



KIDNEY PRECISION MEDICINE PROJECT



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?

Stratify patients
Implementation



Individualized:
Diagnosis
Prognosis
Treatment

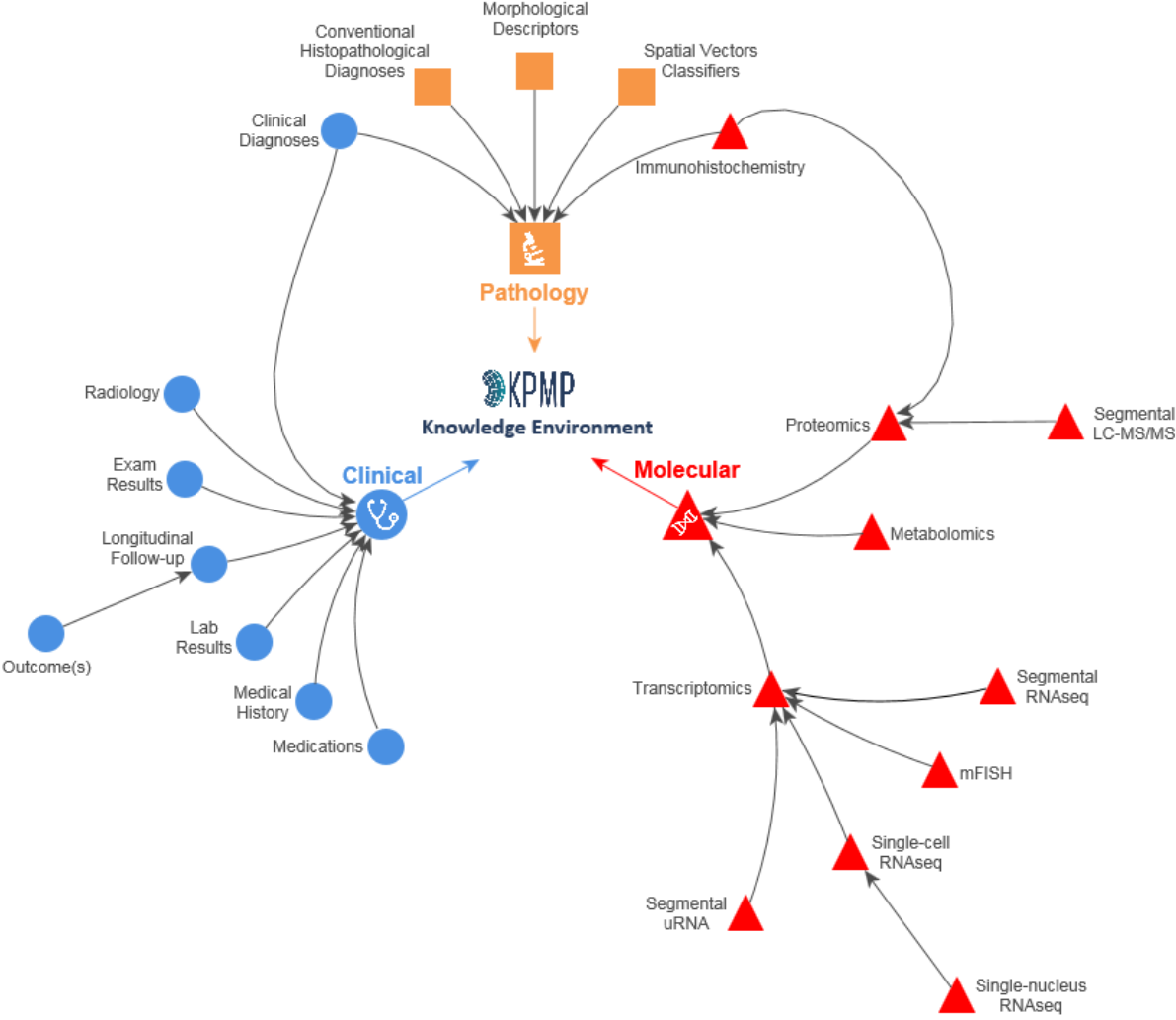
Disaggregation
Anchors / Markers
Map to tissue

