Ontologies & CCF: Anatomical Structures, Cell Types, and Biomarkers

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What is a CCF?

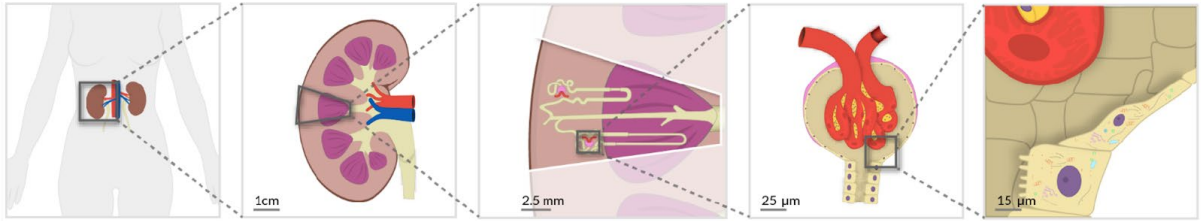
The Common Coordinate System (CCF) consists of ontologies and reference object libraries, computer software, e.g., user interfaces, and training materials that

- enable biomedical experts to semantically annotate tissue samples and to precisely describe their locations in the human body (“registration”),
- align multi-modal tissue data extracted from different individuals to a reference coordinate system (“mapping”) and,
- provide tools for searching and browsing HuBMAP data at multiple levels, from the whole body down to single cells (“exploration”).

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	Organ	Functional Tissue Unit	FTU Sub-structure(s)	Cellular
• Body • Kidney (Left, Right) • Aorta • Renal artery • Renal vein • Ureter	• Renal capsule • Renal pyramid • Renal cortex • Renal medulla • Renal calyx • Renal pelvis	• Nephron • Renal corpuscle • Proximal convoluted tubule • Loop of Henle • Distal convoluted tubule • Connecting tubule • Collecting duct	• Bowman's capsule • Glomerulus • Efferent arteriole • Afferent arteriole	• Parietal epithelial cell • Capillary endothelial cell • Mesangial cell • Podocyte

ASCT Tables

Anatomical Structures and Cell Types (ASCT) tables aim to capture the partonomy of anatomical structures, cell types, and major biomarkers (genomic, epigenomic, transcriptomic, proteomic, lipidomic, and metabolomic).

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 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; 828665. doi:10.1101/828665

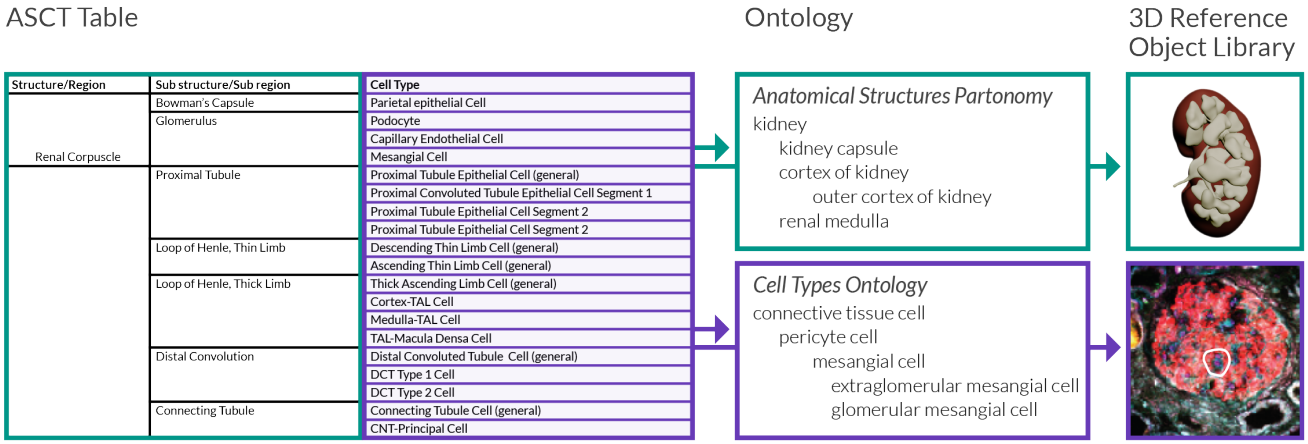
Table 3: Cell types and associated markers from KPMP Pilot 1 transcriptomic studies. Asterisk denotes genes detected by more than one technology. *Italics*, genes detected by a single technology.

