User-Centered Approach to User Interfaces and Data Visualization

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How to construct the Kidney Tissue Atlas

Needs to be: Multi-dimensional, Organized / Tagged (Ontology), Open, Accessible, Query-able

Discovery
Validation

Tissue

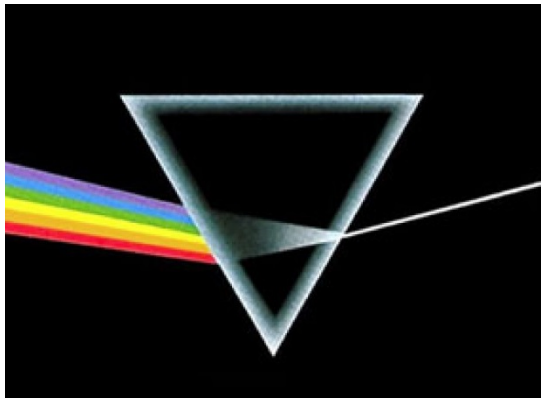
What is there?
What is where?
GUDMAP
HuBMAP
Human Cell Atlas

What changed?

Disaggregation
Anchors / Markers
Map to tissue

Visual display of spatial data

Stratify patients
Implementation

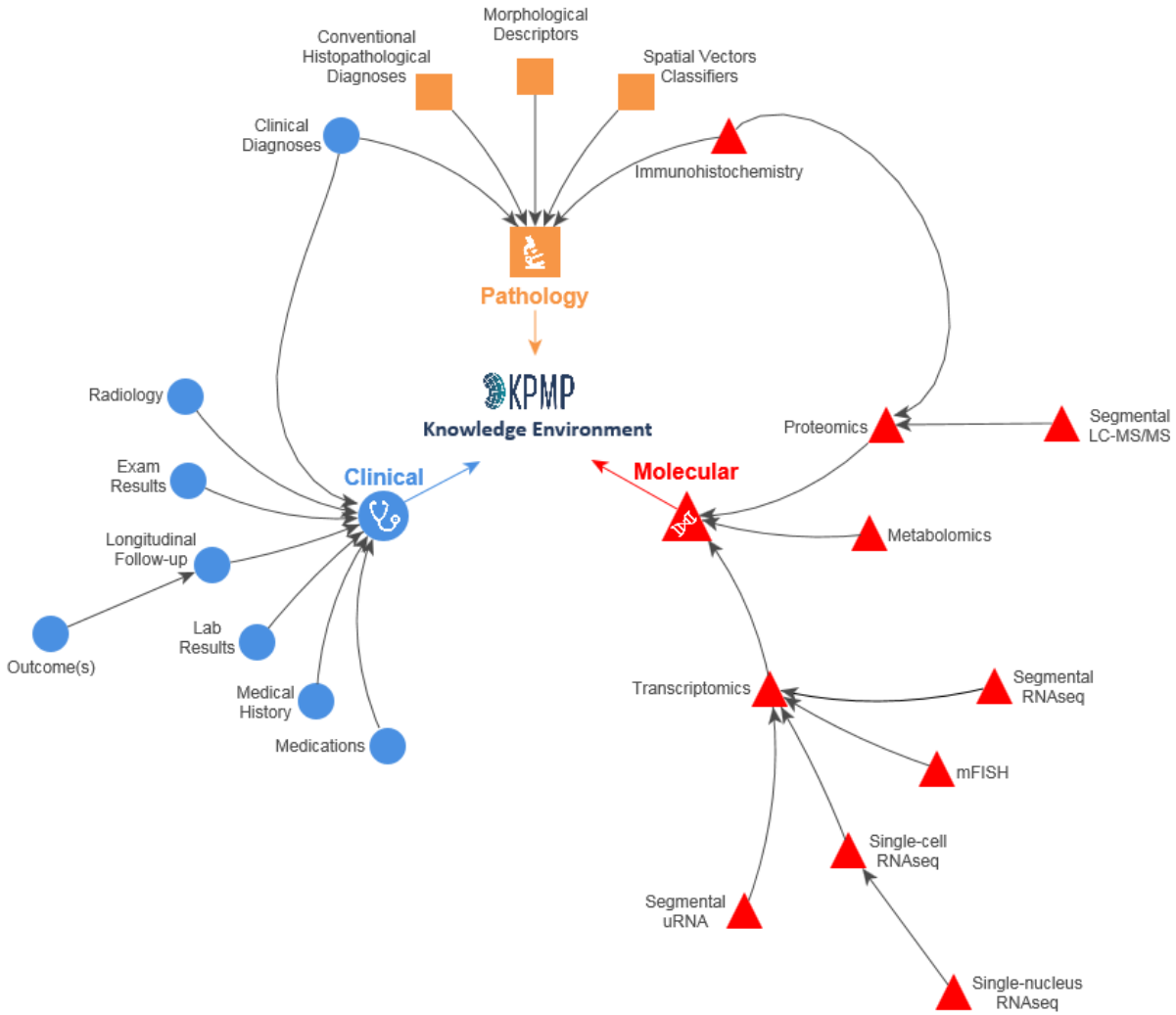


Individualized:
Diagnosis
Prognosis
Treatment

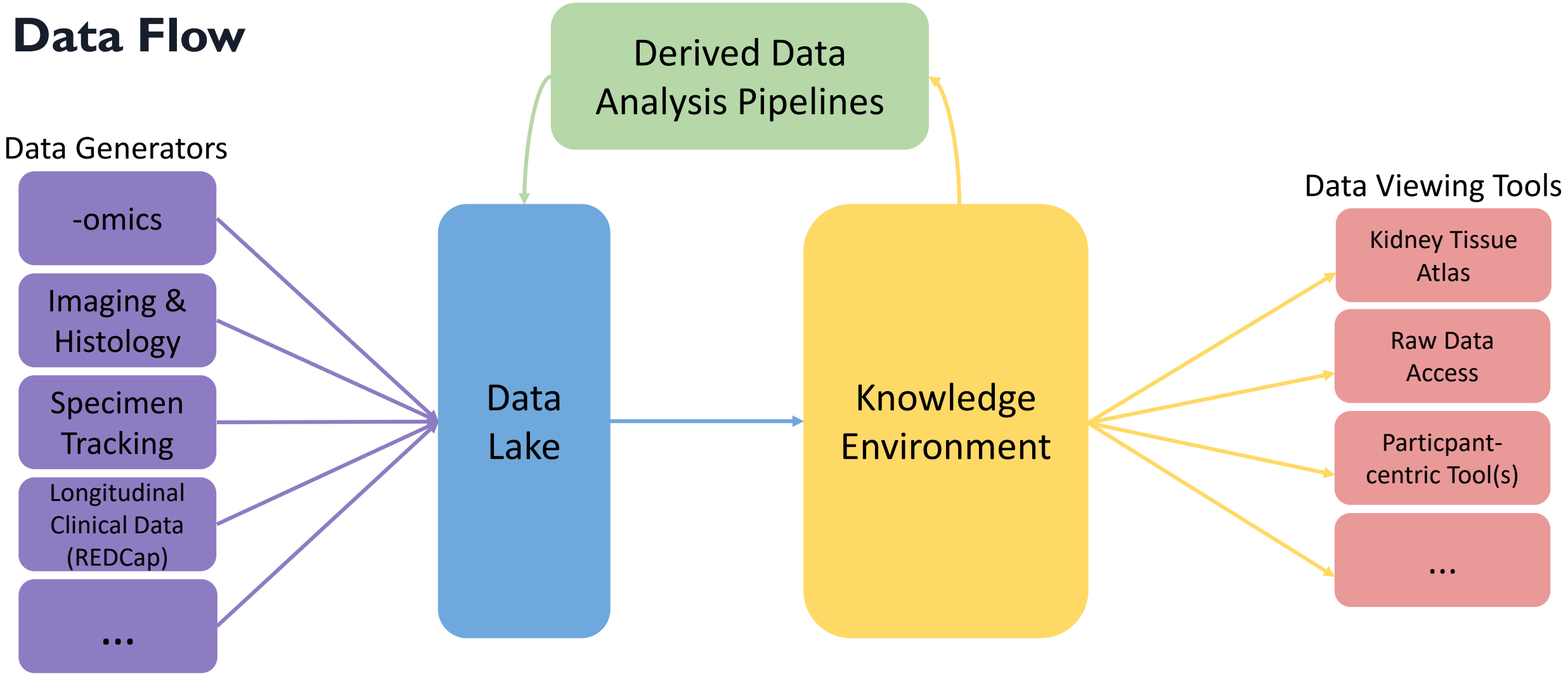
Correlate with
Clinical outcomes
Model systems

Stratification markers for clinical decisions

KPMP Data Types



Data Flow



Data Integration and Metadata: Ontologies

Identity and Access Management: Shibboleth/InCommon Authentication

PATIENT

"If KPMP could come up with clear answers about my disease, it would be great."

PATHOLOGIST

"I expect KPMP to help me link biopsies to outcomes and mechanism."

CLINICIAN

"I'm hoping KPMP gives me the ability to link my individual patients to the best treatments."