Correlate with
Clinical outcomes
Model systems

Visual display of spatial data

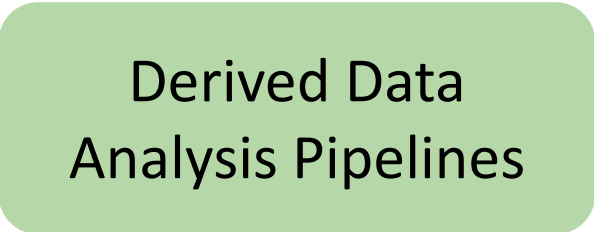
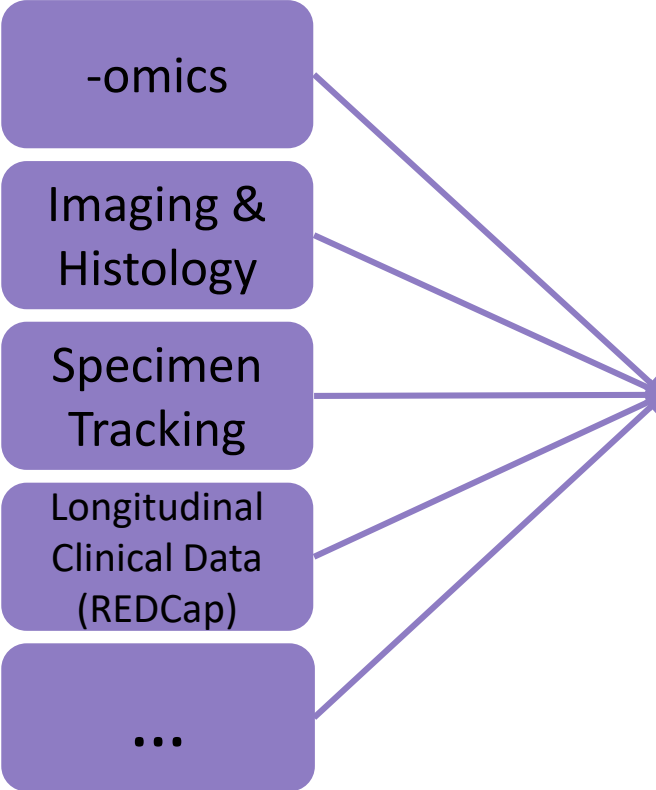
Stratification markers for clinical decisions

KPMP Data Types



Data Flow

Data Generators



Data Viewing Tools



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

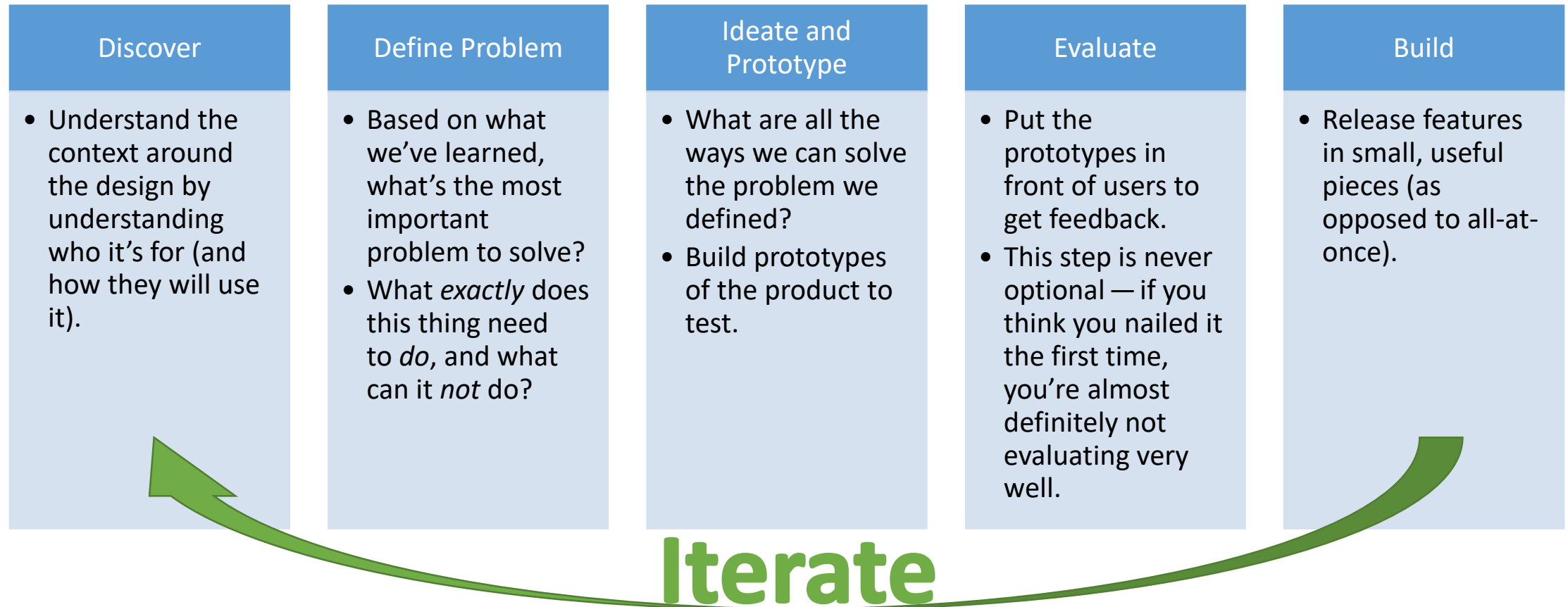
"I work closely with my wet lab and want to use my analytical skills to answer their biological questions using KPMP."



