



HUBMAP Anatomy Knowledge Requirements

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CFDE Anatomy Working Group
Virtual Event

April 20, 2021

WG Goals/Requirements

Anatomy Knowledge Requirements sessions will review the following questions for CFDE groups:

1. **Search:** What are your anatomical search use cases? What kind of research questions inform your targeted exploration of anatomy reference knowledge and associated resources?
2. **Browse:** How do you browse over anatomy reference knowledge in preparation for search? What functionality/experience do you seek during the untargeted browsing of anatomy reference knowledge?
3. **Annotate:** How do you annotate/spatially register against anatomy reference knowledge in support of #1 & #2? How do you ensure FAIRness, consistency and coherence when mapping data onto anatomy reference knowledge?
4. **Represent:** What is your approach to anatomy reference knowledge representation in support of #1 to #3? How is this reference knowledge FAIR? Other items: Any other aspect that the cAWG should be focusing on?



Prelude: Human Reference Atlas



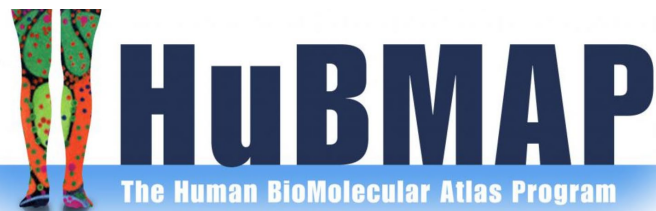
HuBMAP

Vision

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

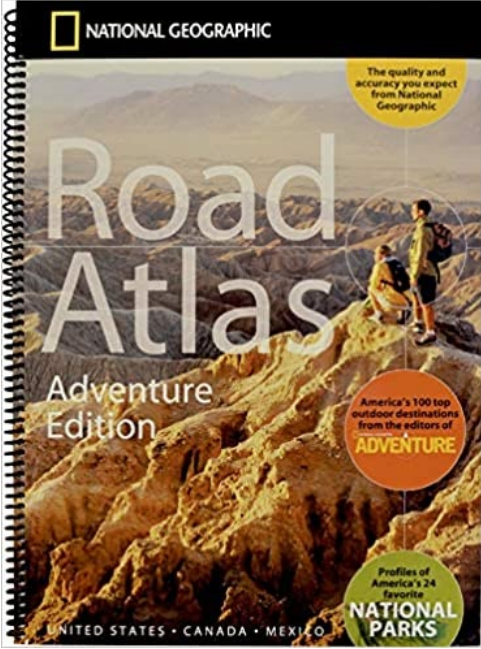
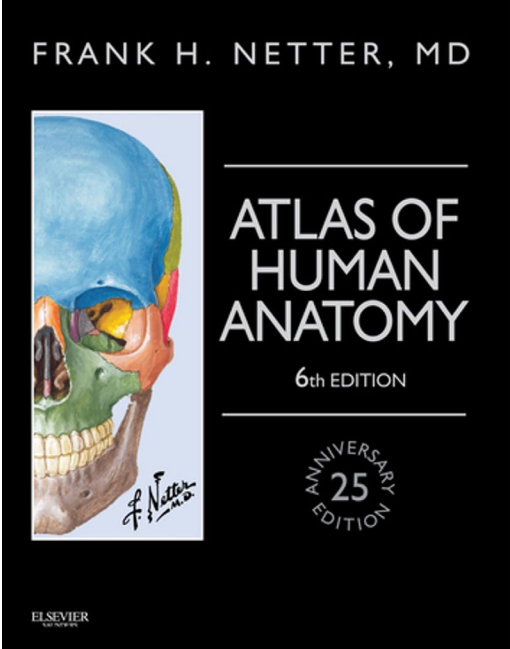
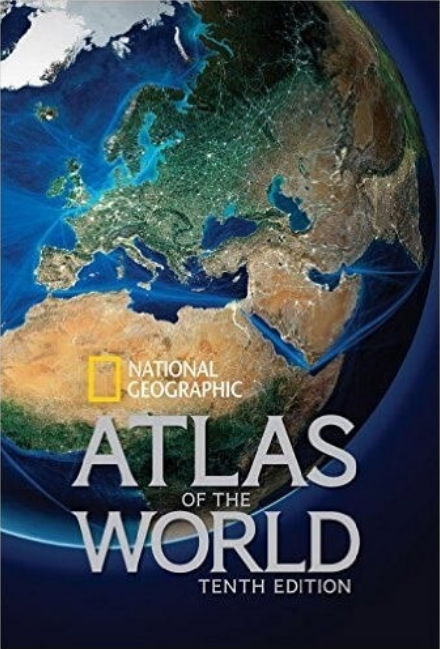
Goals

1. Accelerate the development of the next generation of 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



<https://commonfund.nih.gov/HuBMAP>

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.

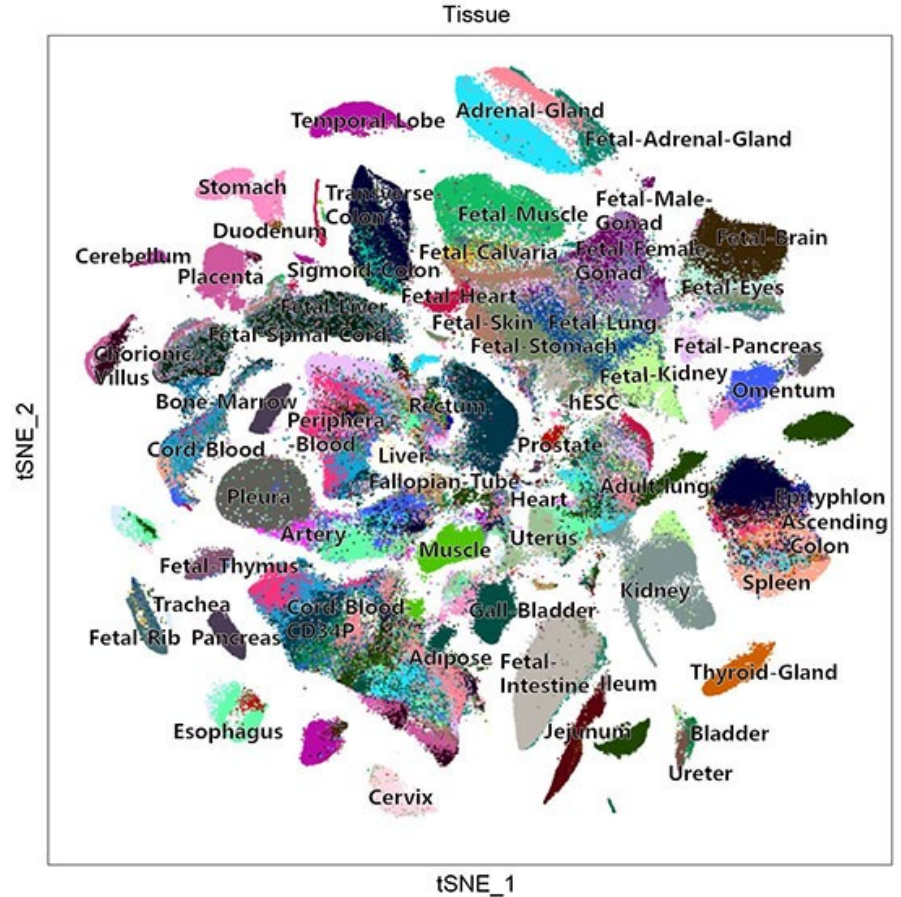
Article | Published: 25 March 2020

Construction of a human cell landscape at single-cell level

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

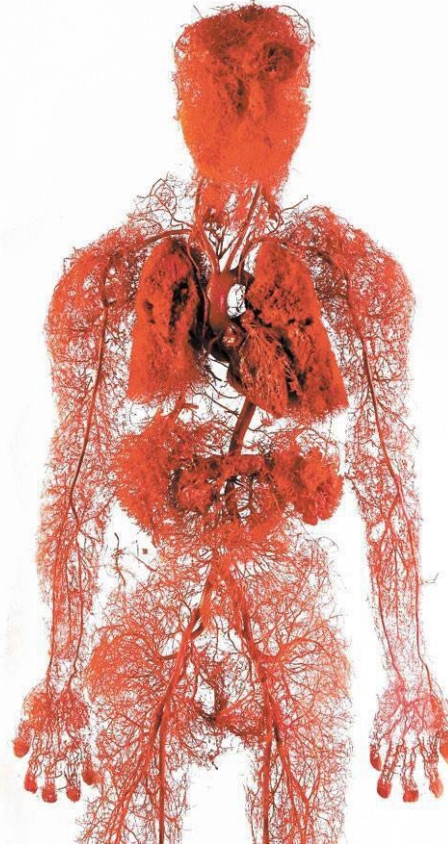
Nature **581**, 303–309(2020) | [Cite this article](#)

55k Accesses | **32** Citations | **409** Altmetric | [Metrics](#)

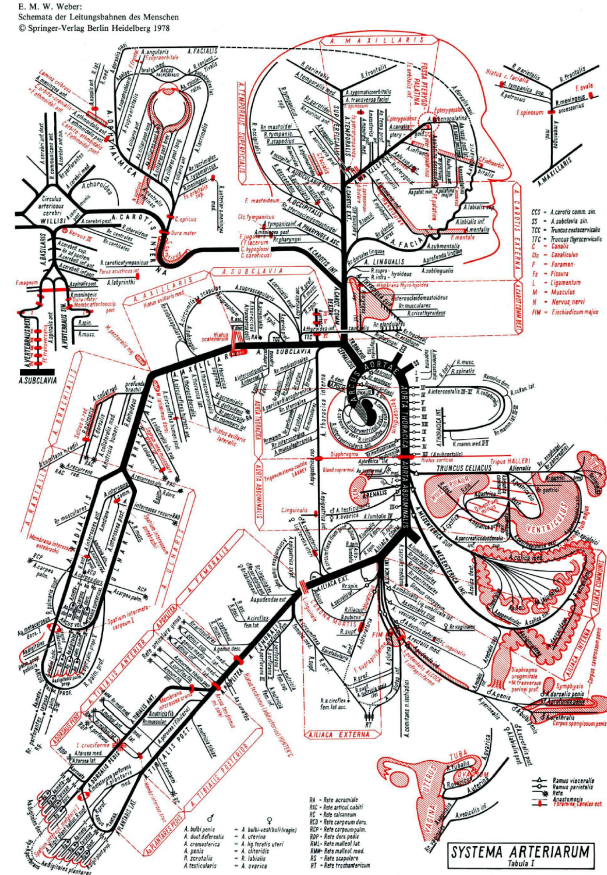


A human reference atlas
 might use human
 anatomy
 as a 'basemap,' or
 an abstract space.

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

The Human Body at Cellular Resolution: The NIH Human Biomolecular Atlas Program.

Snyder et al. *Nature*. 574, p. 187-192.