RESEARCHER: SUMMARY DATA CONSUMER

"I'm not a bioinformatician; I just need the highlights for a quick validation of my gene of interest in AKI and CKD."

RESEARCHER: DATA ANALYST

"I work closely with my wet lab and want to use my analytical skills to answer their biological questions using KPMP."

RESEARCHER: DATA MINER

"I develop tools and analytic methods for kidney researchers to use in KPMP."

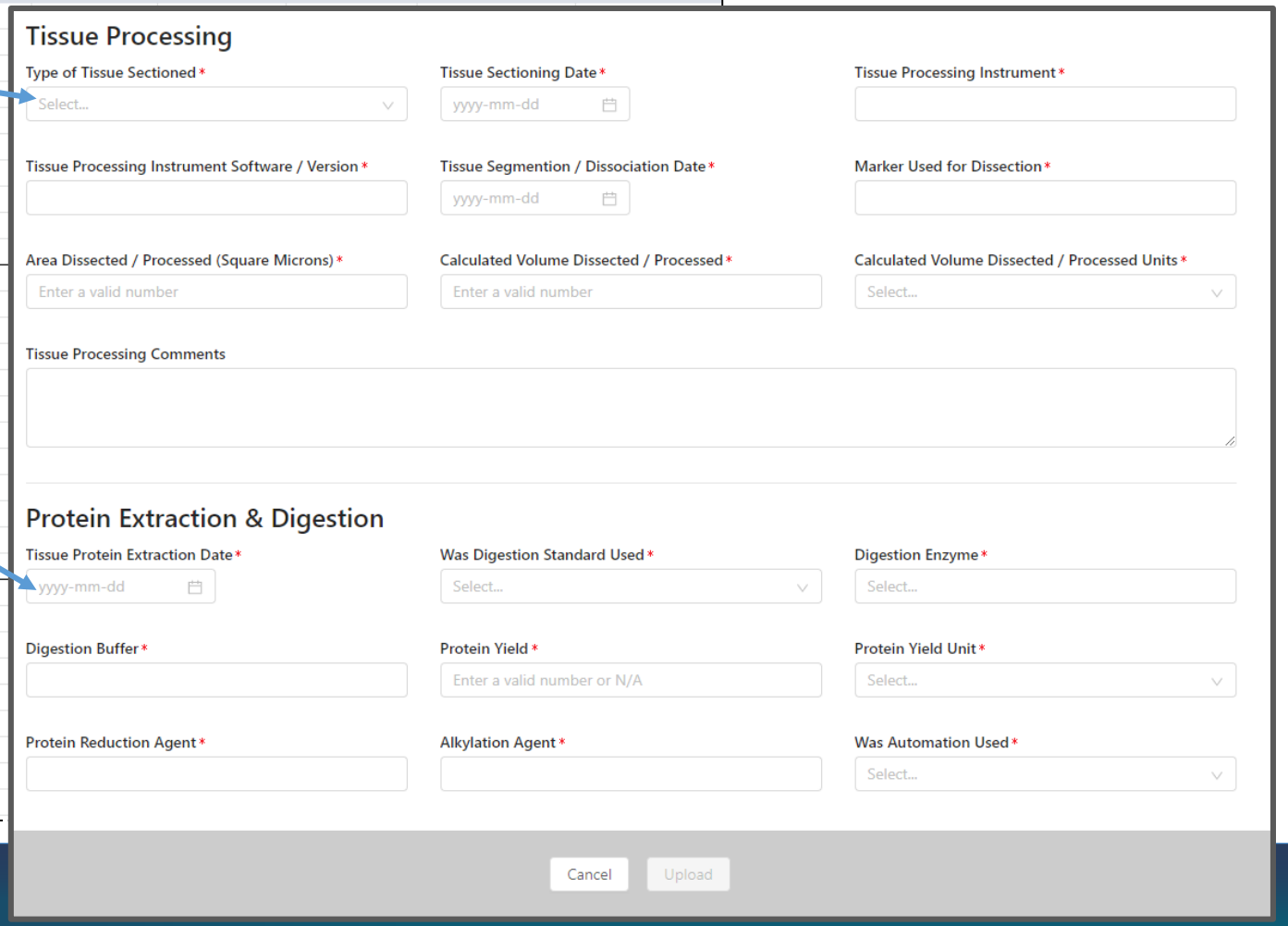
Software Development Process Overview

Discover	Define Problem	Ideate and Prototype	Evaluate	Build
• Understand the context around the design by understanding who it's for (and how they will use it).	• Based on what we've learned, what's the most important problem to solve? • What *exactly* does this thing need to *do*, and what can it *not* do?	• What are all the ways we can solve the problem we defined? • Build prototypes of the product to test.	• Put the prototypes in front of users to get feedback. • This step is never optional — if you think you nailed it the first time, you're almost definitely not evaluating very well.	• Release features in small, useful pieces (as opposed to all-at-once).