RESEARCHER: DATA MINER

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

Software Development Process Overview



Internal Tools

Data Lake Uploader

Metadata Module	Property	Bulk Proteomics	Sub-segmental Proteomics	Near-single-cell Proteomics	Property Type	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 Segmentation / 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					

Tissue Processing

Type of Tissue Sectioned *

Tissue Sectioning Date *

Tissue Processing Instrument *

Tissue Processing Instrument Software / Version *

Tissue Segmentation / Dissociation Date *

Marker Used for Dissection *

Area Dissected / Processed (Square Microns) *

Calculated Volume Dissected / Processed *

Calculated Volume Dissected / Processed Units *

Tissue Processing Comments

Protein Extraction & Digestion

Tissue Protein Extraction Date *

Was Digestion Standard Used *

Digestion Enzyme *

Digestion Buffer *

Protein Yield *

Protein Yield Unit *

Protein Reduction Agent *

Alkylation Agent *

Was Automation Used *

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



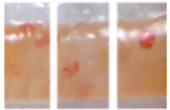
Participant-Centric Tools

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?

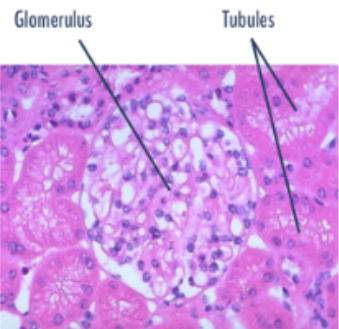
What am I seeing in these images?



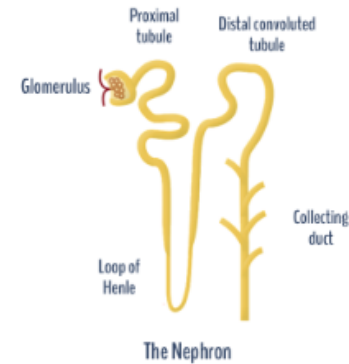
Step 1: Segment

One of your samples is cut into 3 segments.

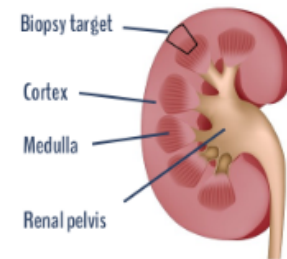
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Looking at this example of a biopsy slide image, a pathologist would look at the components of the kidney such as glomeruli and tubules. This can reveal evidence of disease and tissue damage.



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

KIDNEY PRECISION MEDICINE PROJECT
PARTICIPANT BIOPSY IMAGE VIEWER

WHOLE SLIDE IMAGES

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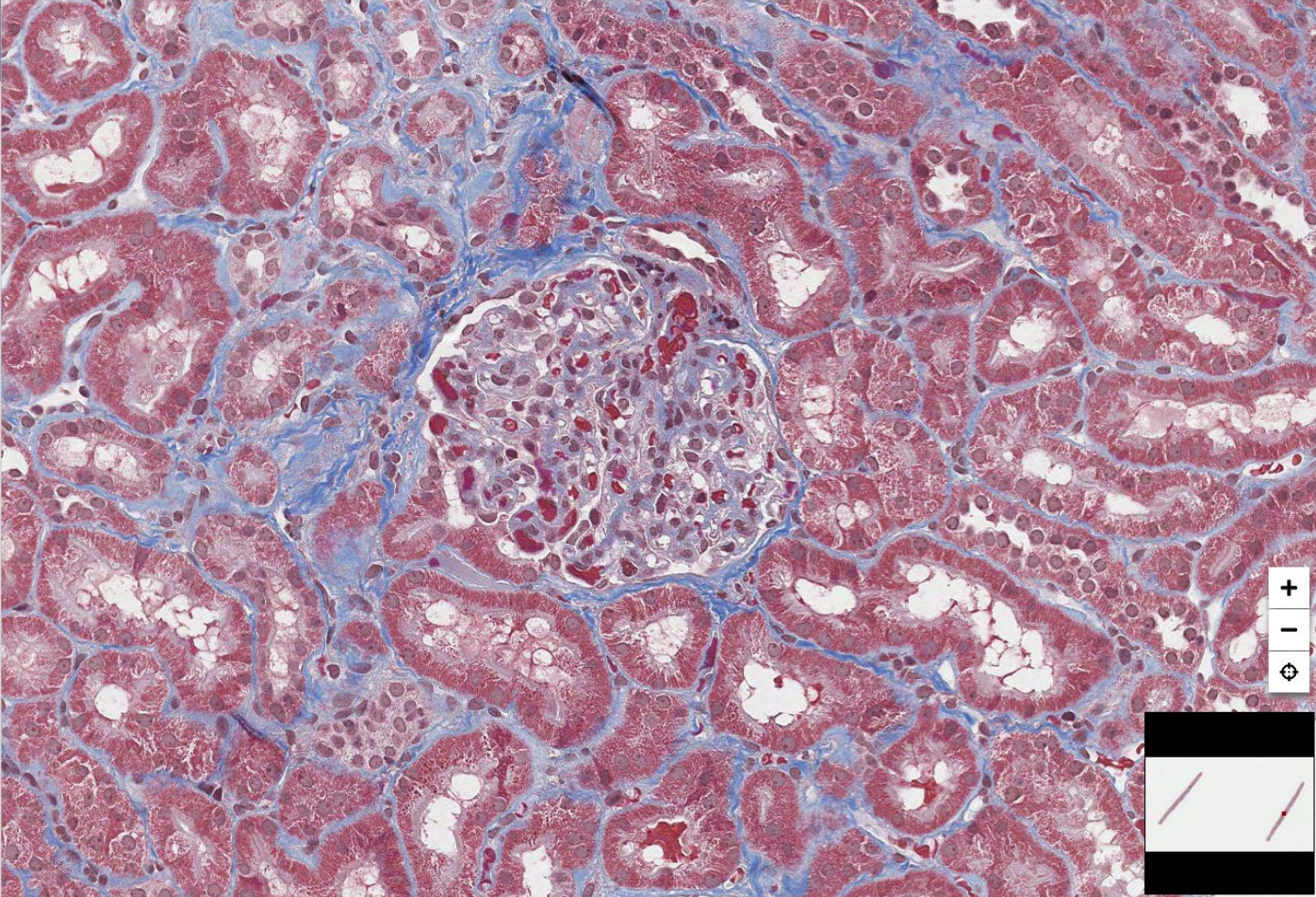
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	KPMP-Ex1_PAS_1of1
	KPMP-Ex1_SIL_1of1
	KPMP-Ex1_TRI_1of1




