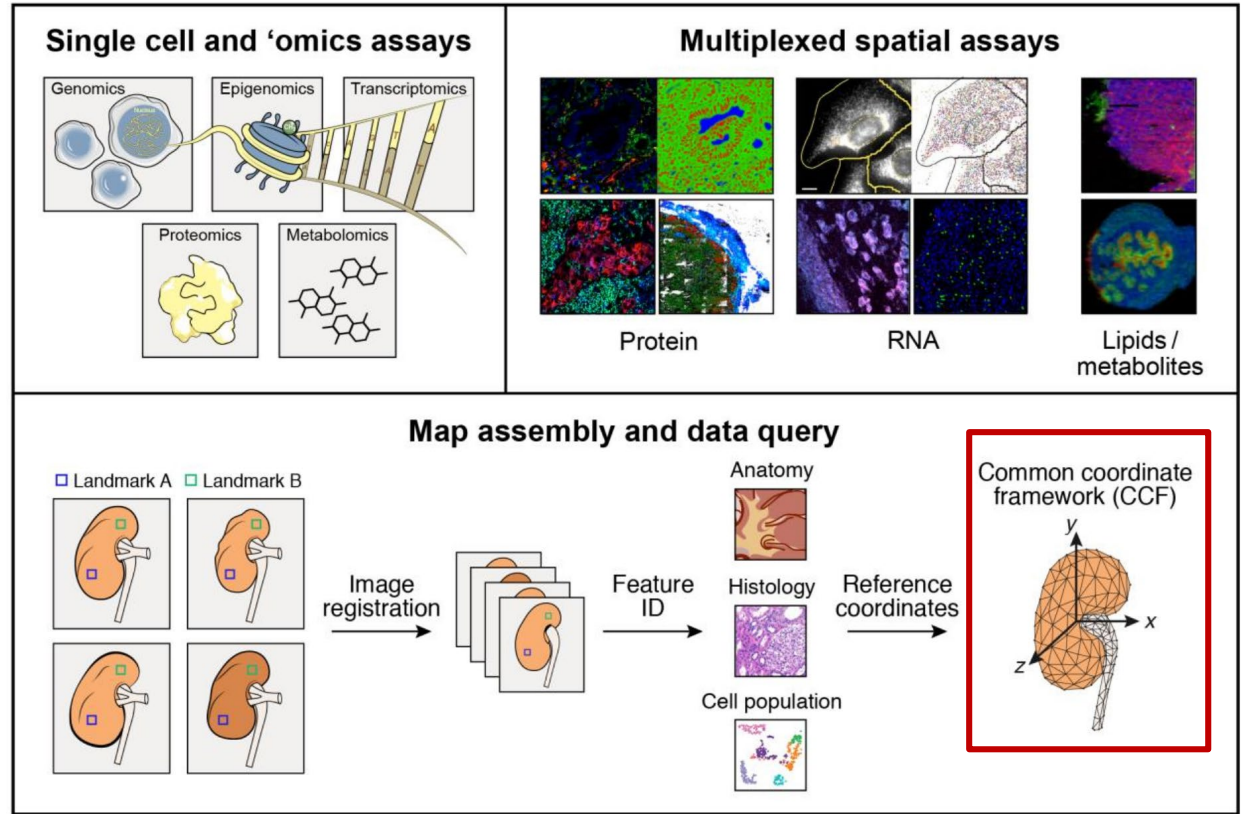**Fig. 3 | Map generation and assembly across cellular and spatial scales.** HuBMAP aims to produce an atlas in which users can refer to a histological slide from a specific part of an organ and, in any given cell, understand its contents on multiple 'omic levels—genomic, epigenomic, transcriptomic, 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.

CCF Requirements

The CCF must capture major **anatomical structures, cell types, and biomarkers** and their interrelations across **multiple levels of resolution**.