Internal Tools

Data Lake Uploader

Metadata Module	Property	Bulk Proteomics	Sub-segmental Proteomics	Near-single-cell Proteomics	Property Typ	Required?	Validations?	Linked With	Display When
Tissue Processing	Type of Tissue Sectioned	N	Y	Y					
Tissue Processing	Tissue Sectioning Date	N	Y	Y					
Tissue Processing	Tissue Processing Instrument	N	Y	Y					
Tissue Processing	Tissue Processing Instrument Software / Version	N	Y	Y					
Tissue Processing	Tissue Segmention / Dissociation Date	N	Y	Y					
Tissue Processing	Marker Used for Dissection	N	Y	Y					
Tissue Processing	Area Dissected / Processed (Square Microns)	N	Y	Y					
Tissue Processing	Calculated Volume Dissected / Processed	N	Y	Y					
Tissue Processing	Calculated Volume Dissected / Processed Units	N	Y	Y					
Tissue Processing	Tissue Processing Comments	N	Y	Y					
Protein Extraction & Digestion	Tissue Protein Extraction Date	Y	Y	Y					
Protein Extraction & Digestion	Was Digestion Standard Used	Y	Y	Y					
Protein Extraction & Digestion	Digestion Enzyme	Y	Y	Y					
Protein Extraction & Digestion	Digestion Buffer	Y	Y	Y					
Protein Extraction & Digestion	Protein Yield	Y	Y	Y					
Protein Extraction & Digestion	Protein Yield Unit	Y	Y	Y					
Protein Extraction & Digestion	Protein Reduction Agent	Y	Y	Y					
Protein Extraction & Digestion	Alkylation Agent	Y	Y	Y					
Protein Extraction & Digestion	Was Automation Used	Y	Y	Y					
Protein Extraction & Digestion	Automation Method	Y	Y	Y					
Protein Extraction & Digestion	Sample Clean-up Method	Y	Y	Y					
Protein Extraction & Digestion	Protein Extraction & Digestion Comments	Y	Y	Y					
Mass Spectrometry	Spectrometry Center	Y	Y	Y					
Mass Spectrometry	MS Instrument	Y	Y	Y					
Mass Spectrometry	MS Instrument Software / Version	Y	Y	Y					
Mass Spectrometry	Spectrometry Date	Y	Y	Y					
Mass Spectrometry	Ionization Method	Y	Y	Y					
Mass Spectrometry	LC Instrument	Y	Y	Y					
Mass Spectrometry	LC Column	Y	Y	Y					
Mass Spectrometry	LC Column Flow Rate	Y	Y	Y					
Mass Spectrometry	Internal Calibration Standard	Y	Y	Y					



Other Internal Tools

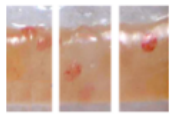
- SpecTrack (Done)
- REDCap instance (Done)
- Single sign-on user authorization service (Done)
- User Portal (In Progress)
- Digital Pathology Repository (In Progress)
  - Web-based slide viewer
  - Ability to annotate and score slides
  - High-performance image segmentation

Participant-Centric Tools

Participant Whole Slide Image Viewer

The whole slide images currently available are from KPMP pilot nephrectomies and non-KPMP biopsy tissue.

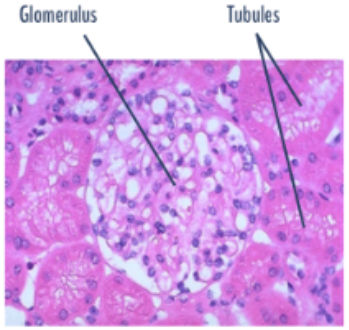
How does my biopsy get turned into images?



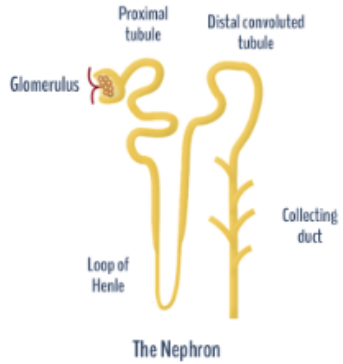
Step 1: Segment

One of your samples is cut into 3 segments.

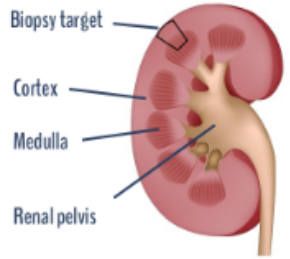
What am I seeing in these images?



Looking at this example of a biopsy slide image, a pathologist would look at the components of the kidney such as glomeruli and tubules. This can reveal evidence of disease and tissue damage.