KPMP-Ex1_TRI_1of1

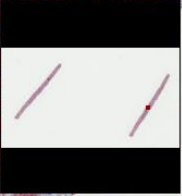
Trichrome Stain

A Masson's trichrome [stain](#) was applied to this biopsy slide. It is called a trichrome stain because it typically shows kidney features in three different colors.

This stain is very helpful for detecting scarring (also called fibrosis), among other things. Scarring shows up as a blue color on the images.





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

Cell types



Select from a list of cell types.

[View cell types](#)

Molecular



Search or select from a list of genes, proteins, and metabolites.

[Open search](#)

Images & Pathology



Search or select from a list of images.

[View images](#)

Clinical



Search or select from a list of clinical characteristics.

[Open clinical search](#)

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!

KPMP Software Demonstrations

This landing page provides links to all of our ongoing software mock-ups and demonstrations. These are all works-in-progress. We welcome your feedback.

Application Demos

Kidney Tissue Atlas

Gene search

This is a demonstration of some of the transcriptomics data visualizations we envision putting into the Kidney Tissue Atlas. This application allows a user to search for a gene of interest and see the corresponding transcriptomics datasets. The data in this demonstration is single-cell, single-nucleus, and LMD RNA-seq data from the Pilot 1 samples, as well as other reference tissue from the Tissue Interrogation Sites.

Kidney Tissue Atlas

Cell type/structure search

This is a demonstration of some of the transcriptomics data visualizations we envision putting into the Kidney Tissue Atlas. This application allows a user to select a cell type of interest and see the corresponding transcriptomics data. The data in this demonstration is single-cell and single-nucleus RNA-seq data from the Pilot 1 samples.

Digital Pathology Repository (DPR)

Slide Viewer Concept

This is a demonstration of the slide viewing capabilities that will be in the Digital Pathology Repository. This demonstration has been pre-loaded with nephrectomy cases from Pilot 1.