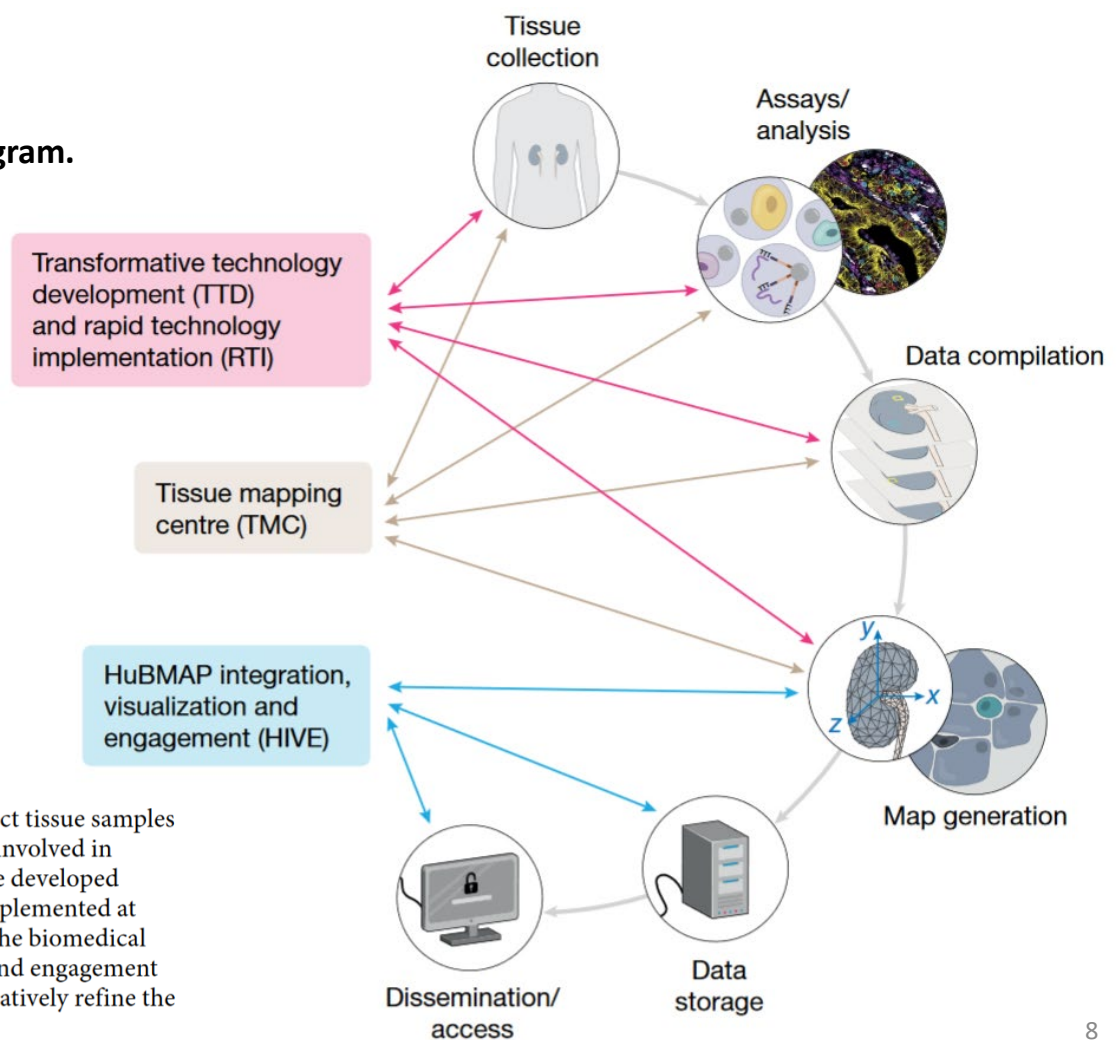


Fig. 1 | The HubMAP consortium. The TMCs will collect tissue samples and generate spatially resolved, single-cell data. Groups involved in TTD and RTI initiatives will develop emerging and more developed technologies, respectively; in later years, these will be implemented at scale. Data from all groups 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.

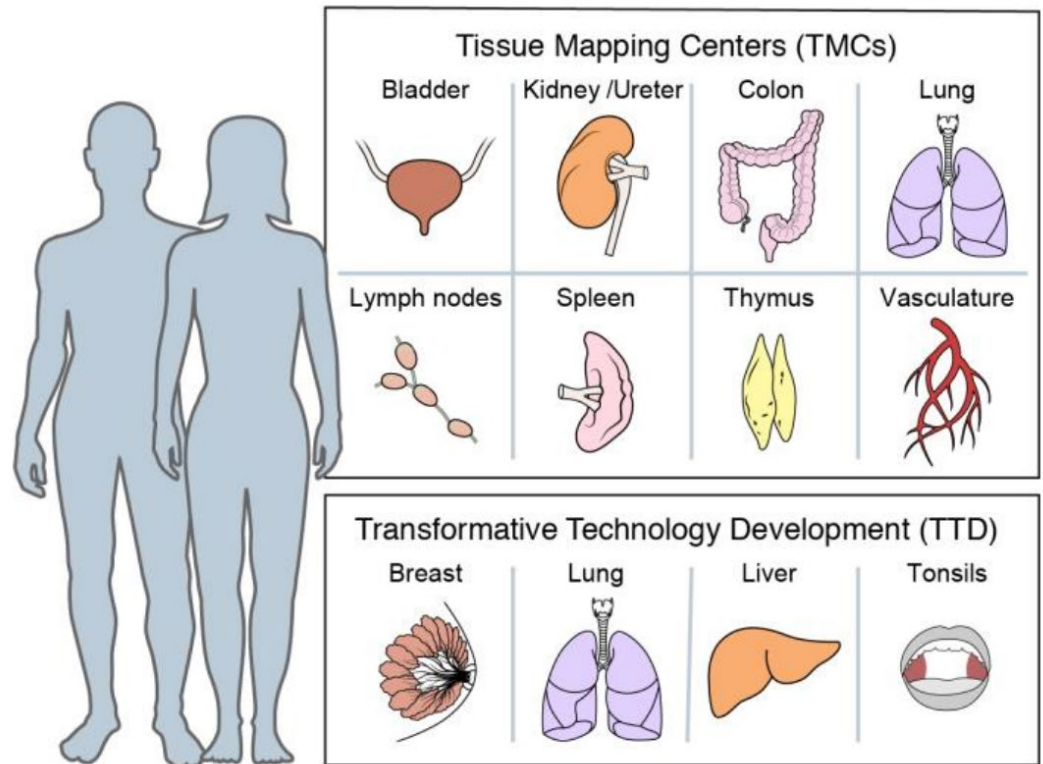


Fig. 2 | Key tissues and organs initially analysed by the consortium.

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.

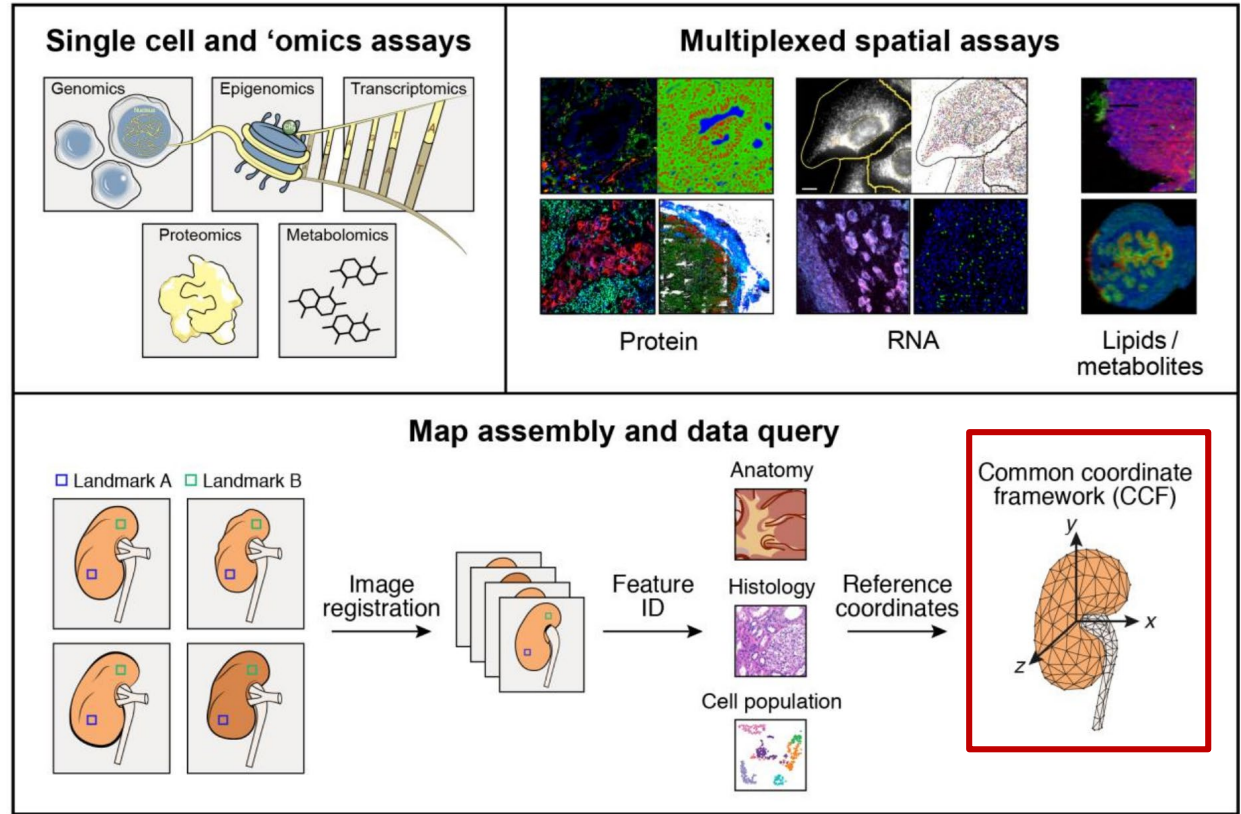


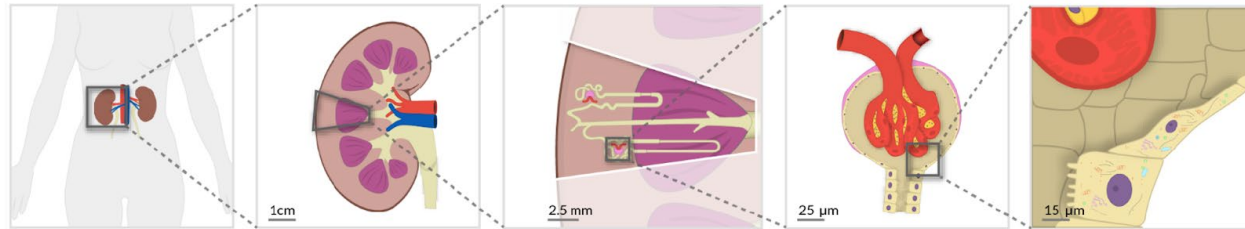
Fig. 3 | Map generation and assembly across cellular and spatial scales. HuBMAP aims to produce an atlas in which users can refer to a histological slide from a specific part of an organ and, in any given cell, understand its contents on multiple 'omic levels—genomic, epigenomic, transcriptomic, proteomic,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

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



CCF: ASCT+B Tables & 3D Reference Organs



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

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

Table 3: Cell types and associated markers from KPMP Pilot 1 transcriptomic studies. Asterisk denotes genes detected by more than one technology. *Italics*, genes detected by a single technology.