Structure/Region	Sub structure/Sub region	Cell Type	Abbreviation	Subset of Marker Genes	Pertinent negatives/comments
Renal Corpuscle	Bowman's Capsule	Parietal epithelial cell	PEC	*CRB2*, CLDN1**	
	Glomerulus	Podocyte	POD	*NPHS2*, PODXL*, NPHS1**	
		Capillary Endothelial Cell	GC-EC	*EHD3*, EMCN*, HECW2*, FLT1*, AQP1**	
		Mesangial Cell	MC	*POSTN*, PIEZO2*, ROBO1*, ITGA8**	
Tubules	Proximal Tubule	Proximal Tubule Epithelial Cell (general)	PT	*CUBN*, LRP2*, SLC13A1*, ALDOB*, GATM**	
		Proximal Convoluted Tubule Epithelial Cell Segment 1	PT-S1	*SLC5A2*, SLC5A12**	There is overlap among the segments
		Proximal Tubule Epithelial Cell Segment 2	PT-S2	*SLC22A6**	
		Proximal Tubule Cell Epithelial Segment 3	PT-S3	*PDZK1IP1*, MT1G**	
	Loop of Henle, Thin Limb	Descending Thin Limb Cell (general)	DTL	*CRYAB*, VCAM1*, AQP1*, SPP1**	*CLDN10* low
		Ascending Thin Limb Cell (general)	ATL	*CRYAB*, TACSTD2*, CLDN3**	*AQP1* low to none
	Loop of Henle, Thick Limb	Thick Ascending Limb Cell (general)	TAL	*SLC12A1*, UMOD**	*SLC12A3* low to none
		Cortex-TAL cell	C-TAL	*SLC12A1*, UMOD**	
		Medulla-TAL cell	M-TAL	*SLC12A1*, UMOD**	
		TAL-Macula Densa cell	TAL-MD	*NOS1*, SLC12A1**	
	Distal Convolution	Distal Convoluted Tubule Cell (general)	DCT	*SLC12A3*, TRPM6**	
		DCT type 1 cell	DCT-1	*SLC12A3*, TRPM6*	*SLC8A1, HSD11B2* (low to none)
		DCT type 2 cell	DCT-2	*SLC12A3*, SLC8A1*, HSD11B2*	Has CNT and DCT signature
	Connecting Tubule	Connecting Tubule Cell (general)	CNT	*SLC8A1*, CALB1, TRPV5*	*SLC12A3* low to none. IC or PC without *SLC8A1* could be in the CNT structure
		CNT-Principal Cell	CNT-PC	*SLC8A1*, AQP2*, SCNN1G**	
		CNT-Intercalated Cell	CNT-IC	*SLC8A1*, CA2, ATP6VOD2**	
		CNT-IC-A cell	CNT-IC-A	*SLC8A1*, SLC4A1*, SLC26A7**	
		CNT-IC-B cell	CNT-IC-B	*SLC8A1*, SLC26A4*, SLC4A9**	
	Collecting Duct	Collecting duct (general) cell	CD	*GATA3**	*GATA3* may be in subpopulation of DCT, CNT and vSMC/P. SLC8A1, CALB1, TRPV5
		CD-PC (general)	CD-PC	*AQP2*, AQP3*, FXYD4*, SCNN1G*, GATA3**	
		C-CD-PC	C-CD-PC		
		M-CD-PC	M-CD-PC		
		Outer medulla-CD-PC	OM-CD-PC		
		Inner Medulla-CD cell	IM-CD	*AQP2*, SLC14A2*	
		Transitional PC-IC cell	tPC-IC	*FXYD4*, SLC4A9*/SLC26A7**	(low to none); Low to No *CALCA* and *KIT* in C-CD-IC-A. It may not be possible to assign IC or PC to CNT or CD structures without regional information of their source.
		CD-IC (general) cell	CD-IC	*CA2, ATP6VOD2**	
		CD-IC-A (general) cell	CD-IC-A	*SLC4A1, SLC26A7*, TMEM213**	
		C-CD-IC-A cell	C-CD-IC-A	*SLC26A7*, SLC4A1**	
		M-CD-IC-A cell	M-CD-IC-A	*SLC26A7*, SLC4A1, KIT*, CALCA*	
		CD-IC-B (general) cell	CD-IC-B	*SLC4A9*, SLC26A4**	
		C-CD-IC-B cell	C-CD-IC-B		
		M-CD-IC-B cell	M-CD-IC-B		
Vessels	Endothelial Cells (non-glomerular)	Endothelial Cell (general)	EC	*EMCN*, PECAM1*, FLT1**	
		EC-Afferent/Efferent Arteriole	EC-AEA	*SERPINE2*, TM4SF1**	likely *PALMD*
		EC-Peritubular capillaries	EC-PTC	*PLVAP**	
		EC-Descending Vasa Recta	EC-DVR	*TM4SF1*, PALMD*	
		EC-Ascending Vasa Recta	EC-AVR	*DNASE1L3**	low to none
		EC-Lymphatics	EC-LYM	*MMRN1*, PROX1*	
Structure/Region	**Sub structure/Sub region**	**Cell Type**	**Abbreviation**	**Subset of Marker Genes**	**Pertinent negatives/comments**
Interstitium	Stroma (non-glomerular)	Vascular Smooth Muscle/Pericyte (general)	vSMC/P	*TAGLN*, ACTA2*, MYH11*, NTRK3, MCAM*	
		vSMC/P-Renin	vSMC/P-REN	*REN*	
		Fibroblast	FIB	*DCN*, ZEB2, C7, LUM*	
	Immune	Macrophages-Resident	MAC-R	*CD163*, IL7R**	
		Macrophage	MAC	*S100A9*	
		Natural Killer Cell	NKC	*NKG7*	
		Dendritic Cell	DC	*APOE*	
		Monocyte	MON	*C1QA, HLA-DRA*	
		T lymphocyte (general)	T	*CD3*	
		T Cytotoxic	T-CYT	*GZMA*	
		B lymphocyte	B	*IGJ*	