It should be **semantically explicit** (using existing ontologies, e.g., Uberon, CL) and **spatially explicit** (e.g., using 3D reference organs for registration and exploration).
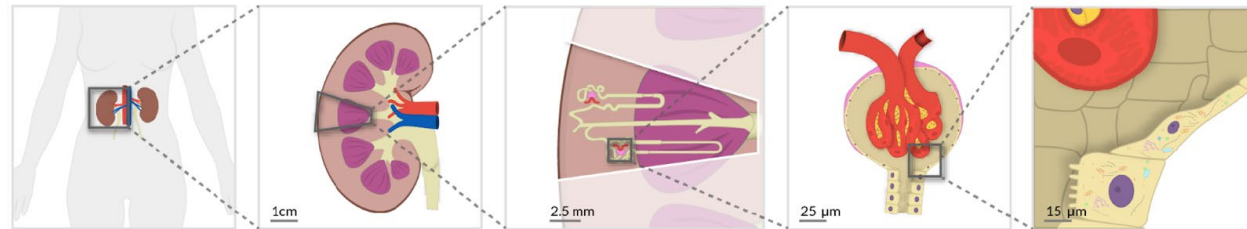
Body
- Body
- Kidney (Left, Right)
- Aorta
- Renal artery
- Renal vein
- Ureter

Organ
- Renal capsule
- Renal pyramid
- Renal cortex
- Renal medulla
- Renal calyx
- Renal pelvis

Functional Tissue Unit
- Nephron
- Renal corpuscle
- Proximal convoluted tubule
- Loop of Henle
- Distal convoluted tubule
- Connecting tubule
- Collecting duct

FTU Sub-structure(s)
- Bowman's capsule
- Glomerulus
- Efferent arteriole
- Afferent arteriole

Cellular
- Parietal epithelial cell
- Capillary endothelial cell
- Mesangial cell
- Podocyte

ASCT+B Tables

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

Structure/Region	Substructure/Subregion	Cell Type	Subset of Marker Genes
Renal Corpuscle	Bowman's Capsule	Parietal epithelial cell	*CRB2*, CLDN1**
	Glomerulus	Podocyte	*NPHS2*, PODXL*, NPHS1**
		Capillary Endothelial Cell	*EHD3*, EMCN*, HECW2*, FLT1*, AQP1**
		Mesangial Cell	*POSTN*, PIEZO2*, ROBO1*, ITGA8**

Partial ASCT+B Table from
- El-Achkar et al. A Multimodal and Integrated Approach to Interrogate Human Kidney Biopsies with Rigor and Reproducibility: The Kidney Precision Medicine Project. bioRxiv. 2019, Updated Aug 2020. doi:10.1101/828665
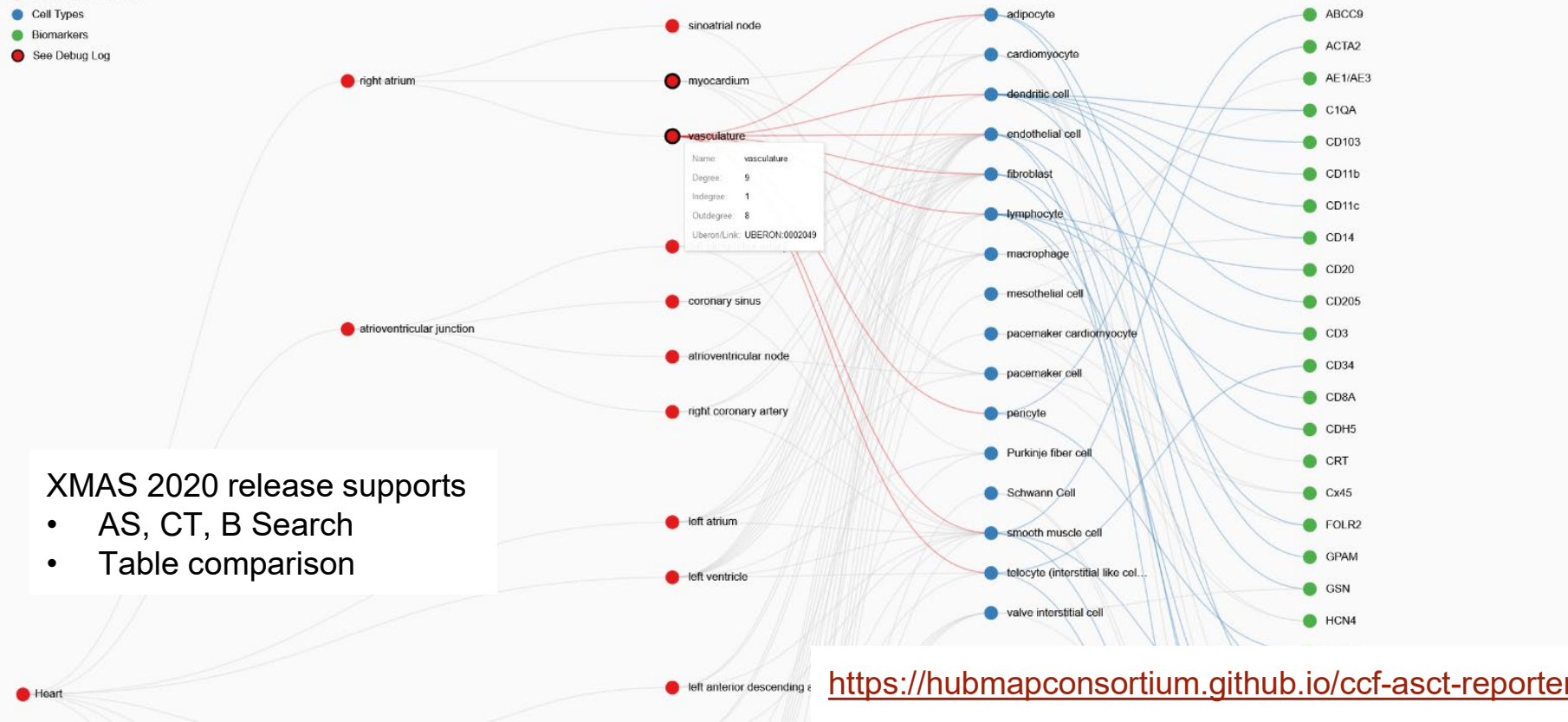
XMAS 2020 release supports
- AS, CT, B Search
- Table comparison