Cell type-based search concepts

Select a cell type

Glomerulus

- Endothelial Glomerular Capillary
- Mesangial Cell
- Parietal Cell
- Podocyte

Interstitialium

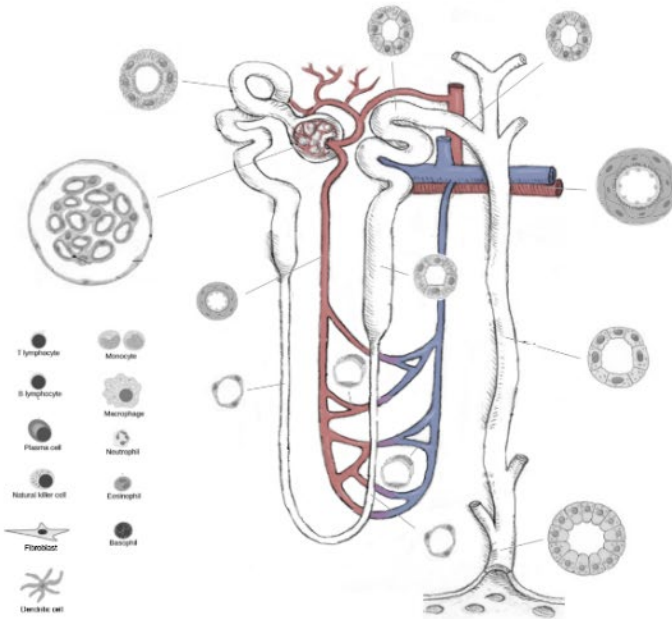
- Activated T-cells
- B-cells
- Cytotoxic T-cells
- Effector Memory T-cells
- Interstitial Fibroblasts
- ISG-activated T-cells
- Macrophages
- Memory T-cells
- Monocytes
- Natural Killer Cells
- Natural Killer T-cells

Tubules

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

Vessels

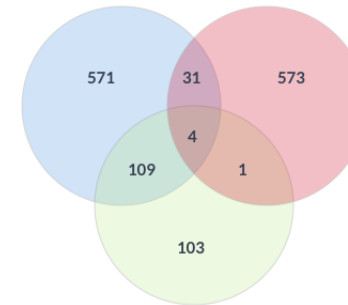
- Endothelial Arteries
- Peritubular Capillaries
- Vascular Smooth Muscle Cells



Podocyte gene expression

Transcriptomics Proteomics Metabolomics Integrated data

Differentially expressed genes



- mdsRNA-seq (UCSF)
- scRNA-Seq (UMich)
- snDrop-Seq (UCSD)

Gene expression across methods

Download

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

Molecular-based search concepts

Search by gene

[gene] expression by cell type across methods

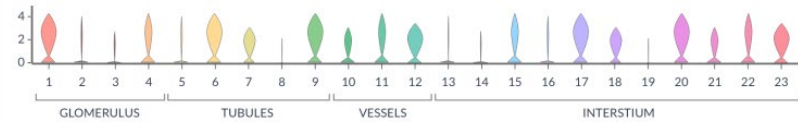
Transcriptomics Proteomics Metabolomics Imaging

Description of the violin plots comparison appears here. Lorem ipsum dolor sit amet, consetetur sadipscing elitr, sed diam nonumy eirmod tempor invidunt ut labore et dolore magna aliquyam erat, sed diam voluptua. At vero eos et accusam et justo duo dolores et ea rebum. Stet clita kasd gubergren, no sea takimata sanctus est Lorem ipsum dolor sit amet. Lorem ipsum dolor sit amet, consetetur sadipscing elitr, sed diam nonumy eirmod tempor invidunt ut labore et dolore magna aliquyam erat, sed diam voluptua. At vero eos et accusam et justo duo dolores et ea rebum.

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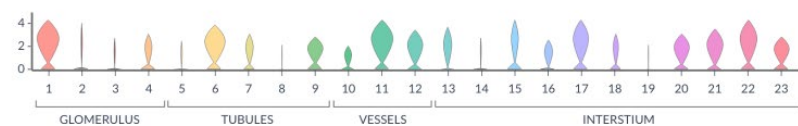
MDSCRNA-SEQ (UCSF/Stanford)

View Details



SCRNA-SEQ (Michigan/Broad/Princeton)

View Details



SNDROP-SEQ (UCSD/WashU)

View Details



Legend

- 1 Parietal Cells
- 2 Podocytes
- 3 Endothelial Glomerular Capillaries
- 4 Mesangial Cells
- 5 Proximal Tubules
- 6 Loop of Henle
- 7 Distal Tubules
- 8 Collecting Duct-Principal Cells
- 9 Collecting Duct-Intercalated Cells
- 10 Endothelial Arteries
- 11 Peritubular Capillaries
- 12 Vascular Smooth Muscle Cells
- 13 Interstitial Fibroblasts
- 14 Macrophages
- 15 Natural Killer Cells
- 16 Monocytes
- 17 Effector Memory T-cells
- 18 Cytotoxic T-cells
- 19 Natural Killer T-cells
- 20 Activated T-cells
- 21 Memory T-cells
- 22 ISG-activated T-cells
- 23 B-cells

[gene] expression by cell types

Transcriptomics Proteomics Metabolomics Imaging

Description of the violin plots comparison appears here. Lorem ipsum dolor sit amet, consetetur sadipscing elitr, sed diam nonumy eirmod tempor invidunt ut labore et dolore magna aliquyam erat, sed diam voluptua. At vero eos et accusam et justo duo dolores et ea rebum. Stet clita kasd gubergren, no sea takimata sanctus est Lorem ipsum dolor sit amet. Lorem ipsum dolor sit amet, consetetur sadipscing elitr, sed diam nonumy eirmod tempor invidunt ut labore et dolore magna aliquyam erat, sed diam voluptua. At vero eos et accusam et justo duo dolores et ea rebum.