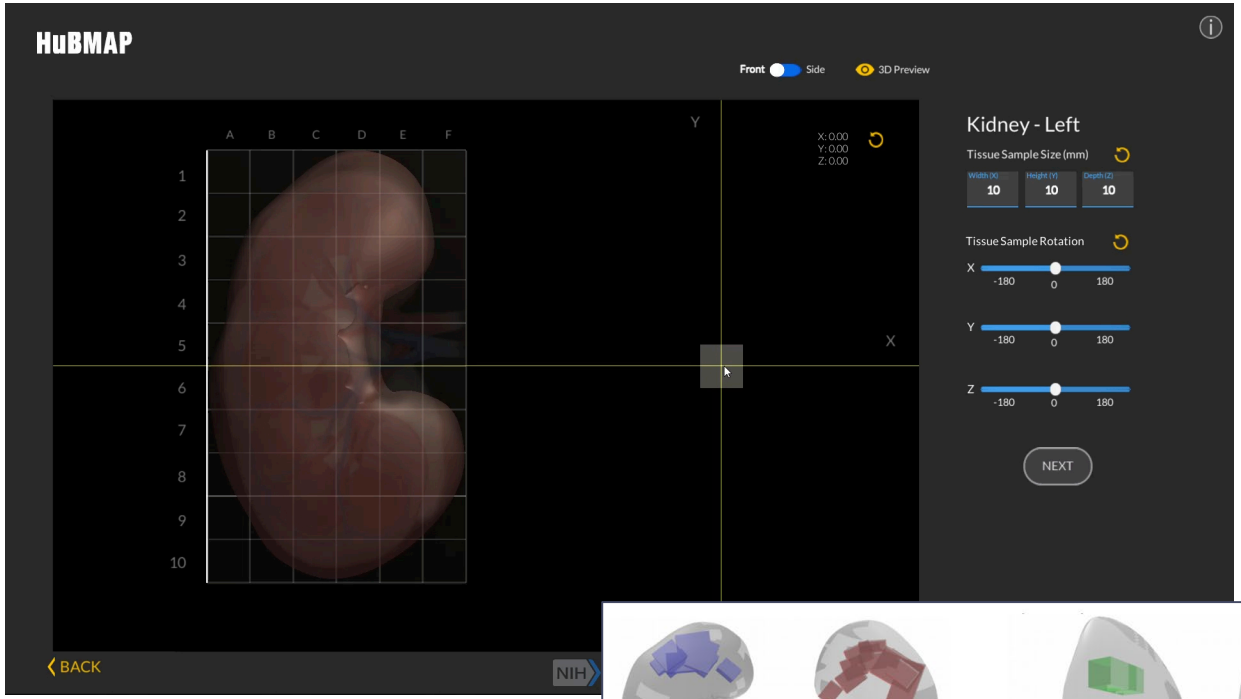
El-Achkar et al. A Multimodal and Integrated Approach to Interrogate Human Kidney Biopsies with Rigor and Reproducibility: The Kidney Precision Medicine Project. bioRxiv. 2019; 828665. doi:10.1101/828665

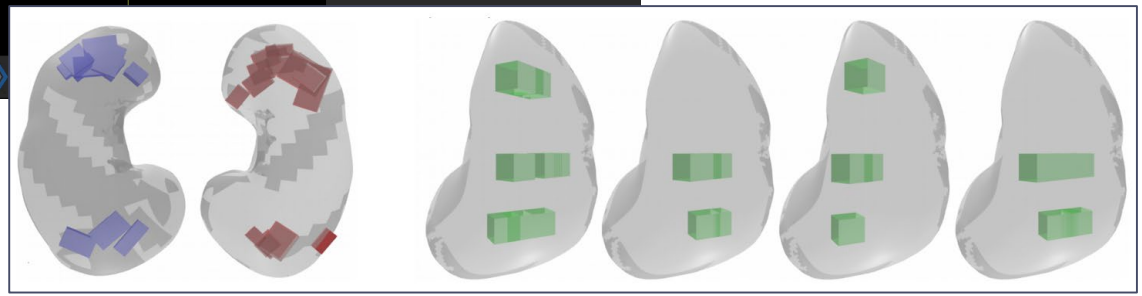
ASCT Table Usage

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



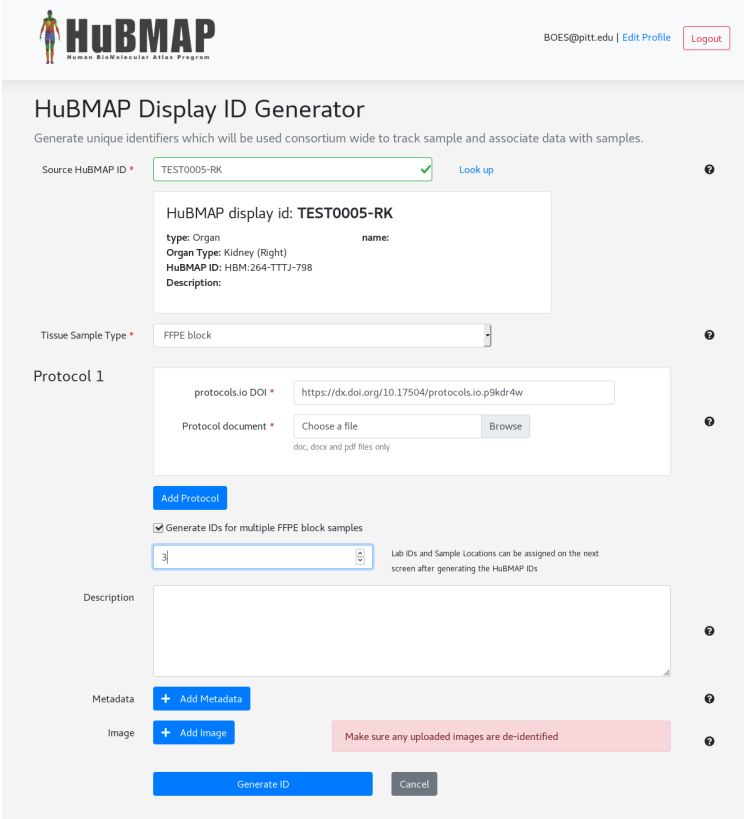
Tissue blocks are registered into the CCF using the Registration User Interface (RUI), and they can be explored via the Exploration User Interface (EUI).