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

Latest ▼   Brain ▼   Tree ▼   ⟳ ⤱ 🔍 ⬇ 📊 🗎

Anatomical Structures   Cell Types ▼   Biomarkers ▼   ⤢

Legend

🔴 Anatomical Structures
🔵 Cell Types
🟢 Biomarkers
🔴 Multi-parent Nodes

precentral gyrus   ● **Primary motor cortex**

○ superior frontal gyrus
○ middle frontal gyrus
○ inferior frontal gyrus,
inferior frontal gyrus   ○ inferior frontal gyrus,
○ inferior frontal gyrus,

○ gyrus rectus (straight...
○ medial orbital gyrus
○ anterior intermediate ...
○ posterior intermediat...
○ lateral orbital gyrus
○ paracentral lobule, ro...
○ paracingulate gyrus
○ frontal operculum
○ orbital operculum

frontal lobe

○ superior rostral gyrus
rostral gyrus   ○ inferior rostral gyrus

○ lateral olfactory gyrus
○ frontomarginal gyrus
○ frontal pole

○ postcentral gyrus
○ suprapariental lobule

○ supramarginal gyrus
inferior parietal lobule   ○ angular gyrus
parietal lobe

○ Astro L1 FGFR3 SE...
○ Astro L1-6 FGFR3 A...
○ Astro L1-6 FGFR3 P...
○ Endo L2-5 NOSTRIN ...
○ Exc L2 LAMP5 KCNG3
○ Exc L2 LINC00507 A...
● **Exc L2 LINC00507 GLRA3**
○ Exc L2-3 LINC00507...
○ Exc L2-3 RORB CCD...
○ Exc L2-3 RORB PTPN3
○ Exc L2-3 RORB RTKN2
○ Exc L3 LAMP5 CARM...
○ Exc L3 RORB OTOGL
○ Exc L3 TH EMIS ENPEP
○ Exc L3-5 FEZF2 ASG...
○ Exc L3-5 FEZF2 LIN...
○ Exc L3-5 RORB LAMA4
○ Exc L3-5 LINC...

○ ABI3BP
○ ACVR1C
○ ADAM33
○ ADAMTS12
○ ADAMTS17
○ ADAMTS20
○ ADAMTS5
● **ADAMTSL1**
○ ANKRD30B
○ APBB1IP
○ ARHGAP42
○ ATP10A
○ BDNF
○ BMPR1B
○ BTNL9
○ CALB1
○ CBLN4
○ CCBE1
○ CCNG2

Name:	ADAMTSL1
Degree:	3
Indegree:	3
Outdegree:	0
Ontology ID:	NONE

https://community.brain-map.org/t/allen-human-reference-atlas-3d-2020-new/

Visualization Controls   ✕ ▼

ASCT+B Tables vs. 3D Reference Organs

ASCT+B for 10 organs on 11/30/2020, 5:37pm ET:

Organ	#AS	#CT	#B	#AS-CT	#CT-B
Brain	184	127	254	127	346
Heart	23	16	35	73	42
Kidney	39	53	83	63	131
Large Intestine	22	33	45	306	72
Liver	16	27	34	29	35
Lung	18	62	103	110	128
Lymph nodes	34	30	50	63	110
Skin	14	32	57	37	99
Small Intestine	20	32	48	195	55
Spleen	33	26	46	48	72

Vasculature   751

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

Female

Male
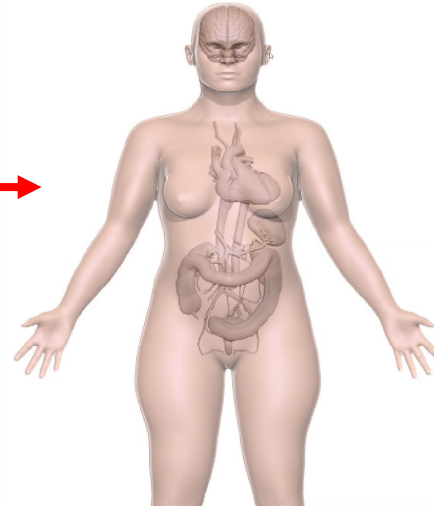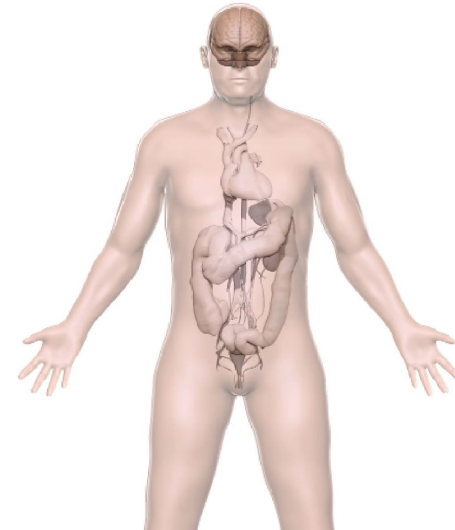
https://hubmapconsortium.github.io/ccf/pages/ccf-3d-reference-library.html (NLM VH organs)
https://community.brain-map.org/t/allen-human-reference-atlas-3d-2020-new/ (brain)
https://www3.cs.stonybrook.edu/~ari/ (male colon)

CCF Exploration User Interface (EUI)