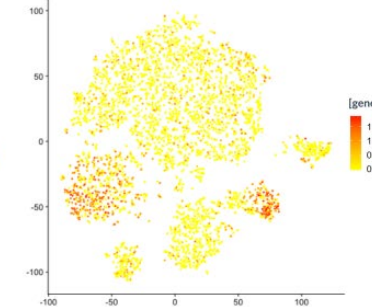
Download

[DATASET]

Reference



[gene]



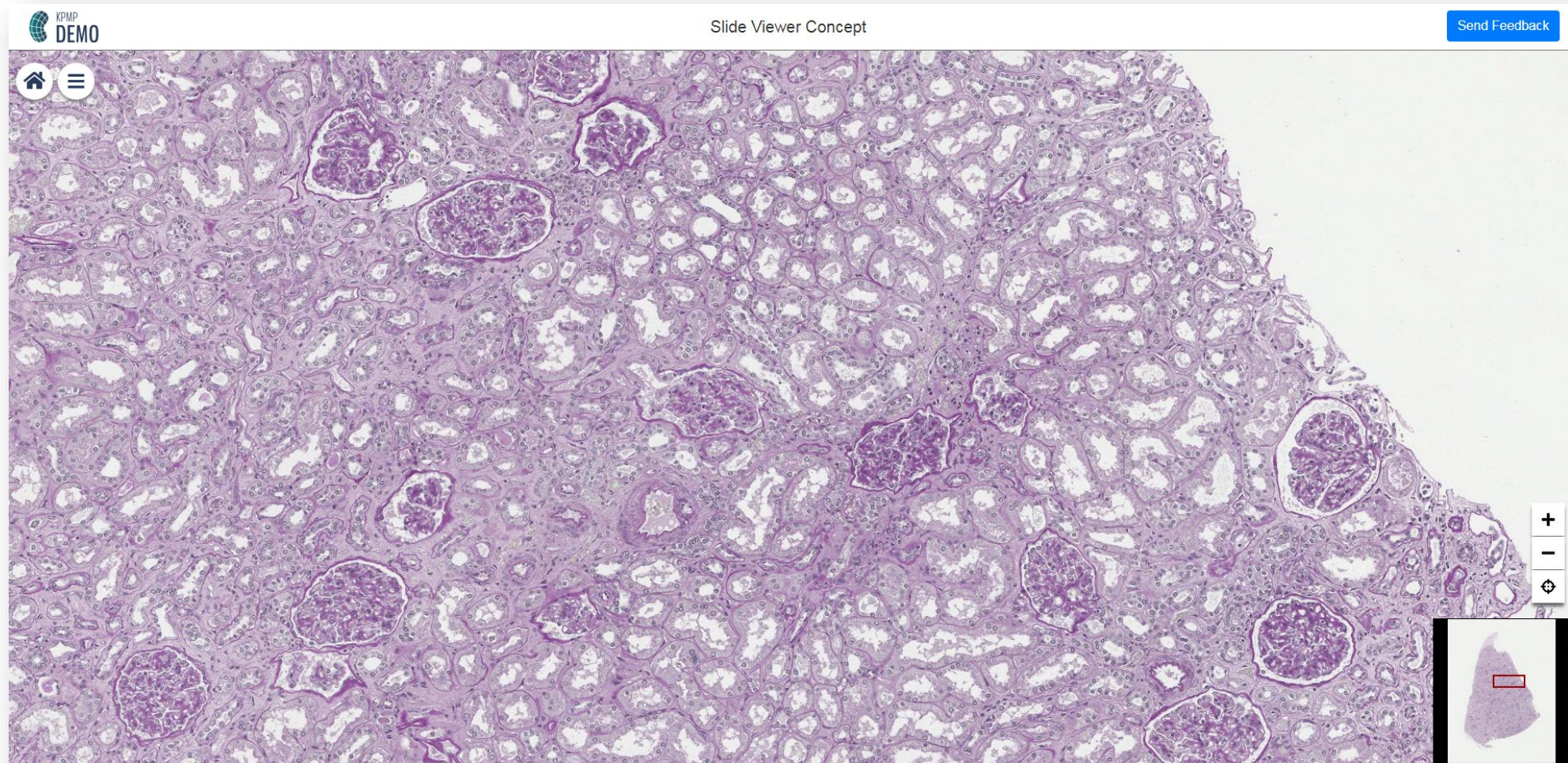
Legend

- 1 Effector Memory T-cells
- 2 Proximal Tubules (NOS) - 1
- 3 Proximal Tubules Convoluted/Straight - S2
- 4 Descending Thin Limb (NOS)
- 5 Proximal Tubules Convoluted - S1
- 6 Cytotoxic T-cells (CD8+)
- 7 Collecting System - Intercalated Cells (NOS)
- 8 Proximal Tubules (NOS)
- 9 Macrophages
- 10 Peritubular Capillaries
- 11 Thick Ascending Limb - Distal Straight
- 12 Monocytes
- 13 Collecting System - Principal Cells (NOS)
- 14 Endothelial Glomerular Capillaries
- 15 Proximal Tubules Straight - S3
- 16 Medullary Collecting Duct Principal Cells
- 17 Distal Convoluted/Connecting Tubule (NOS)
- 18 Natural Killer Cells
- 19 Vasc. Smooth Muscle/Mesangial Cells (NOS)
- 20 Thick Ascending Loop of Henle