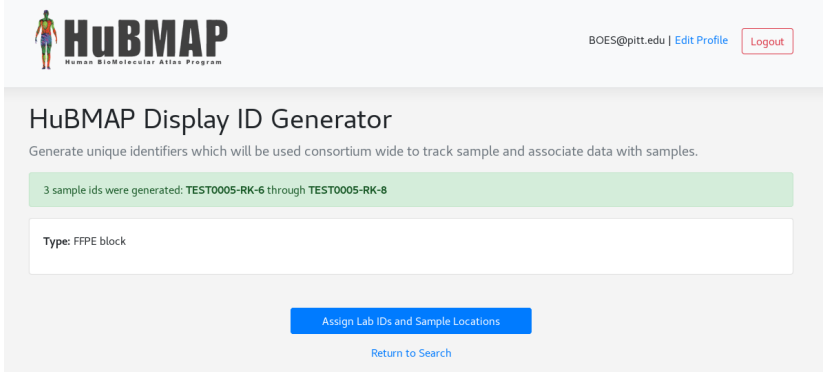


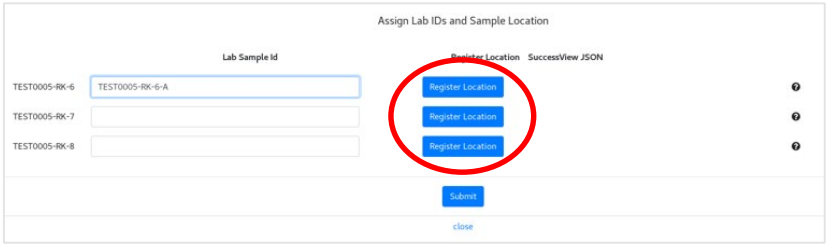


For the first HuBMAP portal release, 48 tissue blocks were registered.