Structure/R region	Sub structure/Sub region	Cell Type	Abbreviation	Subset of Marker Genes	Pertinent negatives/comments
Renal Corpuscle	Bowman's Capsule	Parietal epithelial cell	PEC	<i>CRB2*</i> , <i>CLDN1*</i>	
	Glomerulus	Podocyte	POD	<i>NPHS2*</i> , <i>PODXL*</i> , <i>NPHS1*</i>	
		Capillary Endothelial Cell	GC-EC	<i>EHD3*</i> , <i>EMCN*</i> , <i>HECW2*</i> , <i>FLT1*</i> , <i>AQP1*</i>	
		Mesangial Cell	MC	<i>POSTN*</i> , <i>PIEZO2*</i> , <i>ROBO1*</i> , <i>ITGA8*</i>	
Tubules	Proximal Tubule	Proximal Tubule Epithelial Cell (general)	PT	<i>CUBN*</i> , <i>LRP2*</i> , <i>SLC13A1*</i> , <i>ALDOB*</i> , <i>GATM*</i>	There is overlap among the segments
		Proximal Convoluted Tubule Epithelial Cell Segment 1	PT-S1	<i>SLC5A2*</i> , <i>SLC5A12*</i>	
		Proximal Tubule Epithelial Cell Segment 2	PT-S2	<i>SLC22A6*</i>	
		Proximal Tubule Cell Epithelial Segment 3	PT-S3	<i>PDZK1IP1*</i> , <i>MT1G*</i>	
	Loop of Henle, Thin Limb	Descending Thin Limb Cell (general)	DTL	<i>CRYAB*</i> , <i>VCAM1*</i> , <i>AQP1*</i> , <i>SPP1*</i>	<i>CLDN10</i> low
		Ascending Thin Limb Cell (general)	ATL	<i>CRYAB*</i> , <i>TACSTD2*</i> , <i>CLDN3*</i>	<i>AQP1</i> low to none
	Loop of Henle, Thick Limb	Thick Ascending Limb Cell (general)	TAL	<i>SLC12A1*</i> , <i>UMOD*</i>	<i>SLC12A3</i> low to none
		Cortex-TAL cell	C-TAL	<i>SLC12A1*</i> , <i>UMOD*</i>	
		Medulla-TAL cell	M-TAL	<i>SLC12A1*</i> , <i>UMOD*</i>	
		TAL-Macula <i>Deposa</i> cell	TAL_MD	<i>NOS1*</i> , <i>SLC12A1*</i>	
Distal Convolution	Distal Convoluted Tubule Cell (general)	DCT	<i>SLC12A3*</i> , <i>TRPM6*</i>		
	DCT type 1 cell	DCT-1	<i>SLC12A3*</i> , <i>TRPM6</i>	<i>SLC8A1</i> , <i>HSD11B2</i> (low to none)	
	DCT type 2 cell	DCT-2	<i>SLC12A3*</i> , <i>SLC8A1*</i> , <i>HSD11B2</i>	Has CNT and DCT signature	
	Connecting Tubule	Connecting Tubule Cell (general)	CNT	<i>SLC8A1*</i> , <i>CALB1</i> , <i>TRPV5</i>	<i>SLC12A3</i> low to none. IC or PC without <i>SLC8A1</i> could be in the CNT structure
		CNT-Principal Cell	CNT-PC	<i>SLC8A1*</i> , <i>AQP2*</i> , <i>SCNN1G*</i>	
		CNT-Intercalated Cell	CNT-IC	<i>SLC8A1*</i> , <i>CA2</i> , <i>ATP6VOD2*</i>	
CNT-IC-A cell		CNT-IC-A	<i>SLC8A1*</i> , <i>SLC4A1*</i> , <i>SLC26A7*</i>		
	CNT-IC-B cell	CNT-IC-B	<i>SLC8A1*</i> , <i>SLC26A4*</i> , <i>SLC4A9*</i>		
Collecting Duct	Collecting duct (general) cell	CD	<i>GATA3*</i>	<i>GATA3</i> may be in subpopulation of DCT, CNT and <i>vSMC/P</i> . <i>SLC8A1</i> , <i>CALB1</i> , <i>TRPV5</i>	
	CD-PC (general)	CD-PC			
	C-CD-PC	C-CD-PC	<i>AQP2*</i> , <i>AQP3*</i> , <i>FXYP4*</i>		
	M-CD-PC	M-CD-PC	<i>SCNN1G*</i> , <i>GATA3*</i>		
	Outer medulla-CD-PC	OM-CD-PC			
	Inner Medulla-CD cell	IM-CD	<i>AQP2*</i> , <i>SLC14A2</i>		

Vessels	Endothelial Cells (non-glomerular)	Transitional PC-IC cell	IRC-IC	<i>FXYP4*</i> , <i>SLC4A9*/SLC26A7*</i>	(low to none); Low to No
		CD-IC (general) cell	CD-IC	<i>CA2</i> , <i>ATP6VOD2*</i>	<i>CALCA</i> and <i>KIT</i> in C-CD-IC-A. It may not be possible to assign IC or PC to <i>CNT</i> or CD structures without regional information of their source.
		CD-IC-A (general) cell	CD-IC-A	<i>SLC4A1</i> , <i>SLC26A7*</i> , <i>TMEM213*</i>	
		C-CD-IC-A cell	C-CD-IC-A	<i>SLC26A7*</i> , <i>SLC4A1*</i>	
		M-CD-IC-A cell	M-CD-IC-A	<i>SLC26A7*</i> , <i>SLC4A1*</i> , <i>KIT*</i> , <i>CALCA</i>	
		CD-IC-B (general) cell	CD-IC-B		
		C-CD-IC-B cell	C-CD-IC-B	<i>SLC4A9*</i> , <i>SLC26A4*</i>	
		M-CD-IC-B cell	M-CD-IC-B		
		EC-IC-B cell	EC-IC-B		
		EC-IC-B cell	EC-IC-B		
Vessels	Endothelial Cells (non-glomerular)	Endothelial Cell (general)	EC	<i>EMCN*</i> , <i>PECAM1*</i> , <i>FLT1*</i>	
		EC-Afferent/Effluent Arteriole	EC-AEA	<i>SERPINE2*</i> , <i>TM4SF1*</i>	likely <i>PALMD</i>
		EC-Peritubular capillaries	EC-PTC	<i>PLVAP*</i>	
		EC-Descending Vasa Recta	EC-DVR	<i>TM4SF1*</i> , <i>PALMD</i>	
		EC-Ascending Vasa Recta	EC-AVR	<i>DNASEIL3*</i>	low to none
		EC-Lymphatics	EC-LYM	<i>MMRN1*</i> , <i>PROX1</i>	
Structure/R region	Sub structure/Sub region	Cell Type	Abbreviation	Subset of Marker Genes	Pertinent negatives/comments
Interstitium	Stroma (non-glomerular)	Vascular Smooth Muscle/Pericyte (general)	<i>vSMC/P</i>	<i>TAGLN*</i> , <i>ACTA2*</i> , <i>MYH11*</i> , <i>NTRK3</i> , <i>MCAM</i>	
		<i>vSMC/P</i> -Renin	<i>vSMC/P-REN</i>	<i>REN</i>	
		Fibroblast	FIB	<i>DCN*</i> , <i>ZEB2</i> , <i>C7</i> , <i>LUM</i>	
	Immune	Macrophages-Resident	MAC-R	<i>CD163*</i> , <i>IL7R*</i>	
		Macrophage	MAC	<i>ST00A9</i>	
		Natural Killer Cell	NKG7		
		Dendritic Cell	DC	<i>APOE</i>	
		Monocyte	MON	<i>CTQA</i> , <i>HLA-DRA</i>	
		T lymphocyte (general)	T	<i>CD3</i>	
		T Cytotoxic	T-CYT	<i>GZMA</i>	
	B lymphocyte	B	<i>IGJ</i>		

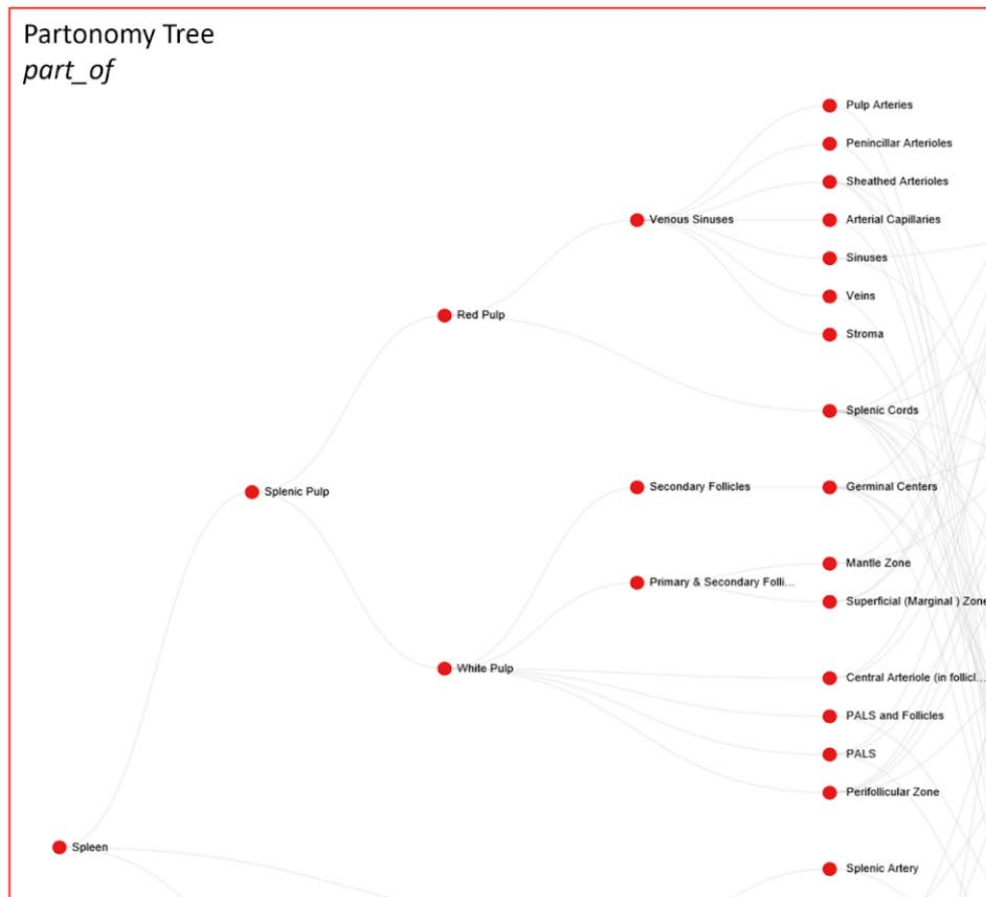
El-Achkar et al. A Multimodal and Integrated Approach to Interrogate Human Kidney Biopsies with Rigor and Reproducibility: The Kidney Precision Medicine Project. bioRxiv. 2019, Updated Aug 2020. doi:10.1101/828665

Anatomical Structures (AS)

Cell Types (CT)

Biomarkers (B)

Partonomy Tree
part_of



Bimodal network describing which CT are located_in what AS

Typology Tree
is_a

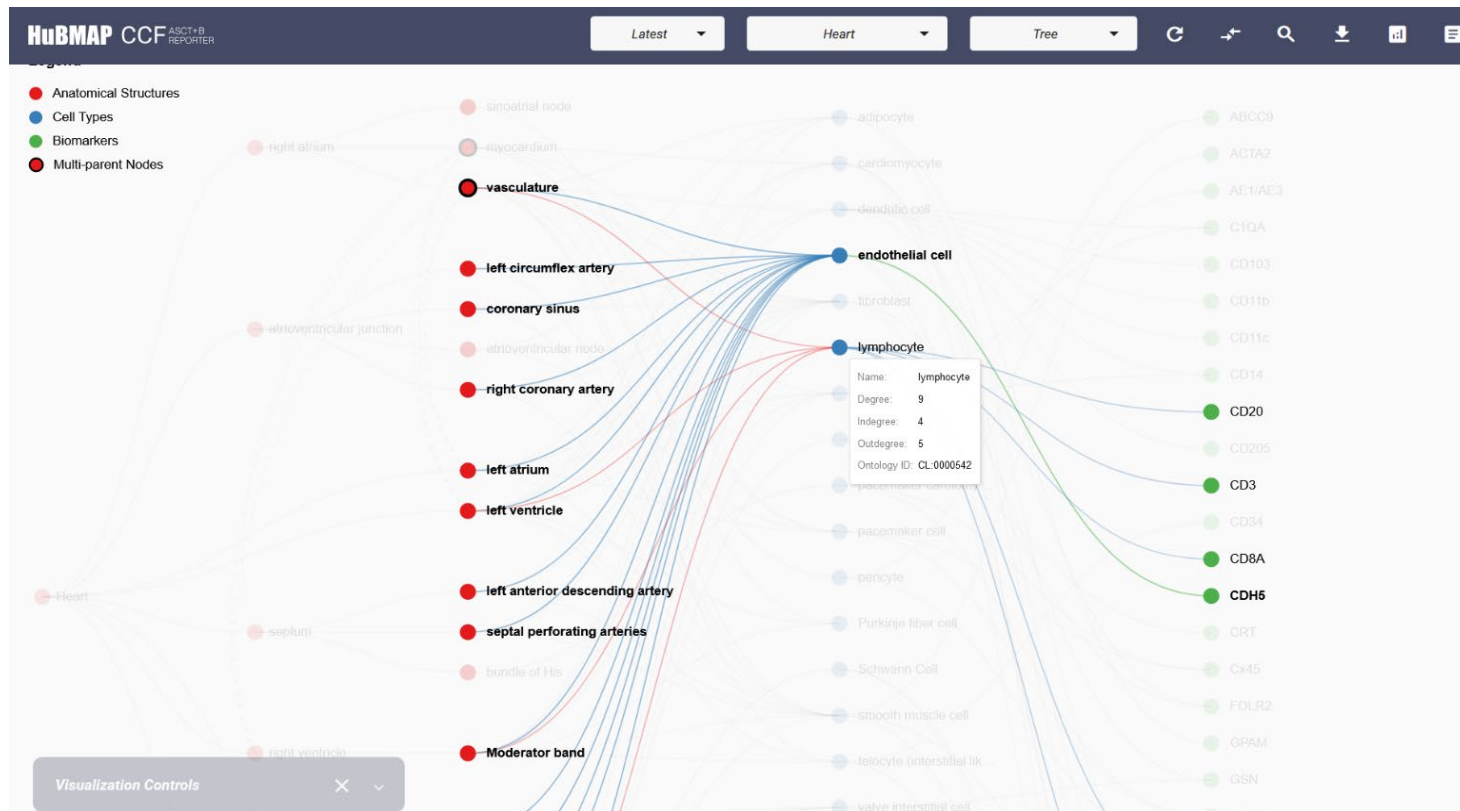
- adventitial stromal cell
- B cell
- Dendritic cell
- Endothelial
- Endothelial cell
- Erythrocytes
- fibroblast
- Fibroblastic reticular cell
- Follicular Dendritic cell
- Granulocytes
- Littoral cell
- Lymphatic endothelium
- macrophage
- Monocytes
- Myofibroblast
- neurons
- NK cell
- Plasma cell
- 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