- 21 Endothelial Arteriole (NOS)
- 22 Activated T-cells
- 23 Natural Killer T-cells
- 24 Loop of Henle (NOS)
- 25 B-cells
- 26 Podocytes
- 27 Parietal Cells
- 28 ISG-activated T-cells
- 29 Memory T-cells
- 30 Interstitial Fibroblasts

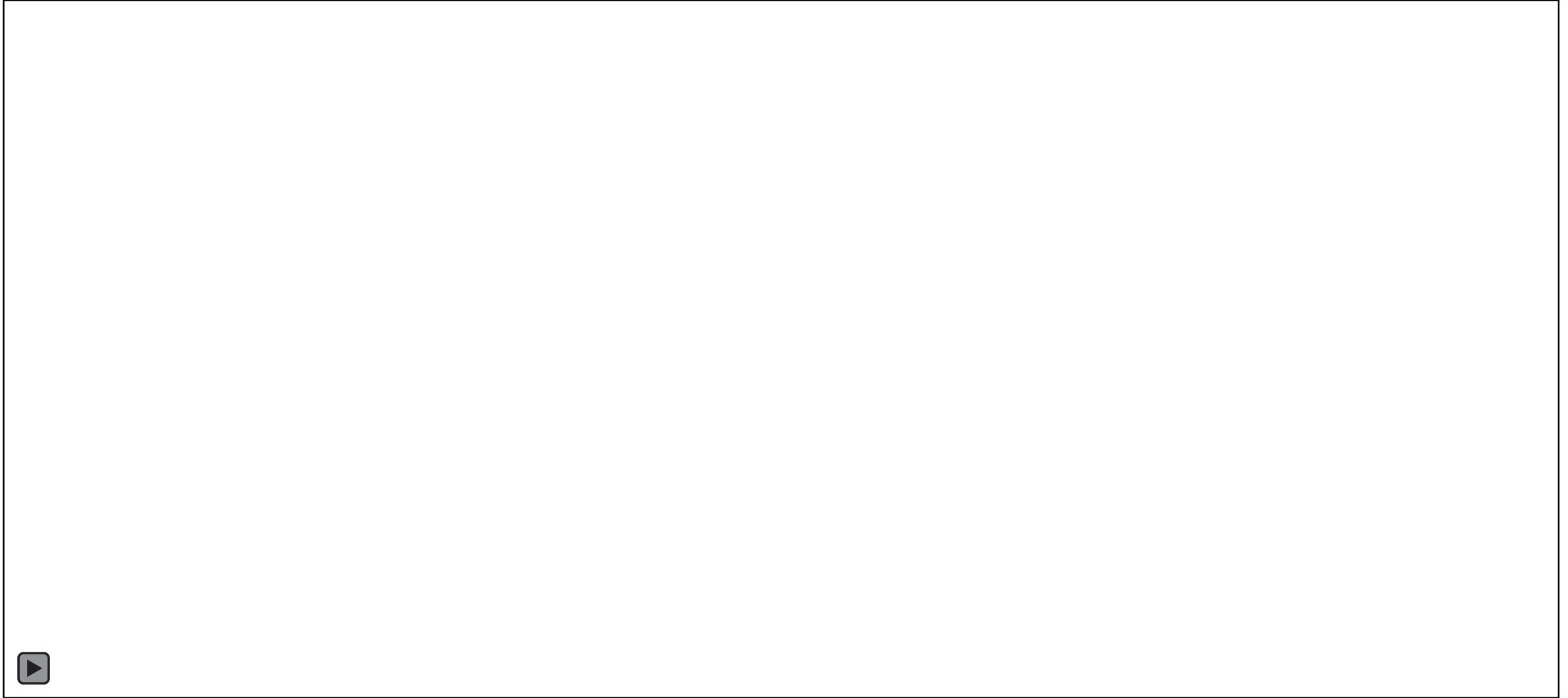
EXPLANATION OF METHODOLOGY APPEARS HERE: Lorem ipsum dolor sit amet, consetetur sadipscing elitr, sed diam nonumy eirmod tempor invidunt ut labore et dolore magna aliquyam erat, sed diam voluptua. At vero eos et accusam et justo duo dolores et ea rebum. Stet clita kasd gubergren, no sea takimata sanctus est Lorem ipsum dolor sit amet. Lorem ipsum dolor sit amet, consetetur sadipscing elitr, sed diam nonumy eirmod tempor invidunt ut labore et dolore magna aliquyam erat, sed diam voluptua. At vero eos et accusam et justo duo dolores et ea rebum.