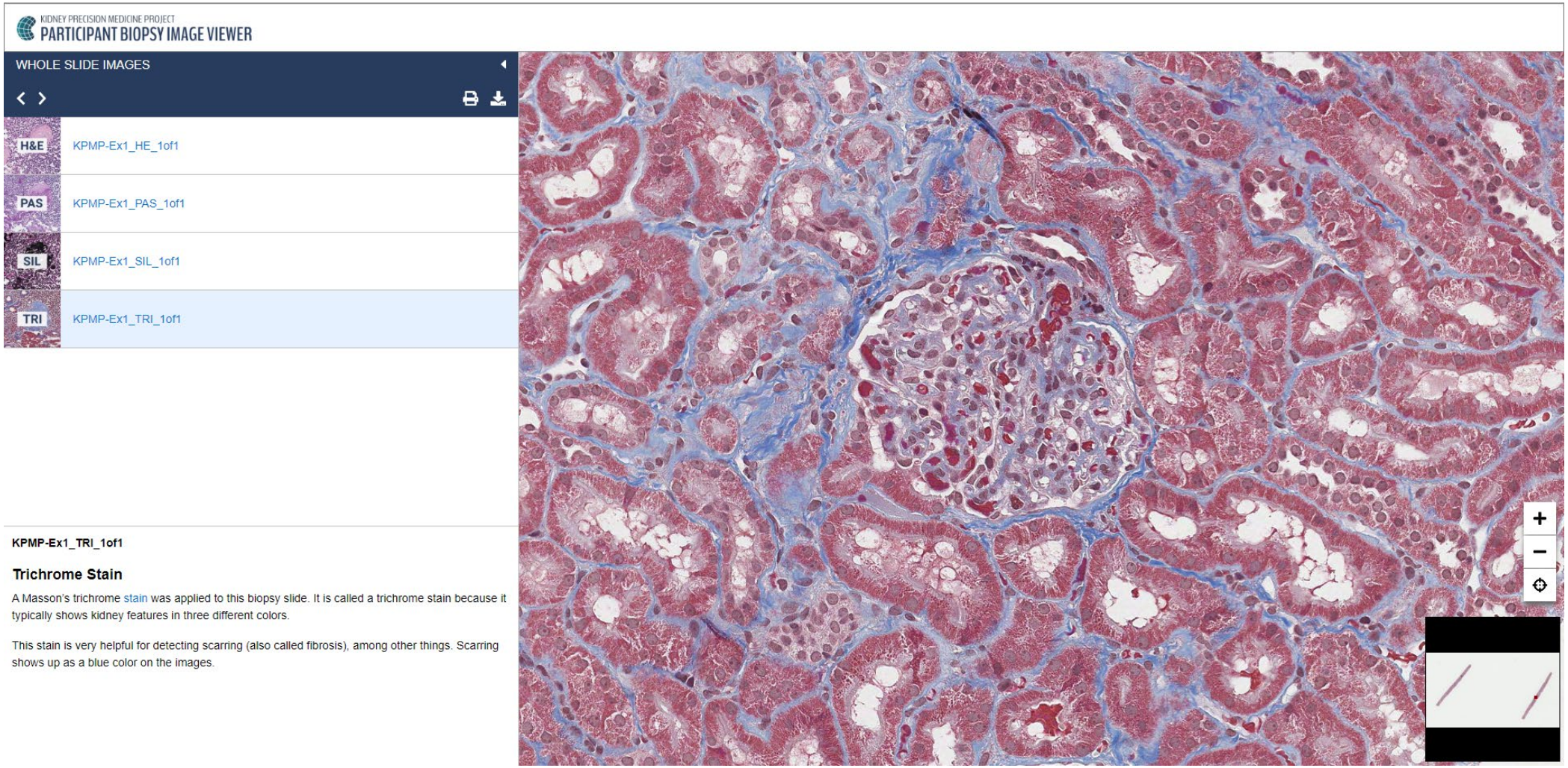


A glomerulus and tubule is part of a nephron. Nephrons are the filtration workhorses of the kidney. Each kidney has around 1 million nephrons.



Nephrons are located in the renal cortex. During the biopsy procedure, the doctor aims to capture multiple nephrons.

Participant Whole Slide Image Viewer

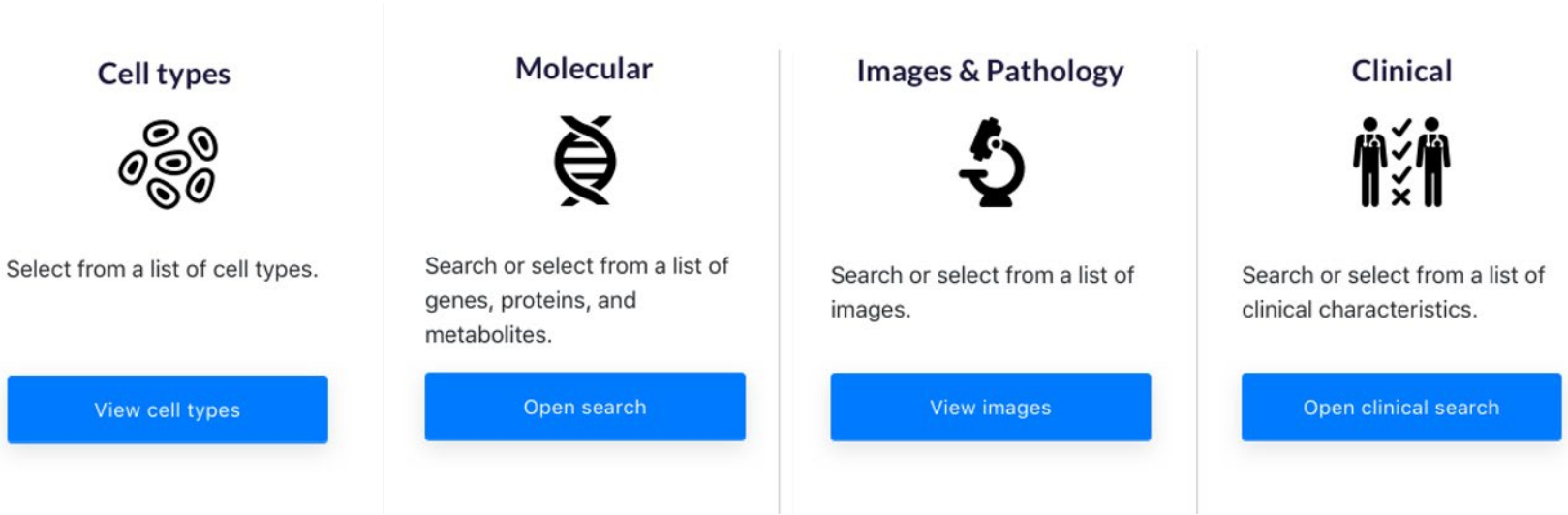


Other Envisioned Participant Tools / Features

- Summary statistics / dashboard about the study in general
- “Where is my tissue?” map
- Compilation of their clinical data

