How to construct the Kidney Tissue Atlas

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

How to construct the Kidney Tissue Atlas

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

Discovery
Validation

Stratify patients
Implementation

Individualized:
Diagnosis
Prognosis
Treatment

Tissue

Disaggregation
Anchors / Markers
Map to tissue

Correlate with
Clinical outcomes
Model systems

Visual display of spatial data

Stratification markers for clinical decisions

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

Knowledge Environment

Clinical
- Outcome(s)
- Lab Results
- Medical History
- Medications
- Longitudinal Follow-up
- Exam Results
- Radiology

Pathology
- Morphological Descriptions
- Spatial Vectors
- Immunohistochemistry
- Proteomics
- Segmental LC-MS/MS

Molecular
- Metabolomics
- Transcriptomics
- Segemental RNA-seq
- Single-cell RNA-seq
- Single-nucleus RNA-seq
- tR-FISH
- Single-cell rRNA-seq
- Single-nucleus rRNA-seq

Conventional Histopathological Diagnoses

KIDNEY PRECISION MEDICINE PROJECT
Data Flow

Data Generators
-omics
Imaging & Histology
Specimen Tracking
Longitudinal Clinical Data (REDCap)
...

Derived Data Analysis Pipelines

Data Lake

Knowledge Environment

Data Viewing Tools
Kidney Tissue Atlas
Raw Data Access
Participant-centric Tool(s)
...

Data Integration and Metadata: Ontologies

Identity and Access Management: Shibboleth/InCommon Authentication

KIDNEY PRECISION MEDICINE PROJECT
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

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

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**

- **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
Molecular-based search concepts

Description of the violin plots comparison appears here. Lorem ipsum dolor sit amet, consectetur adipiscing elit, 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. Sic cilia kasd gubergren, no sea takimata sanctus est Lorem ipsum dolor sit amet, consectetur adipiscing elit, 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

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  • Nephrology:
    • Michael Rose, Becky Reamy, Zach Wright
Questions?