Image-based search concepts

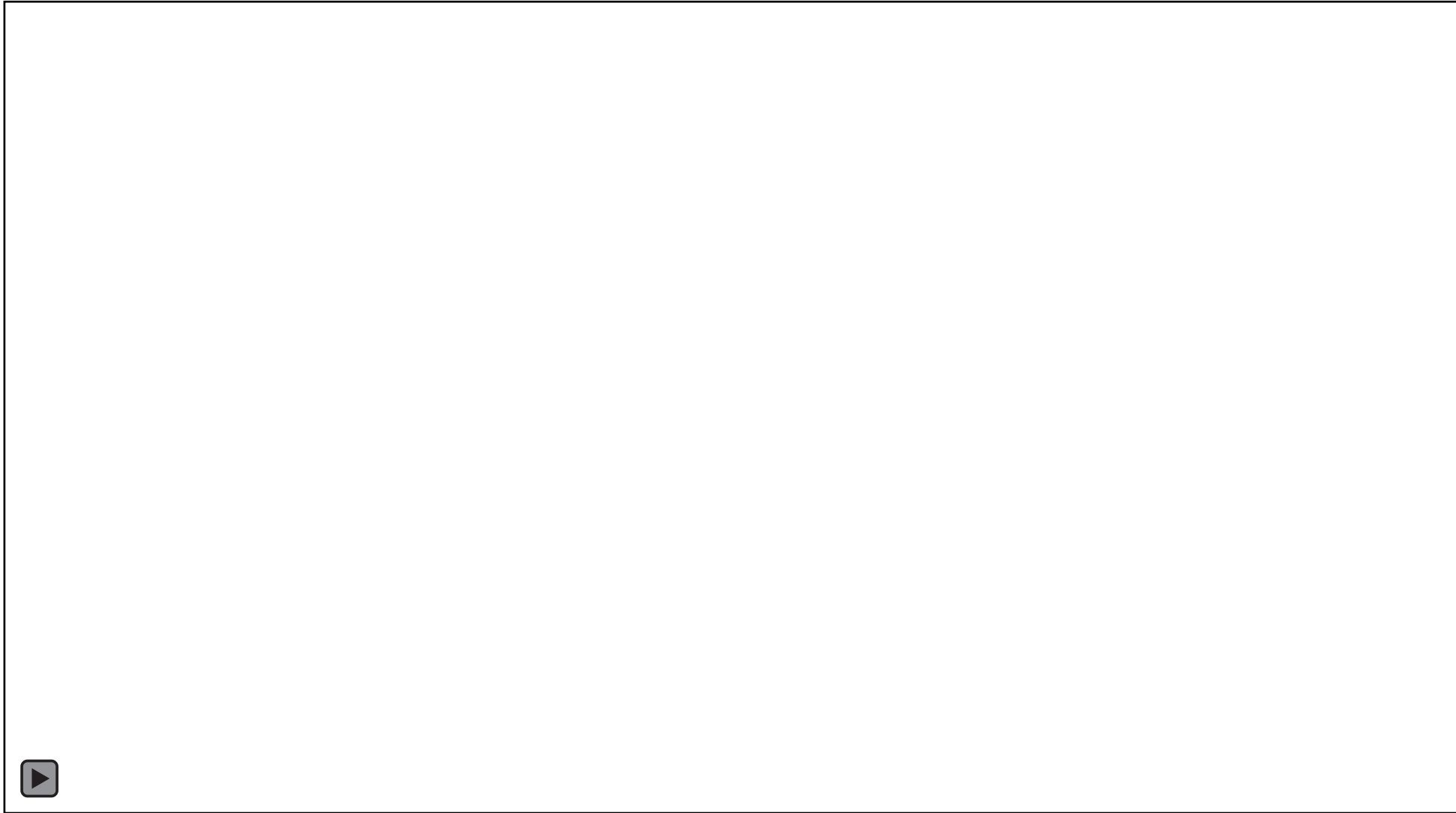
Example available now at:
<https://mydata.kpmp.org>



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



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



Software Team Acknowledgements

- Data Coordinating Center:
 - Jonas Carson, Fred Dowd, Cliff Spital, Justin Prosser
-

- Data Visualization Center (University of Michigan):
 - Pathology Informatics:
 - Ul Balis, Jerome Cheng, Ross Smith
 - Nephrology:
 - Michael Rose, Becky Reamy, Zach Wright



Questions?