CCF ASCT+B Reporter UI



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

Anatomical Structures, Cell Types, plus Biomarkers (ASCT+B) table for Lung v1.0

Description

[Anatomical Structures, Cell Types, plus Biomarkers \(ASCT+B\) tables](#) aim to capture the nested *part_of* structure of anatomical human body parts, the typology of cells, and biomarkers used to identify cell types. The tables are authored and reviewed by an international team of experts.

LABEL	VALUE
Creator(s):	Gloria Pryhuber; Xin Sun
Creator ORCID:	0000-0002-9185-3994 ; 0000-0001-8387-4966
Project Lead:	Katy Börner
Project Lead ORCID:	0000-0002-3321-6137
Creation Date:	2021-03-12
License:	Creative Commons Attribution 4.0 International (CC BY 4.0)
Publisher:	HuBMAP
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Award Number:	OT2OD026671
HuBMAP ID:	HBM868.DWJZ.874
Data Table:	Lung v1.0
DOI:	https://doi.org/10.48539/hbm868.dwjz.874
How to Cite This Data Table:	Gloria Pryhuber; Xin Sun. HuBMAP ASCT+B Tables. Lung v1.0 https://doi.org/10.48539/hbm868.dwjz.874
How to Cite ASCT+B Tables Overall:	Quardokus, Ellen, Hrishikesh Paul, Bruce W. Herr II, Lisel Record, Katy Börner. 2021. <i>HuBMAP ASCT+B Tables</i> . https://hubmapconsortium.github.io/ccf/pages/ccf-anatomical-structures.html . Accessed on March 12, 2021.

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

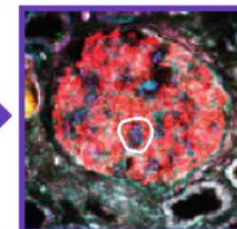
Structure/Region	Sub structure/Sub region	Cell Type
Renal Corpuscle	Bowman's (glomerular) Capsule/parietal layer	Parietal epithelial Cell
	Bowman's (glomerular) Capsule/visceral layer	Podocyte
	Glomerular Tuft	Capillary Endothelial Cell
Tubules	Proximal Tubule	Proximal Tubule Epithelial Cell (general)
		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
	Distal Convolution	TAL-Macula Densa Cell
		Distal Convoluted Tubule Cell (general)
	Connecting Tubule	DCT Type 1 Cell
		DCT Type 2 Cell
Connecting Tubule Cell (general)		
	CNT-Principal Cell	

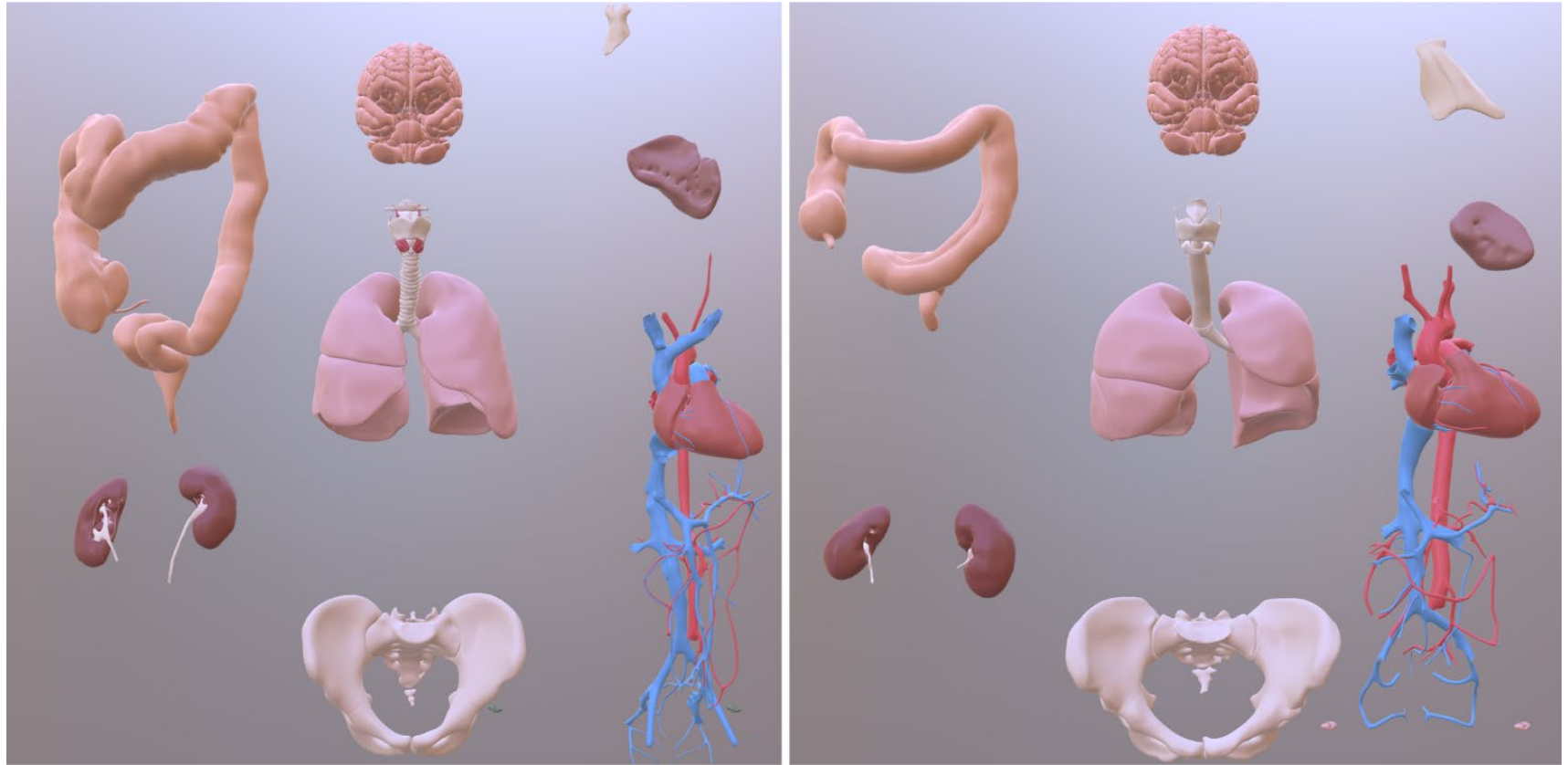
Ontology

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





Overview of CCF 3D Reference Models

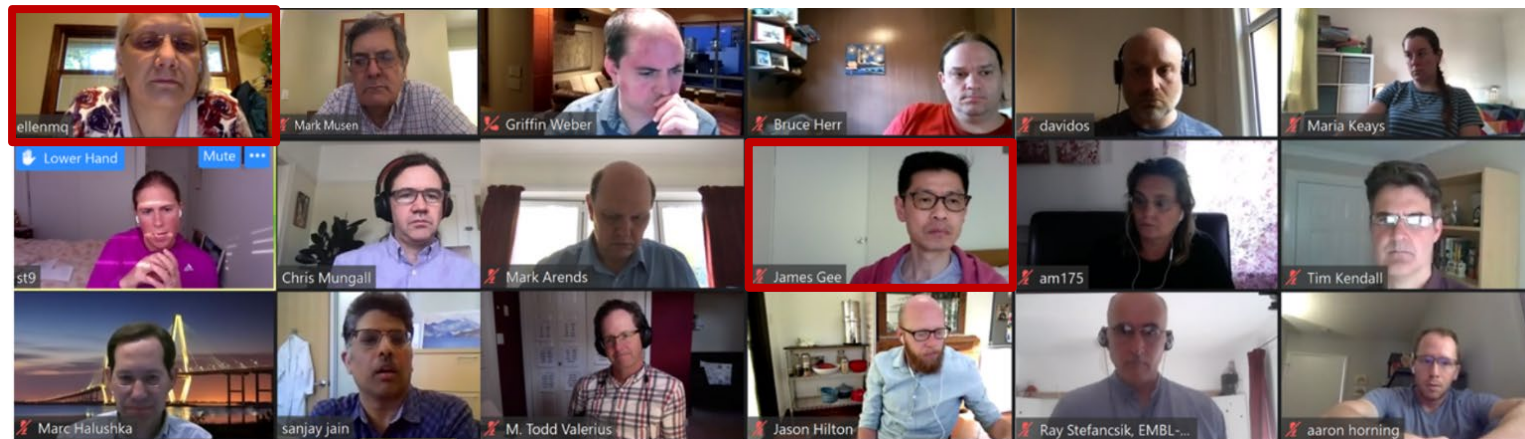
ASCT+B Table Working Group

Lead by Katy Börner and Jim Gee; Ellen M Quardokus serves as Knowledge Manager

Meetings take place monthly to review and approve tables, formalize and unify table design language, discuss and expand table usage, see [WG Charter](#).

Upcoming meetings in **2021**: April 7, May 5, 11a-noon ET.

Please [register](#) to receive invites and updates.