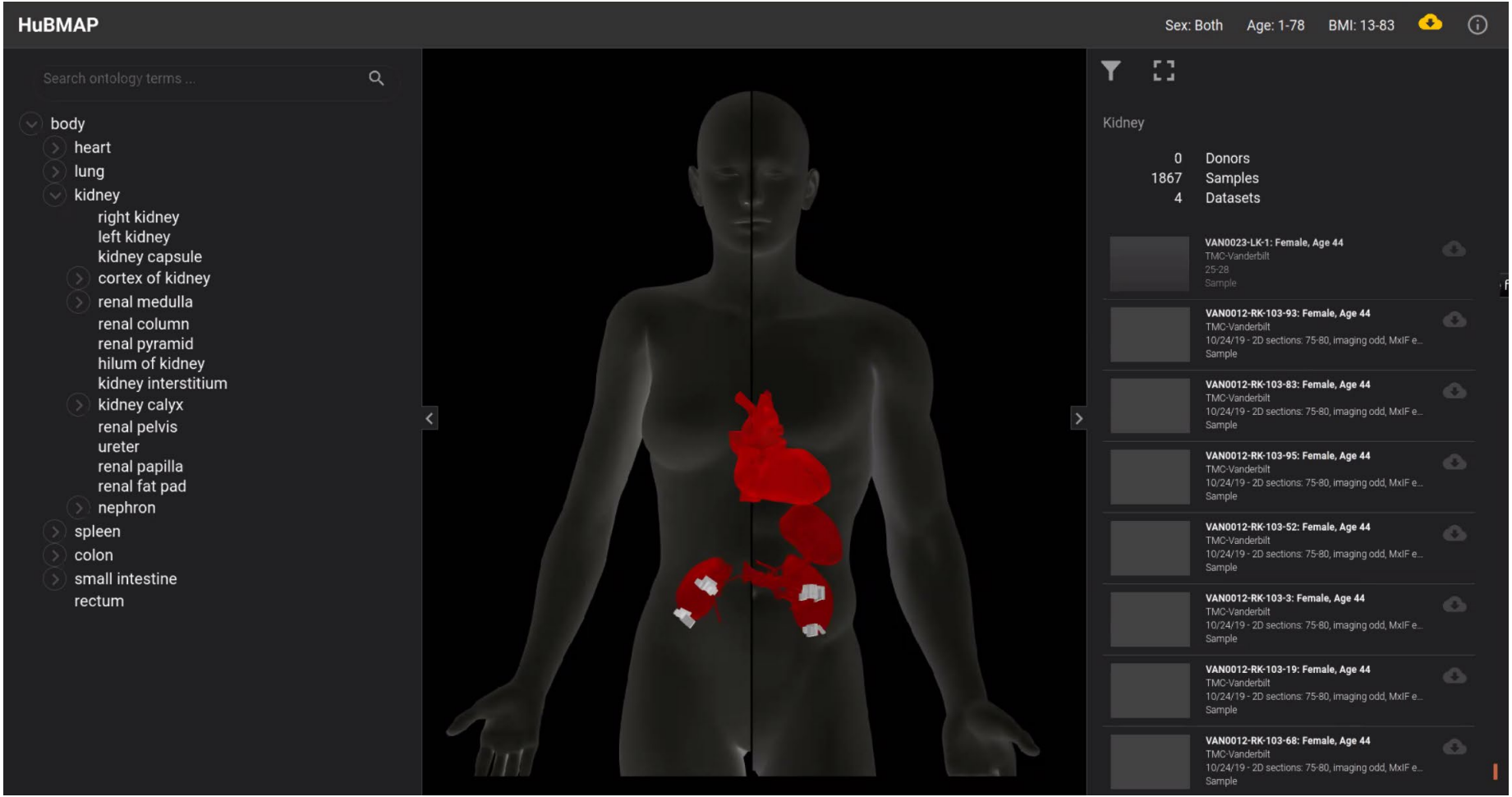
1st Portal Release: Upload Portal



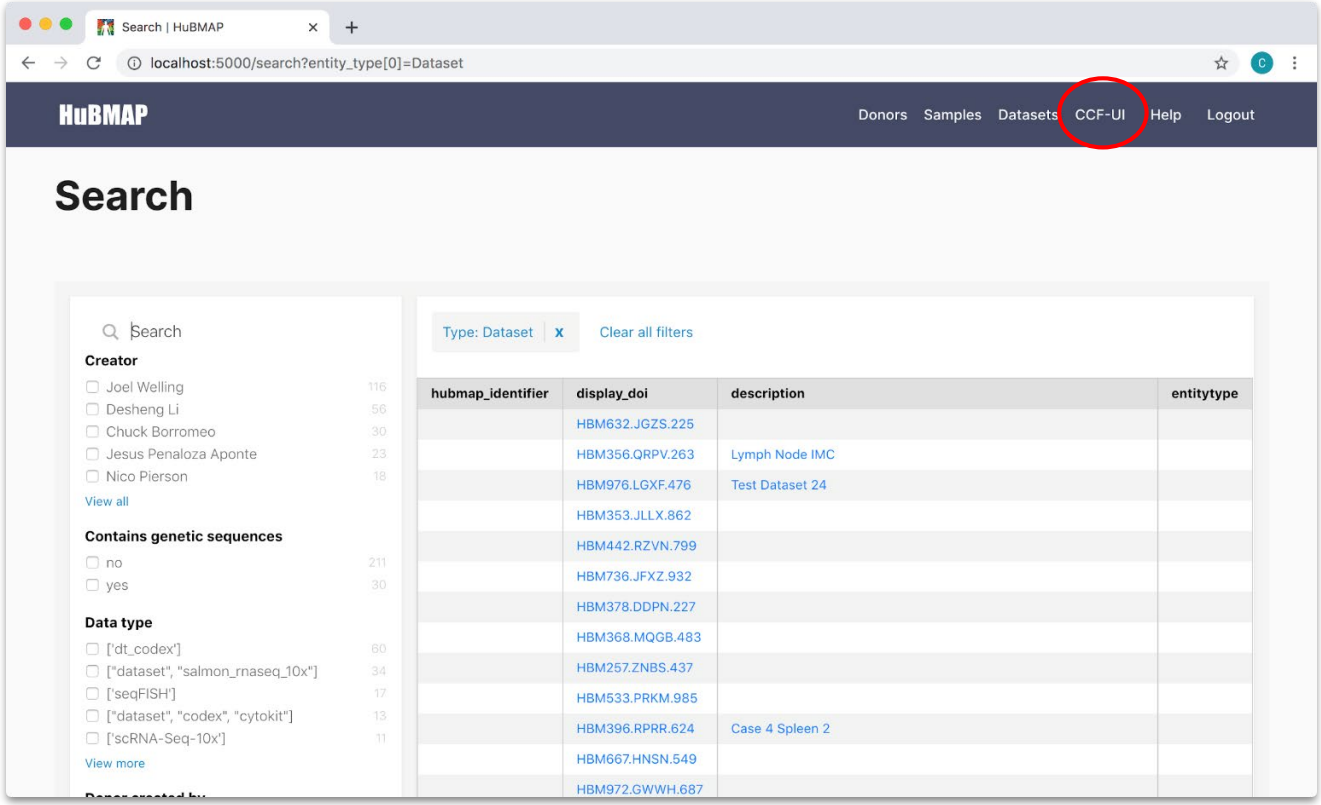




Thanks go to the IEC for providing screenshots


HuBMAP
Sex: Both
Age: 1-78
BMI: 13-83
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
spleen
colon
small intestine
rectum
Kidney
0 Donors
1867 Samples
4 Datasets
VAN0023-LK-1: Female, Age 44
TMC-Vanderbilt
25-28
Sample
VAN0012-RK-103-93: Female, Age 44
TMC-Vanderbilt
10/24/19 - 2D sections: 75-80, imaging odd, MxIF e...
Sample
VAN0012-RK-103-83: Female, Age 44
TMC-Vanderbilt
10/24/19 - 2D sections: 75-80, imaging odd, MxIF e...
Sample
VAN0012-RK-103-95: Female, Age 44
TMC-Vanderbilt
10/24/19 - 2D sections: 75-80, imaging odd, MxIF e...
Sample
VAN0012-RK-103-52: Female, Age 44
TMC-Vanderbilt
10/24/19 - 2D sections: 75-80, imaging odd, MxIF e...
Sample
VAN0012-RK-103-3: Female, Age 44
TMC-Vanderbilt
10/24/19 - 2D sections: 75-80, imaging odd, MxIF e...
Sample
VAN0012-RK-103-19: Female, Age 44
TMC-Vanderbilt
10/24/19 - 2D sections: 75-80, imaging odd, MxIF e...
Sample
VAN0012-RK-103-68: Female, Age 44
TMC-Vanderbilt
10/24/19 - 2D sections: 75-80, imaging odd, MxIF e...
Sample

1st Portal Release



Early draft - limited functionality and design until more data has been indexed.