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
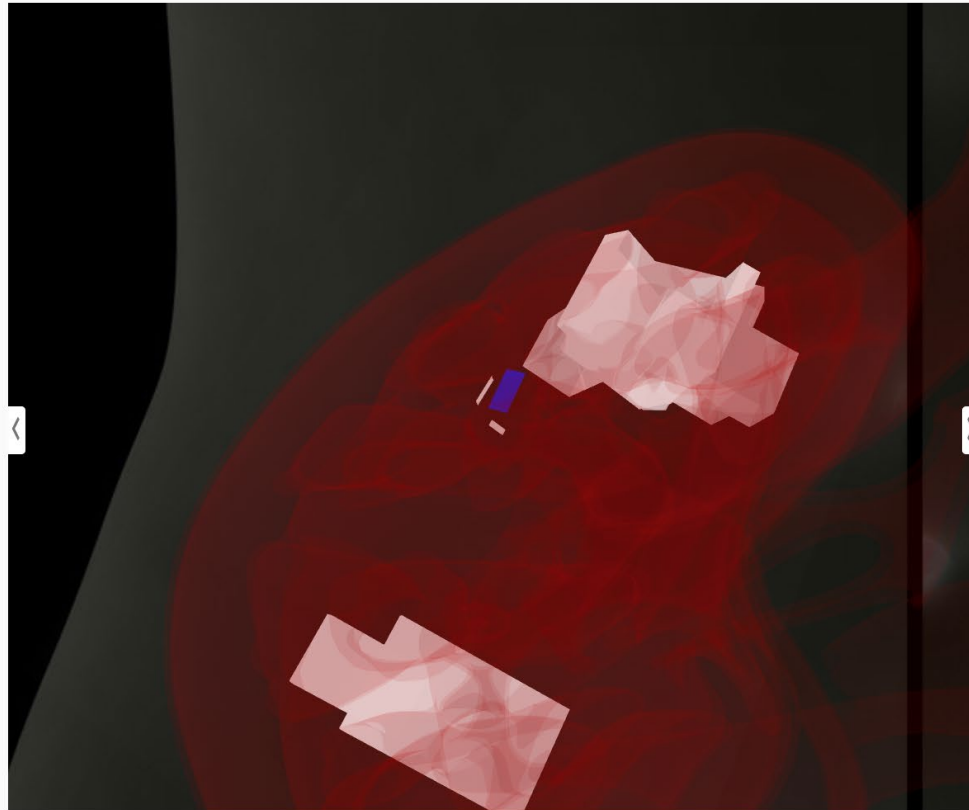   renal papilla
    renal fat pad
    nephron
  spleen
  colon
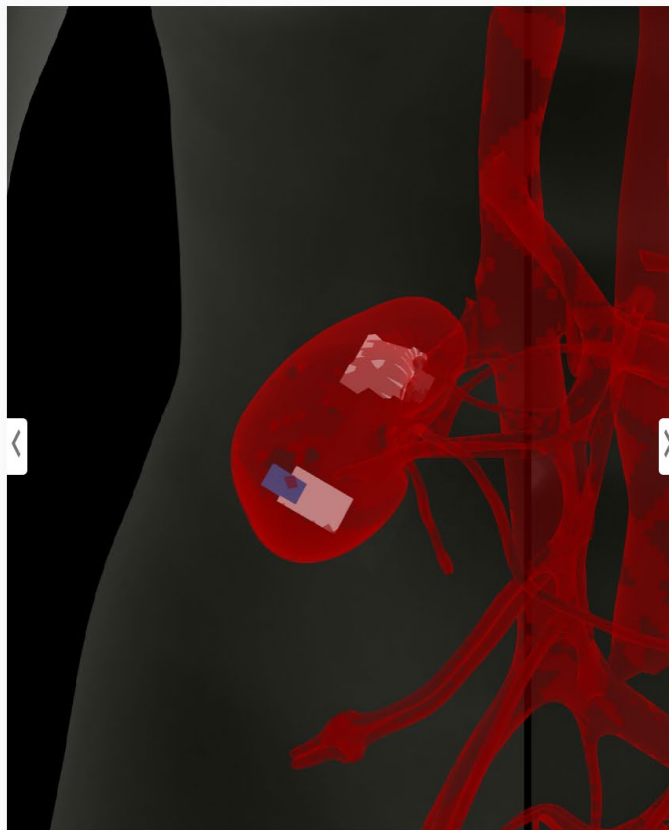
body

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.