	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>

Consortium

Allen Brain Atlas

BICCN

CZI

EU H2020

GTEX

GUDMAP

Gut Cell Atlas

HTAN

HuBMAP

KPMP

LungMAP

MRC

RBK

SPARC

TCGA

Wellcome

Size
#Links



Color



Organ

Adrenal Gland

Bladder

Bone Marrow & Blood

6
Brain

6
Breast

Cervix

Decidua

Eye

Gonads

Heart

6
Intestine, Large

Intestine, Small

9
Kidney

Liver

10
Lung

Lymph Node

Ovaries

Pancreas

Placenta

Prostate

Skin

Spinal Cord

Spleen

Stomach

Testes

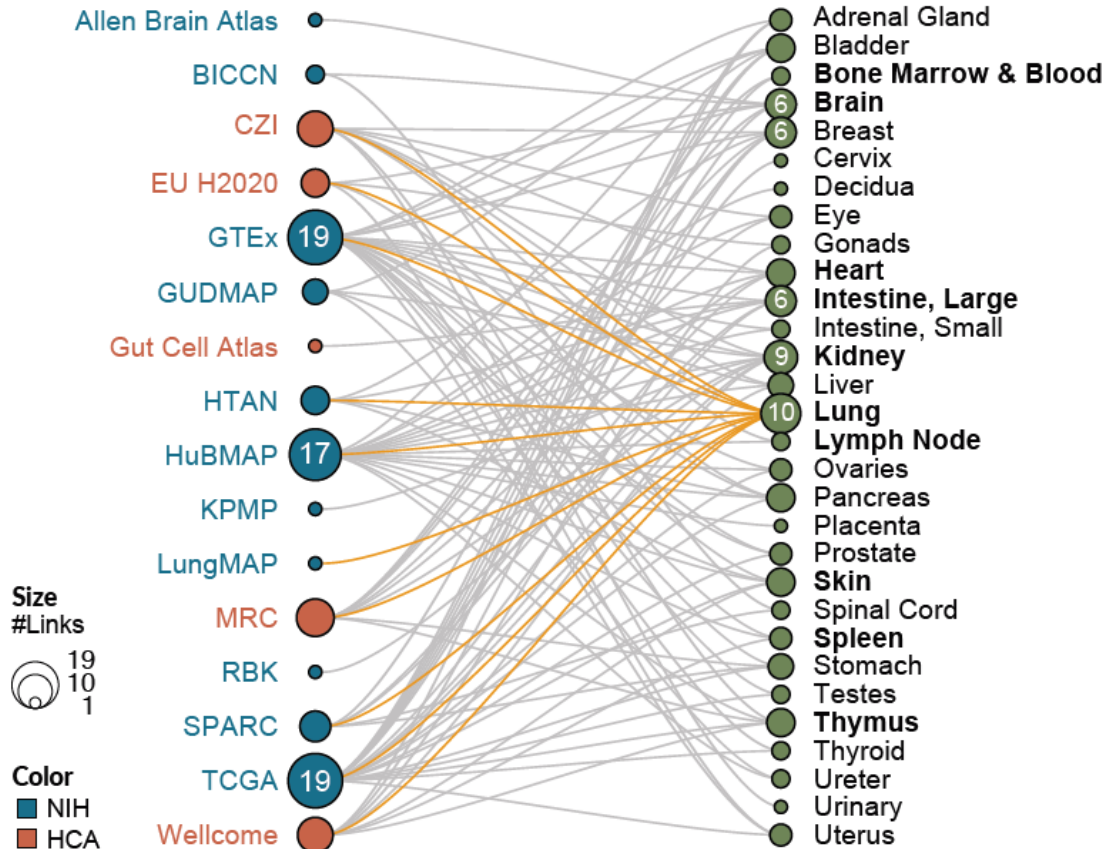
Thymus

Thyroid

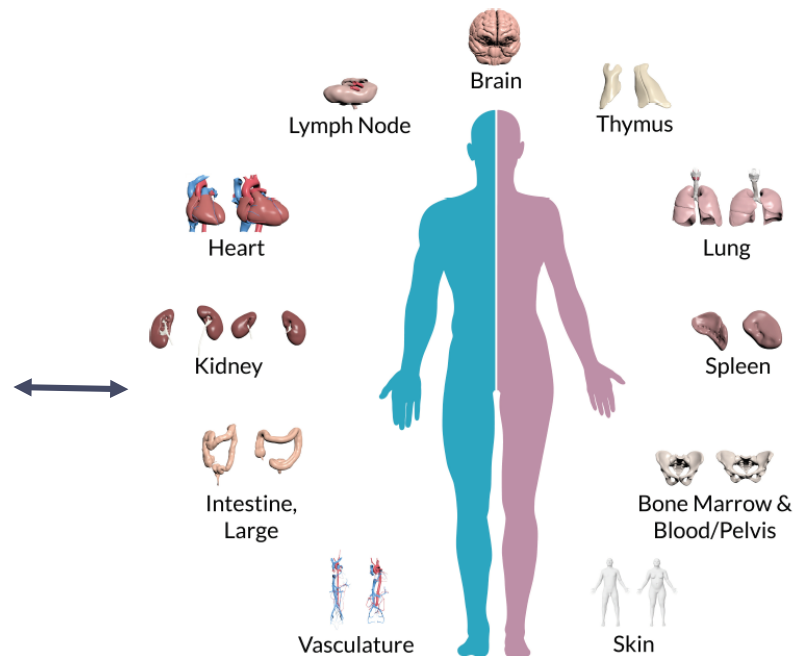
Ureter

Urinary

Uterus



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> (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)

Search


37 Works

Anatomical Structures, Cell Types, plus Biomarkers (ASCT+B) table for Spleen v1.0

Marda Jorgensen, Andrea J. Radtke & Rebecca T. Beuschel

Text File published via HuBMAP

Anatomical Structures, Cell Types, plus Biomarkers (ASCT+B) tables aim to capture the nested part_of structure of anatomical human body parts, the typology of cells, and biomarkers used to identify cell types. The tables are authored and reviewed by an international team of experts.

 No citations were reported. No usage information was reported.

 <https://doi.org/10.48539/hbm625.vplj.455>  Cite

3D Reference Organ for Intestine, Large, Female v1.0

Kristen Browne

Digital Object published via HuBMAP

This reference organ was created using data provided by Arie Kaufman, Stony Brook University as a base for a custom model built using Pixelogic Zbrush.

<https://search.datacite.org/works?query=hubmap&resource-type-id=dataset>

ASCT+B Table Usage

ASCT+B tables guide **CCF Ontology** and **3D Reference Object Library** design that semantically name and spatially place tissue data from different donors into one CCF (i.e., mapping).

ASCT Table

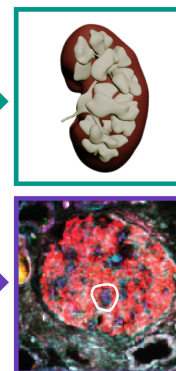
Structure/Region	Sub structure/Sub region	Cell Type
Renal Corpuscle	Bowman's Capsule	Parietal epithelial Cell
	Glomerulus	Podocyte
		Capillary Endothelial Cell
Proximal Tubule	Mesangial Cell	
	Proximal Tubule Epithelial Cell (general)	
	Proximal Convoluted Tubule Epithelial Cell Segment 1	
	Proximal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

Ontology

<i>Anatomical Structures Partonomy</i>
kidney
kidney capsule
cortex of kidney
outer cortex of kidney
renal medulla

<i>Cell Types Ontology</i>
connective tissue cell
pericyte cell
mesangial cell
extraglomerular mesangial cell
glomerular mesangial cell

3D Reference Object Library



Tissue blocks are registered into the CCF using the Registration User Interface (RUI), and they can be explored via the Exploration User Interface (EUI).

Annotate:

How do you annotate/spatially register against anatomy reference knowledge in support of #1 & #2? How do you ensure FAIRness, consistency and coherence when mapping data onto anatomy reference knowledge?



CCF Registration User Interface (RUI)



Document the tissue extraction site by registering tissue blocks within a 3D reference organ.

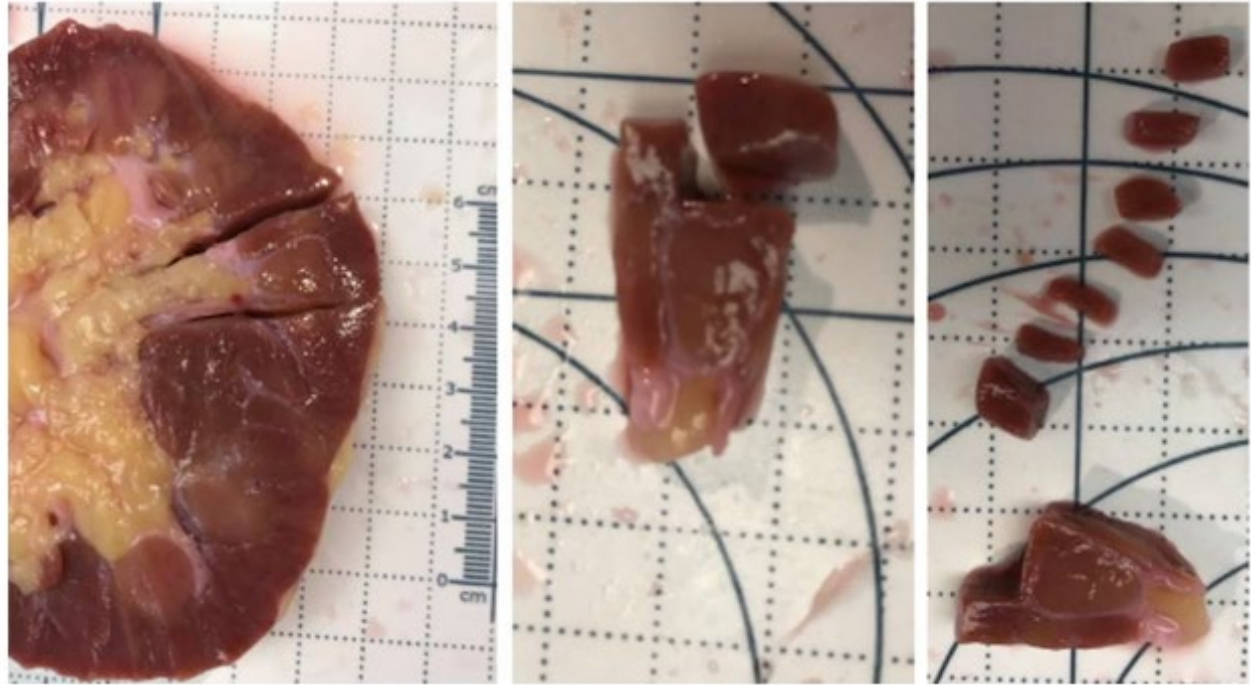
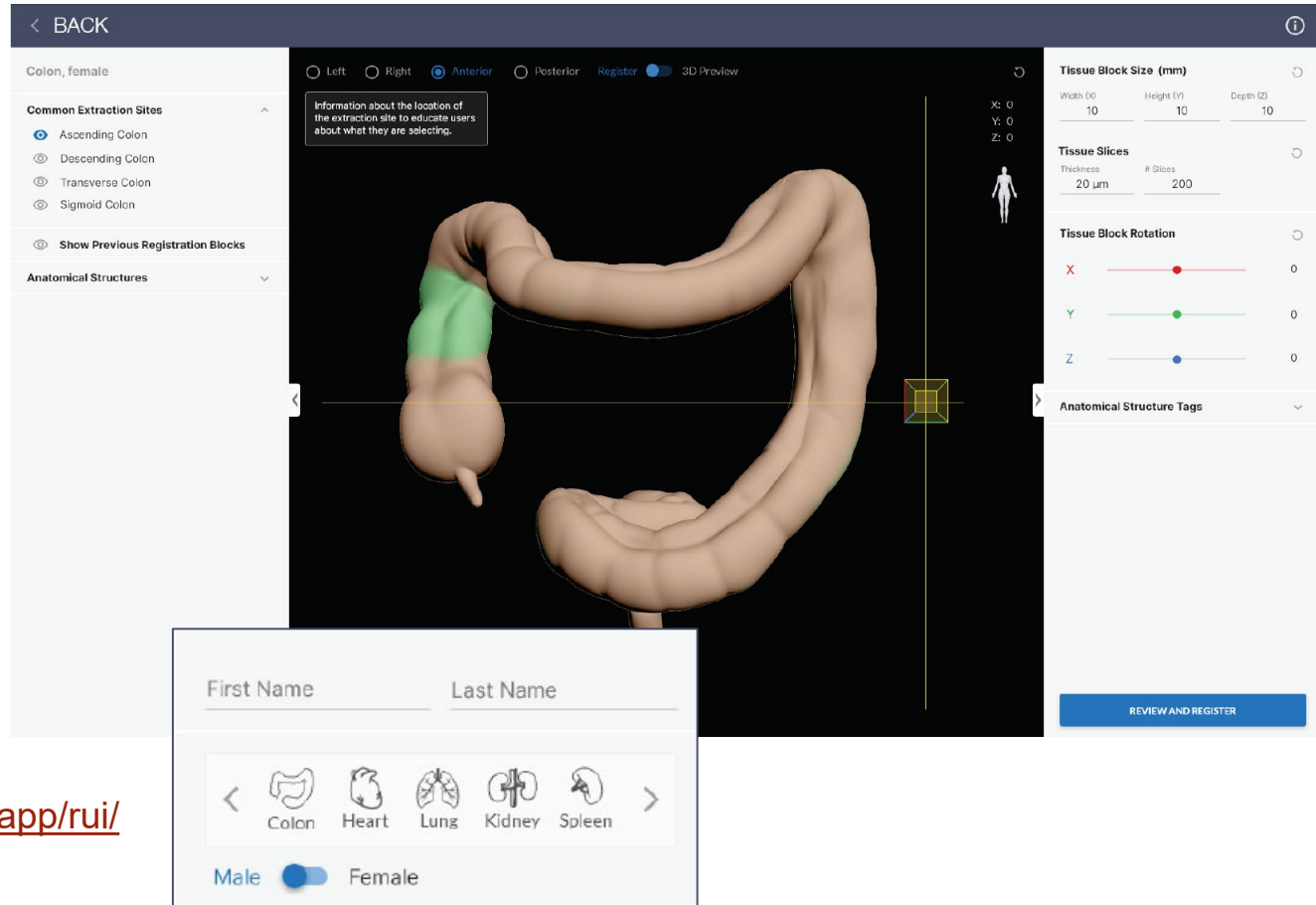