ASCT Table Design

The CCF Session at the NIH-HCA meeting—co-organized with Peter Hunter (SPARC) and James Gee (BICCN)—brought together experts across consortia.

In follow up meetings, 10 ASCT tables have been created via collaborations across consortia. Ontology experts, including Chris Mungall and Mark Musen, provided expert comments.

	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

https://tinyurl.com/ASCT10x10

https://www.humancellatlas.org/coordinators

ASCT Table Meetings

Meetings take place monthly to

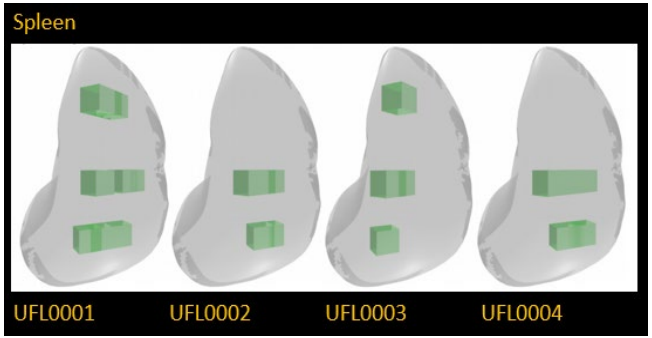
- Review and approve tables.
- Formalize and unify table design language.
- Discuss table usage.

We are working on

- Converting tables into machine readable formats, see example for vasculature.
- Compare tables against Uberon, CL, and other ontologies.
- Compare tables against cell types identified in harmonized HuBMAP data and data generated by other efforts.

ASCT Table Usage

Compare cell types in ASCT tables with cell types identified in HuBMAP data.
Spleen example: Data from five tissue blocks from 4 spleens were harmonized.



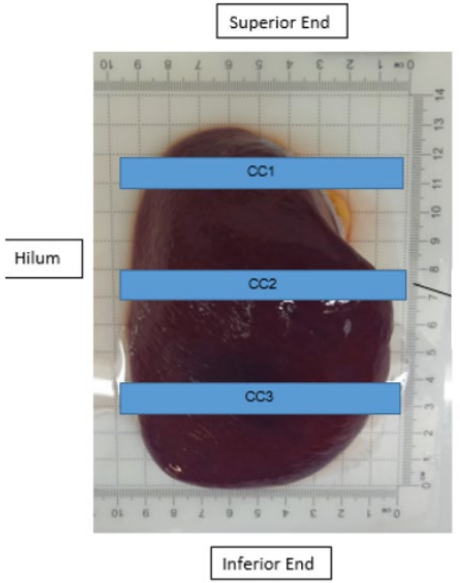
14 years	11m	18y	18y
Female	Male	Male	Male

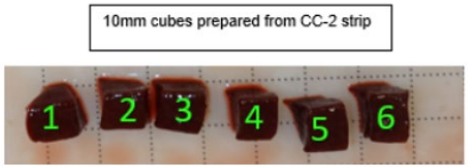
UFL0001-SP-2-8, cube 1
UFL0001-SP-3-4, cube 3

UFL0002-SP-2-2, cube 3

UFL0003-SP-2-2, cube 1

UFL0004-SP-2-1, cube 4





Data provided by TMC-UFL

ASCT Table Usage

Seurat harmonization results: Cell counts and prediction scores

UFL0001-SP-3-4, cube 3		UFL0003-SP-2-2, cube 1		UFL0002-SP-2-2, cube 3		UFL0001-SP-2-8, cube 1		UFL0004-SP-2-1, cube 4	
HBM336.FWTN.636	**6010**	**HBM396.RPRR.624**	**9382**	**HBM472.NTNN.543**	**8738**	**HBM556.QMSM.776**	**5273**	**HBM984.GRBB.858**	**6328**
alpha-beta T cell	372	alpha-beta T cell	773	alpha-beta T cell	1497	alpha-beta T cell	515	alpha-beta T cell	878
B cell	1349	B cell	4463	B cell	6550	B cell	1407	B cell	2803
CD141-positive myeloid dendritic cell	55	CD141-positive myeloid dendritic cell	89	CD141-positive myeloid dendritic cell	19	CD141-positive myeloid dendritic cell	44	CD141-positive myeloid dendritic cell	17
CD14-positive monocyte	1851	CD14-positive monocyte	2242	CD14-positive monocyte	238	CD14-positive monocyte	872	CD14-positive monocyte	802
CD1c-positive myeloid dendritic cell	185	CD1c-positive myeloid dendritic cell	18			CD1c-positive myeloid dendritic cell	162	CD1c-positive myeloid dendritic cell	19
erythroblast	177	erythroblast	42	erythroblast	17	erythroblast	89		
gamma-delta T cell	151	gamma-delta T cell	57	gamma-delta T cell	30	gamma-delta T cell	176	gamma-delta T cell	1241
hematopoietic stem cell	73	hematopoietic stem cell	84	hematopoietic stem cell	56	hematopoietic stem cell	79	hematopoietic stem cell	30
low-quality	93	low-quality	71	low-quality	94	low-quality	129	low-quality	131
natural killer cell	594	natural killer cell	1307	natural killer cell	84	natural killer cell	460	natural killer cell	267
plasma cell	460	plasma cell	171	plasma cell	101	plasma cell	360	plasma cell	75
plasmablast	22	plasmablast	7	plasmablast	28	plasmablast	1	plasmablast	36
splenic endothelial cell	424	splenic endothelial cell	47	splenic endothelial cell	6	splenic endothelial cell	588	splenic endothelial cell	1
splenic fibroblast	15	splenic fibroblast	5	splenic fibroblast	6	splenic fibroblast	20	splenic fibroblast	2
splenic macrophage	189	splenic macrophage	6	splenic macrophage	12	splenic macrophage	371	splenic macrophage	26