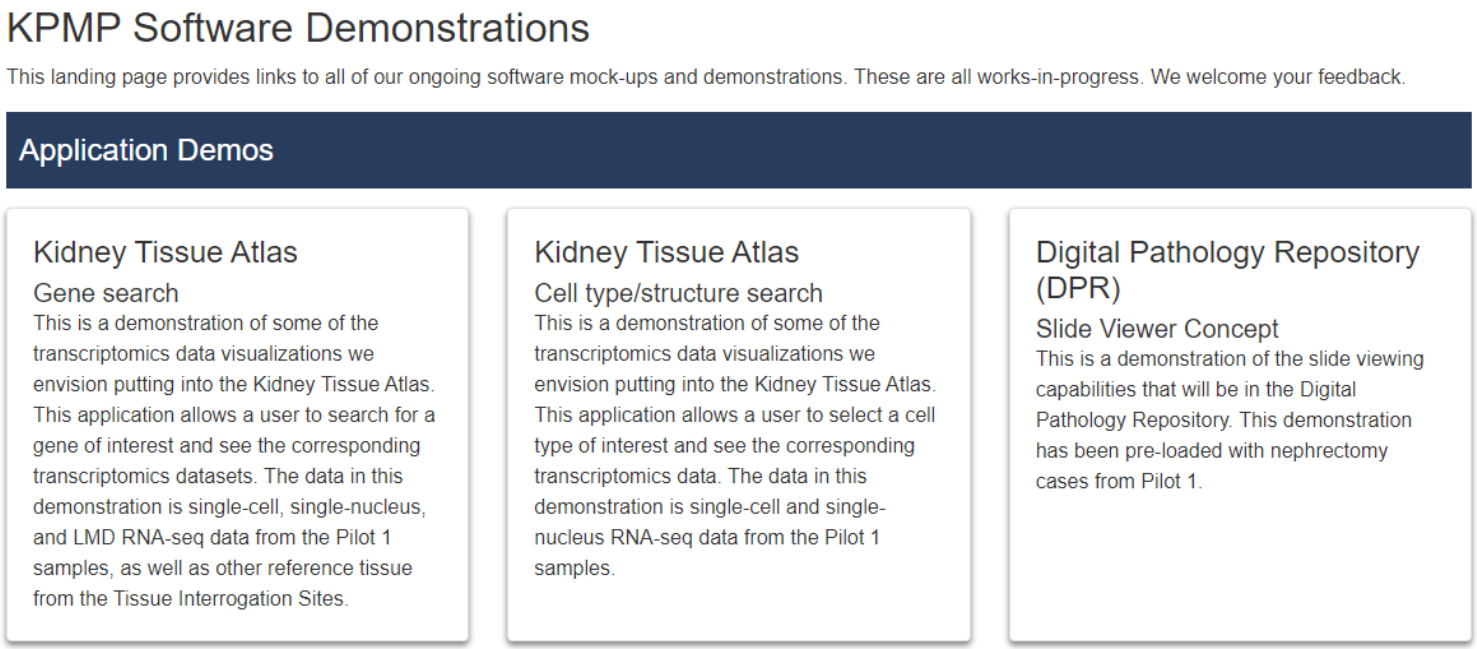
Kidney Tissue Atlas

Envisioning multiple entry points into the atlas



Set-up a webpage for ongoing mock-ups and prototypes: https://demo.kpmp.org

- One-stop-shop for all current design mock-ups, prototypes, and demonstrations
- Simple feedback mechanism embedded into all demos
- Three demos available now!



Cell type-based search concepts

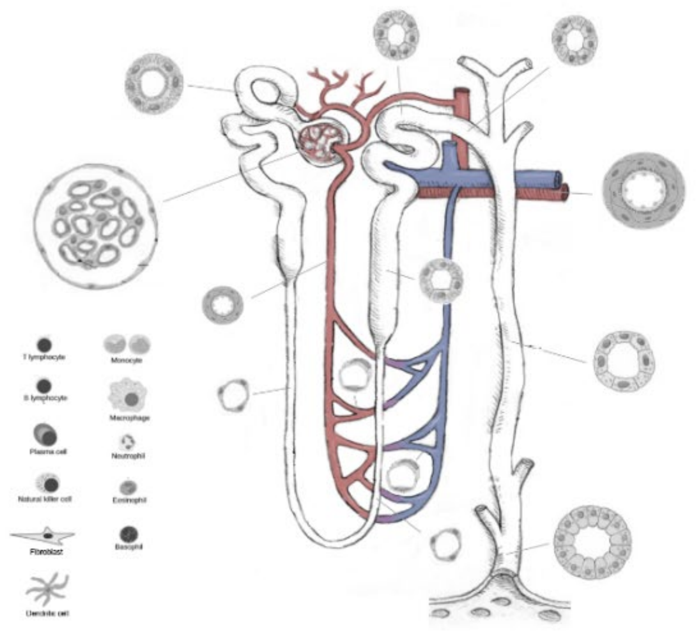
Select a cell type

Glomerulus
- Endothelial Glomerular Capillary
- Messangial Cell
- Parietal Cell
- Podocyte

Interstitium
- Activated T-cells
- B-cells
- Cytotoxic T-cells
- Effector Memory T-cells
- Interstitial Fibroblasts
- ISG-activated T-cells
- Macrophages
- Memory T-cells
- Monocytes
- Natural Killer Cells
- Natural Killer T-cells

Tubules
- Collecting Duct Principal Cells
- Collecting Duct Intercalated Cells
- Distal Tubules
- Loop of Henle
- Proximal Tubules

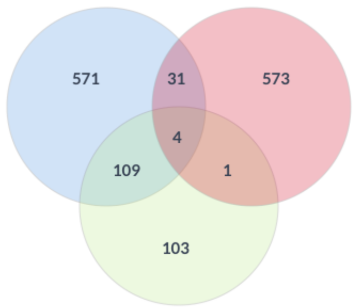
Vessels
- Endothelial Arteries
- Peritubular Capillaries
- Vascular Smooth Muscle Cells



Podoctye gene expression

Transciptomics | Proteomics | Metabolomics | Integrated data

Differentially expressed genes



- ☑ mdscRNA-seq (UCSF)
- ☑ scRNA-Seq (UMich)
- ☑ snDrop-Seq (UCSD)