Image provided by Sanjay Jain, TMC-UCSD

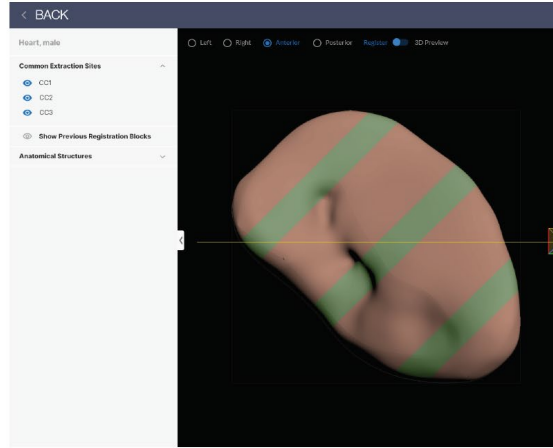
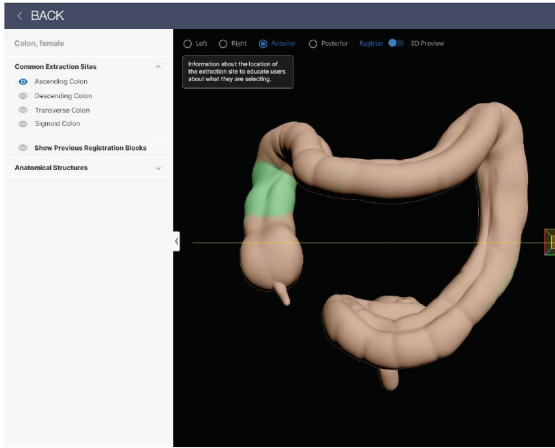
CCF Registration User Interface (RUI) v1.0.0

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/>



Kidney

- Bisection Line

Spleen

- CC1
- CC2
- CC3

Colon

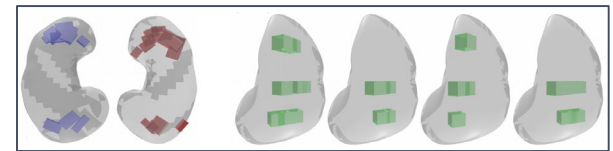
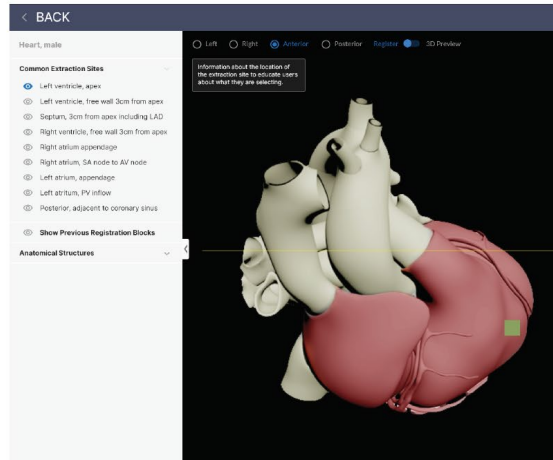
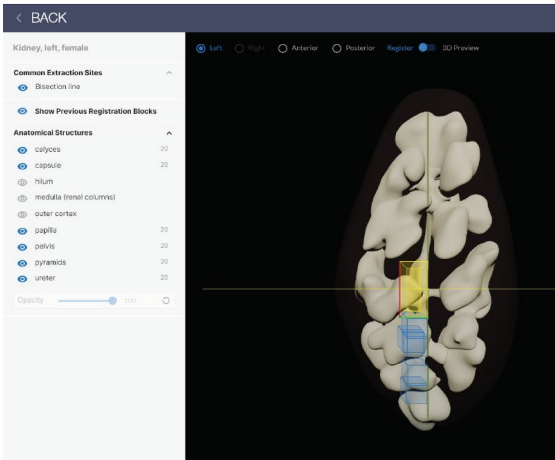
- Ascending Colon
- Descending Colon
- Transverse Colon
- Sigmoid Colon

Heart

- Left atrium, appendage
- Left atrium, PV inflow
- Left ventricle, apex
- Left ventricle, free wall 3cm from apex
- Septum, 3cm from apex including LAD
- Posterior, adjacent to coronary sinus
- Right atrium appendage
- Right atrium, AV (atrioventricular) node
- Right atrium, SA (sinoatrial) node
- Right ventricle, free wall 3cm from apex

Extraction Site Mapping

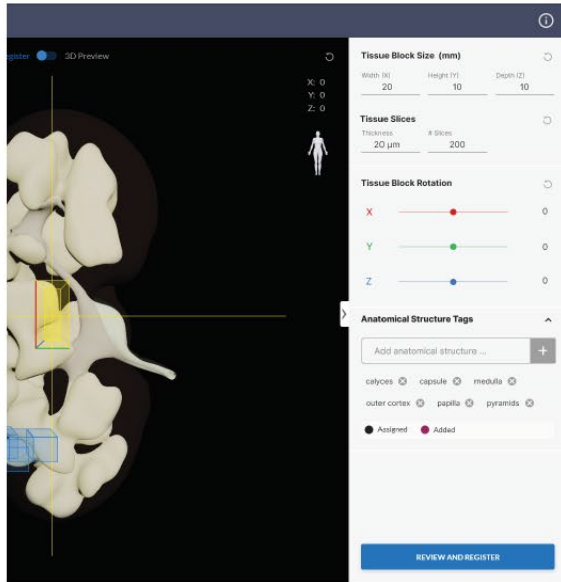
- 7
- 8
- 1
- 2
- 3
- 9
- 5
- 6a
- 6b
- 4



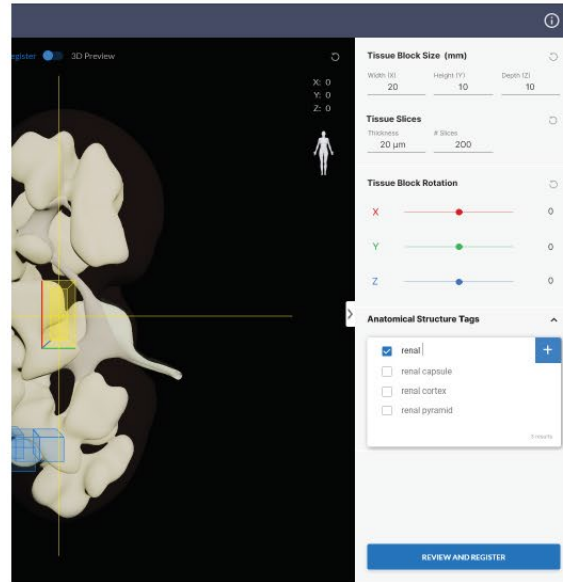
For the first HuBMAP portal release, 48 tissue blocks were registered.

CCF Registration User Interface (RUI) v1.0.0 cont.

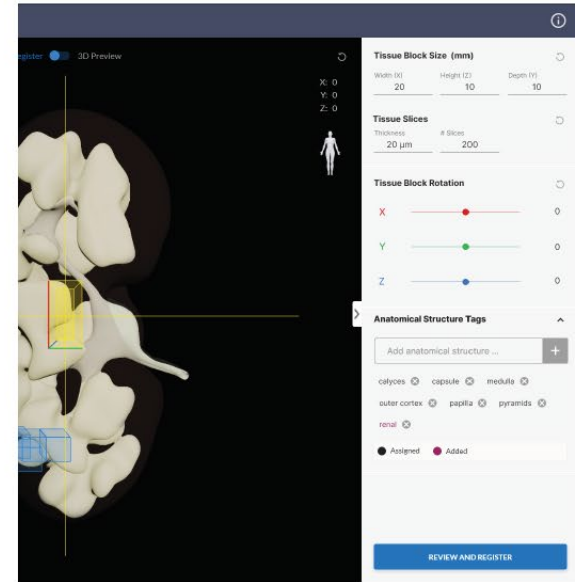
Collision when Tissue Block hits Reference Organ




Tag Search behavior



Custom tag added to list



HuBMAP Upload Portal



BOES@pitt.edu | [Edit Profile](#) [Logout](#)

HuBMAP Display ID Generator

Generate unique identifiers which will be used consortium wide to track sample and associate data with samples.

Source HuBMAP ID * [Look up](#)

HuBMAP display id: **TEST0005-RK**

type: Organ name:

Organ Type: Kidney (Right)

HuBMAP ID: HBM:264-TTJ-798

Description:

Tissue Sample Type *

Protocol 1

protocols.io DOI *

Protocol document * [Browse](#)
doc, docx and pdf files only

[Add Protocol](#)

Generate IDs for multiple FFPE block samples


Lab IDs and Sample Locations can be assigned on the next screen after generating the HuBMAP IDs

Description

Metadata [+ Add Metadata](#)

Image [+ Add Image](#) Make sure any uploaded images are de-identified

[Generate ID](#) [Cancel](#)



BOES@pitt.edu | [Edit Profile](#) [Logout](#)

HuBMAP Display ID Generator

Generate unique identifiers which will be used consortium wide to track sample and associate data with samples.

3 sample IDs were generated: TEST0005-RK-6 through TEST0005-RK-8

Type: FFPE block

[Assign Lab IDs and Sample Locations](#)

[Return to Search](#)

Assign Lab IDs and Sample Location

	Lab Sample Id	Register Location	SuccessView JSON
TEST0005-RK-6	<input type="text" value="TEST0005-RK-6-A"/>	Register Location	?
TEST0005-RK-7	<input type="text"/>	Register Location	?
TEST0005-RK-8	<input type="text"/>	Register Location	?

[Submit](#)

[close](#)

Implemented by the HIVE IEC

CCF Registration User Interface (RUI)

The screenshot displays the CCF Registration User Interface (RUI) for the HuBMAP project. The interface is divided into several sections:

- Header:** "HuBMAP CCF REGISTRATION USER INTERFACE" with a help icon.
- User Information:** Fields for "First Name" (Andreas) and "Last Name" (Bueckle).
- Organ Selection:** Icons for Colon, Heart, Kidney, Spleen, and Stomach. The Kidney is selected.
- Gender and Side:** Radio buttons for "Left", "Right", "Anterior" (selected), and "Posterior". A "Register" toggle is turned on, and "3D Preview" is also on.
- 3D Model:** A central 3D rendering of a kidney with a blue rectangular registration block overlaid on its surface. A small human figure icon is visible to the right of the model.
- Coordinates:** X: 80, Y: 69, Z: 40.
- Left Panel (Anatomical Structures):**
 - Common Extraction Sites: "Show Previous Registration Blocks".
 - Anatomical Structures list:
 - kidney capsule
 - cortex of kidney
 - outer cortex of kidney
 - renal column (highlighted)
 - hilum of kidney
 - renal medulla
 - renal papilla
 - renal pyramid
- Right Panel (Registration Parameters):**
 - Tissue Block Size (mm):** Width (X): 8, Height (Y): 6, Depth (Z): 10.
 - Tissue Slices:** Thickness and # Slices fields.
 - Tissue Block Rotation:** Sliders for X, Y, and Z axes, all set to 0.
 - Anatomical Structure Tags:** "Add Anatomical Structures ..." field with a plus icon. Legend: Assigned (black dot), Added (pink dot).
 - REVIEW AND DOWNLOAD** button.