HBM336.FWTN.636	**1**	**HBM396.RPRR.624**		**HBM472.NTNN.543**		**HBM556.QMSM.776**		**HBM984.GRBB.858**	
alpha-beta T cell	1	alpha-beta T cell	0.81531392	alpha-beta T cell	0.935717083	alpha-beta T cell	0.852839869	alpha-beta T cell	0.819379533
B cell	1	B cell	0.966724409	B cell	0.978509075	B cell	0.958394632	B cell	0.963947327
CD141-positive myeloid dendritic cell	1	CD141-positive myeloid dendritic cell	0.714928889	CD141-positive myeloid dendritic cell	0.870885148	CD141-positive myeloid dendritic cell	0.890455775	CD141-positive myeloid dendritic cell	0.615445273
CD14-positive monocyte	1	CD14-positive monocyte	0.940118127	CD14-positive monocyte	0.937989865	CD14-positive monocyte	0.938657155	CD14-positive monocyte	0.963592885
CD1c-positive myeloid dendritic cell	1	CD1c-positive myeloid dendritic cell	0.563719677			CD1c-positive myeloid dendritic cell	0.803740621	CD1c-positive myeloid dendritic cell	0.783471674
erythroblast	1	erythroblast	0.532657229	erythroblast	0.694290983	erythroblast	0.978894926		
gamma-delta T cell	1	gamma-delta T cell	0.539497766	gamma-delta T cell	0.502216796	gamma-delta T cell	0.740586674	gamma-delta T cell	0.904053159
hematopoietic stem cell	1	hematopoietic stem cell	0.726385726	hematopoietic stem cell	0.764763311	hematopoietic stem cell	0.75724491	hematopoietic stem cell	0.648865012
low-quality	1	low-quality	0.680657174	low-quality	0.68445931	low-quality	0.649134708	low-quality	0.728998052
natural killer cell	1	natural killer cell	0.770988817	natural killer cell	0.623959124	natural killer cell	0.833128238	natural killer cell	0.718629642
plasma cell	1	plasma cell	0.945743141	plasma cell	0.947816498	plasma cell	0.954210246	plasma cell	0.82474102
plasmablast	1	plasmablast	0.445989963	plasmablast	0.593308367	plasmablast	0.535441087	plasmablast	0.558989332
splenic endothelial cell	1	splenic endothelial cell	0.921750546	splenic endothelial cell	0.649250648	splenic endothelial cell	0.949515886	splenic endothelial cell	0.555504115
splenic fibroblast	1	splenic fibroblast	0.883399167	splenic fibroblast	0.886345281	splenic fibroblast	0.878256094	splenic fibroblast	0.820886903
splenic macrophage	1	splenic macrophage	0.646221909	splenic macrophage	0.827945537	splenic macrophage	0.853436501	splenic macrophage	0.880481635