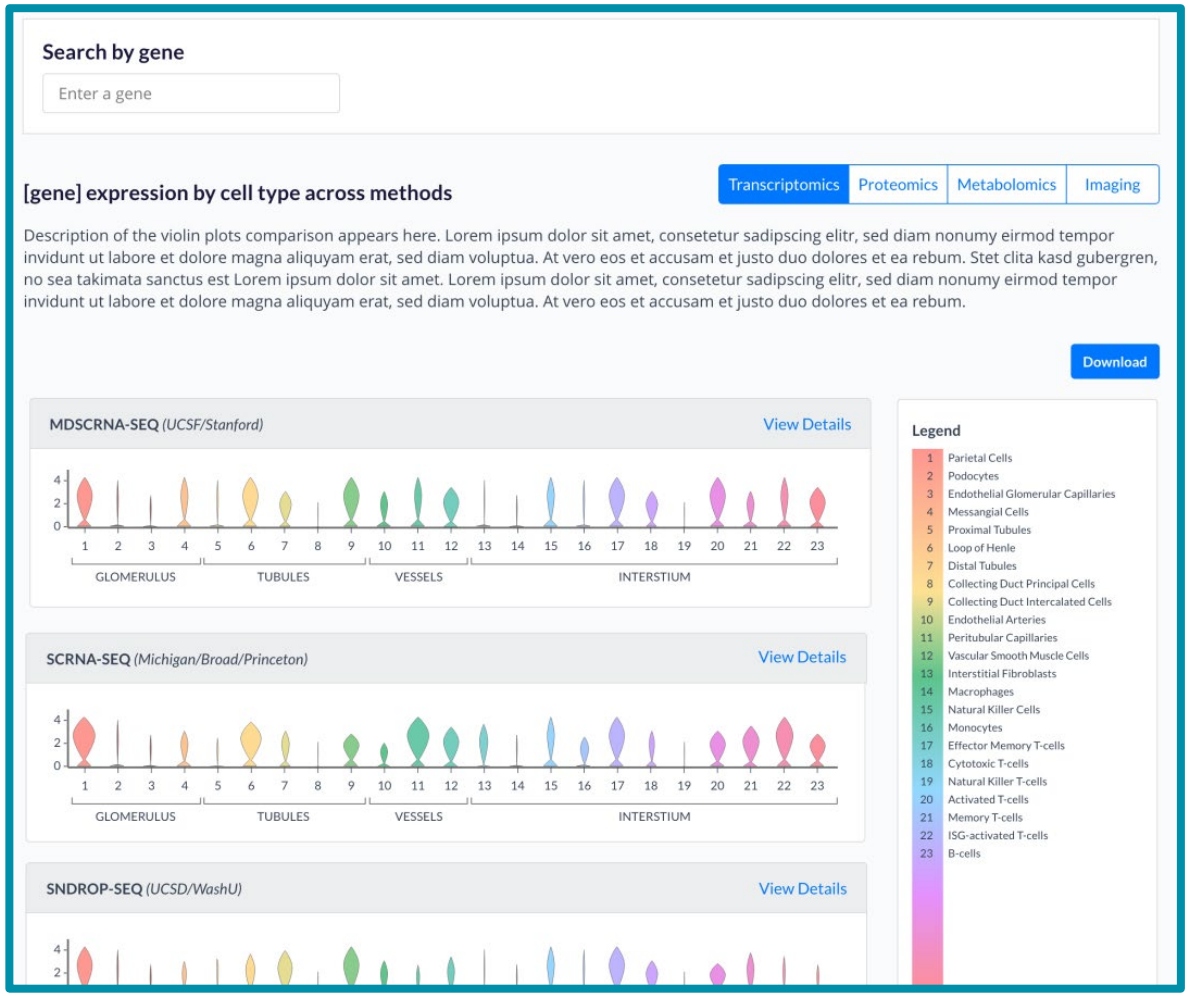
Gene expression across methods

Download

FILTER: value | FILTER: value | FILTER: value

GENE	CONFIDENCE VALUE	MDSCRNA-SEQ (UCSF)		SCRNA-SEQ (UMICH)		SNDROP-SEQ (UCSD)	
GENE	9.1	FC	pVal	FC	pVal	FC	pVal
GENE	9.1	FC	pVal	FC	pVal	FC	pVal
GENE	9.1	FC	pVal	FC	pVal	FC	pVal
GENE	9.1	FC	pVal	FC	pVal	FC	pVal
GENE	9.1	FC	pVal	FC	pVal	FC	pVal
GENE	9.1	FC	pVal	FC	pVal	FC	pVal
GENE	9.1	FC	pVal	FC	pVal	FC	pVal
GENE	9.1	FC	pVal	FC	pVal	FC	pVal
GENE	9.1	FC	pVal	FC	pVal	FC	pVal
GENE	9.1	FC	pVal	FC	pVal	FC	pVal
GENE	9.1	FC	pVal	FC	pVal	FC	pVal
GENE	9.1	FC	pVal	FC	pVal	FC	pVal