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/
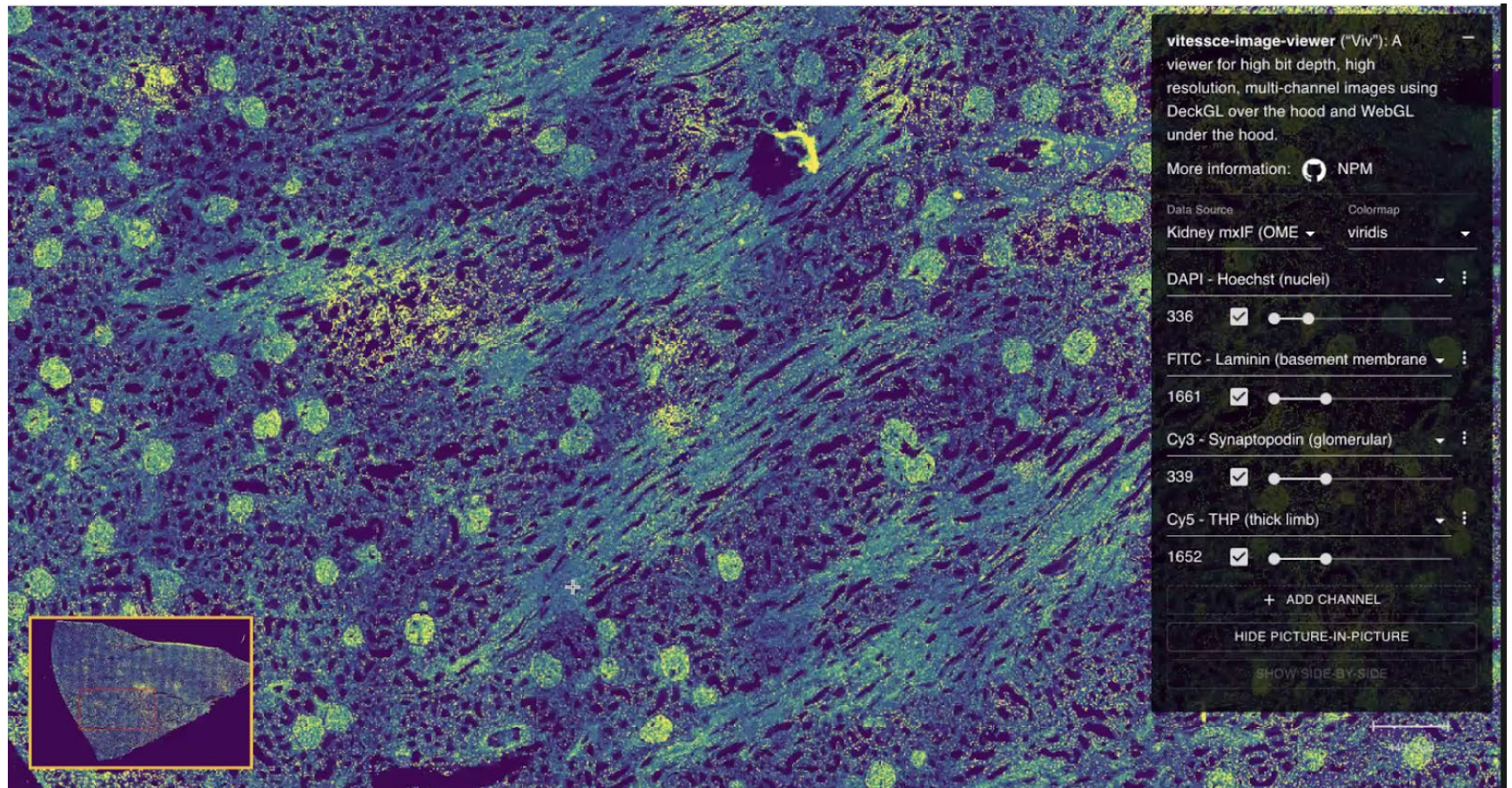
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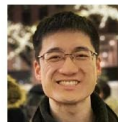
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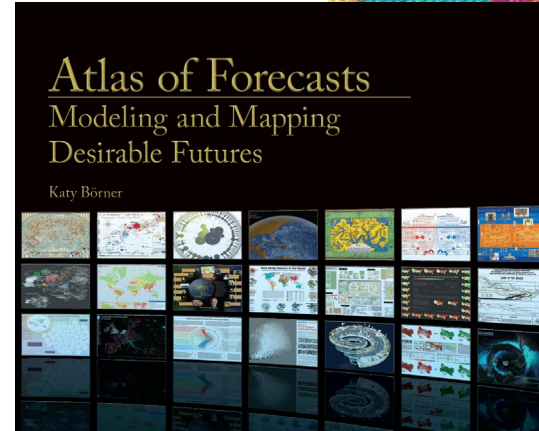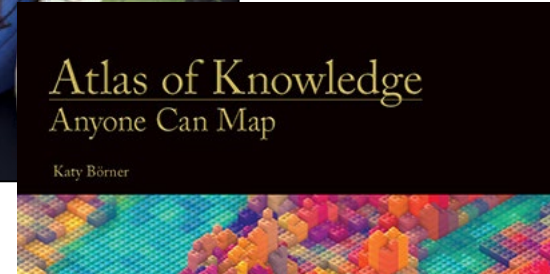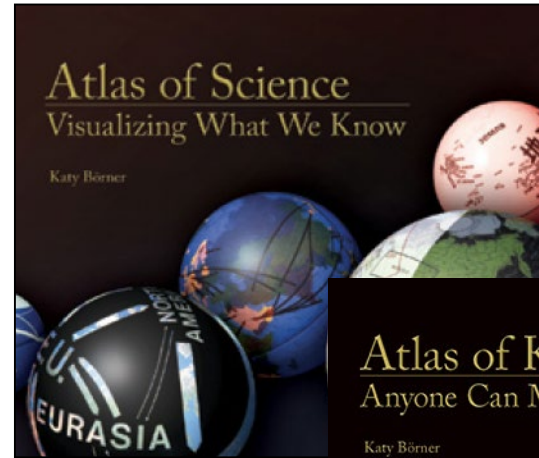
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Katy Börner, Michael Conlon, Jon Corson-Rikert, Cornell, Ying Ding (2012) **VIVO: A Semantic Approach to Scholarly Networking and Discovery**. Morgan & Claypool.

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Q&A