<https://hubmapconsortium.github.io/ccf-ui/rui/>

RUI in Numbers

HuBMAP Data (published) published + unpublished

15 kidney, left
11 kidney, right
15 spleen
4 intestine, large

5	Tissue Data Providers
36	Donors
153	Tissue Blocks
3763	Tissue Sections
269	Tissue Datasets

KPMP

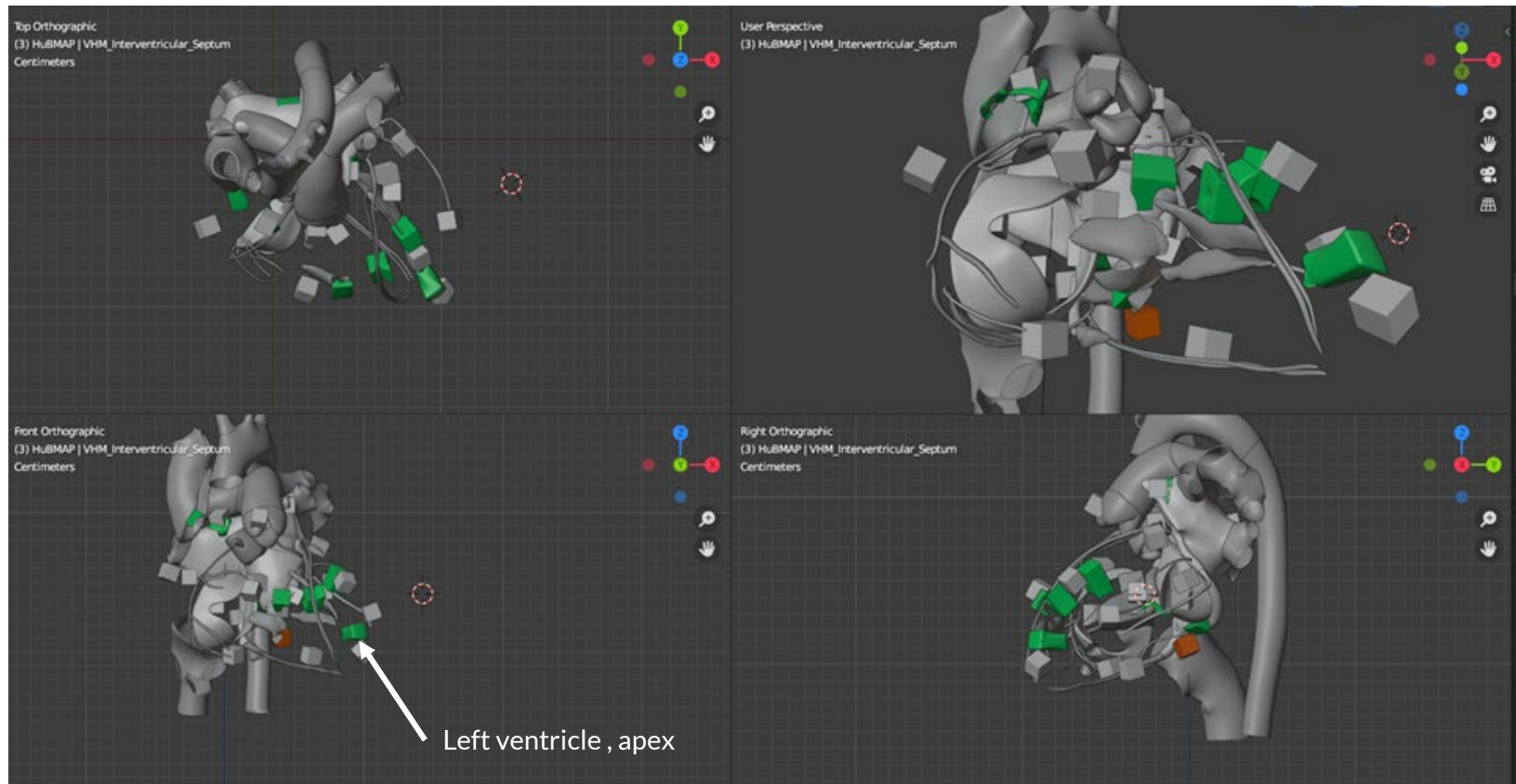
3 kidney, left

SPARC

26 heart (13 male, 13 female)

GTEx

6 **extraction sites** for ca. 400 tissue blocks

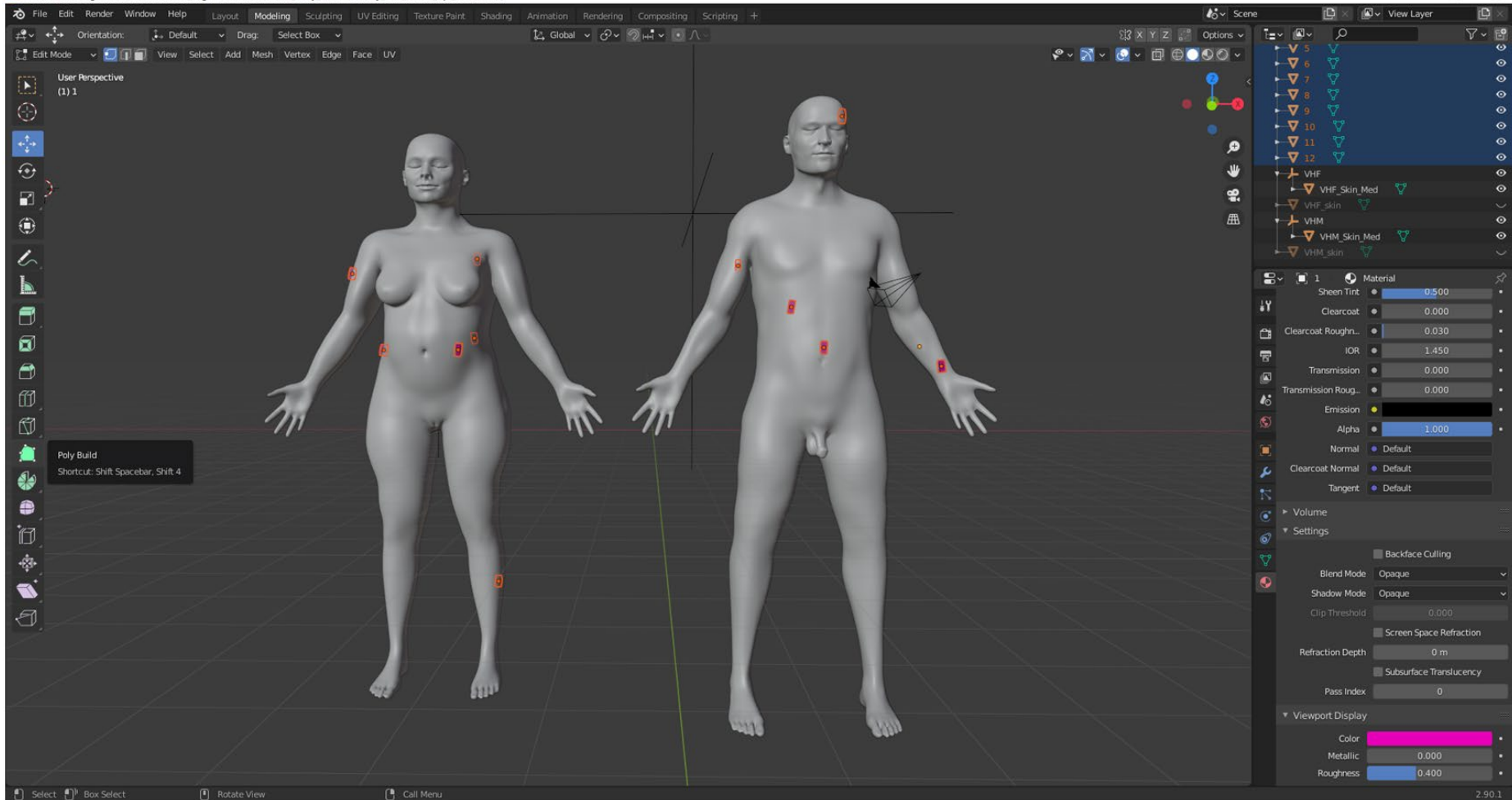


15 extraction sites by Kalyanam Shivkumar, UCLA (SPARC)
10 sites by Shin Lin, UW (HuBMAP)

The screenshot displays the HubMAP CCF Registration web application. The interface is divided into several sections:

- Header:** "HubMAP CCF REGISTRATION" with a user profile icon.
- Navigation:** A top bar with icons for Home, Heart, Anatomy, and Jobs.
- Left Sidebar:**
 - Form fields for "First Name" and "Last Name".
 - Donor Sex: Male (selected) and Female.
 - Anatomical Structures: A dropdown menu.
 - Common Extraction Sites: A list of anatomical locations, including "Left atrium, PV inflow", "Left atrium, appendage", "Left ventricle, apex", "Left ventricle, free wall 3cm from apex", "Posterior, adjacent to coronary sinus", "Right atrium appendage", "Right atrium, AV (atrioventricular) node", and "Right atrium, SA (sinatrial) node".
 - A "Previously Registered Blocks" button with a checkmark.
- Main View:** A 3D anatomical model of a heart. Several colored rectangular blocks are placed on the heart: a blue block on the left atrium, a green block on the left ventricle, and a yellow block on the right atrium. A label "Left ventricle, apex" points to a specific location on the heart. The view is set to "Anterior" orientation.
- Right Sidebar:**
 - Tissue Block Dimensions (mm): Width (X) 10, Height (Y) 10, Depth (Z) 10.
 - Tissue Slices: Thickness and # Slices.
 - Tissue Block Rotation: Sliders for X, Y, and Z rotation, all set to 0.
 - Anatomical Structure Tags: A dropdown menu.
 - A "REVIEW AND DOWNLOAD" button at the bottom.

<https://hubmapconsortium.github.io/ccf-ui/rui>




User Perspective
(1) 1

Poly Build
Shortcut: Shift Spacebar, Shift 4



Search:


What are your anatomical search use cases?
What kind of research questions inform your targeted exploration of anatomy reference knowledge and associated resources?





Browse:


How do you browse over anatomy reference knowledge in preparation for search? What functionality/experience do you seek during the untargeted browsing of anatomy reference knowledge?





Filter:

Subset to focus on a specific subset of the data based on demographics, tissue/assay type, AS, CT, B.