Molecular-based search concepts



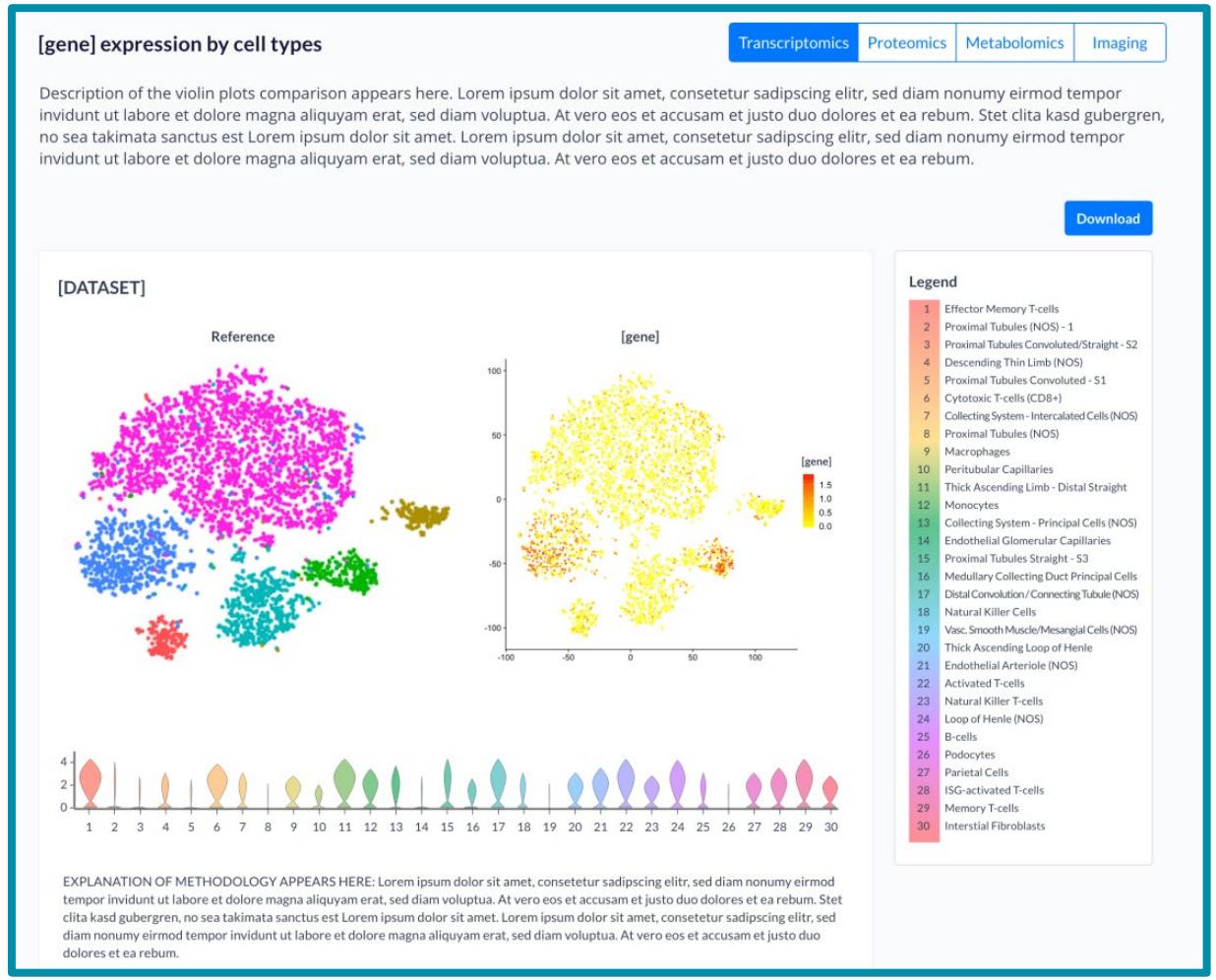
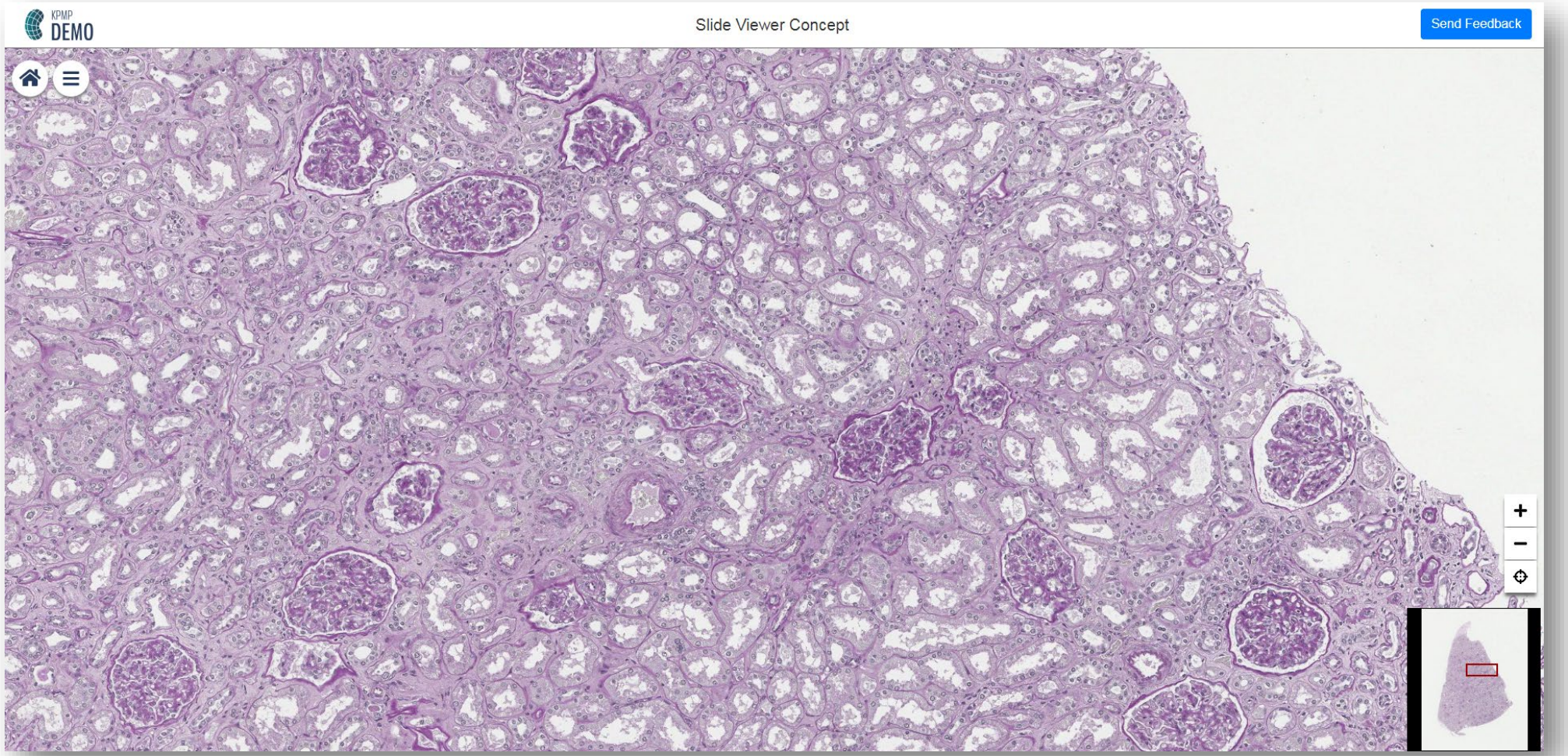
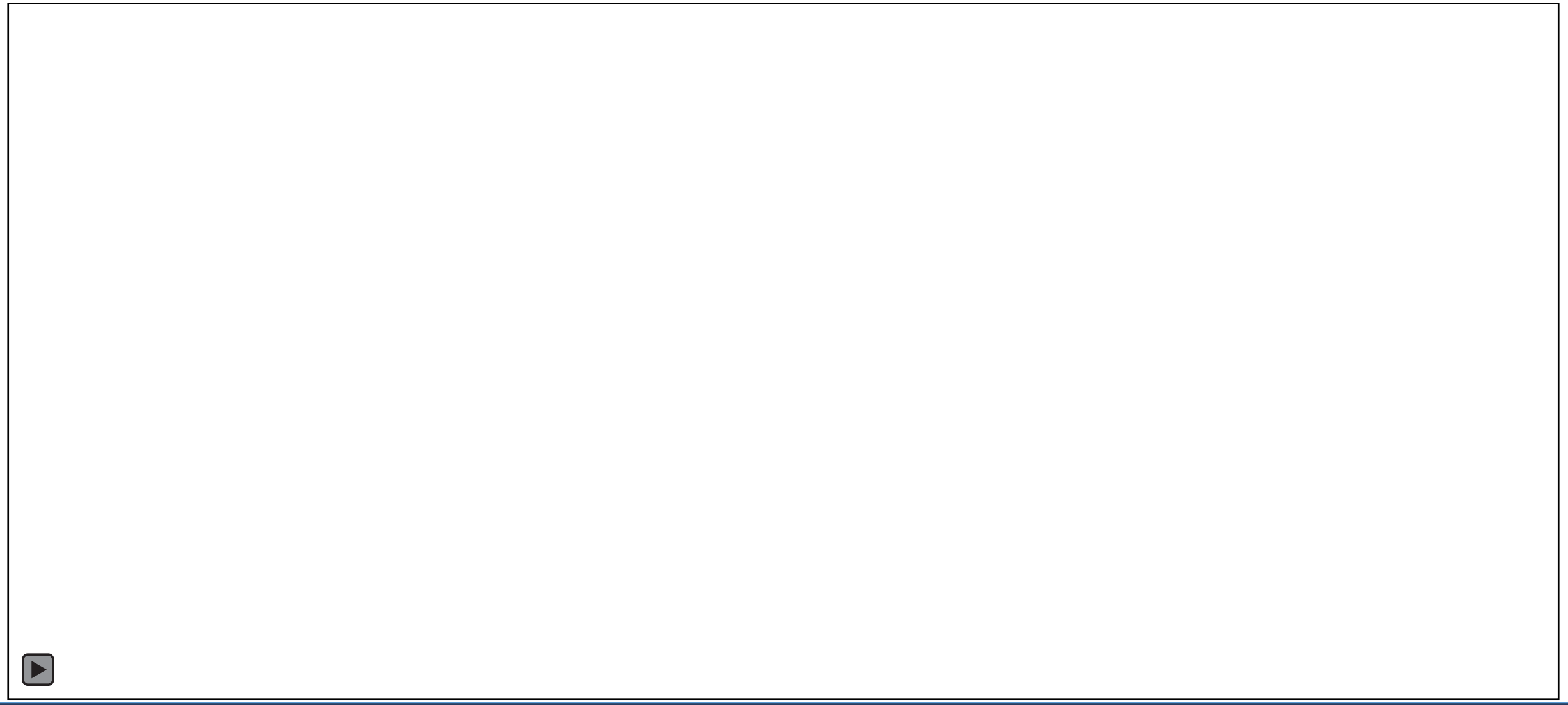