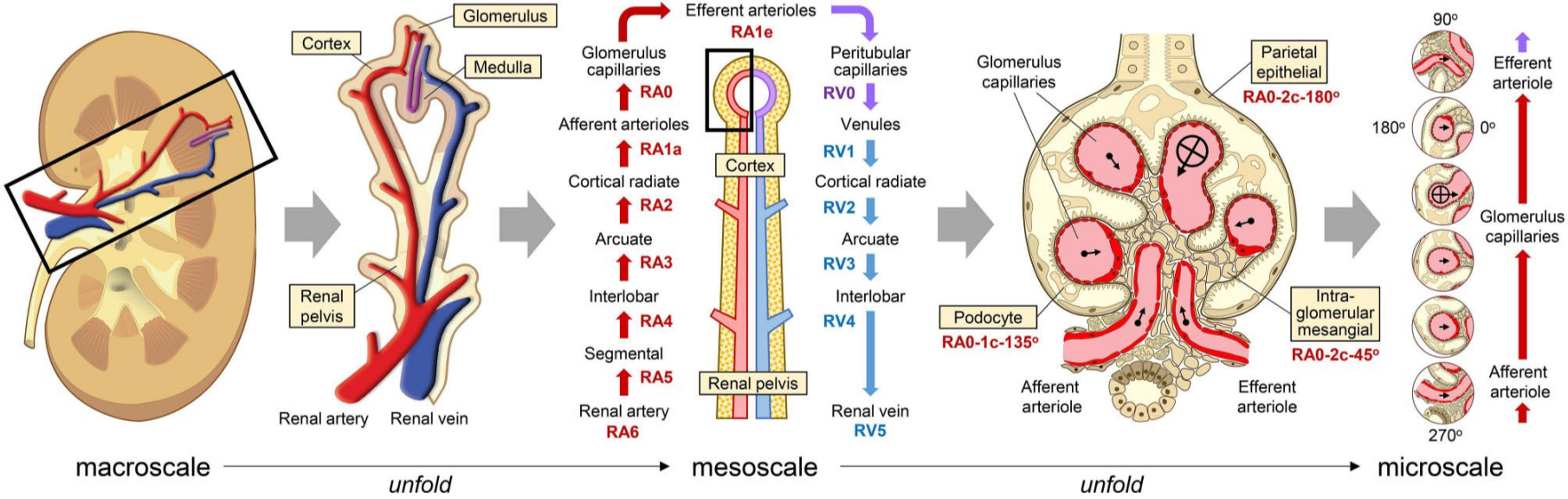
Data provided by MC-NYGC

Example: Converting tables into machine readable formats – Kidney vasculature

Vasculature	renal atery [L/R]				Endothelial Cell (general)	EC	*EMCN*, PECAM1*, FLT1**
		segmental arteries [superior, inferior, anterior, posterior]					
		interlobar aterties					
		arcuate aterties					
		cortical radiate ateries					
		{cortex}	afferent arterioles		EC-Afferent/Efferent Arteriole	EC-AEA	*SERPINE2*, TM4SF1**
			{nephron}	glomerulus capillaries {glomerulus}	Capillary Endothelial Cell	GC-EC	*EHD3*, EMCN*, HECW2*, FLT1*, AQP1**
			efferent arterioles		EC-Afferent/Efferent Arteriole	EC-AEA	*SERPINE2*, TM4SF1**
			{nephron}	peritubular capillaries	EC-Peritubular capillaries	EC-PTC	*PLVAP**
				descending vasa recta	EC-Descending Vasa Recta	EC-DVR	*TM4SF1*, PALMD*
				ascending vasa recta	EC-Ascending Vasa Recta	EC-AVR	*DNASEIL3**
	renal vein [L/R]	cortical radiate veins {cortex}	venules		Endothelial Cell (general)	EC	*EMCN*, PECAM1*, FLT1**
		arcuate veins					
		interlobar veins					

Vasculature	renal artery [L/R]				Endothelial Cell (general)	EC	EMCN*, PECAM1*, FLT1*
Vasculature	renal artery [L/R]	segmental arteries [superior, inferior, anterior, posterior]			Endothelial Cell (general)	EC	EMCN*, PECAM1*, FLT1*
Vasculature	renal artery [L/R]	interlobar arterties			Endothelial Cell (general)	EC	EMCN*, PECAM1*, FLT1*
Vasculature	renal artery [L/R]	arcuate arteries			Endothelial Cell (general)	EC	EMCN*, PECAM1*, FLT1*
Vasculature	renal artery [L/R]	cortical radiate arteries {cortex}			Endothelial Cell (general)	EC	EMCN*, PECAM1*, FLT1*
Vasculature	renal artery [L/R]	cortical radiate arteries {cortex}	afferent arterioles {nephron}		EC-Afferent/Efferent Arteriole	EC-AEA	SERPINE2*, TM4SF1*
Vasculature	renal artery [L/R]	cortical radiate arteries {cortex}	afferent arterioles {nephron}	glomerulus capillaries {glomerulus}	Capillary Endothelial Cell	GC-EC	EHD3*, EMCN*, HECW2*, FLT1*, AQP1*
Vasculature	renal artery [L/R]	cortical radiate arteries {cortex}	efferent arterioles {nephron}		EC-Afferent/Efferent Arteriole	EC-AEA	SERPINE2*, TM4SF1*
Vasculature	renal artery [L/R]	cortical radiate arteries {cortex}	efferent arterioles {nephron}	peritubular capillaries	EC-Peritubular capillaries	EC-PTC	PLVAP*
Vasculature	renal artery [L/R]	cortical radiate arteries {cortex}	efferent arterioles {nephron}	descending vasa recta	EC-Descending Vasa Recta	EC-DVR	TM4SF1*, PALMD
Vasculature	renal artery [L/R]	cortical radiate arteries {cortex}	efferent arterioles {nephron}	ascending vasa recta	EC-Ascending Vasa Recta	EC-AVR	DNASEIL3*
Vasculature	renal vein [L/R)	cortical radiate veins {cortex}	venules {nephron}		Endothelial Cell (general)	EC	EMCN*, PECAM1*, FLT1*
Vasculature	renal vein [L/R)	cortical radiate veins {cortex}			Endothelial Cell (general)	EC	EMCN*, PECAM1*, FLT1*
Vasculature	renal vein [L/R)	arcuate veins			Endothelial Cell (general)	EC	EMCN*, PECAM1*, FLT1*
Vasculature	renal vein [L/R)	interlobar veins			Endothelial Cell (general)	EC	EMCN*, PECAM1*, FLT1*

Capturing vasculature details is critically important for a vasculature based CCF



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.

ASCT Table Discussion

Please join the CCF breakout for a discussion of

- Existing tables
- Planned analyses and visualizations of ASCT+B tables
- Table usage for research design and quality control

Contact MC-IU via infoccf@indiana.edu for questions and suggestions.

Apply for a **Postdoc position** to advance ASCT+B curation and usage, e.g., to understand vascular pathways in the human body (arteries, veins, capillaries, and lymph vessels).

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