CCF Exploration User Interface (EUI)



CCF Exploration User Interface (EUI)

HuBMAP Sex: Both Age: 1-110 BMI: 13-83 Login

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
 - renal pelvis
 - ureter
 - renal papilla
 - renal fat pad
 - nephron

body

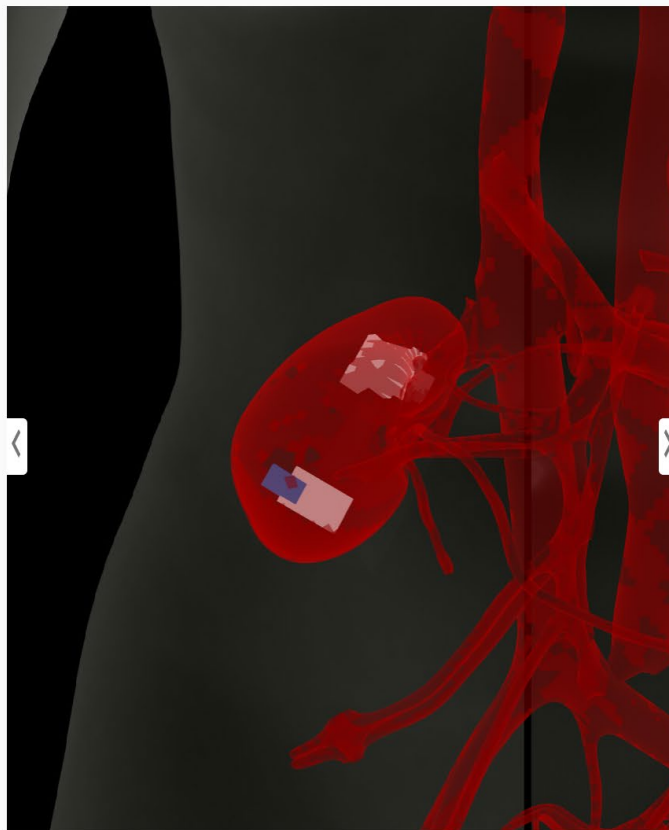
- 2 Centers
- 27 Donors
- 41 Samples

	Female, Age 14, BMI 14.7 HBM894.MPVN.828 TMC-Florida First case collected. Incomplete d...	
	Male, Age 18, BMI 27.1 HBM436.GHWX.449 TMC-Florida section is 190um from block surface	
	Male, Age 56, BMI 32.5 HBM696.XTVL.498 TMC-Vanderbilt Age 56, White Male	
	Male, Age 53, BMI 26.5 HBM652.VRLD.292 TMC-Vanderbilt Age 53, Black Male	
	Male, Age 58, BMI 22.0 HBM477.CJKM.888 TMC-Vanderbilt 107-111	
	Male, Age 18, BMI 25.5 HBM473.VKCM.878 TMC-Florida section is 255um from block surface	
	Male, Age 55, BMI 25.4 HBM824.BLXF.883 TMC-Vanderbilt 13-16	

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



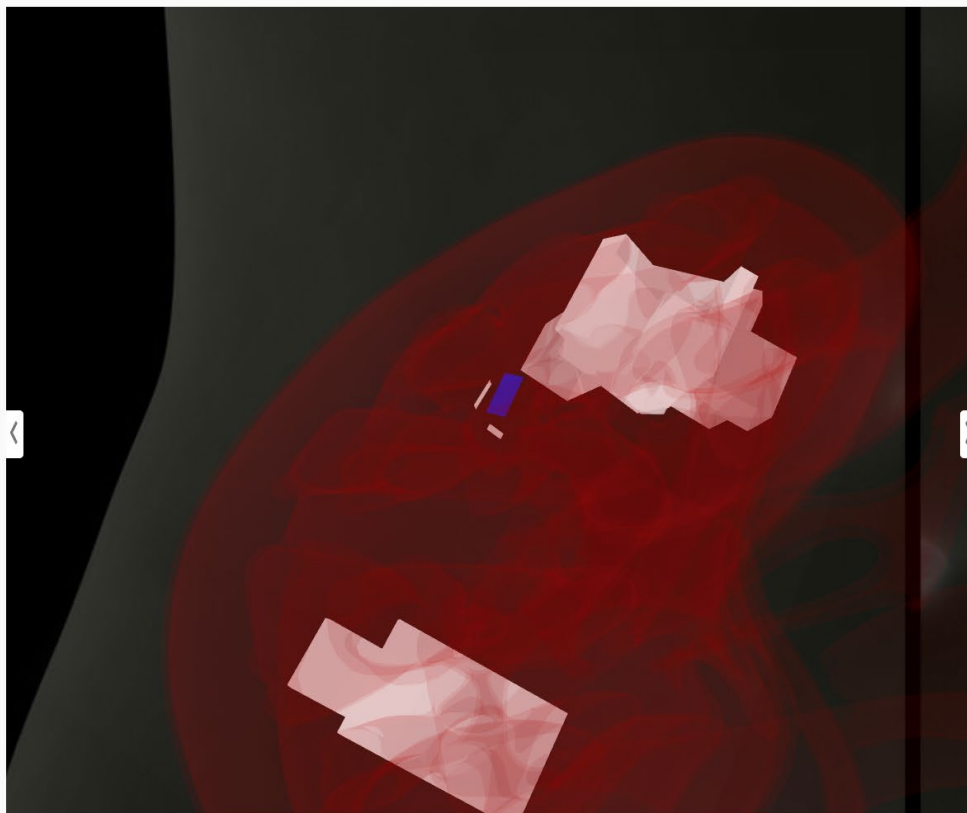
body

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 MIMJK.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	

Search ontology terms ... 

- body
 - heart
 - lung
 - kidney
 - right kidney
 - left kidney
 - kidney capsule
 - cortex of kidney
 - outer cortex of kidney
 - renal medulla
 - outer medulla
 - inner 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
 - small intestine



body

2 Centers
9 Donors
14 Samples



CoverNephrectomy
10.1016/j.jrst.2017.07.006
KPMP-IJOSU
Isolated as a part of a kidney st...



Patient B Cortical biopsy
10.1681/ASN.2016091027
KPMP-IJOSU
Biopsy from Nephrology bioban...



Patient A Cortical biopsy
10.1681/ASN.2016091027
KPMP-IJOSU
Biopsy from Nephrology bioban...



Male, Age 55, BMI 25.4
HBM824.BLXF.883
TMC-Vanderbilt
13-16



Female, Age 66, BMI 31.3
HBM554.ZRCG.496
TMC-Vanderbilt
21-24



Female, Age 58, BMI 23.0
HBM926.VBJV.597
TMC-Vanderbilt
Age 58, White Female



Male, Age 62, BMI 34.9
HBM947.VLDP.894
TMC-Vanderbilt
Kidneys 153-156



Female, Age 44, BMI 28.0
HBM457.NNQN.252
TMC-Vanderbilt
Age 44, white female.



Male, Age 21, BMI 21.8
HBM693.HFJ.752
TMC-Vanderbilt
Age 21, White Male, Trauma Pat...



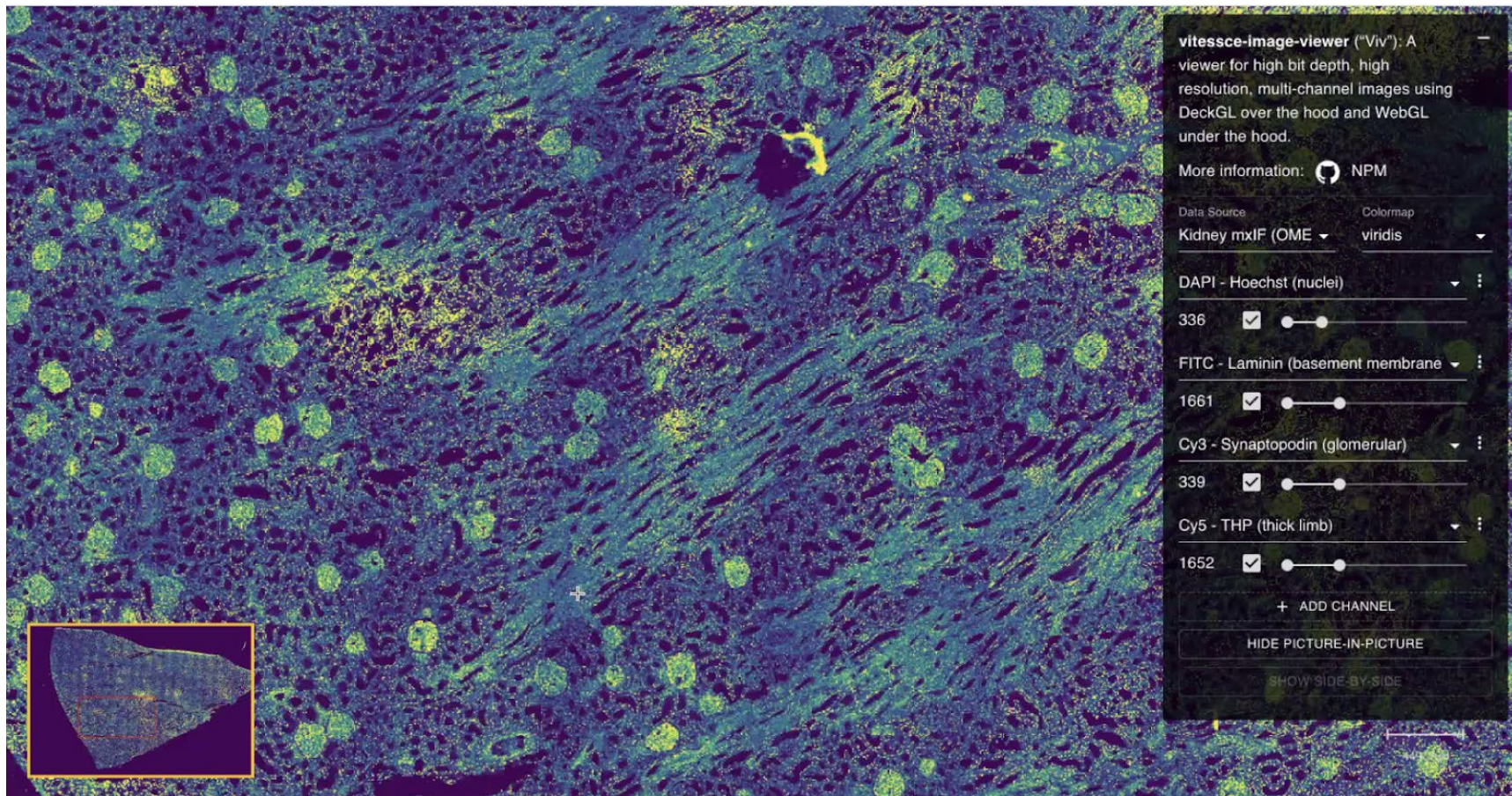
Female, Age 58, BMI 23.0
HBM536.LDTZ.757
TMC-Vanderbilt
Age 58, White Female



Male, Age 48, BMI 35.3



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/>

Represent:

What is your approach to anatomy reference knowledge representation in support of #1 to #3? How is this reference knowledge FAIR? Other items: Any other aspect that the cAWG should be focusing on?



Visible Human MOOC (VHMOOC)




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
HUMAN BIOMOLECULAR ATLAS PROJECT

Visible Human
MOOC

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 cnsctr@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.



TMCs



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Q&A



Human Reference Atlas

Spatial Biology Europe: **ONLINE** LIVE & INTERACTIVE CONTENT SCHEDULE

Please see the full programme for the conference below. Where possible, sessions will be made available OnDemand after the scheduled time slot.

Please note: Access to OnDemand sessions will only be available to delegates who purchase a full access pass

DAY TWO: 15 APRIL 2021

Panel Discussion: Human Reference Atlas

PROFILING &
IMAGING

Moderator: KATY BÖRNER, Victor H. Yngve Distinguished Professor of Engineering and Information Science, **Indiana University**

Panellists:

15:30

-

16:00


JAMES GEE, Associate Professor of Radiologic Science in Radiology. Director, Penn Image Computing and Science Laboratory, Department of Radiology, Perelman School of Medicine, **University of Pennsylvania**

XUEGONG ZHANG, Professor of Pattern Recognition and Bioinformatics, Director, Bioinformatics Division, TNLIST (Tsinghua National Laboratory for Information Science & Technology), Department of Automation, **Tsinghua University**

AMY BERNARD, Director, Science & Technology Strategy, **Allen Institute**

BERNARD DE BONO, Principal Investigator, Associate Professor, **University of Auckland**

<https://www.oxfordglobal.co.uk/spatial-biology-online>



Human Reference Atlas: How to represent clinical, spatial, and semantic features of AS and CT

SPARC: Heart & colon overlap with HuBMAP organs; Heart data registered

GTEX: Well defined sampling sites (ca. 50), 100s of tissue samples.

LINCS: 130 tissues and organs, 1000 cell lines

KidsFirst: First collaboration to register tissue data

KPMP: 3 kidney samples RUI registered

HuBMAP: 25 organs. 1500 AS, 500 CT in 11 ASCT+B tables + 26 reference organs

Demographic/Clinical data: Sex, Age, Ethnicity, BMI, Disease

Provenance: Author, Assay type, date