Image-based search concepts

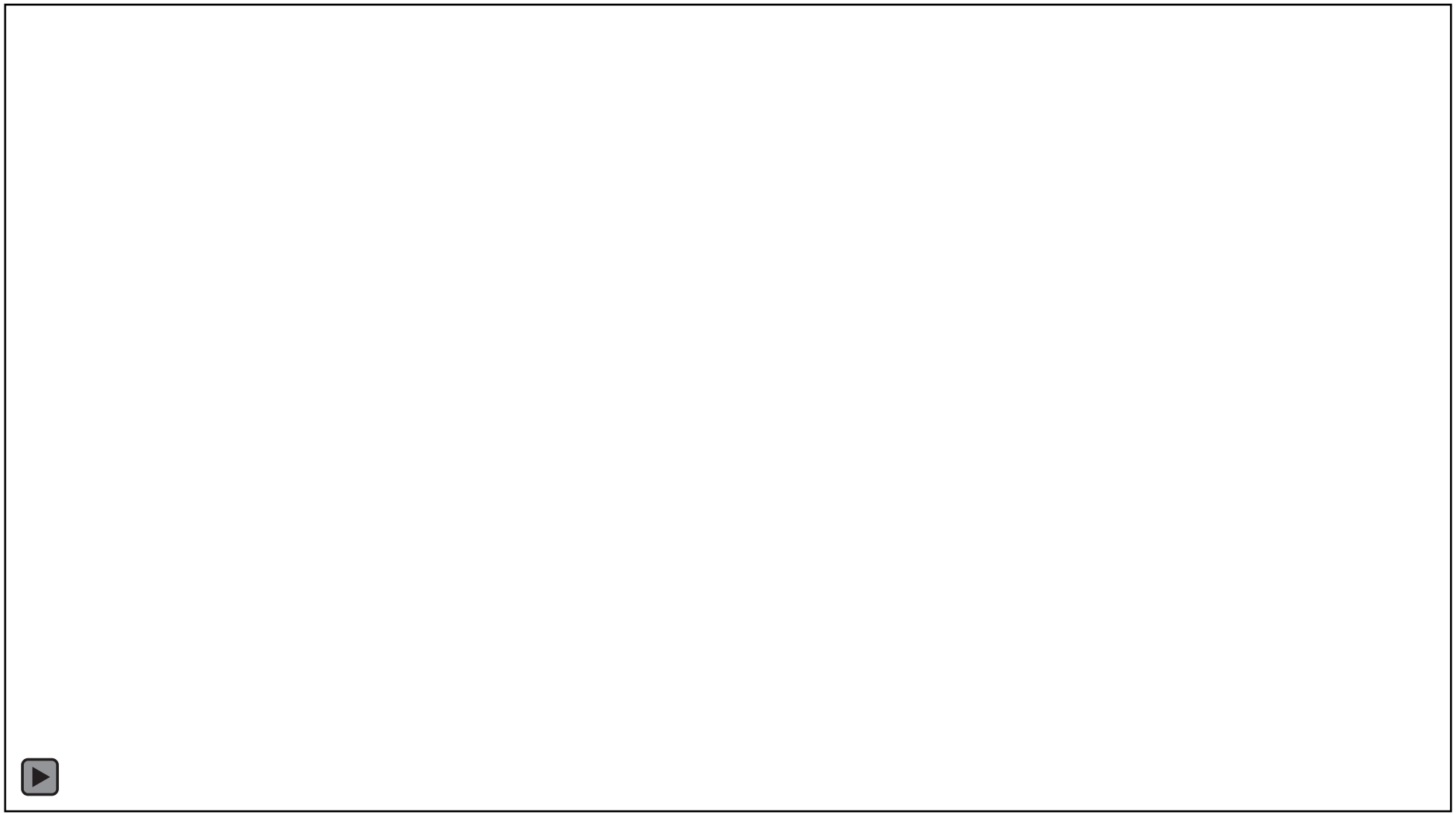
Example available now at:
https://mydata.kpmp.org



Proof-of-concept re: from histology to a schematic



Proof-of-concept re: connecting molecular and spatial data



Software Team Acknowledgements

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  - Pathology Informatics:
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  - Nephrology:
    - Michael Rose, Becky Reamy, Zach Wright

UNIVERSITY OF MICHIGAN

Questions?